META'17 Incheon - Korea

The 8th International Conference on Metamaterials, Photonic Crystals and Plasmonics

Program

July 25 – 28, 2017
Incheon, Korea

metaconferences.org

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META'17 Incheon - Korea

The 8th International Conference on Metamaterials, Photonic Crystals and Plasmonics

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Edited by

Said Zouhdi | Paris-Sud University, France
Junsuk Rho | POSTECH, Korea
Hakjoo Lee | CAMM, Korea

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Jianjia Yi, China
Hao Yu, Singapore
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Jie Zhu, China
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PLENARY SPEAKERS

Federico Capasso

Harvard University, USA

Metaoptics in the visible

Federico Capasso is the Robert Wallace Professor of Applied Physics at Harvard University, which he joined in 2003 after 27 years at Bell Labs where he was Member of Technical Staff, Department Head and Vice President for Physical Research. He is visiting professor at NTU with both the School of Physical and Mathematical Sciences and Electrical and Electronic Engineering. His research has focused on nanoscale science and technology encompassing a broad range of topics. He pioneered band-structure engineering of semiconductor nanostructures and devices, invented and first demonstrated the quantum cascade laser and investigated QED forces including the first measurement of a repulsive Casimir force. His most recent contributions are new plasmonic devices and flat optics based on metasurfaces. He is a member of the National Academy of Sciences, the National Academy of Engineering, the American Academy of Arts and Sciences. His awards include the King Faisal Prize, the IEEE Edison Medal, the SPIE Gold Medal, the American Physical Society Arthur Schawlow Prize in Laser Science, the Jan Czochralski Award for lifetime achievements in Materials Science, the IEEE Sarnoff Award in Electronics, the Materials Research Society Medal, the Wetherill Medal of the Franklin Institute, the Rank Prize in Optoelectronics, the Optical Society Wood Prize, the Berthold Leibinger Future Prize, the Julius Springer Prize in Applied Physics, the European Physical Society Quantum Electronics Prize.

Dirk Englund

MIT, USA

Towards Scalable Semiconductor Quantum Networks

Dirk Englund received his BS in Physics from Caltech in 2002. Following a Fulbright year at TU Eindhoven, he earned an MS in electrical engineering and a PhD in Applied Physics in 2008, both from Stanford University. He was a postdoctoral fellow at Harvard University until 2010, when he started his group as Assistant Professor of Electrical Engineering and of Applied Physics at Columbia University. In 2013, he joined the faculty of MIT's Department of Electrical Engineering and Computer Science. Dirk's research focuses on quantum technologies based on semiconductor and optical systems. Recent recognitions include the 2011 Presidential Early Career Award for Scientists and Engineers, the 2011 Sloan Research Fellowship in Physics, the 2012 DARPA Young Faculty Award, the 2012 IBM Faculty Award, an 2016 R&D100 Award, the OSA's 2017 Adolph Lomb Medal , and the 2017 ACS Photonics Young Investigator Award.

Ortwin Hess

Imperial College London, UK

Active Quantum Nanoplasmonics : From Single Molecule Strong Coupling to Stopped-Light QED and Lasing

Ortwin Hess currently holds the Leverhulme Chair in Metamaterials in the Blackett Laboratory (Department of Physics) at Imperial College London. He obtained the PhD degree from the Technical University of Berlin (Germany) in 1993 and the Habilitation at the University of Stuttgart in 1997. From 2003 to 2010 he was professor at the University of Surrey (Guildford, UK) and visiting professor at Stanford University (1997/98) and at the Ludwig-Maximilians University of Munich (1999/2000). Ortwin's research interests bridge theoretical condensed matter physics with photonics and are focused on light-matter interaction in nano-photonics, metamaterials and spatio-temporal nano-laser dynamics. He discovered the 'trapped-rainbow' principle, had the idea of stopped-light lasing and made defining contributions to the fields of spatio-temporal dynamics of semiconductor lasers, ultraslow light in metamaterials, complex quantum dot photonics and photonic crystals and strong coupling in nanoplasmonics. Ortwin pioneered active nanoplasmonics and optical metamaterials with quantum gain for which he is awarded the 2016 Royal Society Rumford Medal.

Satoshi Kawata

Osaka University, Japan

Tip-enhanced Raman scattering microscopy : plasmonic molecular imaging beyond the limits

Satoshi Kawata has been a Professor (currently Distinguished Professor) of Applied Physics and Frontier Biosciences at Osaka University since 1993, and also a Chief Scientist in RIKEN from 2002 to 2012. He has served as the President of Japan Society of Applied Physics, the President for Spectroscopical Society of Japan, Editor of Optics Communications, and a Director of Board of OSA. Professor Kawata is one of pioneers in near field optics (the inventor of aperture-less near-field scanning optical microscope and tip-enhanced Raman microscopy), two-photon engineering (the inventor of 3D fabrication with two-photon polymerization, isomerization, photo-refraction, and reduction). He has published a number of papers and books on three-dimensional and nano-resolution microscopy, vibrational spectroscopy, bio-imaging, signal recovery and photon pressure on nano-structures. The "8-micron bull" fabricated with his invented two-photon polymerization has been awarded in Guinness World Record Book 2004 Edition. He is a Fellow of OSA, SPIE, IOP, and JSAP.

Yong-Hee Lee

Korea Advanced Institute of Science and Technology (KAIST), Korea

Squeezing of Photonic Energy into A Point-like Space

Yong-Hee Lee received his master degree in Applied Physics and Ph.D degree in Optical Sciences at Korea Advanced Institute of Science and Technology (KAIST) and at the University of Arizona, respectively. During his stay at AT&T Bell Laboratories, he pioneered and demonstrated the first proton-implanted VCSELs in 1990 and holds the original patent on this industrial VCSEL. In 1991 he joined the Department of Physics of KAIST where he continued his research on VCSELs and started new research on photonic crystal nano-lasers. His laboratory demonstrated various forms of photonic crystal laser including the first electrically-driven photonic crystal laser. His recent interest lies in on the physics of light-matter interaction at the nano-scale and the ultimate light source for photonic integrated circuits and quantum information science. From 2003 to 2004 he was an IEEE LEOS Distinguish Lecturer. Prof. Lee served as an Associate Editor of Optics Express. He is a Fellow of IEEE and the Optical Society of America. Domestically he received numerous awards including the National Academy of Science Award, Korea Scientist Award and the most recent Korea Best Scientist and Engineer Award. In 2014 He received the Humboldt Research Award and the IEEE Photonics Society Engineering Achievement Award. He co-authored more than 180 international journal papers and patents related to nanophotonics. He advised and produced over 40 PhD's in physics during his stay at KAIST.

Franco Nori

RIKEN, Japan & University of Michigan, USA

Parity-Time-Symmetric Optics, extraordinary momentum and spin in evanescent waves, and the quantum spin Hall effect of light

Franco Nori is a RIKEN Chief Scientist, as well as Group Director of the "Quantum Condensed Matter Research Group" at CEMS (Center for Emergent Matter Science). Also, he is a Team Leader of the Interdisciplinary Theoretical Science Program at RIKEN (the Japanese National Laboratory). Also, since 1990 he has been a faculty member of the Physics Department at the University of Michigan, Ann Arbor, USA. Prior to this, he did postdoctoral research work at the Institute for Theoretical Physics, at the University of California, Santa Barbara. He received a PhD in Physics from the University of Illinois. He has co-authored over 80 papers in Physical Review Letters as well as over 30 in Science and Nature journals, and has been cited over 29K times, with an h-index of 84. He is an Elected Fellow of the American Physics Society (APS), Institute of Physics (IoP), Optical Society of America (OSA), and the American Association for the Advancement of Science (AAAS). He received the 2014 Prize for Research in Physics, from the Matsuo Foundation, Japan ; and the 2013 Prize for Science, by the Minister of Education, Culture, Sports, Science and Technology, Japan. Also, an "Excellence in Research Award" and an "Excellence in Education Award" from the University of Michigan.

Eli Yablonovitch

UC Berkeley, USA

Optical Antennas ; Spontaneous Emission Faster Than Stimulated Emission

Eli Yablonovitch introduced the idea that strained semiconductor lasers could have superior performance due to reduced valence band (hole) effective mass. With almost every human interaction with the internet, optical telecommunication occurs by strained semiconductor lasers. He is regarded as a Father of the Photonic BandGap concept, and he coined the term "Photonic Crystal". The geometrical structure of the first experimentally realized Photonic bandgap, is sometimes called "Yablonovite".

Prof. Yablonovitch is elected as a Member of the National Academy of Engineering, the National Academy of Sciences, the American Academy of Arts & Sciences, and is a Foreign Member of the Royal Society of London. He has been awarded the Buckley Prize of the American Physical Society, the Isaac Newton Medal of the UK Institute of Physics, the Rank Prize (UK), the Harvey Prize (Israel), the IEEE Photonics Award, the IET Mountbatten Medal (UK), the Julius Springer Prize (Germany), the R.W. Wood Prize, the W. Streifer Scientific Achievement Award, and the Adolf Lomb Medal. He also has an honorary Ph.D. from the Royal Institute of Technology, Stockholm, & the Hong Kong Univ. of Science & Technology, and is honorary Professor at Nanjing University.

Eli Yablonovitch is the Director of the NSF Center for Energy Efficient Electronics Science (E3S), a multi-University Center headquartered at Berkeley. He received his Ph.D. degree in Applied Physics from Harvard University in 1972. He worked for two years at Bell Telephone Laboratories, and then became a professor of Applied Physics at Harvard. In 1979 he joined Exxon to do research on photovoltaic solar energy. Then in 1984, he joined Bell Communications Research, where he was a Distinguished Member of Staff, and also Director of Solid-State Physics Research. In 1992 he joined the University of California, Los Angeles, where he was the Northrop-Grumman Chair Professor of Electrical Engineering. Then in 2007 he became Professor of Electrical Engineering and Computer Sciences at UC Berkeley, where he holds the James & Katherine Lau Chair in Engineering.

Xiang Zhang

UC Berkeley, USA

Parity-time Symmetry Breaking Lasing and Anti-Lasing

Xiang Zhang is the Ernest Kuh Chaired Professor at the University of California, Berkeley and Director of Materials Science Division at Lawrence Berkeley National Laboratory (LBNL). He is also the Director of the NSF Nano-scale Science and Engineering Center (SINAM). He is an elected member of the US National Academy of Engineering (NAE), Academia Sinica and foreign member of Chinese Academy of Sciences. His research in optical metamaterials was selected by Times Magazine as "Top 10 Scientific Discoveries in 2008". Xiang Zhang was a recipient of many awards including the NSF CAREER Award, Fred Kavli Distinguished Lecturehip, Fitzroy Medal, Charles R. Richards Memorial Award, the Max Born Award, the Julius Springer Prize for Applied Physics. He received his BS/MS in physics in Nanjing University, China, and Ph.D from UC Berkeley in 1996 and was on faculty at Pennsylvania State University and UCLA prior returning Berkeley faculty in 2004.

Nikolay Zheludev

University of Southampton, UK & NTU, Singapore

Metamaterials, anapoles and flying donuts

Nikolay Zheludev's research interest are in nanophotonics and metamaterials. He is the Director of the Centre for Photonic metamaterials and Deputy Director of the Optoelectronics Research Centre in Southampton University, UK. He is also co-Director of The Photonics Institute and directs the Centre for Disruptive Photonic Technologies at Nanyang Technological University. His personal awards include the Thomas Young medal (IOP) for "global leadership and pioneering, seminal work in optical metamaterials and nanophotonics", the Leverhulme Trust Senior Research Fellowship ; Senior Research Professorship of the EPSRC ; The Royal Society Wolfson Research Merit Award & Fellowship. He is a Fellow of the European Physical Society (EPS), the Optical Society (OSA) and the Institute of Physics (London). He is Editor-in-Chief of the Journal of Optics (IOP) and an Advisory Board Member for Nanophotonics, ACS Photonics and Nature Publishing Group Scientific Reports. In 2007 created European Physical Society international meeting at the crossroads of nanophotonics and metamaterials, NANOMETA. He was among a small group of research community leaders who provided initial impetus to the International Year of Light, declared by United Nations for 2015.

KEYNOTE SPEAKERS

Harry Atwater
CALTECH, USA

Dynamic Wavefront Control and Imaging with Active Nanophotonic Structures

Che Ting Chan
HKUST, Hong Kong

Pseudo-spins and their consequences in classical waves

Andrei Faraon
California Institute of Technology, USA

Flat and conformal optics with dielectric metasurfaces

Michael Farle
University of Duisburg-Essen, Germany & Immanuel Kant Baltic Federal University, Russia

Functionalized Hybrid Nanomagnets : New Materials for Innovations in Energy Storage and Medical Theranostics

Peer Fischer
Max Planck Institute, Germany

Chiral plasmonic nanostructures

Jean-Jacques Greffet
Institut d'Optique Graduate School, France

Quantum plasmonics

Yurii Gun'ko
Trinity College Dublin, Ireland

Chiral nanomaterials and their applications

Teruya Ishihara
Tohoku University, Japan

Second order optical nonlinearity in metamaterial

Chennupati Jagadish

The Australian National University, Australia

Semiconductor Nanowires and Metastructures for Optoelectronic Device Applications

Yoon Young Kim

Seoul National University, Korea

Extreme elastic anisotropy – realization by metamaterials

Byoungho Lee

Seoul National University, Korea

Metasurfaces for in-plane plasmonic arbitrary pattern generation

Stefan Maier

Imperial College London, UK

Hybrid nanostructures for sub-wavelength imaging, nonlinear optics, and chemistry

Namkyoo Park

Seoul National University, Korea

Acoustic omni meta-atom for decoupled access to all octants of a wave parameter space.

Markus Raschke

University of Colorado Boulder, USA

Seeing with the nano-eye : accessing structure, coupling, and dynamics in matter on its natural length and times scales

Mu Wang

Nanjing University, China

Making Structured Metal Transparent for Ultra-Broadband Electromagnetic and Acoustic Waves

META'17 VENUE

META'17 will be held at the **Songdo Convensia**, 123 Central-ro, Yeonsu-gu, 21998, **Incheon**, Korea.
Tel. : +82-32-210-1037
Fax : +82-32-210-1005
Website : www.songdoconvensia.com

GETTING TO VENUE

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Tel. : +82-32-210-1037
Fax : +82-32-210-1005
Website : www.songdoconvensia.com

Seoul (Downtown) -> Songdo Convensia

- By Subway

Subway Station	Information
University of Incheon (Incheon Line)	Take Seoul subway line number 1 and get off at Bupyeong Station Transfer Bupyeong Station to Incheon subway and get off at University of Incheon Station Take a walk around 10-15minutes to Songdo ConvensiA (next to Sheraton Hotel)
Dongmak Station (Incheon Line)	Take Seoul subway line number 1 and get off at Bupyeong Station Transfer Bupyeong Station to Incheon subway and get off Dongmak Station Through exit 3, take bus 8, 6, 780 to Songdo ConvensiA Bus Stop

- By Taxi

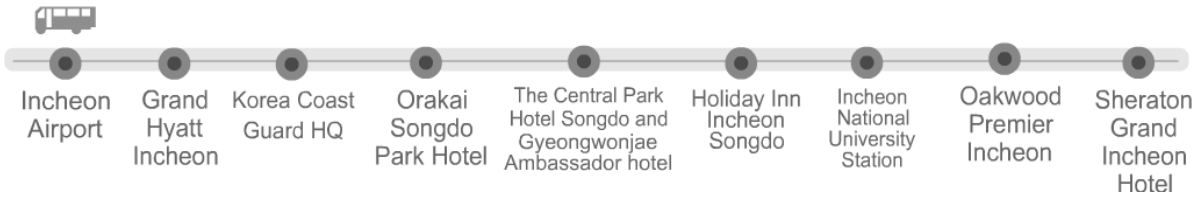
Fee	Taxi Fare ranges from 60,000 – 90,000 KRW ※ Receipt can be collected from driver if needed
Hours	Available 24hours
About	Ask Taxi Driver for 'Songdo ConvensiA' (at Songdo of Incheon City nearby Sheraton Hotel)

Incheon International Airport (ICN) -> Songdo Convensia

1) By KAL-limousine (~40 min, 7,000 KRW)

- Board the limousine bus (6707B) at the platform 4A

- Get off at **Sheraton Grand Incheon Hotel** (last stop)



Time schedule

Departure Point Incheon Airport (Bus Stop #4A) Arrival Point Sheraton Grand Incheon Hotel

Please be advised that actual times may vary depending on traffic conditions.

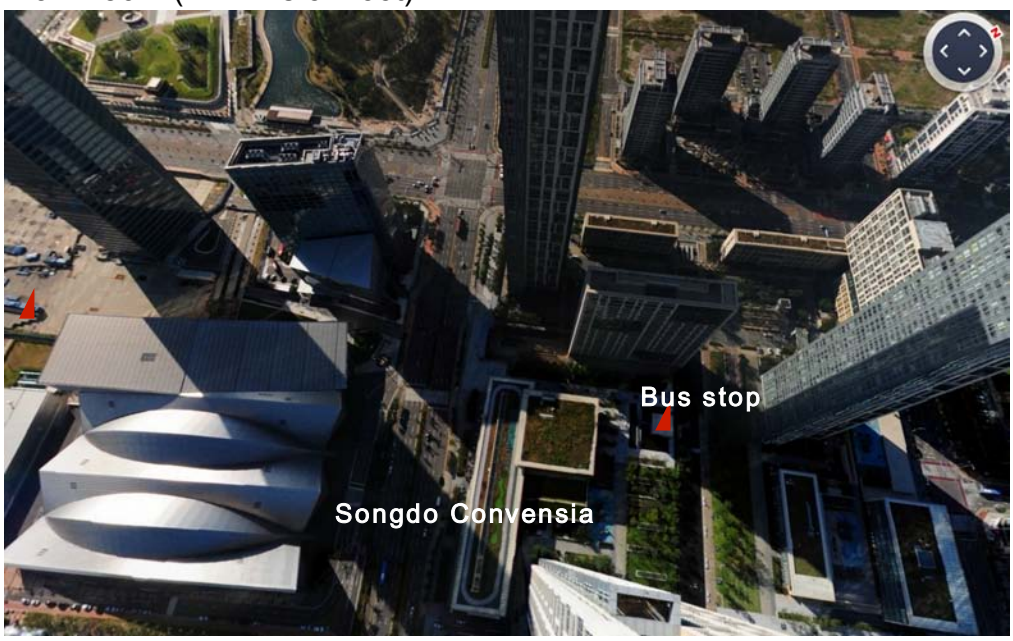
Travel Time : 30min

Departure time					
05:53	06:21	06:58	07:33	08:13	08:58
09:38	10:23	11:13	12:03	12:53	13:43
14:33	15:23	16:14	17:03	17:43	18:22
19:03	19:53	20:42	21:30	22:11	

- For more information, please visit, https://www.kallimousine.com/eng/guide01_en.html or http://www.airport.kr/pa/en/a/3/1/1/index.jsp#none

2) By Bus (~1 hour, ~3,000 KRW)

- Board a bus line 303 at the platform 13A

- Get off at **Songdo The Sharp First World (East gate)** station (~40 mins)
- Walk 450m (~7 mins on foot)
- 

Time schedule

To Incheon	first	05:00	To CAT	first	05:40
	last	21:30		last	23:00
Interval	15min.		Transit time	210분(MI)	
Type	Local City		Fare	KRW 2,800	

GUIDELINES FOR PRESENTERS

ORAL PRESENTATIONS

Each session room is equipped with a stationary computer connected to a LCD projector. Presenters must load their presentation files in advance onto the session computer. Technician personnel will be available to assist you.

Scheduled time slots for oral presentations are 15 mn for regular, 20 mn for invited presentations, 30 mn for keynote talks and 35 mn for plenary talks, including questions and discussions. Presenters are required to report to their session room and to their session Chair at least 15 minutes prior to the start of their session.

The session chair must be present in the session room at least 15 minutes before the start of the session and must strictly observe the starting time and time limit of each paper.

POSTER PRESENTATIONS

Presenters are requested to stand by their posters during their session. One poster board, A0 size (118.9 x 84.1 cm), in portrait orientation, will be available for each poster (there are no specific templates for posters). Pins or thumbtacks are provided to mount your posters on the board. All presenters are required to mount their papers 30mn before the session and remove them at the end of their sessions. Posters must prepared using the standard META poster template (available on the conference website).

PRE-CONFERENCE TUTORIALS

Frontier's Lectures on Metamaterials and Plasmonics

July 24 (Mon.), Seoul National University
Room 118, Building 301, Dept. of ECE

Lecturer	Session	Title
	08:50-09:00	**Opening**
Thomas Zentgraf	09:00-10:00	**Nonlinear Metasurfaces**
Jensen Li	10:00-11:00	**Spin-enabled optics with metamaterials and metasurfaces**
Yongmin Liu	11:00-12:00	**Reconfigurable Plasmonics and Metamaterials**
	12:00-13:30	**Lunch**
Mu Wang	13:30-13:55	**Meet Editors – Physical Review Letters**
Zachary Lapin	13:55-14:20	**Meet Editors – Nature Communications**
Ling Lu	14:20-15:20	**Topological Photonic Crystals**
	15:20-15:30	**Coffee Break**
Andrey Miroshnichenko	15:30-16:30	**Multipole decomposition and nonradiating sources in nanophotonics/metamaterials**
Renmin Ma	16:30-17:30	**Plasmonic nanolasers: fundamental, application and challenges**
Cristian Ciracì	17:30-18:30	**The optics of film-coupled nanoparticles: a bridge to the quantum realm**

Tutorial is free of charge, but registration is required. Please follow the link below to register:
https://docs.google.com/forms/d/1w4N8SrZSUlfRWgeuqDhmHoIDmMCgp9L7xEoPc5kowBI/edit

Chairs:

Namkyoo Park
Seoul National University

Hakjoo Lee
CAMM

Junsuk Rho
POSTECH

Session will be held in **Multimedia Room 118 of Building 301**
Lunch will be served at the faculty **cafeteria, first floor of Building 301**

Access to Meta Pre-conference
- Rm. 118, Building 301, Seoul National University

● From '*Incheon*' or '*Gimpo*' International Airport

- **By public transportation** [~2 hours: KRW ~10,200 (Incheon),~1.5 hour: KRW ~5,200 (Gimpo)]
o Board the limousine bus line number **6003** (The bus stop is **6A,12B in Incheon and 6 in Gimpo**).
o Get off at the front gate of Seoul National University.
o Board a bus line **5511 or 5513, or take a taxi.**
o Get off at either bus stop number 9 or 10 which are in front of buildings 301 and 302 (**last stop**).
- By taxi [~1 hour, KRW ~49,000 (Incheon), ~1 hour, KRW ~19,600 (Gimpo)]

● From Seoul Station

- **By public transportation** [~1 hour, KRW ~1300]
o Take the subway (**line No. 4**) **from Seoul station to Sadang station.**
o Transfer the subway line from No. 4 to No. 2.
o Take the subway (**line No. 2**) **from Sadang to Nakseongdae station.**
o Get out of **Exit 4**, turn left around the GS gas station, and board a bus line **02**.
o Get off in front of buildings 301 and 302 (**last stop**).
- By taxi [~45 minutes, KRW ~13,500]

● From Songdo Convensia, Incheon

- **By public transportation** [~1 hour, KRW ~2,000]
o Take the subway (**line Incheon No. 1**) **from Incheon Nat'l Univ station to Bupyeong station.**
o Transfer the subway line from 'Incheon No. 1' to 'No. 1' (not Incheon No. 1!).
o Take the subway (**line No. 1**) **from Bupyeong to Sindorim station.**
o Transfer the subway line from 'No. 1' to 'No. 2'.
o Take the subway (**line No. 2**) **from Sindorim to Nakseongdae station.**
o Get out of **Exit 4**, turn left around the GS gas station, and board a bus line **2**.
o Get off in front of buildings 301 and 302 (**last stop**).
- By taxi [~45 minutes, KRW ~32,500]

Campus Map of Seoul National University

Accommodation

No.	Name	Distance	Rates	
1	**Hoam Faculty House**	4km (Bus #02, to the last stop: 15 minutes)	Standard Double (KRW 104,500) Standard Twin (KRW 104,500) Deluxe Double (KRW 148,500) Deluxe Twin (KRW 148,500)	**http://www.hoam.ac.kr/**
2	**Novotel Ambassador Seoul Doksan**	10km (~1 hour)	Superior Double (KRW 125,000) Superior Twin (KRW 125,000)	**https://www.ambatel.com/main.amb?null**
3	**Shilla Stay Guro**	10km (~1 hour)	Standard Double (KRW 126,000) Standard Twin (KRW 126,000) Deluxe Double (KRW 137,000)	**http://www.shillastay.com/guro/index.do**
4	**Sheraton Seoul Palace Gangnam Hotel**	14km (~1 hour)	Deluxe Double (KRW 147,250) Deluxe Twin (KRW 147,250)	**http://www.sheratonseoulpalace.com/overview**
5	**Mercure Ambassador Gangnam**	13.5km (~1 hour)	Standard Double (KRW 132,300) Standard Twin (KRW 132,300) Superior Double (KRW 146,300)	**https://mercure.ambatel.com/gangnam/meeting/hallInfo.amb?brand_code=M0456&gnbCode=040000&lnbCode=040200&menu_se=M1244**

*Hotel information is just for your reference. You have your own responsibility to reserve your accommodation.

Nonlinear Metasurfaces

Thomas Zentgraf
Department of Physics
Ultrafast Nanophotonics
Paderborn University, Germany
Email: thomas.zentgraf@uni-paderborn.de

For efficient nonlinear processes the engineering of the nonlinear optical properties of media becomes important. In particular, the phase relation between the fundamental and the nonlinear waves plays here an important role. The most well-known technique for spatially engineering nonlinear properties is the quasi-phase matching scheme for second-order processes like second harmonic generation (SHG). The quasi-phase matching leads to efficient frequency conversion compared to a homogeneous nonlinear medium by providing the extra momentum to compensate the phase mismatch between the fundamental and harmonic waves. The so-called 'poling' is the most widely employed technique for achieving quasi-phase matching. By periodically reversing the crystalline orientation of ferroelectric materials, the sign of the $\chi^{(2)}$ nonlinear susceptibility can be spatially modulated along the propagation direction. However, such a poling only leads to a binary state for the nonlinear material polarization, which is equivalent to a discrete phase change of π of the nonlinear polarization.

Here I will discuss a novel nonlinear metamaterial with homogeneous linear optical properties but continuously controllable phase of the local effective nonlinear polarizability. For the demonstration we use plasmonic metasurfaces with various designs for the meta-atom geometry together with circular polarized light states. The controllable nonlinearity phase results from the phase accumulation due to the polarization change along the polarization path on the Poincare Sphere (the so-called Pancharatnam-Berry phase) and depends therefore only on the spatial geometry of the metasurface. By using a fixed orientation of the meta-atom the nonlinear phase can be spatially arbitrarily tailored over the entire range from 0 to 2π. In contrast to the quasi-phase matching scheme the continuous phase engineering of the effective nonlinear polarizability enables complete control of the propagation of harmonic generation signals, and therefore, it seamlessly combines the generation and manipulation of the harmonic waves for highly compact nonlinear nanophotonic devices. We will demonstrate the concept of phase engineering for the manipulation of the SHG and THG from metasurfaces and the restriction on the symmetry properties of the geometry.

Furthermore, I will discuss a nonlinear Berry phase in the time domain which arises from the rotational Doppler shift that can be observed on spinning metasurfaces. The rotational Doppler shift in nonlinear optics was predicted nearly 50 years ago and recently demonstrated at nonlinear crystals. The Doppler frequency shift was determined for the SHG of a circularly polarized beam passing through a spinning nonlinear optical BBO crystal with three-fold rotational symmetry. In our experiments we found that the SHG signal with a circular polarization opposite to that of the fundamental beam experiences a Doppler shift of three times the rotation frequency of the optical crystal. This finding is of fundamental significance in nonlinear optics and also for tailored nonlinearities, as it provides a further degree of freedom with the design of nonlinear materials, in particular for moving media. We will briefly discuss how this rotational Doppler Effect can be also utilized for spinning metasurfaces in the nonlinear regime.

Biography: Professor Thomas Zentgraf received his bachelor's degree of Engineering from University of Applied Sciences Jena, Germany, in 2001 and a master's degree of Physics of the Technical University Clausthal, Germany, in 2002. After that, he joined the University of Stuttgart, Germany, where he under the supervision of Professor Harald Giessen received his PhD in the 2006. Prof Zentgraf was honored with a Feodor-Lynen-Fellowship by the Alexander von Humboldt Foundation in 2007 and joined as a research fellow the group of Professor Xiang Zhang at the Mechanical Engineering Department at University of California at Berkeley, USA. In 2011 he returned to Germany and became full professor for Applied Physics at the Department of Physics, University of Paderborn, where he is head of the Ultrafast Nanophotonics Group. His research interests focus on using ultrafast spectroscopy to study linear and nonlinear effects in plasmonic and dielectric metamaterials and plasmonic-hybrid materials.

Spin-enabled optics with metamaterials and metasurfaces

Jensen Li
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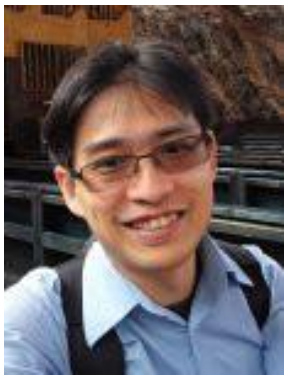

Light, similar to other vector waves such as elastic waves, has a spin-degree of freedom in its propagation. The interaction between spin and motion provides an interesting way to manipulate the orbital motion of light, in addition to the driving force from a refractive index gradient in conventional optics. In this tutorial, I will give an introduction of geometric phase and the associated optical-spin Hall effect in a systematic approach and will show its applications and new opportunities in metamaterials and metasurfaces. For example, the optical spin-Hall effect can be utilized to control dynamically the generation of surface plasmon on a plasmonic metasurface by putting a tailor-made array of anisotropic metamaterial atoms on a surface. When these anisotropic metamaterial atoms are assembled into a three dimensional material, I will also show how these can be used to generate a pseudo-magnetic field or gauge field for photon, which can guide light into cyclotron motion, as if it is a real magnetic field acting on electron motion. These discussions provide a feasible route to spin-enabled optics.

Biography: Dr. Jensen Li received his BEng degree with first class honours in electrical and electronic engineering from the University of Hong Kong in 1998 and his MPhil, PhD degree in physics from the Hong Kong University of Science and Technology in 2000 and 2004. In this period of time, he worked on the zero-th order photonic band gap and the theoretical proposal of acoustic negative index metamaterials.

From 2005 to 2007, Jensen worked in Imperial College London, with support from a Croucher Foundation postdoctoral fellowship, where he developed a theoretical scheme of carpet cloaking.

From 2007 to 2009, he was a postdoctoral researcher at the University of California at Berkeley, participated in the realization of carpet cloaking at infrared frequencies. He also started to work on acoustic metamaterials with super-resolution there.

From 2009 to 2013, he was an assistant professor at the City University of Hong Kong. He continued his research in metamaterials and also worked on alternative schemes in achieving acoustic negative indices without local resonance from theory to realization.In 2013, he joined University of Birmingham as a senior lecturer.

Reconfigurable Plasmonics and Metamaterials

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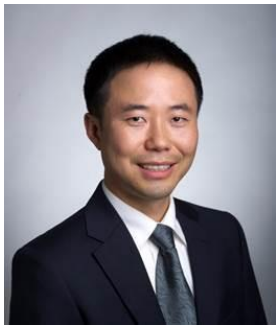

Plasmonics has become a very important branch in nano optics. It allows us to concentrate, guide, and manipulate light at the deep subwavelength scale, promising enhanced light-matter interaction, next-generation optical circuits, sub-diffraction-limited imaging, and ultrasensitive biomedical detection [1-3]. Furthermore, the assembly of judiciously designed metallic structures can be used to construct metamaterials and metasurfaces with exotic properties and functionalities, including anomalous refraction/reflection, strong chirality and invisibility cloak [4,5]. There is a pressing need of tunability and reconfigurability for plasmonics and metamaterials, in order to perform distinctive functionalities and miniaturize the device footprint. In this talk, I will present our recent work in reconfigurable plasmonics and metamateirals. First, I will discuss the first demonstration of reconfigurable plasmonic lenses operating in microfluidic environment, which can dynamically diverge, collimate and focus surface plasmons [6]. Second, I will present a novel graphene metasurface to fully control the phase and amplitude of infrared light with very high efficiency. It manifests broad applications in beam steering, biochemical sensing and adaptive optics in the crucial infrared wavelength range [7]. Finally, I will discuss origami-based, dual-band chiral metasurfaces at microwave frequencies. The flexibility in folding the metasurface provides another degree of freedom for geometry control in the third dimension, which induces strong chirality from the initial, 2D achiral structure [8]. These results open up a new avenue towards lightweight reconfigurable metadevices.

References: [1] S. A. Maier, "Plasmonics: fundamentals and applications", Springer Science+ Business Media (2007); [2] T. Zentgraf et al., "Plasmonic Luneburg and Eaton lenses", **Nature Nanotechnology** 6, 151 (2011); [3] Y. M. Liu, et al., "Compact magnetic antennas for directional excitation of surface plasmons", **Nano Letters** 12, 4853 (2012); [4] Y. M. Liu and X. Zhang, "Metamaterials: a new frontier of science and technology", **Chemical Society Reviews** 40, 2494 (2011); [5] K. Yao and Y. M. Liu, "Plasmonic metamaterials", **Nanotechnology Review** 3, 177 (2014); [6] C. L. Zhao et al., "A reconfigurable plasmofluidic lens", **Nature Communications** 4:2350 (2013); [7] Z. B. Li et al., "Graphene plasmonic metasurfaces to steer infrared light", **Scientific Reports** 5, 12423 (2015); [8] Z. Wang et al., manuscript in preparation.

Biography: Dr. Yongmin Liu obtained his Ph.D. from the University of California, Berkeley in 2009. He joined the faculty of Northeastern University at Boston in fall 2012 with a joint appointment in the Department of Mechanical & Industrial Engineering and the Department of Electrical & Computer Engineering. Dr. Liu's research interests include nano optics, nanoscale materials and engineering, plasmonics, metamaterials, biophotonics, and nano optomechanics. He has authored and co-authored over 50 journal papers, including *Science*, *Nature*, *Nature Nanotechnology*, *Nature Communications*, *Physical Review Letters* and *Nano Letters*. Dr. Liu received Office of Naval Research Young Investigator Award (2016), 3M Non-Tenured Faculty Award (2016), Air Force Summer Faculty Fellowship (2015), and Chinese Government Award for Outstanding Students Abroad (2009). Currently he serves as an editorial board member for *Scientific Reports*, *EPJ Applied Metamaterials* and *Nano Convergence*.

Topological Photonic Crystals

Ling Lu
Institute of Physics, Chinese Academy of Sciences, Beijing, China

Due to the recent discovery of topological insulators, it has been recognized that topology is indispensable in distinguishing phases of matter. Similarly, new optical material systems are being discovered with non-trivial topologies of their global wave-functions in the momentum space, whose interfaces support novel states of light with ideal transport properties such as the robustness to large disorder or fabrication imperfections.

In this talk, I will show experimental realizations and theoretical predictions of 2D and 3D photonic crystals with topologically protected edge and surface states. Specifically, I will discuss single and multimode one-way waveguides, the observation of Weyl points, a single Dirac cone surface state immune to random disorder and topological one-way fibers. This research can be extended to phonons, plasmons and other bosons. These new degrees of freedom in bosonic band topologies promise wide exciting opportunities in both fundamental physics and technological outcomes.

Biography: Ling Lu is a professor in the Institute of Physics of Chinese Academy of Sciences in Beijing China. He obtained his bachelor in Physics in 2003 from Fudan University in Shanghai, China. He got his Ph.D. in Electrical Engineering in 2010 at University of Southern California in Los Angeles. His thesis work, advised by Prof. John O'Brien, was on photonic crystal nanocavity lasers. He was a postdoc and later a research scientist in the Physics Department of Massachusetts Institute of Technology, where he worked with Prof. Marin Soljačić and John Joannopoulos and collaborated with Prof. Liang Fu. His current research focuses on topological photonics.

Multipole decomposition and nonradiating sources in nanophotonics and metamaterials

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Multipole decomposition is indispensable tool in analyzing the optical response of nanoscale structures consisting of finite size elements. In general, there are two complementary approaches based on Cartesian (current) multipoles and Spherical (scattered field) multipoles. For subewavelength elements they produce similar description. But for larger elements certain deviations might occur. In this tutorial, I will provide the basic description of both methods and specify kind of complementary information they provide. I will also introduce the concept of nonradiation sources, provide specific examples of so-called *anapole* modes and demonstrate the importance of toroidal dipole moments.

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1. Kaelberer, M. et al., *Science* **330**, 1510, (2010).
2. Chen, J. et al., *Nature Photonics* **5**, 531 (2011).
3. Grahn, P. et al., *New J. Phys.* **14** 093033 (2012).
4. Miroshnichenko, A. E. et al., *Nature Comm.* **6**, 8069 (2015).

Biography: A/Prof. Andrey Miroshnichenko obtained his PhD in 2003 from the Max-Planck Institute for Physics of Complex Systems in Dresden, Germany. In 2004 he moved to Australia to join the Nonlinear Physics Centre at ANU. During this time A/Prof. Miroshnichenko made fundamentally important contributions to the field of photonic crystals and bringing the concept of the Fano resonances to photonics. In 2007 A/Prof. Miroshnichenko was awarded by APD Fellowship from the Australian Research Council. It allowed him to initiate the research on a new class of tunable photonic structures infiltrated with liquid crystals. Later, in 2011 he was awarded by Future Fellowship from the Australian Research Council. During this period, he pioneered the research of high-index dielectric nanoparticles in the visible range, including one of the first demonstrations of the optically induced magnetic response in silicon nanoparticles. The current topics of his research are nonlinear nanophotonics, topologiccal photonics, and resonant interaction of light with nanoclusters, including optical nanoantennas and metamaterials.

Plasmonic nanolasers: fundamental, application and challenges

Renmin Ma
School of Physics
State Key Lab for Mesoscopic Physics
Collaborative innovation center of quantum matters
Peking University, China
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Plasmonic nanolasers are a new class of quantum amplifiers that deliver coherent surface plasmons well below the diffraction barrier which brings fundamentally new capabilities to biochemical sensing, super-resolution imaging and on-chip optical communication. In this talk, I will review fundamental, application and challenges of this emergent device.

Biography: Ren-Min Ma is an assistant professor in the School of Physics, Peking University. He received his PhD from Peking University. His dissertation was focused on semiconductor physics and devices in low dimensional structures and received the National Top 100 Ph.D. dissertations of China Award. He was a postdoc researcher at UC Berkeley during 2009-2014. He developed the first room temperature semiconductor plasmon laser, directionally emitted waveguide embedded plasmon laser and applied plasmon lasers to sensing field. His current research interests include nanophotonics and nanomaterials.

The optics of film-coupled nanoparticles: a bridge to the quantum realm

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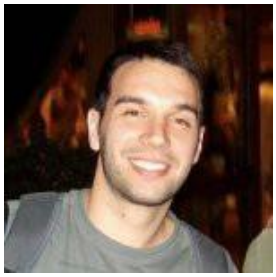

Metals support surface plasmons at optical wavelengths and have the ability to localize light to sub-wavelength regions. The film-coupled nanoparticle system—in which plasmonic nanoparticles are separated nanometer distances from a metal film by an insulating spacer—has unique properties that make it useful for a variety of processes depending on the nanoparticle shape. Nanospheres that are coupled to a film, for example, have been predicted to produce enormous field enhancements—as much as thousands of times that of the incident radiation—in the separating region between nanoparticle and film. For the narrowest (<1 nm) gaps, light can be so tightly confined that the nonlocality associated with the dielectric response of the metal and quantum effects can have a strong impact on the scattering properties of the system, placing strict bounds on the ultimate field enhancement.

Another interesting system is that of nanocubes or planar structures, which support transmission line-like modes between the two planar metal contact regions. Collective scattering of film-coupled nanocubes can strongly modify reflectance properties of the underlying surfaces, creating a nearly ideal absorber at desired wavelengths. The controlled reflectance of the surface might provide a means for enhancing nonlinearity, for example by allowing potentially all of a fundamental beam to be converted into higher harmonics. Moreover, we numerically find a sub-nm gap regime in which nonlocal effects can dramatically enhance the nonlinear optical response of the metal by several order of magnitude.

All mentioned structures can be easily and cheaply fabricated using colloidal nanoparticles, surface chemistries, or atomic layer deposition lithography, allowing for near angstrom-scale control over the spacer thickness and large-area uniformity. At the same time, a reliable way to theoretically describe and numerically model optical properties of plasmonic nanostructures with different length scales requires methods beyond classical electromagnetism. In this tutorial I will present an implementation of the hydrodynamic model that takes into account the nonlocal behavior of the electron response by including the electron pressure and it is generalized so that it can describe electron spill-out and tunneling effects, including nonlocal broadening near metal surfaces.

Biography: Cristian Ciracì obtained his BSc in Computer Science Engineering in February 2005 and his MSc in Science for Engineering in July 2007 at Sapienza, University of Rome (Italy). He received his Ph.D. in Condensed Matter Physics from University of Montpellier, France, with honor degree in September 2010. In November 2010 he joined the Center for Integrated Metamaterials and Plasmonics at **Duke University (U.S.)** as a Postdoc. In March 2014 he joined the Center for Biomolecular Nanotechnologies at the **Istituto Italiano di Tecnologia (IIT)**, Italy, where he currently holds a position as Researcher. His main research activities concern numerical modeling and investigation of electromagnetic propagation in complex media, with particular emphasis on nonlinear optical phenomena. During the years of his research activity he has co-authored several publications on top-tier scientific journals and has been invited to several international conferences. In 2012 his work was featured on the **cover of Science Magazine**.

TECHNICAL PROGRAM

Monday 24th July, 2017

Registration

1st floor lobby

15:30 - 18:30

Tuesday 25th July, 2017

Registration

1st floor lobby

08:00 - 18:00

Opening ceremony

Ballroom

08:45 - 09:00

09:00 - 10:45 — Ballroom

Session 1A1

Plenary Session I

Chaired by: Nikolay Zheludev

09:00 : Plenary talk
Squeezing of Photonic Energy into A Point-like Space
Yong-Hee Lee[1], **M. K. Kim**[2]
[1] *KAIST (Korea),* [2] *Korea University (Korea)*

A three-dimensionally tapered metallic nano-gap resonator with modal volume of $\sim$1.0 x 10-7 λ3 is to be discussed. From a 5-nm-air-gap gold resonator, strong second harmonic signals are generated at a point-like space where electromagnetic energy is highly concentrated. The nonlinear signal is found to be stronger than that from a 100-nm-gap counterpart by a factor of $>$27,000. Rich nonlinear characteristics observed from quantum dots and nm-scale proteins trapped in the nano-gap will also be discussed.

09:35 : Plenary talk
Active Quantum Nanoplasmonics: From Single Molecule Strong Coupling to Stopped-Light QED and Lasing
Ortwin Hess
Imperial College London (United Kingdom)

ANanoplasmonic cavities create a unique environment for controlled spatio-temporal dynamics of light strongly coupled with single quantum emitters (molecules, quantum dots) providing a basis for strong coupling at room temperature, strong coupling quantum spectroscopy and paving the way for few- or single-molecule lasing.

10:10 : Plenary talk
Tip-enhanced Raman scattering microscopy: plasmonic molecular imaging beyond the limits
Satoshi Kawata
Osaka University (Japan)

Tip-enhanced Raman scattering (TERS) microscopy as a version of near-field scanning optical microscopy has been widely used for analyzing molecular distribution of nanomaterials and biomaterials In this presentation, mechanisms of super-resolution and field enhancement of TERS microscopy will be discussed and recent progress of TERS microscopy beyond the limits, such as nanometer resolution, 3D imaging, and deep UV imaging, will be shown.

Coffee Break and Exhibit Inspection

Sponsored by Incheon Tourism Organization

Session 1P1

Poster Session I

10:45 - 11:30

P1: Fine Tuning of Plasmonic Properties for Au Nano-Structures by Electrochemical Metal Dissolution/Deposition
Hiro Minamimoto, Shunpei Oikawa, Kei Murakoshi
Hokkaido University (Japan)

The control method for plasmonic properties of the metal nanodimer structures has been established via electrochemical metal dissolution reactions. The reaction rate can be precisely tuned by changing the electrochemical conditions. With the progress of the electrochemical reactions, the maximum plasmon resonance wavelength shifted to the shorter wavelength region corresponding to the decrease volume of metal nanostructures. Thorough various attempts, unique optical properties emerged by the structural control in an atomic scale was revealed by in-situ electrochemical optical measurements.

P2: Metasurface-based reconfigurable visible light absorber
Gwanho Yoon, Junsuk Rho
Pohang University of Science and Technology (Korea)

Although metamaterials have shown many extraordinary phenomena, most of the metamaterials have been demonstrated in a passive type which acts as obstacle of its real applications. A few works of active metamaterials have been done, but modulation in the visible region is still challenge. Hereby, we suggest an active mechanism enabling high speed modulation in the visible region and tunable perfect absorber by using this mechanism.

P3: Dual Band Frequency Reconfigurable Array Antenna Using Metamaterial
Raimi Dewan[1], M. K. A. Rahim[1], Mohamed Himdi[2], M. R. Hamid[1], M. E. Jalil[1]
[1] *University Technology Malaysia (Malaysia),* [2] *Institut d'Electronique et de Telecommunications de Rennes (France)*

Metamaterial structure of Electromagnetic Band Gap (EBG) incorporated onto dual band array antenna operate at 2.45 GHz (lower band) and 5.8 GHz (upper band) is proposed. The three EBGs with different diode states introduces dual band gap (S21) properties at 2.45 GHz and 5.8 GHz which is verified using Suspended Transmission Line (STL) method. The EBG successfully realize frequency reconfigurable array antenna which able to configure to operate exclusively at both bands, lower band or upper band.

P4: Biomass Charcoal Based Graphene Oxide Solution Would Be a Potential Superconducting Electronic Storage Devices under Magnetic Field
Wu-Jang Huang
National Pingtung University of Science and Technology (Taiwan)

This invention demonstrated ability for using graphene oxide solution from biomass charcoal as a potential electronic storage device. Recently we have found that an unpredicted magneto voltaic occurs in biomass derived graphene sheets oxide solution. For the first time, the directly magneto-voltaic effect in biomass derived graphene oxide solution was observed. The possible mechanism of this process is attributed to the superconducting effect of biomass graphene oxide under a magnetic field.

P5: Metasurface based reconfigurable visible light absorber
Gwanho Yoon, Junsuk Rho
Pohang University of Science and Technology (Korea)

Although metamaterials have shown many extraordinary phenomena, most of the metamaterials have been demonstrated in a passive type which acts as obstacle of its real applications. A few works of active metamaterials have been done, but modulation in the visible region is still challenge. Hereby, we suggest an active

mechanism enabling high speed modulation in the visible region and tunable perfect absorber by using this mechanism.

P6: CPW-fed metamaterial antenna based on mushroom unit cell for dual applications
B. D. Bala[1], M. K. A. Rahim[2], N. A. Murad[2], H. A. Majid[3], M. E. Jalil[2], O. Ayop[2]
[1] *Kano University of Science and Technology (Nigeria),* [2] *Univerisiti Teknologi Malaysia (Malaysia),* [3] *Universiti Tun Hussein Onn Malaysia (Malaysia)*

A CPW fed metamaterial antenna based on mushroom unit cell for dual band applications is proposed. The unit cell is etched on the host transmission line to engineered left-handed properties. Two resonant modes at 5.2 GHz and 7.3 GHz are obtained for the negative order resonant (NOR) and positive order resonant (POR) modes respectively. The simulated results of the reflection coefficients and surface current distributions are presented. The antenna is suitable for WLAN applications (5.15 GHz-5.25 GHz).

P7: An in situ strategy to synthesis of plasmonic gold NPs by using plasmonic molybdenum oxide
Mehri Alsadat Hosseini, Mehdi Ranjbar
Isfahan University of Technology (Iran)

The reduction of HAuCl4 by plasmonic molybdenum oxide nanoparticles synthesized via a simple electrochemical anodizing of molybdenum is investigated. By mixing colloidal plasmonic molybdenum oxide with HAuCl4 aqueous solution, the mixed turned to a red-wine color with pronounce LSPR properties. By using different analysis involving, X-ray diffraction (XRD), transmission electron microscope (TEM), X-ray photoelectron spectroscopy (XPS), furrier transformed infrared (FTIR) spectroscopy, cyclic voltammetry, and UV-Vis spectroscopy the colloidal nanoparticles of Au/MoOx be characterized.

P8: Plasmofluidic assembly of nanometallic structures: from single-molecule SERS to dynamic lithography
Partha Pratim Patra, Junsuk Rho
POSTECH (Korea)

In this presentation we shall discuss how to harness plasmofluidic field (plasmonic field in fluid) to create efficient electromagnetic hot-spots by assembling colloidal nanoparticles to detect single-molecule SERS signals. Also we shall discuss how the extension of this technique can lead to a preamble of reconfigurable dynamic lithography of plasmonic nanostructures at metal-fluid interface.

P9: Plasmon resonances of Mid-IR Antennas and localized absorption enhancement in an absorbing substrate
Lukas Brinek, Tomas Samoril, Martin Hrton, Radek Kalousek, Vlastimil Krapek, Jiri Spousta, Petr Dub, Peter Varga, Tomas Sikola
Brno University of Technology (Czech Republic)

In the contribution the plasmon resonances of mid-IR antennas fabricated on an absorbing silicon rich oxinitride substrate and their utilization for spatially localized absorption enhancement of electromagnetic radiation in this substrate will be discussed. The conclusions of this contribution are also applicable for other spectral regions where the materials exhibit strong absorption resonances, for instance in the visible.

P10: Limits on Self-heating in Plasmonic Circuitry with Gain
Andrey A. Vyshnevyy, Dmitry Yu. Fedyanin
Moscow Institute of Physics and Technology (Russia)

Loss compensation by optical gain in semiconductor media is a promising solution to the problem of high intrinsic losses in nanoscale plasmonic structures. However, any realization of the surface plasmon amplification scheme is unavoidably associated with the heat generation problem. The stronger the pump, the higher heat generation. Here, we estimate the lower bound to the heat generation rate, suggest possible thermal management solutions and discuss limits of plasmonic circuitry.

P11: Flexibly tunable plasmonic color filters for wide color display
Jaehyuck Jang[1], Niloufar Raeis-Hosseini[1], Trevon Badloe[1], Dasol Lee[1], Heonyoung Jeong[1], Duc Minh Nguyen[1], Gwanho Yoon[1], Minkyung Kim[1], Emilien Beck[2], Junsuk Rho[1]
[1] *Pohang University of Science and Technology (POSTECH) (Korea),* [2] *University of Rennes 1 (France)*

Artificial subwavelength structures exhibiting multiple resonances in the visible range, known as color filters, are widely used in color printing beyond diffraction limit and color displays. Here, we propose a new reflective

color filter structure comprising of a triangle periodic array of cross-shaped aluminum nanorods with various angles of rotation symmetry. Flexible tunability of color in wide color gamut is demonstrated on the device by changing the incident polarization.

P12: Modulation instability of intensive surface plasmon polaritons in a thin film structure
Sergey Moiseev, Dmitrii Korobko, Igor Zolotovskii, Andrei Fotiadi
Ulyanovsk State University (Russia)

The evolution of intensive surface plasmon polariton waves in a metal film-dielectric substrate structure is investigated taking into account absorption properties of metal. The transformation of slightly modulated plasmon polariton wave into a sequence of surface pulses due to modulation instability effect in a structure with amplification is demonstrated.

P13: Surface plasmon polariton amplification by direct current in semiconductor-graphene-dielectric structure
Sergey Moiseev, Yuliya Dadoenkova, Andrei Fotiadi, Aleksei Abramov, Aleksei Kadochkin, Igor Zolotovskii
Ulyanovsk State University (Russia)

The interaction of slow surface plasmon polariton waves of far-infrared regime with an electric current induced in the graphene deposited on the boundary between a semiconductor film and dielectric substrate is investigated. It is shown that under the phase matching condition, when phase velocity of a surface plasmon polaritons approaches the drift velocity of charge carriers in graphene, a surface wave can be substantially enhanced by the drift current in graphene.

P14: Differentiating surface waves and waveguide modes guided by interfaces with one-dimensional photonic crystals
Muhammad Faryad
Lahore University of Management Sciences (Pakistan)

One-dimensional photonic crystals are made of multi-layers of different dielectric materials with periodic arrangement. Such photonic crystals support surface waves at their interfaces as well as waveguide modes guided by individual constituent layers. This study examines the differences and similarities between the two types of modes. The differentiation is necessary to fully exploit the promise of photonic crystals in integrated optics.

P15: Enhancing the infrared absorption of hybrid organic-inorganic perovskites using a high-Q metasurfaces
Govind Dayal, Ranjan Singh
Nanyang Technological University (Singapore)

We report on design, fabrication, and characterization of high-Q metasurfaces and their multispectral response at near infrared frequencies. The metasurfaces perforated with an array of overlapping annular and rectangular apertures support fundamental and higher order plasmonic resonances which result in high-Q response at mid-infrared frequencies. We show that spectral response of the metasurface can be tuned to a great amount by judicially engineering the hybridization of plasmon resonance in metasurfaces.

P16: A spectroscopic ellipsometry demonstration of ultrasharp subradiant plasmons
Mohammad Taghinejad, Hossein Taghinejad, Hesam Moradinejad, Ali A. Eftekhar, Ali Adibi
Georgia Institute of Technology (USA)

We numerically design and experimentally demonstrate ultra-sharp (FWHM = 6 nm) and tunable lattice plasmon and Fano-type resonances using plasmonic nanopatch devices, where diffractive coupling of the out-of-plane electric dipoles plays a primary role. Systematic spectroscopic ellipsometry measurements reveals exotic potentials of the investigated nanopatch devices for polarization engineering and enhanced light matter interactions.

P17: Visible Near-Zero Refractive Index Metamaterials
Andres Ochoa, M. Gonzalez, Nantakan Wongkasem
University of Texas Rio Grande Valley (USA)

Near-zero refractive index designs based on hyperbolic metamaterials operating in the visible regime is proposed. The structure is composed of metal-dielectric multilayer, where the dielectric constants are opposite in order to tune the design for a specific wavelength and purpose. The near zero refractive index is designed

to be within the visible range. 42 % transmittance is observed at 405 nm. Low transmittance issues can be optimized by adjusting the fill factor.

P18: GHz acoustic modulation of extraordinary optical transmission in a metamaterial based on a square nano-hole array in a gold film

Yuta Imade[1], Ronald Ulbricht[1], Hirotaka Sakuma[1], Paul H. Otsuka[1], Motonobu Tomoda[1], Osamu Matsuda[1], Hwi Kim[2], Gwan-Woo Park[2], Oliver B. Wright[1]

[1] *Hokkaido University (Japan),* [2] *Korea University (Korea)*

Gigahertz modulation of light transmitted by an extraordinary optical transmission (EOT) metamaterial structure is studied using optical pump-probe spectroscopy. The GHz frequency oscillations in the intensity of transmitted light from sample consisting of a lattice of square nano-holes in a gold film on a glass substrate are monitored experimentally. Numerical simulations of the transient deformations and strain distributions show that variations in the nano-hole area produce the dominant contribution to the GHz optical modulation.

P19: Photonic Crystal-based Magnetoplasmonic Heterostructures with Garnet for Surface Plasmon Resonance Sensors

Daria Ignatieva[1], Serguei K. Sekatskii[2], Pavel Kapralov[3], Grigory Knyazev[1], Mohammed Nue-E-Alam[4], Mikhail Vasiliev[4], Kamel Alameh[4], Vladimir I. Belotelov[1]

[1] *Lomonosov Moscow State University (Russia),* [2] *Ecole Polytechnique Federale de Lausanne (Switzerland),* [3] *Russian Quantum Center (Russia),* [4] *Edith Cowan University (Australia)*

The work is devoted to the study of the novel layered heterostructures with 1D photonic crystals and magnetooptical garnet layers providing ultra-high quality factor magnetoplasmonic resonances. Such structures are specially designed to exhibit ultra-narrowresonances due to the excitation of the long-range propagating magnetoplasmons with the experimentally observed propagation distance of 50μm. Experimentally obtained FOM in such structures is up to 2200 which makes them very promising for sensing applications.

P20: High Q-factor dual band tunable polarization independent THz flexible metasurface for chemical sensing applications

Mohammed Janneh[1], Ayodya Pradhipta Tenggara[2], Andrea De Marcellis[1], Doyoung Byun[2], Elia Palange[2]

[1] *University of L'Aquila (Italy),* [2] *Sungkyunkwan University (Korea)*

We report on the electromagnetic properties of a flexible dual band THz tunable metasurface able to achieve absorption coefficients and quality-factors up to 99.8 % and 120, respectively. The metasurface elemental unit shape and bending capability allow for a polarization insensitive spectral response and for a resonance frequencies fine tuning. Moreover, minimum variations of non-absorbing substances refractive index up to 5'10-5 can be identified by using the absorber as a sensing device with detection sensitivities up to 250GHz/RIU.

P21: Study on the Transmission Characteristics of the Symmetrical Semicircular Cavity Filter Based on SPPs

Zhi-Shuang Wang, Guanmao Zhang, Hairui Liu

Lanzhou University (China)

A novel structure of the symmetrical semicircular cavities MIM (metal-insulator-metal) filter based on the aperture coupled method is proposed and the transmission spectrum of the filter is obtained by using the finite element method (FEM). Using the adjustable characteristics of this filter, the transmission characteristics of the three communication windows (850nm, 1310nm, 1550nm) at optical telecommunication regime can be controlled. The excellent performance of this filter can be applied in micro-nano optical devices, especially in optical fiber communication.

P22: Light enhancement dependence on organic film thickness caused by the generation of surface plasmons in phase and their scattering

Yuuta Mizoguchi[1], Takuya Yoneda[1], Taichi Ishiguro[1], Kenichi Kasahara[1], Naoki Ikeda[2], Yoshimasa Sugimoto[2]

[1] *Ritsumeikan University (Japan),* [2] *Nanotechnology Innovation Center (Japan)*

Net Photoluminescence enhancement of Alq3 on Ag was estimated, changing the Alq3 thickness by removing the optical interference effect occurring inside the film. Enhancement difference observed for devices with different Alq3 thicknesses can be explained by aggregate behavior of the energy transfer of excitons to surface plasmons.

P23: Full Color display using extraordinary optical transmission in silver block array
Kihwan Moon, Young Jin Lee, Seokhyeon Hong, Soon-Hong Kwon
Chung-Ang University (Korea)

The transmission-type display requires high intensity of transmitted light. However, the metal structure has high reflectance and absorbance. To overcome disadvantages, we introduced extraordinary optical transmission (EOT). A transmitted light through subwavelength scale metal apertures is enhanced by EOT. In addition, EOT has narrow peak in narrow aperture. We obtained green and red colors, which have high transmittance over 80 %, and blue color transmission spectrum using cross-shape slit array consisted of silver nanoblocks.

P24: Influence of oxygen on photochemical transformation of silver nanoparticles
Karol Kolataj, Jan Krajczewski, Andrzej Kudelski
University of Warsaw (Poland)

One way to obtain metallic nanoparticles with different shapes is employment of light in phototransformation method. In this approach one can obtain nanoparticles with the desired final geometry by changing wavelength of light used for irradiation. This method of synthesis of nanoparticles allows obtaining less contaminated nanoobjects. In this work we have also present the first example of phototransformation in oxygen-free environment (as an oxidizing agent 1,4-benzoquinone has been used).

P25: Surface nanostructuring for high-resolution surface plasmon resonance imaging
Frederic Alexandre Banville[1], Mitradeep Sarkar[1], Clement Colin[1], Julien Moreau[2], Mondher Besbes[2], Michael Canva[1], Paul G. Charrette[1]
[1] *Sherbrooke University (Canada),* [2] *Paris Saclay University (France)*

Surface plasmon resonance imaging is a very effective technique for studying surface phenomena in complex biological materials. However, its spatial resolution is limited by the propagative nature of the surface plasmons. In this work, we studied exhaustively by numerical simulations the excitation of surface plasmons on continuous films, and we demonstrate how a higher resolution can be achieved by nanostructuring the metal surface. This method can significantly reduce the surface plasmons propagation length from several micrometers to submicrometer distances.

P26: Magneto-Optical Effect in Hybrid Plasmonic Nanostructures
Marion Rodier, Christopher Kelly, Affar S. Karimullah, Calum Jack, Ryan Tullius, Malcolm Kadodwala
University of Glasgow (United Kingdom)

The magneto-optical effect occurs in magnetic chiral media, and can be detected by use of polarised light. Although this effect is of interest in the study of the light matter interaction, it has not been studied in depth because of the weakness of the effect. Hybrid plasmonic nanostructures were used to detect a magneto-optical effect. The aim here was also to detect this effect at a low magnetic field with a high intensity.

P27: Fabrication of Al-doped ZnO thin films for plasmonic applications
Farzana Fadakar Masouleh, Ihab Sinno, Robert Buckley, Paul Teal, Gideon Gouws, Ciaran Moore
Victoria University of Wellington (New Zealand)

A sputtering process is presented that enables the deposition of aluminum-doped zinc oxide films with a significant carrier density and thus controllable plasmonic properties. These thin films were characterized using Ultraviolet-visible and Fourier transform infrared spectroscopy, and Hall-effect measurements. Analysis of the results shows a carrier concentration of up to 2.6x1020 cm-3, as well as transmission above 80 % for 500 nm thick films at wavelengths up to 1900 nm making them well-suited to plasmonic applications.

P28: Asymmetric Bow-tied Plasmonic Demultiplexer Using Multimode Interference
Kotaro Nakayama, Asashi Sumimura, Masashi Ota, Ryo Watanabe, Takahiro Furuki, Yuya Ishii, Mitsuo Fukuda
Toyohashi University of Technology (Japan)

We have demonstrated an asymmetric bow-tied plasmonic demultiplexer for a wavelength division multiplexing system to realize large-capacity information processing. The developed demultiplexer was designed based on a multimode interference structure consisting of patterned SiO2 on a gold film. This demultiplexer selectively guides 1.31- and 1.55-μm-wavelength plasmonic signals to different output ports. The experimentally measured insertion loss and crosstalk at the developed demultiplexer were $\leq$ 8.4 dB and $\leq$ -2.3 dB, respectively.

P29: Enhancing light matter interaction in monolayer MoS2 with patterned plasmonic nanostructures using two different configurations

Pavithra Sriram, Dong-Sheng Su, Ta-Jen Yen
National Tsing Hua University (Taiwan)

Monolayer molybdenum disulfide (MoS2) has intense attention in recent years for their unique optical properties. However monolayer MoS2 suffers from insufficient light matter interaction because of its atomically thin nature. Plasmonic nanostructures can be easily integrated and boost the light matter interaction of 2D TMDCs. In this study, we demonstrated the enhanced Photoluminescence of MoS2 using two different hybrid configurations of Au-MoS2. Reported results allow us to engineer optical properties of two dimensional materials.

P30: Tunable Reflector based on Metal/Insulator/Metal cavity with graphene

Young Jin Lee, Seokhyeon Hong, Kihwan Moon, Soon-Hong Kwon
Chung-Ang University (Korea)

We proposed the tunable reflector formed by graphene in Metal/Insulator/Metal cavity. The structure can control the reflectivity not only effectively by strongly confined electric fields but also sensitively by variable permittivity of graphene. Consequently, we can control the reflectivity by modifying the gate voltage of graphene.

P31: Ultrafast Transient Dynamics of Optical Loss Compensation in Aggregated Gain-Plasmon Polymeric Films

Alireza Rahimi Rashed[1], Mohamed Elkabbash[2], Betul Kucukoz[3], Quang Nguyen[2], Ahmet Karatay[3], Gul Yaglioglu[3], Giuseppe Strangi[2], Ekmel Ozbay[1], Humeyra Caglayan[1]
[1] *Bilkent University (Turkey),* [2] *Case Western Reserve University (USA),* [3] *Ankara University (Turkey)*

We present a comprehensive study via transient absorption spectroscopy (TAS) to investigate ultrafast exciton-plasmon dynamics of hybrid aggregates consisted of core-shell quantum dots (QDs) and Au Nanoparticles (NPs) leading to optical loss mitigation. The results suggest modifying the way of analyzing the transient absorption spectra of loss mitigated systems. We show that appropriate choice of the pump wavelength and by changing the pump power we can conclusively prove the existence of loss mitigation using UTAS.

P32: Bright off-axis directional light harvesting with plasmonic corrugations

Alireza Rahimi Rashed[1], Hamed Sattari[2], Ekmel Ozbay[1], Humeyra Caglayan[1]
[1] *Bilkent University (Turkey),* [2] *Ecole Polytechnique Federale de Lausanne (Switzerland)*

We introduce a new plasmonic bulls-eye antenna to efficiently harvest the emitted light from diamond Nitrogen Vacancy (NV) centers. The designed structure shows a great performance even better than double-side corrugated structures. In addition, we study for the first time asymmetric structures to steer emitted beam in two-axis. Our results show that spatial off-axial steering angle over a cone is approachable by applying optimal asymmetries to grooves and ridges of the plasmonic antenna.

P33: Positional irregularities in nanowire metamaterials

Tatjana Gric[1], O. Hess[2]
[1] *Vilnius Gediminas Technical University (Lithuania),* [2] *Imperial College London (United Kingdom)*

Irregularities in metamaterials are usually perceived to have detrimental impacts. Here, we demonstrate that positional irregularities also open up an innovative way to control the properties of interface waves between two layers of nanowire metamaterials.

P34: Fe3O4@Au Core-shell Nanoparticle with Suprastructure Au shell for SERS

Dong Kyu Lee, Van Tan Tran, Younseong Song, Jeonghyo Kim, Jaebeom Lee
Pusan National University (Korea)

Suprastructure like core-shell nanoparticle was synthesized under the wet chemistry environment. Fe3O4 was fully covered self-assembly of AuNPs on Fe3O4 nanoparticle which was observed by TEM. To form suprastructure like Au NP coating on Fe3O4 NPs, ion reducing method assisted with layer-by-layer (LBL) structure of AuNPs and PEI on the surface of Fe3O4 NPs were proceeded. This material was used as surface enhanced Raman scattering (SERS) substrate.

P35: Magnetoplasmonic core-shell Au@FeCo nanoparticles and their magnetic property compared with solid and hollow types

Junyoung Kwon, Menqi Wei, Jaebeom Lee
Pusan National University (Korea)

Recently, the relationship between magneto-optics and plasmonics has been actively studied. But, localized surface plamonic resonance (LSPR) effect on magnetic phase, especially on the motion of magnetic dipole moments, is not confirmed yet. Here, solid, core-shell, and hollow-type of iron-based magnetoplasmonic (MagPlas) nanoparticles (NPs) are produced via thermolysis synthesis route.

P36: Fabrication, Properties and Applications of Multidimensional Magnetoplasmonic Assembled Structures

Van Tan Tran, Younseong Song, Jeonghyo Kim, Sangjin Oh, Jaebeom Lee
Pusan National University (Korea)

A magnetic field is successfully utilized to induce the fabrication of multidimensional structures composed of magnetite coated silver core/shell particles, which exhibit intriguing optical properties. The magnetoplasmonic 2D film exhibits strong dual reflected colors caused by structural and plasmon resonance scattering. Based on this platform, various colorimetric sensors were fabricated for detection of humidity and mechanical forces without sophisticated instruments.

P37: Magneto-Plasmonics of Checkerboard Au-Ni Nanoparticle Arrays

Mikko Kataja[1], Sara Pourjamal[1], Nicolo Maccaferri[2], Paolo Vavassori[2], Tommi Hakala[1], Mikko Huttunen[1], Paivi Torma[1], Sebastiaan van Dijken[1]
[1] *Aalto University (Finland),* [2] *CIC nanoGUNE (Spain)*

We report a new method of integrating ferromagnetic and noble metal plasmonic nanostructures leading to strong magneto-optical (MO) responses and optical reflectivity. The structure consists of Ni and Au nanoparticles ordered into periodic checkerboard arrays. Diffractive far-field coupling between the individual emitters of the lattice results in the excitation of two orthogonal surface lattice resonance (SLR) modes. Local analyses of the radiation fields indicate that Ni and Au nanoparticles actively contribute to SLRs and MO activity of the array.

P38: Design Considerations to Maximize Near Field Enhancement in a Plasmonic Dimer

Debadrita Paria, Ambarish Ghosh
Indian Institute of Science (India)

Recently there has been a lot of focus on the integration of plasmonic nano structures with graphene in order to increase graphene's light absorbing capability and its use as an improved photodetector. The present work aims at exploring the best possible design and choice of material for achieving maximum near field enhancement in a plasmonic dimer geometry. Simulations are done to understand the coupling mechanism in the plasmonic dimer which can be used for focusing intense light to graphene.

P39: Controlling Interface States in 1D Photonic Crystals by tuning Bulk Geometric Phases

Wensheng Gao[1], Meng Xiao[1], Baojie Chen[2], Edwin Y. B. Pun[2], Che Ting Chan[1], Wing Yim Tam[1]
[1] *Hong Kong University of Science and Technology (China),* [2] *City University of Hong Kong (China)*

We show here that one can achieve robust interface states through the control of geometrical phase such that interface states can be guaranteed in even or odd, or in all photonic bandgaps of 1D photonic crystals. We verify experimentally the designed interface states in 1D multilayered photonic crystals fabricated by electron beam vapor deposition. We also obtain the geometrical phases by measuring the reflection phases at the bandgaps of the PCs and achieve good agreement with the theory.

P40: Investigating Corresponding Unequal Divided Circles Unit Cells Response as Alternate Electromagnetic Absorbing Matter

Abdul Aziz Muhammad Ezanuddin, Herwansyah Lago, Yeng Seng Lee
Universiti Malaysia Perlis (Malaysia)

This paper discover ways of exploiting corresponding unequal divided circles (CUDC) unit cells with different formations and its related electromagnetic surface wave behavior using 3D tetrahedral eigenmode computation. Strategically placed unit cells using identified formation, known electromagnetic surface wave can either be allowed to pass through, blocked and redirect to desire angle within designated area. Engineered CUDC presented shows strong resonance at 5.9 GHz and produced stable electromagnetic bandgap (EBg) region from 5.9265 GHz to 5.9516 GHz.

P41: Dichroic phase modulation at near-infrared wavelengths based on bilayer metasurface
Kyookeun Lee, Gun-Yeal Lee, Hansik Yun, Sang-Eun Mun, Jeong-Geun Yun, Byoungho Lee
Seoul National University (Korea)

We present a bilayer metasurface that modulates phase of light at two different wavelengths independently. A unit cell of the metasurface is composed of stacked poly-silicon nanofins with different geometric parameters, including height, length, width, and rotation angle. Each nanofin gives different amplitude and phase at each target wavelength, so that phase of each wavelength can be tailored independently. The proposed metasurface can be applied to dichroic splitters, full-color holography, and achromatic optical elements.

P42: Terahertz nano-metamaterials for rotation-free performance
Sang-Hun Lee[1], Dong-Kyu Lee[1], Young Min Jhon[1], Joo-Hiuk Son[1], Minah Seo[2]
[1]*Korea Institute of Science and Technology (Korea),* [2]*University of Seoul (Korea)*

In this work, we designed three types of terahertz (THz) nano-slot-antenna arrays to obtain rotation-free performance in transmission. Honeycomb- and the chlorophyll-shape patterned arrays show multi resonance features in transmission, induced by the strong resonance coupling between adjacent slots, and those are azimuthally rotation-free to normal incidence. For interpreting this interesting phenomena, coupled harmonic oscillator model was applied and the resultant spectra were analyzed in terms of coupling strength.

P43: Active focal tuning of graphene-metal metasurface lenses
Zongduo Huang, Bin Hu, Zi Wang, Juan Liu
Beijing Institute of Technology (China)

Conventional metallic metasurfaces are difficult to achieve tunable devices once a structure is fabricated. We propose a method to realize metasurfaces with active focal tuning by graphene-metal hybrid structures. Tunable metasurface lenses in both mid-infrared and terahertz frequencies are proposed.

P44: High-efficiency electro-optic transmission modulation with multiply stacked Si p-n junction subwavelength gratings
Ki Young Lee, Jae Woong Yoon, Seok Ho Song
Hanyang University (Korea)

We theoretically propose a high-performance electro-optic(EO) modulators based on multiple p-n junction semiconductor metasurfaces. The proposed devices operate with a high-Q guided-mode resonance undergoing EO resonance shift by the assigned voltage signal. Using rigorous electrical and optical modeling methods, we theoretically demonstrate a modulation depth of 84 %, on-state efficiency 85 %, and on-off extinction ratio of 19 dB at 1,550 nm wavelength under electrical control signals within a favorably low bias voltage range from -4 V to +1 V.

P45: Holographic and interferometric approach to trap helical light within a metafilm cavity
Sun-Je Kim, Seung-Yeol Lee, Jangwoon Sung, Byoungho Lee
Seoul National University (Korea)

A novel and simple approach to trap helical light within a subwavelength metafilm cavity is proposed with a theory and numerical calculations. A silver metasurface giving phase-gradient, dielectric thin-film, and a half-infinite silver mirror are stacked in order to form a metafilm cavity. The proposed comopact scheme is based on generalized Snell's law using geometric phase of the metasurface and strong interference of multiple scatterings.

P46: Designing flat lenses using a transformation optics approach
Mircea Giloan, Robert Gutt, Gavril Saplacan
Company for Applied Informatics (Romania)

In the context of transformation optics theory we developed a method for designing optical devices able to manipulate the wave vectors in the specific manner required by the functionality of the device. This new approach was applied for designing both diverging and converging flat lenses. As the waves propagate inside the transformation media of the lenses the wave vectors are properly changed in order to impose a converging or diverging propagation of the emergent waves.

P47: High Performance Hybrid Meta-Surface for Radio Telecommunication
M. M. Hasan, M. R. I. Faruque, Fais Mansoor, M. T. Islam
Universiti Kebangsaan Malaysia (Malaysia)

Meta-surfaces offer an alternative to bulk three-dimensional metamaterials. Because of the two-dimensional nature of the meta-surface structures, they occupy less physical space and can exhibit lower loss. We have pointed a 2.15 GHz wide bandwidth meta-surface for C-band applications. The proposed structure is consisted of ring resonators, where the dimensions of a single unit cell is 11x11 mm2 and the effective medium ratio 5.27.

P48: Triangular Shape Left-Handed Meta-Surface Based on Meta-Atom Cluster for C-Band Operation
M. R. I. Faruque, M. M. Hasan
Universiti Kebangsaan Malaysia (Malaysia)

In this paper, a triangular shaped left handed meta-surface based on the meta-atom cluster has been demonstrated for C-band applications. Measurement also done and the measured and simulated results are well complied together. The measured results show resonance of the transmission coefficient at 7.40 GHz and the left handed characteristics exhibits from 16.66 GHz to 18.0 GHz.

P49: Tunable beam steering with reconfigurable phase-change metasurface
Yu Han Chen[1], Cheng Hung Chu[2], Ming Lun Tseng[1], Hsiang-Chu Wang[1], Ting-Yu Chen[1], Jie Chen[1], Wei-Yi Tsai[1], Din Ping Tsai[1]
[1] *National Taiwan University (Taiwan),* [2] *Academia Sinica (Taiwan)*

We present the tunable optical response of phase change material, which can be used to metasurfaces with varied functionalities. The concept of reconfigurable metasurface, which have different combination of unit cells with various geometries and phase states are proposed. The research is promising to apply to the area of the metadevice.

P50: Reflection phase measurements by thick-gap Fabry-Perot interferometry and correction of numerical aperture effect
Tsz Kit Yung, Wing Yim Tam
(Hong Kong)

Metamaterials, artificial materials with sub-wavelength structures capable of exhibiting novel electromagnetic behaviors, have been actively perused as a hot research topic in recent years. The small feature sizes have led to challenges in characterizing the properties of the metamaterials. A new method for measuring the absolute phase change on reflection for small samples in the optical range using converging incident beam is presented as the usual techniques work only for bulk samples and in discrete wavelengths.

11:30 - 12:05 — Ballroom

Session 1A2

GEN1. Plasmonics and nanophotonics I

Chaired by: Sylvain Combrie

11:30 : Invited talk
Physical and chemical origin of spectral fluctuation in surface enhanced resonance Raman scattering at single hotspot between silver nanoparticle dimer
Tamitake Itoh
National Institute of Advanced Industrial Science and Technology (Japan)

Single molecule (SM) surface-enhanced resonance Raman scattering (SERRS) at a hotspot has exhibited both intensity and spectral fluctuations, resulting in difficulty in SERS reliable analysis. To reduce the degree of complexity, we quantitatively investigate the origin of SERS spectral fluctuation based on the EM mechanism. The physical origin is analyzed as molecular motion within several angstroms and the chemical origin is analyzed as creation-annihilation of defects inside the molecule. SERRS is only method to investigate such extremely fine fluctuations.

11:50 : Super-radiant photoluminescence of plasmonic cube-in-cube nanoparticles
Jeong-Eun Park, Sungi Kim, Jiwoong Son, Yeonhee Lee, Jwa-Min Nam

Seoul National University (Korea)

Here we designed and synthesized interior nanogap-engineered cube-in-cube nanoparticles in high precision and a high yield via a galvanic void formation process. The cube-in-cube nanoparticles show significantly enhanced PL and the PL intensity and quantum yield are 31 times and 16 times higher than those of Au nanocubes, respectively, which have the highest PL intensity and quantum yield reported for metallic nanostructures. Finally, we check the long-term photostability of the PL signal under continuous illumination for 1h.

11:30 - 12:15 — Room 106

Session 1A3

GEN20. Transformational Electromagnetics and Cloaking

Chaired by: Paul Kinsler

11:30 : Omnidirectional Invisibility Cloak Based on A Two-step Linear Transformation
Youming Zhang, Yu Luo, Baile Zhang
Nanyang Technological University (Singapore)

Realizing an invisibility cloak has drawn great research interests since the theory of transformation optics was proposed. However, previous demonstrations of invisibility cloaks suffered from various problems due to the complex parameters required, though significant achievements have been achieved both in microwave and optical frequencies recently. Here, we propose and demonstrate a cloak based on a two-step linear transformation that works for omnidirection at microwave frequencies. This work could push the research of cloak realizations one step forward.

11:45 : Gradient permittivity plasma and metamaterial in numerical analysis to reduce the size of cloaking
Alexandre Bambina[1], Syuhei Yamaguchi[1], Akinori Iwai[2], Yuki Kabe[1], Shigeyuki Miyagi[1], Osamu Sakai[1]
[1] *The University of Shiga Prefecture (Japan),* [2] *Kyoto University (Japan)*

Clocking for microwaves is investigated numerically in a model integrating plasma with anisotropic metamaterial. Realization of cloaking requires media with designed permittivity and permeability parameters. Invisibility observed in this study is based on spacial gradient of permittivity in plasma and anisotropic permeability in metamaterial. This report demonstrates our numerical results based on the finite-difference time-domain (FDTD) method. These results indicate potentials and possible advantages coming from spacial gradient of plasma permittivity with anisotropic.

12:00 : Curvature and Transformations
Paul Kinsler[1], Jonathan Gratus[1], Martin McCall[2]
[1] *Lancaster University (United Kingdom),* [2] *Imperial College London (United Kingdom)*

We discuss the presence and role of curvature in transformation optics and other transformation fields. Further, we show where and why it is not induced by cloaking transformations, but where and why it can be in other cases.

11:30 - 12:25 — Room 109

Session 1A4

SP14. Fano resonances in optics and microwaves: Physics and application I

Organized by: Eugene Kamenetskii and Almas Sadreev

Chaired by: Eugene Kamenetskii and Almas Sadreev

11:30 : Invited talk
Explicit demonstration of how path interference can enhance plasmonic nonlinearity
Mehmet Emre Tasgin
Hacettepe University (Turkey)

We demonstrate why nonlinear frequency generation, e.g. second harmonic generation and four-wave mixing, can be enhanced via interference of conversion paths. We derive a single equation for the amplitude of the generated nonlinear oscillations. On this equation we show that cancellation in the denominator gives rise to conversion enhancement. We utilize this phenomenon to obtain further enhancement using interference of the multiple conversion paths.

11:50 : Invited talk
Cross-polarization mode excitation and cross-polarization mode coupling in photonic crystal slabs
Dmitry A. Bykov, Leonid L. Doskolovich, Nikita V. Golovastikov
Samara National Research University (Russia)

We study Fano resonances in photonic crystal slabs in conical diffraction mounting. Using two-dimensional coupled-mode theory we obtain simple approximations of the structure's reflection and transmission coefficients. These approximations, which can be interpreted as multivariable generalizations of the Fano line shape, allow to describe a number of important optical effects arising in conical diffraction mounting: cross-polarization excitation of the structure's quasiguided modes, coupling of TE-like and TM-like modes, and emergence of exceptional points.

12:10 : Effect of substrate on Q-factor of optical bound states in the continuum
Andrey Bogdanov[1], Zarina Sadrieva[1], Ivan Sinev[1], Kirill Koshelev[1], Anton Samusev[1], Ivan Iorsh[1], Osamu Takayama[2], Radu Malureanu[2], Andrei Lavrinenko[1]
[1] *ITMO University (Russia),* [2] *Technical University of Denmark (Denmark)*

We experimentally and theoretically analyze the role of substrate on the optical bound states in the continuum (BICs). We reveal that a high-index substrate could destroy even in-plane symmetry protected BIC due to leakage into the diraction channels opening in the substrate. We show how two concurrent loss mechanisms (scattering due to surface roughness and leakage into substrate) contribute to the suppression of the resonance lifetime.

11:30 - 12:30 — Room 104-105

Session 1A5

SP37. Structural Color for Displays and Imaging

Organized by: Debashis Chanda

Chaired by: Debashis Chanda

11:30 : Invited talk
Dual-color plasmonic pixels for high-density information storage
Esmaeil Heydari, Justin Sperling, Steven Neale, Alasdair W. Clark
University of Glasgow (United Kingdom)

We demonstrate a new plasmonic approach to high-density optical data storage, using dual-color plasmonic nano-pixels to encode two information sets into the same unit area using single arrays of two-state metal nano-apertures.

11:50 : Invited talk
High-Resolution Color Prints With Plasmonic and Dielectric Nanoantennas
Joel K. W. Yang
Singapore University of Technology and Design (Singapore)

Antennas operating in the visible spectrum have enabled color printing through geometry control of nanostructures. These color prints exhibit polarization-dependent colors, ultra-high resolution $\sim$100,000 dpi, and

fade resistance. Recent developments have demonstrated active color tuning, stacked plasmonic colors, and scale-up. Predominantly, metallic nanostructures have been investigated. However, developments in high-index dielectric nanoantennas are promising in overcoming some shortfalls in nanometallics, i.e. ohmic losses, and heating effects. In this talk we present our latest results in nanostructured colors.

12:10 : Invited talk
Dynamic Full Color Plasmonic Surface and Active Addressing
Daniel Franklin, Shin-Tson Wu, Debashis Chanda
University of Central Florida (USA)

We demonstrate a liquid crystal-plasmonic system capable of producing the full RGB color basis set solely as a function of voltage. This is achieved through surface morphology induced polarization dependent color and liquid crystal effects which manifest at different voltages. We further show the integration of such a surface with a thin-film-transistor array to display arbitrary images.

11:30 - 12:10 — Room 107-108

Session 1A6

SP1. Nano-Plasmonics for Sensing I

Organized by: Andrea Toma and Remo Proietti Zaccaria

Chaired by: Andrea Toma and Remo Proietti Zaccaria

11:30 : Invited talk
Tunable plasmonic sensing through enhanced Raman spectroscopy
Bikas Ranjan, Akihiro Kuno, Takayuki Umakoshi, Prabhat Verma
Osaka University (Japan)

Plasmonic enhancement is the key phenomenon for sensing a molecule or a sample that has weak scattering, through enhanced Raman spectroscopies, such as SERS or TERS. In such techniques, there can be two different resonances, one associated with the oscillations of the localized surface plasmons and the other associated with the Raman scattering. If the two resonances are tuned to the same wavelength, the resultant enhancement can be huge and hence makes a better sensing device.

11:50 : Invited talk
Dynamic color displays based on catalytic metasurfaces
Xiaoyang Duan, Simon Kamin, Marcus Matuschek, Frank Neubrech, Na Liu
Max Planck Institute for Intelligent Systems (Germany)

Plasmonic color generation based on metasurfaces provides resolutions far beyond the diffraction limit of light enabling new possibilities for printing color images or optical data storage. However, the realization of dynamic plasmonic displays remains a challenging task. In the present paper, we utilize catalytic magnesium nanostructures, which change their optical properties during exposure to hydrogen, to demonstrate dynamic color generation. The technique could pave the way for animating high resolution images and could provide new routes for detecting counterfeits.

11:30 - 12:10 — Room 110-111

Session 1A7

SP22. Near, Mid and Far Infrared Photonics I

Organized by: Artur Davoyan

Chaired by: Kelly Mauser

11:30 : Invited talk
Van der Waals Materials for Active Infrared Photonics
Michelle C. Sherrott[1], William S. Whitney[1], Philip W. Hon[2], Deep M. Jariwala[1], Katherine T. Fountaine[2], Luke A. Sweatlock[2], Harry Atwater[1]
[1] *California Institute of Technology (USA),* [2] *Northrop Grumman Aerospace Systems (USA)*

In this talk, we will present results on van der Waals materials for active infrared photonics, with a focus on graphene and few-layer black phosphorus. We take advantage of the electrostatically tunable optical properties of graphene to design active devices for controlling absorption, emission, and phase. We additionally consider ultrathin black phosphorus as a novel platform for IR optoelectronics, demonstrating gate-tunable transmittance due to an ambipolar Burstein-Moss and Quantum Confined Franz-Keldysh effect.

11:50 : Invited talk
Terahertz-Light Emission in Graphene-Based Active Plasmonic Metamaterial Heterostructures
Taiichi Otsuji, Takayuki Watanabe, Akira Satou, Deepika Yadav, Stephane Boubanga-Tombet, Tetsuya Suemitsu, Victor Ryzhii
Tohoku University (Japan)

This paper reviews recent advancement on the research toward graphene-based active plasmonic metamaterials for terahertz (THz) light emission. The dual-gate graphene channel transistor structure serves carrier population inversion, promoting spontaneous broadband THz emission. Active plasmonic meta-surfaces implemented into the gate structure can transcend the incoherent light-emitting action to the amplified stimulated emission of THz radiation.

11:30 - 12:10 — Room 113

Session 1A8

Symposium II. Recent Advances in Complex Materials and Nanophotonics I

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

11:30 : Invited talk
A controlled-NOT gate based on THz metamaterials
Fang-Fang Ren, Wei-Zong Xu, Jiandong Ye
Nanjing University (China)

We demonstrate a double-layer bi-anisotropic metamaterial showing strong asymmetric polarization rotation, which can realize a controlled-NOT gate logical transformation between two orthogonal linear polarizations around 0.53 THz. Such a 3D chiral metamaterial opens up new opportunities for the construction of high efficiency optical logic processors towards ultrafast data transmission and information processing.

11:50 : Invited talk
Near-field imaging of chiral optical fields on plasmonic materials
Hiromi Okamoto, Shun Hashiyada, Tetsuya Narushima, Yoshio Nishiyama
Institute for Molecular Science (Japan)

To investigate internal structures of chiral optical responses in nanomaterials, we developed near-field optical activity imaging systems, and observed near-field CD images of two-dimensional gold nanostructures.

Local CD signals with amplitudes as large as 100 times the macroscopic CD signals of the same samples were obtained, even for achiral structures. Furthermore, local linearly polarized near-field excitation of highly symmetric circular disks (that give no local CD signals) yielded circularly polarized scattering fields.

11:30 - 12:10 — Room 114

Session 1A9

SP34. Advanced numerical and theoretical tools as applied to modern nano photonics: Plasmonics and Metamaterials I

Organized by: Kofi Edee

Chaired by: Kofi Edee

11:30 : Invited talk

Radiative heat-transfer between metallic gratings using adaptive spatial resolution

Riccardo Messina, Antonio Noto, Brahim Guizal, Mauro Antezza
University of Montpellier (France)

We calculate the radiative heat transfer between two metallic gratings by exploiting the Adaptive Spatial Resolution metod. This technique dramatically improves the rate of convergence allowing to explore smaller separations. The heat flux shows a remarkable amplification of the exchanged energy, due to spoof-plasmon modes. We find a consistent disagreement with some previously obtained results going up to 50 % (this disagreement is explained in terms of an incorrect connection between the reflection operators of the two gratings).

11:50 : Invited talk

The Fourier Modal Method with Adaptive Spatial Resolution under conical mounting

Brahim Guizal
University of Montpellier (France)

The Fourier Modal Method equipped with the concept of Adaptive Spatial Resolution (FMMASR) is derived and presented, in details, in the case of lamellar diffraction gratings under conical mounting. In the present work, we focus on efficiency and reduction of the numerical load.

11:30 - 12:30 — Room 115

Session 1A10

Symposium I. Hybrid Optically Active Nanomaterials I

Organized by: Xing Yi Ling, Jerome Plain and Alexander Govorov

Chaired by: Xing Yi Ling, Jerome Plain and Alexander Govorov

11:30 : Invited talk

Bimetallic Nanocatalysts with Integrated Functions of Plasmonics and Catalysis toward Energy Conversion

Chun-Hong Kuo[1], Yu-Chun Chuang[2], Brian T. Sneed[3], David A. Cullen[4]
[1] *Academia Sinica (Taiwan),* [2] *National Synchrotron Radiation Research Center (Taiwan),* [3] *Center for Nanophase Materials Sciences (USA),* [4] *Oak Ridge National Laboratory (USA)*

Wearing Pt on Cu nanocubes to form the bimetallic nanocatalysts is domeonstrated. By heterogeneous coating of Pt, the ultimate rhombic dodecahedral core-frame nanostrcutures were obtained. Turning the amount of Pt atoms, the frames evoled at the 100 corners to form the vertex-stretching ones. The corres-

ponding nanoframes could be obtained after removing the Cu cores. The nanoframes showed superior performances in the ORR and the photoreduction of 4-nitrophenol, rendering them the cost-efiicient alternatives for noble metal catalysts.

11:50 : Invited talk
Plasmonic Titanium Nitride for Solar Energy Conversion
Alberto Naldoni[1], Urcan Guler[1], Harsha Reddy[1], Alexander O. Govorov[2], Alexander Kildishev[1], Alexandra Boltasseva[1], Vladimir M. Shalaev[1]
[1]Purdue University (USA), [2]Ohio University (USA)

Refractory titanium nitride (TiN) is an emerging alternative plasmonic material with resonances in the visible and near-infrared. Its exceptional stability in corrosive chemical environment and its durability at high temperature enable the use of TiN for a wide range of solar energy conversion applications. We will present our recent results on the use of plasmonic TiN for photocatalysis, solar/thermophotovoltaics, and our progress on the large-scale fabrication of refractory plasmonic nanostructures.

12:10 : Invited talk
Surface-enhanced Raman spectroscopy of single-molecules at nanometer and at angstrom-scale
Hyun-Hang Shin, Gyujin Yeon, Zee Hwan Kim
Seoul National University (Korea)

A common wisdom of surface-enhanced Raman scattering (SERS) is that the optical property is completely determined by the overall geometry of nanostructures (sizes, shapes, and gap-distances) and dielectric constants, despite the fact that real metallic surfaces have atomic surface defect structures and diffuse electron densities extending beyond metallic boundaries. This classical picture of plasmonics leads to the belief that plasmonic length-scale (size of localized field distribution) cannot usually go below $\sim$10 nm. I will demonstrate the use of single-molecule SERS to follow individual chemical reaction events1, and also spectroscopic evidences that the plasmonic hotspots can be as small as 1 angstrom. I will further discuss its implication in molecular spectroscopy, photochemistry, and nano-scale imaging.

11:30 - 12:10 — Room 116

Session 1A11

SP39. Potential application of metamaterials I

Organized by: Tae In Choi

Chaired by: Q-Han Park

11:30 : Invited talk
Introduction of Office of Naval Research Global
Simin Feng
Office of Naval Research Global (USA)

Office of Naval Research Global (ONRG) is a funding organization within the United States Department of the Navy to support worldwide basic scientific research in the areas of Navy interest. This talk will provide an overview about the ONRG mission and funding opportunities.

11:50 : Invited talk
Metal oxides for Plasmonic and Metamaterial Applications
Heungsoo Kim[1], Nick Sharac[2], Nick S. Bingham[2], Nicholas Charipar[1], Jeff Calame[1], Alexander Vlasov[1], Guy Beadie[1], Marc Currie[1], Chase Ellis[1], Joseph Tischler[1], Jeff Owrustky[1], Joshua Caldwell[1], Alberto Pique[1]
[1]U.S. Naval Research Laboratory (USA), [2]NRC Postdoctoral Fellow at Naval Research Laboratory (USA)

Transparent conducting oxides (TCOs) exhibit low loss plasmonic properties in the near infrared region of the electromagnetic spectrum and their carrier density can be tuned by doping. In this talk, we will present details on the properties of TCOs, such as Sn-doped In2O3 and Al-doped ZnO, and VO2 along with light trapping

metamaterial devices consisting 1D and 2D metallic gratings and TCO, which forms a Schottky contact with Si, for solar cell applications with enhanced photocurrent.

11:30 - 12:15 — Room 117

Session 1A12

GEN2. Metamaterials and negative index materials I

Chaired by: Marina S. Leite

11:30 : Manipulating the spatial distribution of magnetic near-field by a four-unit coding metamaterial
Lifang Lang, Guo Li, Sheng Ji, Hong Chen, Yunhui Li
Tongji University (China)

In this paper a coding metamaterial with '0' or '1'state controlled by a photo-relay is proposed, whose working frequency is about 3.0 MHz or 3.2 MHz. By arranging four units of this coding metamaterial in a square area, some special coding sequences can be easily realized, like '0000' and '0101'.Both numerical and experimental results demonstrate that, under the coding sequence '0000', for instance, the magnetic field distribution are relatively uniform, as well as '0101' provides a diagonal field distribution.

11:45 : A broadband optical diode for linearly polarized light using symmetry-breaking metamaterials
Minkyung Kim[1], Kan Yao[2], Gwanho Yoon[1], Inki Kim[1], Yongmin Liu[2], Junsuk Rho[1]
[1] *Pohang University of Science and Technology (Korea),* [2] *Northeastern University (USA)*

We experimentally demonstrate a thin bi-layer metamaterial supporting asymmetric transmission for linearly polarized light but not for circularly polarized light over a broad bandwidth in the near-infrared region. We provide a simple and intuitive working principle, along with full-wave simulations that agree well with the experimental results. We also prove that our design is extremely insensitive to spatial misalignment, which might occur during the nanofabrication process.

12:00 : Flexible Chipless RFID Based Frequency Selective Surface
Mohd Ezwan Jalil[1], Mohamad Kamal A. Rahim[1], Noor Asmawati Samsuri[1], Mohamed Himdi[2], Raimi Dewan[3], Kamilia Kamardin[3]
[1] *Universiti Technologi Malaysia (Malaysia),* [2] *Institut d'Electronique et de Telecommunications de Rennes (France),* [3] *Universiti Teknologi Malaysia (Malaysia)*

This paper present the design of metamaterial frequency-selective surface for chipless Radio-frequency Identification. Three circular ring with different radius are as resonating elements as main identification element for coding of chipless RFID. From simulated result, the proposed structure archive high transmittance, which is range between 95 % and 90 % at 3.50, 4.88 and 6.73 GHz The proposed chipless RFID tag offer high amount bit number without any size and capability of operating when mounted on metamaterial.

11:30 - 12:30 — Room 118

Session 1A13

SP20. Nanophotonics and plasmonics for information applications I

Organized by: Haitao Liu

Chaired by: Jiangbo Zhu

11:30 : Invited talk
Balanced Gain Loss devices in augmented contexts: modulated Bragg structures and some related disordered systems

Henri Benisty, Anatole Lupu
Paris Sud University (France)

Balanced Gain Loss devices in augmented contexts: modulated Bragg structures and some related disordered systemsBalanced gain and losses in geometries beyond those of mere trivial compensation have prompted a series of optical counterparts evoking the fascinating physics of parity-time symmetry. We will expose two more complex variants. Firstly, those that arise when tackling such a simple issue as apodizing a complex periodic index sequence. And secondly a very disordered version whereby statistics of the outcome becomes nontrivial, in relation with non-ergodicity and so called Geometric Brownian Motion (GBM): random walk in multiplicative space.

11:50 : Invited talk
Modeling localized surface plasmon resonance with propagative surface plasmon polaritons in optical nanogap antennas
Haitao Liu[1], Hongwei Jia[1], Fan Yang[2], Ying Zhong[3]
[1] *Nankai University (China),* [2] *Tsinghua University (China),* [3] *Tianjin University (China)*

The resonance behavior of optical antennas is commonly attributed to the excitation of a localized surface plasmon resonance (LSPR), which can be theoretically defined as the quasi normal mode (QNM). To clarify the physical origin of the LSPR, we build up an analytical model of the LSPR by considering a multiple scattering process of propagative surface plasmon polaritons (SPPs) on the antenna arms, which establishes explicit relations between the concepts of the LSPR and the propagative SPP.

12:10 : Invited talk
Exact theory of Purcell effect and resonant-state expansion
Egor Muljarov, Wolfgang Langbein
Cardiff University (United Kingdom)

We present a general analytic theory of the Purcell effect, which is based on the expansion of the Purcell factor into all relevant resonances of the cavity and on exact calculation of their effective mode volumes. We use the exact normalization of modes which we have developed earlier for formulation of the resonant-state expansion, a new rigorous perturbation theory of resonances in open systems. We verify our theory on analytically solvable examples and apply it to more complicated resonators.

Lunch and Exhibit Inspection

12:10 - 14:00

14:00 - 14:45 — Room 106

Session 1A14

GEN1. Plasmonics and nanophotonics II

Chaired by: Tamitake Itoh

14:00 : Fano resonances in nonlinear photonic structures and its applications for optical bistability/switching
Thu Trang Hoang, Quang Minh Ngo
Vietnam Academy of Science and Technology (Vietnam)

This work presents the spectral properties of Fano resonances generated in nonlinear photonic structures with emphasis on optical switching/bistability. The simple photonic structures such as slab waveguide gratings and coupled slab waveguide gratings in which Fano resonances with various quality and asymmetric factors are designed and their characteristics analyzed with a finite-difference time-domain method. We demonstrate the switching/bistable behaviors of the structure at Fano resonance which provides a significant switching intensity reduction compared to the established Lorentzian resonant structures.

14:15 : Do Surface Plasmons Convey Geometric Phase?

Salman Daniel[1], **Kimmo Saastamoinen**[1], **Toni Saastamoinen**[1], **Ismo Vartiainen**[1], **Ari T. Friberg**[1], **Taco D. Visser**[2]
[1] *University of Eastern Finland (Finland),* [2] *Vrije Universiteit (The Netherlands)*

Surface plasmons polaritons (SPPs) are electromagnetic surface waves that can be generated by and converted back into freely propagating light beams by applying metallic structures, such as gratings or slits. In this work we investigate experimentally whether SPPs in the process light beam $\rightarrow$ SPP $\rightarrow$ light beam convey the geometric (Pancharatnam-Berry) phase, which appears on passing a beam of light cyclically through a series of polarizing components.

14:30 : Surface plasmon-polaritons and transverse spin angular momentum at the boundary of hyperbolic metamaterial with arbitrary orientation of the optical axis
Vladimir Belyi, Svetlana Kurilkina, Nikolai Kazak, Vladimir Agabekov
National Academy of Sciences of Belarus (Belarus)

The possibility is established and the conditions are found for localization of plasmon-polaritons (PPs) near the boundaries of hyperbolic metamaterials (HMs) of both I and the II types with arbitrary orientation of the optical axis. It is grounded that such surface PP has the transverse spin momentum which depends on the wavelength of the exiting wave, the orientation of the optical axis of the hyperbolic metamaterial, and dielectric properties of bordered media.

14:45 - 16:00 — Room 106

Session 1A15

Symposium II. Recent Advances in Complex Materials and Nanophotonics II

Organized by: Konstantin Vytovtov

Chaired by: Mathias Marconi

14:45 : Invited talk
Quantum Optics with Nanowires
V. Zwiller[1], **A. Elshaari**[2], **K. Jons**[2], **M. Versteegh**[2], **L. Yang**[2], **A. Fognini**[1], **I. Esmaeil Zadeh**[1], **L. Schweickert**[2], **J. Zichi**[2], **K. Zeuner**[2], **T. Lettner**[2]
[1] *Kavli Insitute of Nanoscience (The Netherlands),* [2] *Quantum Nano Photonics (Sweden)*

We will discuss our first attempts at combining semiconducting nanowire based single photon emitters and superconducting nanowire single photon detectors on a chip to realize integrated quantum circuits.

15:05 : Material-induced chiroptical response of a single mirror-symmetric nanostructure
Pawel Wozniak[1], **Sergey Nechayev**[1], **Shadi Sorayya**[1], **Uwe Mick**[1], **Israel De Leon**[2], **Robert W. Boyd**[2], **Gerd Leuchs**[1], **Peter Banzer**[1]
[1] *Max Planck Institute for the Science of Light (Germany),* [2] *Max Planck University of Ottawa (Canada)*

Chirality, an exciting property of objects lacking in mirror symmetry, provides the ability to sense the handedness of light's polarization. Instead of following the conventional apporach based on purely geometrical aspects, we now introduce a novel and versatile concept realized by a heteromaterial composition of nanostructures. Here, we report on our experimental and numerical observation of optical activity of geometrically symmetric nanoassemblies enabled by heteromaterial selection.

15:20 : Invited talk
Ultrafast imaging of acoustic wave propagation in microsphere-based metamaterial structures
P. H. Otsuka[1], **S. Mezil**[1], **V. Gusev**[2], **O. Matsuda**[1], **M. Tomoda**[1], **T. Gan**[3], **N. Boechler**[4], **A. A. Maznev**[3], **N. Fang**[3], **O. B. Wright**[1]
[1] *Hokkaido University (Japan),* [2] *l'Universite du Maine (France),* [3] *Massachusetts Institute of Technology (USA),* [4] *University of Washington (USA)*

We perform spatio-temporal imaging of acoustic waves in a metamaterial based on silica microspheres arranged in different patterns on a glass substrate. An ultrafast optical pump-probe system is used to obtain time-

resolved 2D images of both surface and bulk acoustic wave interactions with the microspheres. We also identify the metamaterial frequency band gap regions through a detailed examination of the experimentally and theoretically-obtained acoustic dispersion relations.

15:40 : Invited talk
Long-tailed superthermal light in coupled photonic crystal nanolasers
Mathias Marconi[1], Julien Javaloyes[2], Philippe Hamel[1], Fabrice Raineri[1], Ariel Levenson[1], Alejandro Yacomotti[1]
[1] *Paris Sud University (France),* [2] *Universitat de les Illes Baleares (Spain)*

We generate long-tailed superthermal light on the non-lasing mode of a nanophotonic ensemble formed by two coupled nanolasers. An original and simple experimental technique is implemented in order to access the full probability distribution of output pulse energies. We interpret our results on the basis of a mean field theory and find, through an analogy with out-of-equilibrium thermodynamics, a new route for the generation of superthermal light statistics as a rapid cooling, quenching, of mode fluctuations.

14:00 - 16:00 — Room 109

Session 1A16

SP14. Fano resonances in optics and microwaves: Physics and application II

Organized by: Eugene Kamenetskii and Almas Sadreev

Chaired by: Eugene Kamenetskii and Almas Sadreev

14:00 : Invited talk
Mid-Infrared Nonlinear Nanophotonics in Anisotropic Dielectrics Using Surface Phonon Polaritons
Ilya Razdolski[1], Nikolai Christian Passler[1], Joshua D. Caldwell[2], Martin Wolf[1], Alexander Paarmann[1]
[1] *Fritz Haber Institute of the Max Planck Society (Germany),* [2] *Naval Research Laboratory (USA)*

Surface phonon polaritons provide a unique plattform for mid-infrared nonlinear nanophotonics due to broken inversion symmetry and pronounced crystal anisotropy in many of the host materials. Here we experimentally demonstrate resonant enhancement of second harmonic generation due to excitation of localized and propagating surface phonon polaritons in Silicon Carbide. In particular, we observe drastic additional enhancement of the second harmonic response for resonant interactions of the surface phonon polaritons with anisotropic weak phonon modes in subdiffractional nanostructures.

14:20 : Invited talk
High-Q Fano resonances and SERS applications of 3D metamaterials
Changzhi Gu, Zhe Liu, Shengyan Yang, Junjie Li
Chinese Academy of Sciences (China)

We report a series of studies on 3D folded metamaterial, by which Fano resonances can be excited and the line shape, intensity and Q factor can be modulated. Different combinations of the vertical and planar building blocks of the 3D folded metamaterials result in diverse properties of the Fano resonance, which have practical applications in filter, ultrasensitive biosensor, active SERS substrate, etc.

14:40 : Invited talk
Light-tunable Fano resonances in metal-dielectric multilayer structures
Shinji Hayashi[1], Dmitry V. Nesterenko[2], Anouar Rahmouni[2], Zouheir Sekkat[2]
[1] *Kobe University (Japan),* [2] *Moroccan Foundation for Advanced Science, Innovation and Research (Morocco)*

We demonstrate here the tuning of Fano resonance by light irradiation. The photo-tuning was made possible by incorporating azo-dye molecules in a dielectric waveguide layer. Due to the photoisomerization of the molecules, the refractive index of the waveguide layer changes upon pump light irradiation, resulting in the shift of the Fano line shape. The change in the refractive index estimated from the experimental data falls in a range less than ∼7.0x10-4.

15:00 : Invited talk
Interference of plasmonic vortex fields with different angular momenta
Keiji Sasaki
Hokkaido University (Japan)

We showed that the optical vortex field can be confined into nano-space using plasmonic multimer structures. In this transfer from chiral photons to plasmons, the total angular momentum is conserved, while the orbital and spin angular momenta can be exchanged. Here, we demonstrate that plasmonic nano-vortex field is formed as interference of chiral photons having different angular momenta. We show that this interference field induces optical torque and central force, which leads to orbital rotation of nanoparticles in nano-space.

15:20 : Invited talk
Coupling between photonic crystal cavities and waveguides for ultrafast optical switching
Yanhui Zhao, Chenjiang Qian, Kangsheng Qiu, Jing Tang, Yue Sun, Xiulai Xu
Chinese Academy of Sciences (China)

We propose a coupled photonic crystal cavity-waveguide structure to achieve Fano resonance by placing partially reflecting elements in waveguide, and the Fano resonance can be greatly enhanced by introducing optical gain material into the cavity. Additionally, coupling between photonic molecules and waveguides in photonic crystal slab structures are investigated for ultrafast optical switching with a time scale of a few picoseconds by optimizing the radii of air holes between two cavities of photonic molecule.

15:40 : Invited talk
Fano resonances in light scattering by finite obstacles
Andrey E. Miroshnichenko
The Australian National University (Australia)

Light scattering by finite obstacles, either single particle or a number of particles in arbitrary configuration, exhibits various resonant effects. It turns out that almost any resonant response, either in directional or total scattering light scattering, can be efficiently described in terms of Fano resonance. One of the peculiar feature of the Fano resonance is complete destructive interference, which can be associated with radiationless excitations, such as nontrivial anapole modes.

14:00 - 16:00 — Room 104-105

Session 1A17

SP15. Parity-Time and related symmetries in Photonics, Plasmonics, Acoustics I

Organized by: Anatole Lupu, Henri Benisty and Kin Hung Fung

Chaired by: Anatole Lupu, Henri Benisty and Kin Hung Fung

14:00 : Invited talk
PT symmetric structures for single-sided diffraction and broadband non-reciprocity
Choloong Hahn[1], Youngsun Choi[2], Jaeong Yoon[2], Seok Song[2], C. H. Oh[2], Pierre Berini[1]
[1] *University of Ottawa (Canada),* [2] *Hanyang University (Korea)*

We discuss single-sided diffraction gratings and waveguide isolators based on exceptional-point optical structures.

14:20 : Invited talk
Parametric Parity-Time Symmetric Waveguide Array
Sendy Phang, Gabriele Gradoni, Stephen C. Creagh, Ana Vukovic, Trevor M. Benson
University of Nottingham (United Kingdom)

A parameteric PT-coupler in which the PT-symmetry is satisfied both in transverse and longitudinal directions is presented in this summary paper. The stability of this structure resembles that of parametric amplifiers, such that the stability of the system not only depends on the gain/loss but also on the parametric parameter. This structure exhibits unique behaviour such as thresholdless lasing and stability re-emergence.

14:40 : Invited talk
Parity-Time Symmetry Based Lasers
Ren-Min Ma
Peking University (China)

This talk will describe how to construct novel microscale laser devices by parity-time symmetry in a non-Hermitian micro-ring cavity system.

15:00 : Invited talk
Experimental realization of the manipulation of exceptional points using magnetic fields
Xu-Lin Zhang, C. T. Chan
The Hong Kong University of Science and Technology (China)

We study a pair of coupled ferromagnetic waveguides under an external magnetic field. We find this two-state non-Hermitian system has an exceptional point and a subsequent symmetry recovery due to the presence of accidental degeneracy points when the system has no loss. Experimental measurements on the transmission spectra and field distributions clearly demonstrate the presence of the exceptional point and symmetry recovery.

15:20 : Invited talk
Invisibility on Demand
Zeki Hayran[1], Ramon Herrero[2], Muriel Botey[2], Hamza Kurt[1], Kestutis Staliunas[2]
[1] *TOBB University of Economics and Technology (Turkey),* [2] *Universitat Politecnica Catalunya (Spain)*

We propose a universal integral relation (a generalized Hilbert transform) relating the real and imaginary parts of the complex permittivity function of an object, which can provide invisibility with respect to particular range of directions, and for particular frequency ranges, i.e. on a specific demand. We demonstrate such invisibility by finite-difference-time-domain numerical calculations.

15:40 : Invited talk
Smith-Purcell radiation in the presence of short-range disorder and from low-energy electrons
Ido Kaminer[1], Steven Earl Kooi[1], A. Massuda[1], C. Roques-Carmes[1], R. Shiloh[2], Bo Zhen[1], Y. Shen[1], R. Remez[2], S. A. Skirlo[1], Y. Yang[1], K. K. Berggren[1], J. D. Joannopoulos[1], A. Arie[2], Marin Soljacic[1]
[1] *Massachusetts Institute of Technology (USA),* [2] *Tel-Aviv University (Israel)*

The emission of light from electrons passing in proximity to periodic grating structures includes both resonant plasmonic features and Smith-Purcell collective excitations. We observe both and distinguish between them, finding surprising robustness to disorder in the Smith-Purcell radiation. We also demonstrate the emission of visible light induced by low-energy electrons (1.5 - 6 kV) from sub 60 nm pitch gratings. The experimental results compare nicely to numerical simulations.

14:00 - 16:10 — Room 107-108

Session 1A18

SP1. Nano-Plasmonics for Sensing II

Organized by: Andrea Toma and Remo Proietti Zaccaria

Chaired by: Andrea Toma and Remo Proietti Zaccaria

14:00 : Invited talk
Nanoscale optical force spectroscopy in the vicinity of plasmonic and dielectric nanostructures
Taka-Aki Yano, Masahiko Hara
Tokyo Institute of Technology (Japan)

We performed atomic force microscope (AFM)-based optical force spectroscopy to quantitatively characterize optical forces generated in the vicinity of plasmonic and dielectric nanostructures. The optical forces were either attractive or repulsive, which was controlled by size- and shape-dependent unique optical resonances of the nanostructures.

14:20 : Invited talk

Harnessing interband and intraband nonlinearities in transparent conducting oxides via two-colour excitation

Matteo Clerici[1], N. Kinsey[2], C. DeVault[2], J. Kim[2], E. Carnemolla[3], L. Caspani[4], A. Shaltout[2], D. Faccio[3], V. Shalaev[2], A. Boltasseva[2], M. Ferrera[3]
[1] *University of Glasgow (United Kingdom),* [2] *Purdue University (USA),* [3] *Heriot-Watt University (USA),* [4] *University of Strathclyde (United Kingdom)*

We investigated the effect of combined interband and intraband nonlinearities in aluminium zinc oxide thin films. We show that suitably timed two-colour pulsed excitations increase the material modulation bandwidth at near-infrared wavelengths and unlock novel functionalities including ultrafast modulation of the transmitted and reflected radiation frequency.

14:40 : Invited talk

Campanile Near-Field Probes Fabricated by Nanoimprint Lithography

Alexander Koshelev[1], Giuseppe Calafiore[1], Thomas P. Darlington[2], Nicholas J. Borys[2], Alexander Weber-Bargioni[2], P. James Schuck[2], Keiko Munechika[1], Stefano Cabrini[2]
[1] *aBeam Technologies (USA),* [2] *Lawrence Berkeley National Laboratory (USA)*

Optical transformer is a plasmonic antennas that can focus the light in few nanometers space efficiently and broadband. By means of Nano Imprinting Lithography, it has been fabricated on top of an optical fiber in a configuration called Campanile Tip. It is an efficient probe tip for Scanning Near Field Optical Microscopy and Spectroscopy. We will show the fabrication process, the optical characterization and the performances as high resolution SNOM tip.

15:00 : Keynote talk

Ultrafast nanoscopy: imaging structure, function, and dynamics of matter on its natural length and times scales

Markus Raschke
University of Colorado Boulder (USA)

I will present the advances in multimodal linear, nonlinear, and spatio-temporal nano-imaging for the study of fundamental optical and plasmonic phenomena, coupled single molecule or quantum dynamics, with unprecedented nanometer spatial and femtosecond resolution, sensitivity and precision.

15:30 : Invited talk

Nanoantennas for Enhanced THz Radiation - Matter Interaction

Luca Razzari
INRS-EMT (Canada)

We present our recent investigations regarding the interaction of localized terahertz (THz) radiation with nanomaterials. Details about the design of resonant metallic nanostructures for THz field confinement will be given, together with some examples of applications.

15:50 : Invited talk

Laser nano-engineered functional surfaces for high-performance organic optoelectronic devices

Hong-Bo Sun, Xu-Lin Zhang, Jing Feng
Jilin University (China)

We report high-performance organic optoelectronic devices including organic light-emitting devices (OLEDs) and organic solar cells (OSCs) employed with laser nano-engineered functional surfaces. The proposed laser induced functional surfaces can help manipulate light-structure interactions in these devices. As a result, the electroluminescence efficiency of OELDs and photon-to-electron conversion efficiency of OSCs are considerably improved.

14:00 - 15:55 — Room 110-111

Session 1A19

SP22. Near, Mid and Far Infrared Photonics II

Organized by: Artur Davoyan

Chaired by: Michelle Sherott

14:00 : Invited talk
Rectification in infrared-active, nonlinear metasurfaces
Richard Osgood[1], Jimmy Xu[2], Gustavo Fernandes[2], Minyi Kang[3], Ki-Bum Kim[3], Lalitha Parameswaran[4], Mordechai Rothschild[4], Yassine Ait-El-Aoud[1], S. A. Giardini[1], Steven Kooi[5]
[1]US Army NSRDEC (USA), [2]Brown University (USA), [3]Seoul National University (Korea), [4]MIT Lincoln Laboratory (USA), [5]MIT (USA)

Rectifying stripe-teeth metasurfaces, microanteanna arrays with infrared (IR) resonances, coupled to vertical Metal-Insulator-Metal (MIM) diodes having an insulating barrier layer, were designed and analyzed with IR microscopy and current-voltage (I-V) measurements and models. Resonances agree well with FDTD models and NbOx-based diodes have modest large barrier heights and nonlinear I-V curves. These, and Al2O3-based microrectenna arrays, were illuminated by IR and vis laser beams, and their direct current was characterized as a function of bias voltage and compared to quantum rectification models.

14:20 : Invited talk
Widely Tunable Semiconductor Antennas for Reconfigurable Metasurfaces
Jon A. Schuller
UC Santa Barbara (USA)

The ability to engineer the optical phase at subwavelength dimensions has led to metasurfaces that provide unprecedented control of electromagnetic waves. To reach their ultimate potential, metasurfaces must incorporate reconfigurable functions. The central challenge is achieving large tunability in subwavelength elements. Here, we describe two different approaches for achieving order-unity refractive index shifts: free-carrier refraction and thermo-optic tuning.

14:40 : Invited talk
Topological plasmons in graphene
Thomas Christensen[1], Dafei Jin[2], Ling Lu[3], Marin Soljacic[1]
[1]Massachusetts Institute of Technology (USA), [2]University of California (USA), [3]Chinese Academy of Sciences (China)

We discuss recent work on topological plasmonic states in two-dimensional electron gases under an applied magnetic field. By periodic nanostructuring, new high-frequency topological edge states can be synthesized beyond the conventional low-frequency edge magnetoplasmon. In moderately doped graphene, these high-frequency unidirectional edge plasmons can exist at frequencies up to tens of terahertz, reaching the far-infrared regime.

15:00 : Invited talk
Dirac Plasmons in Topological Insulator Bi2Se3
Chihun In, Sangwan Sim, Soonyoung Cha, Beom Kim, Hyemin Bae, Hyunyong Choi
Yonsei University (Korea)

Terahertz (THz) responses of topological insulator Bi2Se3 exhibit a strong interaction between Dirac surface plasmon and optical phonon near 2 THz. Employing time-resolved THz spectroscopy, we investigated the spectral manifestation of plasmon-phonon interaction after photoexcition. Ultrafast THz measurements in Bi2Se3 micro-ribbon reveal the ultra-high modulation depth of 2,4 % assisted by Fano-like plasmon-phonon-destructive interference. When plasmon frequency is controlled by changing the dimension of Bi2Se3 micro-slits, we observe the different relaxation dynamics of hot optical phonon after photoexcitation.

15:20 : Graphene Plasmon-Assisted Mid-Infrared Light Emission
Laura Kim[1], Victor Brar[2], Seyoon Kim[1], Harry Atwater[1]
[1]California Institute of Technology (USA), [2]University of Wisconsin (USA)

Plasmon emission is predicted to be a highly efficient decay mechanism of photoexcited hot carriers in grap-

hene, competing with optical phonon emission. To facilitate coupling of emitted plasmons with photons, we created graphene nanoribbons whose resonances live above, below and near the optical phonon energy. We observe carrier density-dependent graphene plasmon-assisted light emissions in the mid-infrared under femtosecond laser excitation. We explore how plasmonic modes alter decay pathways for photoexcited hot carriers and affect the resulting infrared radiation.

15:35 : Invited talk
Analytical description of nonlinear plasmonic phenomena in nanostructured graphene
J. D. Cox, R. Yu, F. J. Garcia de Abajo
ICFO-Institut de Ciencies Fotoniques (Spain)

We present an analytical, classical electromagnetic description of the nonlinear optical response associated with tunable plasmons in graphene nanostructures. Our model uses two-dimensional graphene conductivities as input to obtain the nonlinear response of the desired nanostructures. The results are shown to be in excellent agreement with realistic quantum-mechanical simulations based on a tight-binding description of electrons in graphene combined with the random-phase approximation for the response functions.

14:00 - 16:00 — Room 113

Session 1A20

Symposium II. Recent Advances in Complex Materials and Nanophotonics III

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

14:00 : Invited talk
Coherent absorption of light by graphene and other plasmonic structures
Alessandro Tredicucci
Universita di Pisa (Italy)

Coherent perfect absorption (CPA) and coherent perfect transparency (CPT) is discussed in 2D structures for instance based on graphene or intersubband transitions of a semiconductor heterostructure. In particular, asymmetric devices are analyzed, either relying on plasmonic resonances, properly engineered in a metal-dielectric metamaterial, or, more simply, constituted by an optically conductive surface on top of a substrate.

14:20 : Invited talk
Volume plasmon polariton modes in semiconductor hyperbolic metamaterials
Dongxia Wei[1], **Christian Harris**[2], **Stephanie Law**[1]
[1] *University of Delaware (USA),* [2] *Lincoln University (USA)*

This paper describes the first observation of volume plasmon polariton (VPP) modes in semiconductor hyperbolic metamaterials (HMMs). The metamaterials are grown using molecular beam epitaxy, after which gold gratings are fabricated on top. These gratings allow light to couple to the high-wavevector VPP modes in the HMM. Experimental data is compared to simulations, and a good agreement is found, the experimental VPP dispersion curve matches predictions. Potential applications of VPPs include subdiffraction focusing and waveguiding.

14:40 : Invited talk
Four-wave mixing of dispersive and solitary waves in polariton waveguiding systems
Alexey Yulin
ITMO University (Russia)

Different regimes of resonant scattering of quasi-linear excitations on solitary waves in polariton systems are considered. One and two dimensional waveguides are studied by numerical simulations. It is shown that the efficient new frequencies generation can take place in these systems at low intensities of the pump. The resonance condition for the scattering is derived and compared against the results of the numerical modeling. The recoil of the scattering on dynamics of the solitary waves is also addressed.

15:00 : Invited talk
The Talbot Effect in a Metamaterial
Hamdam Nikkhah, T. J. Hall
University of Ottawa (Canada)

The effect of anisotropy and spatial dispersion of a metamaterial on the Talbot effect may be engineered in principle. This has profound implications for applications of the Talbot Effect such as the design of multimode interference coupler (MMI). The presentation reports findings on the design of a metamaterial, and its approximation by a Kronig-Penney material that is designed to suppress the modal phase error, which limits the scaling of MMI port dimension.

15:20 : Invited talk
Investigation of Locally Resonant Nanophononic Metamaterials with Ultralow Thermal Conductivity
Bing Li[1], K. T. Tan[1], Johan Christensen[2]
[1] *The University of Akron (USA),* [2] *Universidad Carlos III de Madrid (Spain)*

We present theoretical and numerical investigations on the locally resonant nanophononic metamaterials with ultralow thermal conductivity. The anomalous dynamics and thermal transport properties induced by various hybridizations between the local resonances of the branched nanopillars and the bulk modes of the host nanowires are verified by finite element analysis. A cantilever-in-mass model is proposed to theoretically analyze and control the resonance hybridization band. Particularly we report on near-zero thermal coefficients at local resonances with flat dispersion curves.

15:40 : Invited talk
Connection between negative induced absorption and negative index of refraction for iron doped potash-alumina-borate glasses subjected to thermal-radiation treatment
A. N. Salakhitdinov[1], E. M. Ibragimova[2], M. K. Salakhitdinova[3]
[1] *Tashkent University of Information Technologies (Uzbekistan),* [2] *Institute of Nuclear Physics Academy of Science (Uzbekistan),* [3] *Samarkand State University (Uzbekistan)*

This work experimentally revealed, that 60Co-gamma-irradiation of potash-alumina-borate glasses doped with 2 mass.$\%$ of iron oxide to the dose of 1.7 MR in the temperature range of 150-300 $^{\circ}$C induced differential optical density changes within -5.7$\leq\Delta$DI$\leq$-3 in the wave length range of 300/350 nm, which is characteristic for meta-material.

14:00 - 16:00 — Room 114

Session 1A21

SP34. Advanced numerical and theoretical tools as applied to modern nano photonics: Plasmonics and Metamaterials II

Organized by: Kofi Edee

Chaired by: Kofi Edee

14:00 : Invited talk
Graphene based 1D photonic crystals bands via the Fourier Modal Method
Maha Ben Rhouma[1], Meherzi Ouslati[1], Brahim Guizal[2]
[1] *University of Tunis El Manar (Tunisia),* [2] *University of Montpellier (France)*

The Fourier Modal Method (FMM) is used to obtain the band structure of a 1D graphene based photonic crystal. The structure consists of graphene layers periodically inlayed in a homogeneous dielectric medium. In the model, the graphene sheet is considered as layer with atomic thickness. Under these conditions, we show that it is possible to use the FMM in order to obtain a polynomial eigenvalue problem allowing the computation of the band structure.

14:20 : Invited talk
Analytical T-matrix solution to the 1D grating diffraction problem

Alexey A. Shcherbakov
Moscow Institute of Physics and Technology (Russia)

The combination of two rigorous methods, namely, the C-method and the true modal method for 1D grating diffraction problem allows one, first, to analytically prove the validity of the Rayleigh expansion in the grating region, and, second, to obtain a general analytical solution to the diffraction problem in form of the T-matrix, which elements are written as quadratures involving grating profile function.

14:40 : Invited talk
Nitride-on-silicon platform for UV-visible photonics with integrated microlaser sources
Julien Selles[1], Thierry Guillet[1], Valentin Crepel[1], Bruno Gayral[2], Benjamin Damilano[3], Mathieu Leroux[3], Meletis Mexis[3], Stephanie Rennesson[3], Fabrice Semond[3], Farsane Tabataba-Vakili[4], Iannis Roland[4], Xavier Checoury[4], Philippe Boucaud[4], Christelle Brimont[1]
[1] *Montpellier University (France),* [2] *Grenoble Alpes University (France),* [3] *Cote d'Azur University (France),* [4] *Paris Sud University (France)*

Microlasers covering the UV to blue spectral range are important building blocks for biochemical detection applications. This work presents a series of microdisk lasers realized within the same GaN-on-Si photonic platform scheme, and operating at room temperature under pulsed optical pumping over a broad spectral range extending from 275 nm to 470 nm. The III-nitride microdisks embed either binary GaN/AlN multiple quantum wells (MQWs) for UV operation, or ternary InGaN/GaN MQWs for violet and blue operation.

15:00 : Invited talk
Numerical modeling of biperiodic structures by a vertical mode expansion method
Hualiang Shi[1], Ya Yan Lu[2]
[1] *Beijing Computational Science Research Center (China),* [2] *City University of Hong Kong (Hong Kong)*

The vertical mode expansion method (VMEM) is a special numerical method tailor-made for analyzing the scattering of light by structures with multiple finite-height cylindrical objects. In this paper, a VMEM with 2D boundary integral equations is implemented for biperiodic structures consisting of cylindrical objects with arbitrary cross sections.

15:20 : Invited talk
Polynomial modal method for complex Meta-surfaces modeling
Kofi Edee, Jean-Pierre Plumey, Antoine Moreau
Clermont Auvergne University (France)

Here We present a polynomial modal method that is particularly suited for the simulation of strong interaction between an electromagnetic field components and complex metasurfaces. Advanced coordinates transformation such as matched coordinates and tilted coordinates are included in order to hold efficiently the complexity of the geometry without any approximation. Such a tool even offers the possibility to control the way the resonators are periodically arranged.

15:40 : Invited talk
Tailoring fluctuation-induced interactions with nanostructures
Francesco Intravaia
Max-Born-Institut (Germany)

We investigate how the strength and the functional dependence of fluctuation-induced interactions are altered by acting on the geometry and the material properties of the system's constituents.

14:00 - 16:05 — Room 115

Session 1A22

Symposium I. Hybrid Optically Active Nanomaterials II

Organized by: Xing Yi Ling, Jerome Plain and Alexander Govorov

Chaired by: Xing Yi Ling, Jerome Plain and Alexander Govorov

14:00 : Keynote talk
III-V Semiconductor Nanowires for Optoelectronics Applications
Chennupati Jagadish
The Australian National University (Australia)

In this talk, I will introduce the importance of semiconductor nanowires and their potential applications and discuss about how these nanowires can be synthesized and how the shape, size and composition of the nanowires influence their structural, electronic and optical properties. I will discuss the role of surface non-radiation recombination and how the quantum efficiency of these nanowires will be discussed.

14:30 : Invited talk
Electronic structure and optical gain of InAsBi/InP pyramidal quantum dots
Zhigang Song[1], Sumanta Bose[1], Weijun Fan[1], Xiaohong Tang[1], S. S. Li[2]
[1] *Nanyang Technological University (Singapore),* [2] *Chinese Academy of Sciences (China)*

The electronic structure and optical gain of the InAsBi/InP pyramidal quantum dots(QDs) are calculated by using multiple band k.p method. The Bi indeed decreases the band gap of the InAsBi/InP pyramidal QDs and thus may achieve the 2 and 3um laser emission. The wavelength can be tuned by controlling the concentration of Bi.

14:50 : Invited talk
Novel Magnetoplasmonic Nanoparticle and its Assembled Structures
Jaebeom Lee
Pusan National University (Korea)

A magnetic field is successfully utilized to induce the fabrication of multidimensional structures composed of magnetite coated silver core/shell (Ag@Fe3O4) particles, which exhibit intriguing optical properties. Also we report a proof-of-concept experimental results using biocompatible FeSe QDs and femtosecond infrared laser, leading to remarkable excitation-dependent photoluminescence in two-photon luminescence (2PL).

15:10 : Invited talk
Magnetic and Electric Resonances in Core/Shell Nanostructures
John Parker[1], Norbert F. Scherer[1], Stephen K. Gray[2]
[1] *The University of Chicago (USA),* [2] *Argonne National Laboratory (USA)*

The optical responses of core/shell nanostructures composed of silica cores and numerous small silver nanoparticles composing an outer shell are studied with a finite-difference time-domain (FDTD) approach. Light scattering cross sections are decomposed via a multipolar analysis in order to reveal their magnetic and electric multipolar character. The analysis is presented for core-shell structures illuminated by a variety of scalar and vector incident light beams, showing how various modes can be selectively excited.

15:30 : Invited talk
Nitrogen fixation using plasmonic photoanode composed of n-semiconductor and metal nanostructures
Tomoya Oshikiri
Hokkaido University (Japan)

Ammonia has received considerable attention as a potential energy carrier and as a fuel in addition to its use as a fertilizer because it is a non-carbon-based chemical that is easily condensed into a liquid. In this study, we introduce the nitrogen fixation to obtain ammonia using plasmonic photoanode composed of n-semiconductor and gold nanostructures. The plasmonic photoanode can synthesize ammonia from nitrogen, water, and visible light.

15:50 : Organizing Shape-Controlled Plasmonic Nanoparticles into Large-Area 2-Dimensional and 3-Dimensional Metacrystals
Yih Hong Lee[1], Hiang Kwee Lee[1], Yijie Yang[1], Ruibin Jiang[2], Jianfang Wang[2], Xing Yi Ling[1]
[1] *Nanyang Technological University (Singapore),* [2] *The Chinese University of Hong Kong (China)*

One of the grand challenges in nanotechnology is controlling the organization of nanoparticles into scalable superlattices with tunable crystal structures. Here, we present a bottom-up approach to direct the self-assembly of shape-controlled plasmonic nanoparticles into multiple large-area 2-dimensional and 3-dimensional metacrystals. Using Ag octahedra and nanocubes, we demonstrate the ability to assemble each particle morphology into 3 distinct 2D metacrystals with areas larger than 50 cm2. We further show the im-

portance of crystal design in surface-enhanced Raman scattering.

14:00 - 16:10 — Room 116

Session 1A23

SP39. Potential application of metamaterials II

Organized by: Tae In Choi

Chaired by: Tae In Choi

14:00 : Invited talk
Air-filled acoustic metamaterials for wide range compressibility tuning
Sam Hyeon Lee[1], Chung Kyu Han[1], Eun Bok[1], Haejin Choi[1], Oliver Bernard Wright[2]
[1] *Yonsei University (Korea),* [2] *Hokkaido University (Japan)*

Metamaterials consisting of Helmholtz resonators exhibit compressibility several times larger than that of air but tuning range is limited. Here we present an acoustic metamaterial based on internally connected double Helmholtz resonators. The wall separating the two Helmholtz resonators has two holes one of which is simply open whereas the other is covered with a thin taut membrane. We experimentally demonstrate tuning the effective compressibility continuously from zero to 10 relative to air. Applications include tunable acoustic lens.

14:20 : Keynote talk
Acoustic omni meta-atom for decoupled access to all octants of a wave parameter space
Sukmo Koo, Choonlae Cho, Jun-Ho Jeong, Namkyoo Park
Seoul National University (Korea)

Although the decoupling of fundamental wave parameters has been envisaged as an ideal platform towards the top-down and deterministic reconfiguration of the meta-atom (Pendry, Science 312, 2006), its feasibility has remained as a plausible idea. In this talk we present our recent proposal for a new design strategy for the meta-atom (Koo et. al., Nat. comm. 13012, 2016).

14:50 : Invited talk
Lossy acoustic bipolar cylindrical cloak with negative index metamaterial
Yong Yoon Lee[1], Doyeol Ahn[2]
[1] *Korea Testing Laboratory (Korea),* [2] *University of Seoul (Korea)*

While, it was shown that for the lossless acoustic cloak the illumination direction independent cloaking can be achieved with the structure with compressed geometry and complementary media, the effect of the material loss have not been fully explored yet. Here, we show that realistic cloaking materials with moderate loss still works when complementary media is introduced but with attenuated back scattering waves.

15:10 : Invited talk
Development of mechanical machining technology for microwave absorber metasurfaces
Eun-Chae Jeon[1], S. H. Moon[1], J. R. Lee[1], Minsung Heo[2], M. J. Kim[2], Jong-Hwa Shin[2], Tae-Jin Je[1], Tae-In Choi[3]
[1] *Korea Institute of Machinery and Materials (Korea),* [2] *KAIST (Korea),* [3] *Center for Advanced Meta-Materials (Korea)*

We designed microwave absorber metasurfaces consisting of three layers: a patterned conductor, and insulator and a conductor, and developed ultra-fine mechanical machining technologies for manufacturing of the designed metasurfaces. The patterns of the conductor should e accurately machined for avoiding decrease in absorbance of the metasurfaces. We optimized a few machining parameters, and succeeded to manufacture the microwave absorber metasurfaces without machining erros (delamination, warpage and burr). The develped technology can be applied to military industries (stealth weapons).

15:30 : Invited talk

Aircraft infrared signature control using metamaterials
Hyung Hee Cho
Yonsei University (Korea)

Infrared signals from the stagnation region where the aerodynamic heating occurs due to supersonic flow and engine and surrounding hot parts of aircraft are detectable and directly related to survivability. To implement the infrared stealth, it is necessary to reduce the CRI, the difference of intensities between object and background. We have designed metamaterials to control the spectral infrared emissivity, suppresses detectable band emission and enhance non-detectable band. Finally, the infrared stealth performance of metamaterial was evaluated.

15:50 : Invited talk
Compressive sensing and enhanced detectors with plasmonic metasurfaces
Augustine Urbas
Air Force Research Lab (USA)

This presentation will examine efforts to determine the maturity of metamaterials and metasurfaces for defense applications. In particular an ongoing demonstration activity in compressive spectral sensing will be discussed.

14:00 - 16:00 — Room 117

Session 1A24

SP19. META-magnetism and interdisciplinary applications II

Organized by: Ilya Razdolski, David Schmool, Ko-Wei Lin and Vasily Temnov

Chaired by: Ilya Razdolski, David Schmool, Ko-Wei Lin and Vasily Temnov

14:00 : Invited talk
Light induced magnetization dynamics
Martin Aeschlimann
University of Kaiserslautern (Germany)

New developments in femtosecond x-ray and extreme-ultraviolet sources make it possible to probe element-specific spin dynamics in multispecies magnetic systems. These nascent optical tools therefore provide new and detailed information that is mostly not accessible by using visible light, and allow for the design of experiments that can help to identify the microscopic mechanisms of ultrafast spin dynamics. Using femtosecond soft x-ray pulses we were able to investigate the ultrafast breakdown of the magnetic coupling in heterogeneous magnetic materials.

14:20 : Invited talk
Microscopic Electron-Phonon Scattering Dynamics In a Model Ferromagnet
Svenja Vollmar, Kai Leckron, Hans Christian Schneider
University of Kaiserslautern (Germany)

We describe our recent work on electron-phonon scattering in spin-degenerate and ferromagnetic model systems. For the latter, we employ a ferromagnetic Rashba model, in which the exchange interaction and spin-orbit coupling both contribute to the spin splitting. We show that a novel torque matrix element controls the spin-flip that is achievable in a system without precession around effective internal spin-orbit fields. For a combined magnetic and spin-orbit splitting, such precessional dynamics play an important role.

14:40 : Invited talk
Phononics in ferromagnets: coherent phonons to manipulate magnetization at the nanoscale
Alexey V. Scherbakov
Ioffe Institute (Russia)

We utilize resonant phonon modes of phononic ferromagnetic nanostructures to manipulate their magnetization. Coherent phonons of the resonant frequencies excited by a femtosecond laser pulse remain localized

inside a ferromagnetic layer and drive the magnetization precession. By tuning the precession frequency by external magnetic field, we achieve conditions of magnon-phonon resonance, which results in the drastic increase of the precession amplitude and lifetime.

15:00 : Invited talk
Ultrafast spin dynamics driven by pure phonon excitation
Sebastian F. Maehrlein[1], Ilie Radu[2], Pablo Maldonado[3], Alexander Paarmann[1], Michael Gensch[4], Alexandra M. Kalashnikova[5], Roman V. Pisarev[5], Martin Wolf[1], Peter M. Oppeneer[3], Tobias Kampfrath[1]
[1] *Fritz Haber Institute of the Max Planck Society (Germany),* [2] *Max-Born Institute Berlin (Germany),* [3] *University of Uppsala (Sweden),* [4] *Helmholtz-Zentrum Dresden-Rossendorf (Germany),* [5] *A.F. Ioffe Physical Technical Institute (Russia)*

The future of information processing relies on the rapid manipulation of spin states. There upon, we present a novel, non-invasive way to change the spin order of the model ferrimagnet Yttrium Iron Garnet on ultrafast time scales, while keeping its electronic ground state unperturbed. Here, the resonant excitation of high-frequency optical phonons reveals a coupling of lattice vibrations to the spin order within few picoseconds, leading to a novel quasi-equilibrium state of the magnetization that survives for several nanoseconds.

15:20 : Invited talk
Impact of the optically-generated dynamical strain on the magnetic anisotropy of metallic films
Alexandra M. Kalashnikova[1], Vladimir N. Kats[1], Tatiana L. Linnik[2], Alexey S. Salasyuk[1], Andrew W. Rushforth[3], Andrey V. Akimov[3], Alexey V. Scherbakov[1]
[1] *Ioffe Institute (Russia),* [2] *V. E. Lashkaryov Institute of Semiconductor Physics (Ukraine),* [3] *University of Nottingham (United Kingdom)*

We employ femtosecond laser pulses to excite magnetization precession in thin films of magnetostrictive metal galfenol Fe0.81Ga0.19, grown on (311)- and (001)-GaAs substrates. We demonstrate unambiguously that dynamical strain, generated due to picosecond lattice temperature increase, can alter magnetic anisotropy of the galfenol film. This dynamical strain-induced change of anisotropy allows excitation of magnetization precession even in relatively high magnetic fields, when the conventional contribution to the magnetic anisotropy change from the temperature increase itself becomes inefficient.

15:40 : Invited talk
MDM ferrite meta atoms and the field chirality in microwaves
E. O. Kamenetskii, R. Joffe, R. Shavit
Ben Gurion University of the Negev (Israel)

Long range dipole-dipole correlation in a ferrite sample are treated in terms of collective excitations of the system as a whole. These are magneto-dipolar-mode (MDM) oscillations. The YIG disks, distinguishing by multi-resonance MDM spectra, demonstrate unique properties: energy eigenstates and eigen power-flow vortices. MDMs enable strong confinement of microwave radiation to subwavelength scales. In microwave structures with embedded MDM ferrite samples, one observes quantized fields with topologically distinctive characteristics. These fields are termed magnetoelectric (ME) fields.

14:00 - 15:55 — Room 118

Session 1A25

SP20. Nanophotonics and plasmonics for information applications II

Organized by: Haitao Liu

Chaired by: Haitao Liu

14:00 : Invited talk
Nonlinear optical imaging and spectroscopy of gap plasmons in single metal particle-on-film nanocavities
Dangyuan Lei

The Hong Kong Polytechnic University (China)

I will discuss our earlier and recent study on the light scattering response, photoluminescence and nonlinear optical properties of several plasmonic nanocavities comprised of metal film-coupled nanosphere monomers and dimers. Together with 3D full-wave electromagnetic simulations, the plasmon hybridization theory and multipole expansion model will be used to theoretically understood the observed experimental results such as single-particle scattering, polarization-resolved one-photon and two-photon photoluminescence and second-harmonic generation.

14:20 : Invited talk

Fully controllable volumetric generation of vortices based on dielectric metasurface

Lingling Huang[1], Xu Song[1], Bernhard Reineke[2], Tianyou Li[1], Xiaowei Li[1], Juan Liu[1], Shuang Zhang[3], Yongtian Wang[1], Thomas Zentgraf[2]

[1] *Beijing Institute of Technology (China),* [2] *University of Paderborn (Germany),* [3] *University of Birmingham (United Kingdom)*

The generation of optical vortex beams has emerged as a vital approach to applications ranging from high-capacity optical communication to parallel laser fabrication. Here, we propose and experimentally demonstrate volumetric vortices generation based on dielectric geometric metasurface. By employing the concepts of Dammann vortex gratings and spiral Dammann zone plates, 3D optical vortex arrays with micrometer spatial separation is achieved. Importantly, we show that the topological charge distribution can be spatially variant and fully controlled by the design.

14:40 : Ultratransparent medium and its applications

Jie Luo, Zhihong Hang, Yun Lai

Soochow University (China)

We demonstrate the realization of ultratransparent medium, with extreme transparency beyond any existing solid materials on earth. In an optimized example, near 100 % transmission rate have been realized for almost any incident angle within (-90, 90)°. A proof-of-principle microwave experiment has been performed to demonstrate near 100 % transmission within (-60, 60)°. The ultratransparent medium opens a new route to approach the ultimate transparency. Its applications include generalized transformation optics, microwave transparent wall, etc.

14:55 : Invited talk

Fabrication and Nonlinear Effects of Lithium Niobate Microdisk Resonators

Fang Bo[1], Jie Wang[1], Zhenzhong Hao[1], Jiao Cui[1], Sahin Ozdemir[2], Yongfa Kong[1], Feng Gao[1], Guoquan Zhang[1], Lan Yang[2], Jingjun Xu[1]

[1] *Nankai University (China),* [2] *Washington University (USA)*

In this presentation, we will report the mass fabrication of lithium niobate microdisk resonators on a chip. The quality factors for the fabricated resonators can be higher than one million. Nonlinear effects including second harmonic generation, electro-optic effect, and thermo-optic effect were observed in these resonators.

15:15 : Invited talk

Exploiting spin-orbit interactions via engineered transverse spin angular momentum in photonic integrated circuits

Zengkai Shao[1], Jiangbo Zhu[2], Ziyang Hu[2], Yujie Chen Yu[1], Yanfeng Zhang[1], Siyuan Yu[2]

[1] *Sun Yat-sen University (China),* [2] *University of Bristol (United Kingdom)*

We present the experimental investigation of transverse spin angular momentum engineering in the evanescent fields of whispering-gallery modes in integrated micro-ring resonators. The spin-orbit interactions of light in the transversely confined fields and the cylindrical vector vortices in this structure are exploited for the manipulation of light within the degrees of freedom of optical angular momenta.

15:35 : Invited talk

Strong couplings among triple Fano resonances in a 3D metamaterial

Jiafang Li, Zhiguang Liu, Zhi-Yuan Li

Chinese Academy of Sciences (China)

We report our recent experimental and theoretical works on strong couplings among triple Fano resonances in a 3D metamaterial, which is formed by integrating vertical asymmetric split-ring-resonators (aSRRs) along a planar metallic hole array with extraordinary optical transmission (EOT) built by means of homemade focused-

ion-beam (FIB) manipulations.

Coffee Break and Exhibit Inspection

Sponsored by POSTECH Mechanical Engineering Department

Session 1P2

Poster Session II

16:00 - 16:40

P1: Enhancement of gain and impedance bandwidth of a monopole antenna by using a dual band Stub-loaded AMC
Kashif Nisar Paracha, Sharul Kamal Abdul Rahim, Yong Wai Yan, Mohamad Harris Misran
Universiti Teknologi Malaysia (Malaysia)

A dual band sub-loaded artificial magnetic conductor (AMC) structure is presented for dual band WLAN application. It has been shown that by varying the stub length of the structure, the higher AMC band can be tuned. The proposed AMC has been used as a reflector for monopole antenna to show the gain of the antenna is improved up to 6.3 dBi, whereas fractional impedance bandwidth has increased from 14.68 to 33.87 .

P2: Accurate Prediction of Longitudinal Electromagnetic Mode Profile Sculpting in Wire Media
Jonathan Gratus, Taylor Boyd, Paul Kinsler, Rosa Letizia
Lancaster University (United Kingdom)

Using a wire medium with high dielectric wires of varying radius, we can sculpt the longitudinal electromagnetic wave profile. Such sculpted wave profiles have applications in signal processing and accelerator physics. The required design modulation of the wires was calculated using concepts of spatial dispersion, and full 3D CST Studio simulations of the structures were run. Predictions and simulations were in excellent agreement, validating our design process.

P3: Ultrafast Terahertz Active Metamaterials integrated with MSM-2DEG Varactors
Ji Hyun Hwang, Muhammad Tayyab Nouman, Kye-Jeong Lee, Jae-Hyung Jang
Gwangju Institute of Science and Technology (Korea)

We propose ultrafast amplitude modulation scheme of terahertz waves based on metamaterials integrated with metal-semiconductor-metal (MSM) two-dimensional electron gas (2DEG) varactors. The MSM-2DEG varactors embedded into the split gap of metamaterials are based on AlGaN/GaN heterostructures, which enable ultrafast modulation. By applying a bias voltage across the split gaps, the effective capacitance of metamaterials changes. This capacitance change leads to resonant frequency shift of metamaterials and amplitude modulation.

P4: Polarization and Pattern Reconfigurable Antenna with EBG Structures
Muhammad Faizal Ismail[1], Mohamad Kamal Abd Rahim[2], Mohamad Rijal Hamid[2], Huda Majid[2]
[1] *UniversitiTun Hussein Onn Malaysia (Malaysia),* [2] *UniversitiTeknologi Malaysia (Malaysia)*

An antenna incorporated with an array of EBG structure with pattern and polarization reconfigurability is proposed. The polarization of the proposed antenna can be switched from linear to circular polarization and vice versa. Meanwhile, the radiation pattern is tuned by controlling the connection between the EBG patches and the ground plane. Five elements of EBG is located at both side and higher from of the antenna to give configuration of -14, 0 and 14 degree of radiation pattern.

P5: Investigation of a Resonator Based Metamaterial Fascinating Sensor Applications
Md. Naimur Rahman, M. T. Islam, Md. Zulfiker Mahmud, Md. Amanath Ullah, Gan Kok Beng, Mandeep Jit Singh
Universiti Kebangsaan Malaysia (Malaysia)

A resonator based metamaterial for sensor application is studied in this paper. The resonator is encompassed by a partial ground plane and excited by a microstrip feed-line. The proposed metamaterial occupies a

compact size of 20 mm x 20 mm and is imprinted on a low cost, lossy FR4 substrate. The characteristic parameters are analyzed to find the concurrency between the simulated and measured results. The presented metamaterial is applied in sensor applications.

P6: Encoding and Display with 3D Metastructures
Xiang Xiong, Zheng Han Wang, Y. S. Hu, Ru Wen Peng, Mu Wang
Nanjing University (China)

The history of manufactured mirror can be traced back to thousands of years ago. Yet people never imagined that the same object can be used as a reflector (mirror) and an absorber by simply rotating its geometrical orientation. In recent decades, as the development of subwavelength optics and plasmonics, optical properties of a structured metal film become extremely diverse...

P7: A Meta-Inspired Muti-standard Wideband Antenna for Mobile Applications
Touhidul Alam[1], Md. Amanath Ullah[1], Md. Naimur Rahman[1], Mohd Tarmizi Ali[2], Mohammad Tariqul Islam[1]
[1] *Universiti Kebangsaan Malaysia (Malaysia),* [2] *Universiti Teknologi MARA (Malaysia)*

A metamaterial ground planed structured antenna is proposed for multiband wireless mobile applications. The proposed structure consists of microstrip fed polygonal radiator with a metastructure partial ground plane, which can operate within 1.77 GHz to 4.55 GHz. The antenna covers mostly used mobile application bands,such as GSM 1800, 1900, 2100,WCDMA, Bluetooth, WLAN 2400, WiMAx 2.5. The novel outcomes of this antenna are to achieve wideband with compact size metamaterial structured antenna.

P8: A Three Dimensional Antenna Inspired by Metamaterial for Human Head Imaging
Md. Amanath Ullah, Touhidul Alam, Mohammad Zulfiker Mahmud, Gan Kok Beng, Mohammad Tariqul Islam
Universiti Kebangsaan Malaysia (Malaysia)

A 3D antenna design followed by metamaterial unit cell is presented in this paper for portable microwave imaging system to scan human head. The proposed antenna is based on bounded H-shaped 10x10 mm2 unit cell. 3x3 array of the unit cell is used as ground. Finally the antenna achieved operating band at 2.90-3.24 GHz which is within the operating band suggested by researchers for human head imaging. The overall dimension of the antenna is 50x34x14mm3.

P9: A Metamaterial Inspired Patch Antenna for Handheld Mobile Communication
Md. Amanath Ullah[1], Farhad Bin Ashraf[1], Md. Naimur Rahman[1], Mohd Tarmizi Ali[2], Mohammad Tariqul Islam[1]
[1] *Universiti Kebangsaan Malaysia (Malaysia),* [2] *Universiti Teknologi MARA (Malaysia)*

A metamaterial inspired dual band rectangular patch antenna design for feature phones is introduced in this paper. The proposed antenna design is based on 10x10mm2 unit cell. The Metamaterial unit cell is used in this antenna to reduce Specific Absorption Rate. The proposed antenna can operate at most widely used GSM 900MHz and 1900MHz. The antenna shows 1.34 W/kg and 1.2 W/Kg of 1g SAR at 0.95 GHz and 1.9GHz, respectively.

P10: Gain Enhancement of Triple Band CSRR Antenna by Using Frequency Selective Surface Based Reflector
Md. Zulfiker Mahmud[1], Md Amanath Ullah[1], Md. Samsuzzaman[2], Md. Touhidul Alam[1], Mohammad Tariqul Islam[1]
[1] *Universiti Kebangsaan Malaysia (Malaysia),* [2] *Patuakhali Science and Technology University (Bangladesh)*

A high gain circular split-ring resonator (CSRR) triple band antenna with Frequency Selective Surface (FSS) is presented in this paper. The proposed FSS structure is used to enhance the gain of the antenna. Significant improvement in gain has been noticed after implementing the proposed FSS layer. The antenna achieved realized gain of 2.4dBi without the FSS where the same antenna with FSS attained 4 dBi of realized gain at the resonant frequency.

P11: Dual-Band Meta-Inspired Microstrip Antenna for WLAN and WiMAx Application
Farhad B. Ashraf, Touhidul Alam, Zulfiker Mahmmud, Salehin Kibria, Mohammad Tariqul Islam
Universiti Kebangsaan Malaysia (Malaysia)

This paper presents a dual-band antenna operating at WLAN 2.4 GHz and WiMAx 2.5 and 5 GHz. The

proposed antenna size is 30x30x1.6 mm3. A left-handed metasurface providing negative refractive index is used as a patch and also as a ground of the antenna. The proposed metamaterial antenna archives resonant frequency at 2.53 GHz (2.46-2.57 GHz) and 5.58 GHz (5.45-5.72 GHz) bandwidth of 97.9 MHz and 273.9 MHz, respectively.

P12: Cost Effective Negative Indexed Metamaterial for Specific Absorption Rate Reduction
Farhad B. Ashraf, Touhidul Alam, Md. Amanath Ullah, Md. Naimur Rahman, Mohammad Tariqul Islam
Universiti Kebangsaan Malaysia (Malaysia)

A simply fabricated double negative metamaterial to reduce specific absorption rate (SAR) of wireless mobile antenna is proposed in this article. Low cost of fabrication and oil impregnated paper are the main attraction in this paper. Elliptic based metamaterial (EMTM) are used to reduce the SAR for 1gm mass of human tissue. The simulation is performed using head phantom integrated in CST Microwave studio. The SAR has been reduced by 12 % and 10 % at 900MHz and 1800 MHz, respectively.

P13: A Rectangular Gap-Coupled Resonators Antenna for Low SAR Mobile Applications
Touhidul Alam, Farhad B. Ashraf, Mohammad Zulfiker Mahmud, Mohd Fais Mansor, Mohammad Tariqul Islam
Universiti Kebangsaan Malaysia (Malaysia)

A single rectangular gap-coupled resonator inspired mobile wireless antenna is presented for low specific absorption rate applications. The proposed antenna consists of a microstrip fed rectangular with a slotted partial ground plane. The antenna achieves multiband characteristics. The antenna is fabricated on copper clad bio-degradable substrate material, made of biomass, organic source material, moulding ceramic powder and polymeric binder. The perceptible novelties of the proposed antenna is appreciable SAR reduction with covering most widely used mobile communication bands.

P14: Resonator Structure Metamaterial Based Microwave Sensor Using Microstrip Technology
Md. Naimur Rahman[1], Mohammad Tariqul Islam[1], Touhidul Alam[1], Farhad B. Ashraf[1], Md. Samsuzzaman[2]
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A microwave metamaterial for using sensor application based on resonator structures is proposed in this study. The metamaterial structure consists of a resonator which is surrounded by a partial ground frame and excited by a microstrip feeding transmission line. The metamaterial has a dimension of 30 x 30 x 1.28 mm3, which is imprinted on Rogers RO3010 (tm) substrate. The results exhibit that the metamaterial is quite appropriate for the microwave sensor applications.

P15: Chiral Resonance-Based Microwave Sensors
Mario Gonzalez, A. Ochoa, Nantakan Wongkasem
University of Texas Rio Grande Valley (USA)

A one turn wire spiral structure is proposed as a sensor element in microwave sensors. Based on the changes of the structure's radius and height, the chiral helical structure is significantly sensitive to circularly polarized waves. The linear optical activity shift is observed within the chirality band. This proposed helical structure is an excellent sensor element to be employed in microwave sensors, which will benefit a multitude of sensor applications.

P16: Dual-UWB T-Slotted AMC for Mandatory UWB Channels
N. F. M. Aun[1], Ping Jack Soh[1], Mohd Faizal Jamlos[2], Herwansyah Lago[3], Azremi Abdullah Al-Hadi[3]
[1]*Universiti Malaysia Perlis (Malaysia),* [2]*Universiti Malaysia Pahang (Malaysia),* [3]*University Malaysia Perlis (Malaysia)*

A flexible dual band Artificial Magnetic Conductor (AMC) operating in the two Ultra Wideband (UWB) mandatory channels is proposed. Operations are centered at 4 GHz (channel 1) and 8 GHz (channel 6) based on the IEEE 802.15.4 for Wireless Body Area Network (WBAN) applications. Upon validation of its dual-UWB performance, the proposed AMC is subsequently incorporated on a circular-based patch antenna to determine its contribution in improving the antenna's reflection coefficient and impedance bandwidth.

P17: Phase change metamaterial pollution sensor
Weiling Dong[1], Yimei Qiu[2], Xilin Zhou[1], Agnieszka Banas[3], Krzysztof Banas[3], Tun Cao[2], Robert E. Simpson[1]
[1]*Singapore University of Technology and Design (Singapore),* [2]*Dalian University of Technology (China),*

[3] *National University of Singapore (Singapore)*

We demonstrate a tuneable metamaterial device for gas sensing. The transmission peak of this metamaterial is tuned to over a wide frequency band in the mid-infrared. Upon inducing a structural phase transition in the chalcogenide, the transmission peak is red-shifted by 333 nm. We further engineered the peak transmission wavelength by controlling the geometry of the metamaterial's features. The tuneable chalcogenide metamaterial-based filters will have extensive applications in sensing, displays, and spectroscopy.

P18: Unloaded and Loaded Circular Shaped Flexible Linear to Circular Polarizer using Polydimethylsiloxane (PDMS)

Hidayath Mirza[1], Ping Jack Soh[1], Mohd Faizal Jamlos[1], Muhammad Nazrin Ramli[1], Azremi Abdullah Al-Hadi[1], R. Ahmad Sheikh[2], Emad S. Hassan[2], Sen Yan[3]

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A flexible, linear to circular polarizer based on the flexible Polydimethylsiloxane (PDMS) and textiles is designed. The two structures consist of unit elements each sized at 46x56x3 mm3 at 2.0387 GHz and 68x58 x3 mm3 at 2.5757 GHz for the unloaded and loaded designs. They demonstrated 3dB AR BWs of 33.17 % (1.997 GHz to 2.79 GHz) for the unloaded circular and 19.51 % (2.54 GHz to 3.09 GHz) for the loaded circular-shaped patch.

P19: Electrically reconfigurable terahertz meta-molecules

Hyunseung Jung[1], Jaemok Koo[1], Wonwoo Lee[1], Chihun In[2], Hyunyong Choi[2], Moon Sung Kang[1], Hojin Lee[1]

[1] *Soongsil University (Korea),* [2] *Yonsei University (Korea)*

In this study, we propose an intriguing metamaterial design method to achieve actively customized tuning of terahertz resonance properties. The proposed metamaterial devices are based on the inter-atomic bonding of meta-atoms, which is referred as 'moleculization' of meta-atoms, and realized by controlling the conductance of interconnected graphene bridges. Based on the numerical and experimental results, we confirm that the proposed moleculization system successfully exhibits a broad tuning range of resonance frequency in terahertz regime.

P20: Swastika-Shaped Flexible Linear to Circular Polarizer using Textiles

Hidayath Mirza[1], Ping Jack Soh[1], Mohd Faizal Jamlos[1], Muhammad Nazrin Ramli[1], Azremi Abdullah Al-Hadi[1], R. Ahmad Sheikh[2], Emad S. Hassan[2], Sen Yan[3]

[1] *University Malaysia Perlis (Malaysia),* [2] *Jazan University (Saudi Arabia),* [3] *KU Leuven (Belgium)*

A flexible, linear to circular polarizer using Felt as a substrate and Shieldit fabric as a conducting material is designed. The structure demonstrates a 10 dB fractional bandwidth (FBW) of 13.17 %. its 3dB axial ratio bandwidth ranges from 2.01 GHz to 2.29 GHz. Presented unit cell is 56x67.2 x3mm3 which is about 0.4067x0.4881 x0.0218λ at 2.0387GHz. A phase difference of 81.78o is observed,which is equal to 90.86 % in terms of conversion ratio.

P21: Unloaded-Dodecagon-Shaped Flexible Linear to Circular Polarizer using Polydimethylsiloxane (PDMS)

Hidayath Mirza[1], Ping Jack Soh[1], Mohd Faizal Jamlos[1], Muhammad Nazrin Ramli[1], Azremi Abdullah Al-Hadi[1], R. Ahmad Sheikh[2], Emad S. Hassan[2], Sen Yan[3]

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This paper presents the design of a flexible and robust linear to circular polarizer using Polydimethylsiloxane (PDMS) and Shieldit fabric. The size of the unit cell is 58 x 48 x 3.17 mm3, which is about 0.3757 x 0.3109 x 0.0205 in terms of wavelength for operation at 1.94 GHz. The simulated structure demonstrated a 3 dB axial ratio bandwidth of 34.53 % ranging from 1.63 GHz to 2.31 GHz.

P22: Optical switching of scattering direction in Si rectangle dimer

Bona Ku, Seokhyeon Hong, Soon-Hong Kwon

Chung-Ang University (Korea)

Resonant scattering of nanodimer composed of silicon enables controlling of scattering direction depending on wavelength of incident light. Silicon has two representative resonance, called electric and magnetic dipole. We make a dimer structure consisting of silicon rectangles. In this study, the direction of forward scattering in proposed dimer is tuned by changing wavelength of incident light. The maximun angle of forward scattering is shifted 45° when the wavelength of incident wave is changed 30 nm.

P23: Wearable Textile Antenna with a Dual-band AMC Plane for GPS and WLAN Applications
Ezzaty Faridah Nor Mohd Hussin[1], Ping Jack Soh[1], Mohd Faizal Jamlos[1], Herwansyah Lago[1], Azremi Abdullah Al-Hadi[1], Mariana Ricca[2], Sven Kuhn[2], Niels Kuster[2]
[1] *Universiti Malaysia Perlis (Malaysia),* [2] *Swiss Federal Institute of Technology (ETH) (Switzerland)*

A wearable planar textile antenna with dual-band AMC plane for GPS and WLAN applications is presented. The antenna design begins with two rectangular slotted octagonal patch to enable miniaturization. This radiator is placed on top of a Kevlar substrate and integrated with AMC plane beneath it. The AMC unit cells are formed using a corner-truncated square patch with dodecagonal ring for dual-band operation at 1.575 GHz and 2.45 GHz, resulting gain enhancement to 3.05 dB and 3.897 dB, respectively.

P24: A 4x4 Ku-band Array Antenna Excited by Variable CRLH Phase-Shift Lines Network
Muhammad Kamran Khattak, Heejun Park, Muhammad Salman Khattak, Abdul Rehman Khan, Changhyeong Lee, Sungtek Kahng
Incheon National University (Korea)

A 4x4 (16 element) planar array antenna for Ku-band satellite communication is presented in this paper. The proposed antenna is a two layered structure where the top layer consists of rectangular microstrip patches while the bottom layer consists of corporate feeding structure energizing the antenna patches through aperture.

P25: AMC- integrated Dual Band Slot Antenna for WBAN Applications
Fatin Nabilah Giman[1], Ping Jack Soh[1], Mohd Faizal Jamlos[2], Herwansyah Lago[1], Mohamed Fareq AbdulMalek[3]
[1] *University Malaysia Perlis (Malaysia),* [2] *Universiti Malaysia Perlis (Malaysia),* [3] *University of Wollongong in Dubai (United Arab Emirates)*

This paper is presents an optimized structure of a slotted dual-band textile antenna integrated with an optimized artificial magnetic conductor (AMC) plane made using felt and ShieldIt Super. These structure operates at 2.45GHz and 5.8GHz for WBAN applications. The realized gain of this structure is about 2.38dB and 6.53dB at 2.45GHz and 5.8GHz, respectively. The antenna has a satisfactory reflection coefficient, bandwidth, and high front-to-back ratio (FBR) and exhibit properties suitable for wearable applications.

P26: Adaptive GPS Array Antennas Using the Non-Linear ω-β Metamaterial Feeds
Heejun Park[1], Dajung Han[1], Changhyeong Lee[1], Muhammad Kamran Khattak[1], Sungtek Kahng[1], Hosub Lee[2]
[1] *Incheon National University (Korea),* [2] *(Korea)*

This paper presents an approach to enable a typical GPS receiver to be much less susceptible to intentional disruption such as jamming and change in link environment. In order for the GPS receiver to cope with jamming and to get adaptivity, 4x4 or 8x8 elements beamforming antenna is designed using metamaterials. The design results show the antenna gain much higher than 5dBi and the movable various beam patterns.

P27: A programmable flexible perfect absorber
Niloufar Raeis-Hosseini, Yoon Gwanho, Junsuk Rho
Pohang University of Science and Technology (Korea)

Phase change metamaterial (PCM) is a potential candidate in planar structures to make a new generation of tunable optical devices. We developed a tunable perfect absorber based on PCM, which works as a non-volatile memory. By exploiting the advantage of switching the PCM between amorphous and crystalline states, we fabricated a flexible programmable perfect absorber. The suggested device reflects the basic requirements of a re-writable and non-volatile memory by absorbing the light into a thin film of a PCM.

P28: A New Meta-atom-based Stop-Band Filter for Ultra Wideband Applications
S. S. Islam, M. R. I. Faruque, S. Abdullah, M. M. Hasan, M. T. Islam
Universiti Kebangsaan Malaysia (Malaysia)

In this study, a meta-atom-based ultra wideband stop-band filter is presented. Initially, a pi-shaped metamaterial was designed. The metamaterial shows wide band negative refractive index and near zero refractive index property. The metamaterial was then utilized in designing a filter that performs stop-band operation over an ultra wide band region. Measured results were provided for the metamaterial and the filter.

P29: Left Handed Meta-Surface Absorber for Energy Harvesting Application

M. M. Hasan, M. R. I. Faruque
Universiti Kebangsaan Malaysia (Malaysia)

In this paper, the proposed absorber structure shows a wide bandwidth of 4.66 GHz and applicable for C-, x- and Ku-band applications. The absorber is developed by electric-inductive-capacitive resonators that are capable of not only high absorption, but also channelling almost all the absorbed power to a resistive load. The size of every unit cell of the absorber unit cell is 10x10 mm2 and array slab is 150x200 mm2.

P30: Designing High Gain WiMAx Antenna Using Metamaterial Inspired Technique

M. I. Hossain[1], M. R. I. Faruque[2], M. T. Islam[2]
[1] *International Islamic University Chittagong (Bangladesh),* [2] *Universiti Kebangsaan Malaysia (Malaysia)*

In this paper, a high gain microstrip antenna with double negative metamaterial (DNG) is proposed for WiMAx application. The experimental and numerical results show that the proposed metamaterial loaded antenna operates over a wide frequency range about 2 GHz (2.95 to 5 GHz). The DNG metamaterial loading leads to enhance antenna gain more than twice compared to conventional one at 3.5 GHz WiMAx band. The metamaterial loading does not affect the radiation efficiency of antenna.

P31: Flexible Antenna with Artificial Magnetic Conductor using Liquid Metal at 5.8 GHz

M. R. Ramli[1], Ping Jack Soh[2], Mohd Faizal Jamlos[2], Mohd Firdaus Ibrahim[2], Herwansyah Lago[3], Azremi Abdullah Al-Hadi[3]
[1] *Universiti Teknologi Malaysia (Malaysia),* [2] *Universiti Malaysia Perlis (Malaysia),* [3] *University Malaysia Perlis (Malaysia)*

A flexible fluidic antenna embedded in a PDMS structure integrated with a liquid metal AMC plane is presented. The antenna is designed based on the operating principles of a patch antenna to cover its operation in the WLAN ISM 5.8 GHz. The main innovation of this work is the integration of a AMC plane made fully using liquid metal embedded in PDMS to enable a highly flexible antenna, besides potentially adding tunability feature to the structure in the future.

P32: A Flexible Circularly Polarized Antenna Integrated with AMC for CubeSat Application

Abdul Halim Lokman, Soh Ping Jack, Mohd Faizal Jamlos, Saidatul Norlyana Azemi, Herwansyah Lago, Azremi Abdullah Al-Hadi
Universiti Malaysia Perlis (Malaysia)

This paper proposes the design of circularly polarized antenna operating in the S-band frequency integrated with an Artificial Magnetic Conductor (AMC) plane with a total size dimension of 0.506λ x 0.506λ x 0.0267λ. The AMC provide an enhancement of the antenna gain from 3.52 dB to 5.89 dB at 2.3 GHz. Most importantly, it performed well with circular polarization characteristics centered at 2.3 GHz.

P33: The Method to Suppress the Coupling Between the Multiple Nearby Quasi-Yagi Antennas by Using Left-Handed Transmission Lines

Changhyeong Lee, Dajung Han, Heejun Park, Abdul Rehman Khan, Muhammad Salman Khattak, Muhammad Kamran Khattak, Sungtek Kahng
Incheon National University (Korea)

In this paper, we propose a method to handle the isolation problem of a MIMO antenna for WiFi access point(AP). Firstly, a quasi-Yagi antenna is designed with a transmission-line balun at the feed. Secondly, this conventional quasi-Yagi antenna is adopted for the two closely placed MIMO elements for 2.4 GHz-AP equipment, and the coupling between them is checked. The 180o delay-line of one element is long and next to the feed of the other element, which is an obstacle.

P34: Rpi as A Mechanism to Control Reconfigurable Receiver Ability of RSSI Scanning and Tracking System Modeling

Mohd Ilman Jais, Thennarasan Sabapathy, Muzammil Jusoh, MD Rabiul Awal, Iszaidy Ismail
Universiti Malaysia Perlis (Malaysia)

This paper presents a scanning and tracking system based on received signal strength indication (RSSI). Deployed raspberry-pi (Rpi) is used as a mechanism to control reconfigurable receiver ability and as a tracking decision maker based on captured incoming RSSI. The proposed prototype is verify by the obtained real-time experimental and found as $\pm 4^{\circ}$. Hence, this work validates Rpi as a mechanism to control reconfigurable receiver ability of RSSI scanning and tracking system modeling with minimum angle error.

P35: Miniaturization of Broadband Series Feed Array Antenna Using Double Negative Pi-shaped Metasurface

Md. Imtiaz Islam[1], Mohd Faizal Jamlos[1], Mohd Aminudin Jamlos[2], Ping Jack Soh[1], Siti Zuraidah Ibrahim[1], Toufiq Md Hossain[1], Rizalman Mamat[3]
[1]Universiti Malaysia Perlis (Malaysia), [2]UniMAP (Malaysia), [3]Universiti Malaysia Pahang (Malaysia)

This communication presents miniaturization of broadband series feed array antenna using double negative pi-shaped metasurface. The array antenna consists of 3x7 rectangular patches using series feeding operated from 4.38 GHz to 6.07 GHz. Double negative pi-shaped metasurface has applied in the ground plane in 7x5 form which miniaturize the array antenna size by 59.1 % in length operating at 4.19 GHz to 6.09 GHz. Moreover, the maximum gain achieved is 6.7 dBi

P36: Design and Performance of Polydimethylsiloxane Magnetic Ferrite Micromachine 24GHz Branch-Line Coupler

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[1]Multimedia University (Malaysia), [2]Universiti Malaysia Perlis (Malaysia), [3]Universiti Malaysia Pahang (Malaysia)

In this paper, the use of polydimethylsiloxane (PDMS) a flexible polymer, as a substrate for the realization 3dB branch-line coupler (BLC) operated at 24GHz is presented. In particular, the synthesis of Fe3O4 with PDMS generate so-called nanocomposite polymeric magnetic ferrite (NPMDS), a promising elements with flexible, lightweight, resistant capability against dust and corrosion are realized. The presented BLC design exhibited considerable return loss (S11), transmission and coupling of (3+/-1) dB and isolation for Automotive Collision Avoidance System (ACAS) application.

P37: Enhanced Performance of 3dB Branch-Line Coupler with Diamond Shaped Negative Permittivity Metamaterial

Noorlindawaty Md. Jizat[1], Mohd Faizal Jamlos[2], Rizalman Mamat[3]
[1]Multimedia University (Malaysia), [2]Universiti Malaysia Perlis (Malaysia), [3]Universiti Malaysia Pahang (Malaysia)

The invention presents bandwidth enhancement, tight coupling and improved isolation parameter of 3dB branch-line coupler (BLC) using a diamond shaped unit cell negative permittivity metamaterial with arrangement of 2x2 array cell without compromise the size in comparison with conventional ones. In particular, advantages from the invention include a low profile BLC with promising return loss, transmission, tight coupling, isolation, phase difference and bandwidth enhancement. Such features are highly potential for Butler Matrix application at 5.9GHz V-2-V DSRC band.

P38: Split Ring Resonator (SRR)-based Metamaterial Radome for WLAN MIMO Point-to-Point Communication Antenna

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[1]Universiti Malaysia Perlis (Malaysia), [2]UniMAP (Malaysia)

This paper presents split ring resonator (SRR)-based metamaterial radome for point-to-point communication at 5.8 GHz. Antenna structure has been formed using 2x2 array structure with high directivity and radome is placed on top of it. The performance of radome characteristics are evaluated in terms of bandwidth, directivity, radiation pattern and isolation between two antennas. MIMO characteristics of isolation achieved a maximum of -75dB between two arrays with the presence of SRR.

P39: Double-Negative Left- Handed Metamaterial Radome to Enhance Gain and axial Ratio of Antenna

Ojo Rasheed[1], Mohd Faizal Jamlos[1], Md. Imtiaz Islam[1], Ping Jack Soh[1], Mohd Aminudin Jamlos[2]
[1]Universiti Malaysia Perlis (Malaysia), [2]UniMAP (Malaysia)

The patch antenna gain and axial ratio enhanced when a dielectric radome double negative (DNG) metamaterial of H-shaped unit cells positioned on top of the patch. The radome is comprising of alternately two layers of negative permeability and permittivity substrate. Circular polarization's axial ratio of 2.329 dB has been realized by the presence of DNG metamaterial radome compared to 5.57 dB of without the radome. The gain has been increased as well from 8.25 dB to 9.57 dB.

P40: Optical properties of bulk and waveguide structures based on tunable hyperbolic metamaterials

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Institute of Microelectronics and Optoelectronics WUT (Poland)

In the last decade hyperbolic metamaterials has become an emerging class of media offering unique electromagnetic response. Within this paper we demonstrate that functionality of such structure can be further extended by employment of stimulus-sensitive functional materials providing control of optical properties of complete Tunable Hyperbolic Metamaterial (THMM) structure. In particular, we put the main emphasis on controllable dispersion, light stopping and gain/absorption in the near- and mid-infrared range of frequency.

P41: A Compact Printed Monopole Antenna with Double-Negative (DNG) Metamaterial for Super Wideband (SWB) Wireless Application

Samir Salem Al-Bawri[1], Mohd. Faizal Jamlos[1], Syed Alwee Aljunid Syed Junid[1], Mohd Aminudin Jamlos[2], Rizwan Khan[1]

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A printed super wideband (SWB) monopole antenna for wireless communication applications using a very small double negative (DNG) unit cell metamaterial is proposed in this paper. A compact key-shaped radiation patch electrically dimensions at 0.152 λo x 0.140 λo with respect to its lowest operating frequency is used to achieve SWB performance when it is integrated with the investigated DNG. Moreover, the 10 dB impedance bandwidth of the proposed antenna is from 3.47 GHz to 60 GHz.

P42: Đąomposite Langmuir-Blodgett multilayers of dioctyl sodium sulfosuccinate with oligo phenylenevinilene and gold nanoparticles

Aliaksandr Salamianski[1], Vladimir Enokovich Agabekov[1], Nina Karatay[1], Alexander Agashkov[2], Vladimir Nikolaevich Belyi[2], Nikolai Stanislavovich Kazak[2]

[1] *Institute of Chemistry of New Materials of National Academy of Sciences (Belarus),* [2] *Institute of Physics of National Academy of Sciences (Belarus)*

Composite Langmuir-Blodgett films (8 layers) of dioctyl sodium sulfosuccinate with oligo phenylenevinylene and gold nanoparticles of size 50 to 80 nm were formed on glass surfaces. Its morphology and optical properties (phase shift) were studied.

P43: A Double-Negative Meta-Surface structure for Performance Enhancement of Vehicle-to-Vehicle Circular Array Antenna

Md. Imtiaz Islam[1], Mohd Faizal Jamlos[1], Mohd Aminudin Jamlos[2], Ping Jack Soh[1], Siti Zuraidah Ibrahim[1], Abdulrahman Alqadami[1], Rizalman Mamat[3]

[1] *Universiti Malaysia Perlis (Malaysia),* [2] *UniMAP (Malaysia),* [3] *Universiti Malaysia Pahang (Malaysia)*

A new design of metasurface with double-negative (DNG) characteristic has been proposed for bandwidth and gain improvement of the circular array antenna. The antenna structure is formed by circular radiating patches and DNG metasurface unit cells which are placed at the ground plane in form of 5x3 array. It is found that that DNG metasurface improved the antenna bandwidth from 2.04 GHz to 2.7 GHz and maximum gain enhanced from 5.5 dBi to 5.776 dBi at 5.9 GHz.

P44: Mutual Coupling Reduction of Two Closely Spaced Meander Line Antennas Using Left-Handed Double-Negative (DNG) Metamaterial Substrate for DSRC V-2-V Application

Mohd Faizal Jamlos[1], Md. Imtiaz Islam[1], Mohd Aminudin Jamlos[2], Ping Jack Soh[1], Siti Zuraidah Ibrahim[1], Abdulrahman Alqadami[1], Rizalman Mamat[3]

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This paper highlights a mutual coupling reduction of two closely spaced meander line antennas by using left-handed split ring resonator (SRR) metamaterial for 5.9 GHz DSRC application. The antenna consists of two closely spaced meander line antennas where SRR unit cells are placed vertically between two antennas and another 4x3 cells at the ground plane. The SRRs significantly reduce mutual coupling and good MIMO characteristics have been achieved for the designed antennas like diversity gain and effective correlation coefficient.

P45: SNG Split Ring Resonator Metamaterial-based Symmetric Reciprocal Five Port Reflectometer for Early Breast Tumour Detection System

Toufiq Md Hossain[1], Mohd Faizal Jamlos[1], Samir Salem Al-Bawri[1], Md. Imtiaz Islam[1], Mohd Aminudin Jamlos[2]

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Investigation of Single Negative (SNG) Split Ring Resonator (SRR)-based compact symmetric reciprocal 5 Port Reflectometer (5PR) has been alluded. The SRR-based 5PR has realized a dual bandwidth of 1072 MHz

(803 MHz to 1.875 GHz) and 1056 MHz (3 GHz to 4.956 GHz). Moreover, the results of 5PR has realized |S11| = 0 for and = 0.5 for transmission coefficients which aligned with theoretical values. The 5PR can be used for portable imaging system for early breast tumor detection.

P46: AMC as a Medium to Improve Gain of Microstrip Patch Antenna
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This paper proposes a microstrip rectangular patch antenna using a structure of artificial magnetic conductor (AMC). This type of antenna is designed to operate at 16 GHz, where the potential fifth generation (5G) band may be located. By adding AMC structure, the proposed antenna offers about 22.9 % size reduction of the conventional antenna. Moreover, higher gain has been achieved, which is from 6.87 dB to 7.99 dB with 494 MHz of frequency bandwidth.

P47: Bandwidth Enhancement using AMC Metamaterial Structure in Reconfigurable Antenna for 5G Applications
Norfatihah Bahari[1], Mohd Faizal Jamlos[1], Mohd Aminudin Jamlos[2]
[1] *Universiti Malaysia Perlis (Malaysia),* [2] *UniMAP (Malaysia)*

This paper presents a reconfigurable U-shaped slot patch antenna with a metamaterial structure of artificial magnetic conductor (AMC). The AMC structure consists of windmill-shaped slot unit cells are placed in between of two substrates to boost the performances of antenna. Compared to the ordinary antenna, the antenna with AMC structure offers better reflection coefficient and wider bandwidth which is from -10.35 dB to -27 dB and from 64 MHz to 342 MHz, respectively.

P48: Study on the mutual electromagnetic couplings between vertical split ring resonators
Che-Chin Chen[1], Atsushi Ishikawa[2], Ming-Hua Shiao[1], Yu-Hsin Lin[1], Chien-Nan Hsiao[1], Hai-Pang Chiang[3], Takuo Tanaka[4]
[1] *Instrument Technology Research Center-NARlabs (Taiwan),* [2] *Okayama University (Japan),* [3] *National Taiwan Ocean University (Taiwan),* [4] *Metamaterials Laboratory - RIKEN (Japan)*

We demonstrate the couplings between vertical SRRs by transmittance experiments and numerical simulations. Two different arrangements inclusive of rectangular and interlacing rectangular arrays are characterized. For both arrangements, the resonance frequencies are increased while the transmittances are decreased with decreasing distance between vertical SRRs. The weak current densities and magnetic field distribution in the small distance arrays lead to higher resonant frequencies. The interlacing rectangular array is compared to the similar inter distance rectangular arrays as well.

P49: Multi cavity magnetite nanocrystals: preparation and characterization
Hui Wu, Jaebeom Lee
Pusan National University (Korea)

A wet chemistry process was designed to synthesize multi cavity magnetite(Fe3O4) nanorod using FeOOH as precursor.Both the precursor and magnetite were characterized by xRD. The FeOOH was measured by Thermogravimetric Analyzer(TGA) and Differential Scanning Calorimetry(DSC).And the TEM images indicate that the magnetite has a nanorod structure with multi cavity. The length of the magnetite nanorods are around 50nm. the cavities are quasi-spherical shape with a diameter of 6nm.

16:40 - 18:20 — Room 106

Session 1A26

Symposium II. Recent Advances in Complex Materials and Nanophotonics IV

Organized by: Konstantin Vytovtov

Chaired by: Dmitry Chigrin

16:40 : Invited talk

Experimental demonstration of a negative Kerr nonlinearity of graphene through chirped-pulse-pumped self-phase modulation

David Castello-Lurbe[1], J. Van Erps[1], J. L. Cheng[1], I. Pasternak[2], A. Krajewska[2], T. Ciuk[2], W. Strupinski[2], H. Thienpont[1], N. Vermeulen[1]
[1] *Vrije Universiteit Brussel (Belgium),* [2] *Institute of Electronic Materials Technology (Poland)*

A negative Kerr nonlinearity of quasiundoped graphene at telecom wavelengths is demonstrated experimentally based on our novel chirped-pulse-pumped self-phase modulation approach. Since a positive Kerr nonlinear index had been assumed for graphene so far, our result will modify considerably strategies for exploiting waveguide nonlinearity enhancement induced by graphene layer deposition.

17:00 : Invited talk

Light on Wheels - Transverse Angular Momentum as a Tool for Nanophotonics

Peter Banzer
Max Planck Institute for the Science of Light (Germany)

We discuss the concept of photonic wheels, i.e., light carrying an angular momentum (density) perpendicular to the propagation direction, as a versatile and very flexible tool for nanophotonics. We review recent studies involving transverse angular momenta.

17:20 : Invited talk

Photo-thermal control of gold nanoparticle loaded microgels

Dmitry N. Chigrin
DWI - Leibniz Institute for Interactive Materials (Germany)

Microgels are cross-linked polymeric chains with dimensions ranging from several hundreds of nano- to a few tens of micro-meters. Temperature-responsive microgels can exhibit extremely large deformation in response to a variation of temperature of the environment. In this presentation, we discuss our recent advances in the development of physical models capable to describe optically controlled, gold nanoparticle loaded microgel systems. We discuss how shape and volume of microgels can be controlled using light.

17:40 : Invited talk

Collective nano-optomechanics

E. Gil-Santos, W. Hease, A. Lemaitre, M. Labousse, C. Ciuti, G. Leo, I. Favero
Universite Paris Diderot (France)

We introduce a new technique to resonantly post-tune ensembles of nanophotonic resonators with light. The method is scalable, highly precise, and compliant with on-chip structures. Building on the method, we develop medium-scale nano-optomechanical architectures where first collective phenomena do emerge. We report as first example the light-mediated frequency locking of multiple nanomechanical oscillators.

18:00 : Invited talk

Lasing in dark and bright modes of a finite-sized plasmonic lattice

Tommi Hakala, Heikki Rekola, Aaro Vakevainen, Jani-Petri Martikainen, Marek Necada, Antti Moilanen, Paivi Torma
Aalto University School of Science (Finland)

We have obtained lasing in plasmonic nanoparticle arrays at visible wavelengths. The lasing action occurs simultaneously in two modes at different energies, namely the bright and dark modes of the plasmonic lattice. We have found an intriguing out-coupling mechanism through which the dark mode can radiate to the far field. It is based on the finite size of the array.

16:40 - 19:00 — Room 109

Session 1A27

SP33. Recent progress in novel functionalities of plasmonic and metamaterial structures I

Organized by: Kazuaki Sakoda and Teruya Ishihara

Chaired by: Kazuaki Sakoda and Teruya Ishihara

16:40 : Invited talk

Generation of spin waves in nanophotonic structures by femtosecond laser pulses

Vladimir Belotelov, Mikhail Kozhaev, Alexander Chernov, Daria Sylgacheva, Anatoly Zvezdin
Russian Quantum Center (Russia)

Optical non-thermal excitation of magnetostatic spin waves is performed in magnetophotonic crystals (MPCs) and plasmonic structures. It is demonstrated that when excited at the resonance of the MPC the magnetization precession amplitude is enhanced by a factor of 2.5, while the local inverse Faraday effect can be increased up to 5.6 times compared to a stand-alone magnetic film. The origin of the enhancement is the concentration of the electromagnetic energy within the magnetic layer due to the optical confinement.

17:00 : Invited talk

New features of photonic Dirac cones on the gamma point

Kazuaki Sakoda
National Institute for Materials Science (Japan)

We derive a necessary and sufficient condition for the photonic Dirac cone on the gamma point of periodic metamaterials and photonic crystals. We formulate a Green tensor to show that the propagation direction of the Dirac-cone modes can be controlled by the polarization of the incident wave. We analyze lossy slab modes to show that their group velocity exceeds the light velocity, which apparently contradicts special relativity. This problem of superluminal propagation is resolved by considering the energy velocity.

17:20 : Invited talk

Polarization dependence of transverse photo-voltage in porous thin metal films

Teruya Ishihara, Marjan Akbari
Tohoku University (Japan)

Photo-induced voltage is generated in a metallic thin film when the light beam is obliquely incident. The voltage perpendicular to the incident plane (transverse photo-induced voltage: TPIV) is dependent on azimuth angle and ellipticity of the light polarization. By rotating the relative configuration of the film and the electromagnetic field of light, it is possible to duduce its polarization state, which can be utilized to develop a broadband ellipticity meter.

17:40 : Invited talk

Regulation of microwave propagation in space and frequency domains by plasma-metamaterial composites

Osamu Sakai[1], A. Bambina[1], A. Iwai[2], S. Yamaguchi[1], Y. Kabe[1], S. Miyagi[1]
[1] *The University of Shiga Prefecture (Japan),* [2] *Kyoto University (Japan)*

Plasma is suitable for a component and/or an alternative of metamaterial.By installation of plasma into solid metamaterial structure, metamaterial becomes tunable, energetic and nonlinear. Plasma also provides spatial gradient of refractive index due to the inherent spatial profile of electron density, and it controls propagation paths of electromagnetic waves, similar to the cloaking devices composed of solid metamaterial. These findings extends roles of metamaterial further to scientific areas that have not been covered by metamaterial.

18:00 : Invited talk

A generic way for creating topological electromagnetic states

Xiao Hu
International Center for Materials Nanoarchitectonics (Japan)

Topological photonic phenomena are attracting significant interests from viewpoints of both basic science and potential applications. We have proposed a new way to realize two-dimensional (2D) topological photonic crystals based on honeycomb lattice of dielectric cylinders. The idea can be applied for various systems.

18:20 : Invited talk
Enhanced Magneto-chiral Effects at Microwave Frequencies by a Single Metamolecule
Satoshi Tomita
Nara Institute of Science and Technology (Japan)

We have experimentally and numerically studied the directional birefringence of x-band microwaves by magneto-chiral (MCh) effects of a single metamolecule at room temperature. By applying a dc magnetic field, we observe an emergence of the MCh effects with simultaneous space-inversion and time-reversal symmetry breaking. The MCh effect is enhanced by using the magnetic resonance of the magnetic meta-atom. Numerical calculation predicts a giant MCh effect by interacting magnetic resonance with a specific resonant structural optical activity.

18:40 : Invited talk
Optical Cloaking with Existing Materials
Kotaro Kajikawa
Tokyo Institute of Technology (Japan)

We report macroscopic scattering cancellation caused by difference of local-electric polarization field between core and shell materials. We employ this phenomena to to find parameters for the optical cloaking of metallic nanowires.

16:40 - 17:40 — Room 104-105

Session 1A28

SP15. Parity-Time and related symmetries in Photonics, Plasmonics, Acoustics II

Organized by: Anatole Lupu, Henri Benisty and Kin Hung Fung

Chaired by: Anatole Lupu, Henri Benisty and Kin Hung Fung

16:40 : Invited talk
Topological and nonreciprocal dynamics in optomechanical systems with exceptional points
J. G. E. Harris, H. Xu, D. Mason, Luyau Jiang
Yale University (USA)

We demonstrate that adiabatic closed-loop operations on a system of damped oscillators can be used to achieve topological control and nonreciprocity.

17:00 : Invited talk
Stable transport with nonlinear PT-broken active couplers
Sergej Flach
Center for Theoretical Physics of Complex Systems (Korea)

I will discuss two examples of nonlinear PT -broken active couplers. First, I consider light propagation through a pair of nonlinear optical waveguides with absorption, placed in a medium with power gain. The active medium boosts the in-phase component of the overlapping evanescent fields of the guides, while the nonlinearity of the guides couples it to the damped out-of-phase component creating a feedback loop. As a result, the structure exhibits stable stationary and oscillatory regimes in a wide range of gain-loss ratios.

17:20 : Invited talk
Lorentz-force picture for controlling optical polarizations in non-Hermitian potentials
Sunkyu Yu, Xianji Piao, Choonlae Cho, Namkyoo Park
Seoul National University (Korea)

We introduce the manipulation of optical polarizations in non-Hermitian potentials, applying the Lorentz-force picture defined by effective material parameters. From the analogy with relativistic E'B drift in electrodynamics, the collective evolution of the states of polarization to the designer pole is demonstrated on the Poincare sphere. We will also introduce the criteria for the metamaterial realization toward the E'B drift analogy.

17:40 - 18:40 — Room 104-105

Session 1A29

GEN23. Emerging applications

Chaired by: George Palikaras

17:40 : Anisotropic high field terahertz response of free standing multi walled carbon nanotubes
Byounghwak Lee[1], Ali Mousavian[2], Michael Paul[2], Eunhee Jeang[3], Dai-Sik Kim[4], Yun-Shik Lee[2]
[1] *Korea Military Academy (Korea),* [2] *Oregon State University (USA),* [3] *3National Cancer Center (Korea),* [4] *Seoul National University (Korea)*

We demonstrate that multi-walled carbon nanotubes (MCNTs) highly aligned on a U-shaped polyethlene reel exhibit distinctly anistropic terahertz (THz) responses. For THz polarization parallel to the MCNTs axis, strong THz pulses induce nonlinear absorption in the quasi-one-dimensional conducting media, while only linear effect is observed in the perpendicular polarization configuration. A theoretical analysis of transmitted THz pulses measured in THz time domain spectroscopy (THz-TDS) reveal that intense THz fields enhance permittivity in carbon nanotubes by generating change carriers.

17:55 : Super-Resolution by Nonlinear Photo-Modulated Reflectivity
Omer Tzang[1], Dror Hershkovitz[2], Ori Cheshnovsky[2]
[1] *University of Colorado (USA),* [2] *Tel Aviv University (Israel)*

We introduce a far field label-free SR methodology that is based on the nonlinear reflectance changes induced by photo-modulation. Following an ultra-short pump pulse, an overlapping delayed probe pulse monitors the nonlinear reflectance changes. Spatial resolution within the diffraction limited spot is enhanced as the square root of the nonlinearity order. The method is compatible with semiconductors and metals, in vacuum and air, ultrathin and thick samples alike. Examples of resolution enhancement in several materials ($<$90nm) are demonstrated.

18:10 : High Efficient Plasmonic Spectral Imaging using Algorithmic Data Compression and Recovery Techniques
Woo Yong Jang[1], Zahyun Ku[2], James Park[2], Augustine Urbas[2], Michael Noyola[2]
[1] *University of Dayton Research Institute (USA),* [2] *Air Force Research Laboratory (USA)*

We report the progress on developing the next generation IR imaging strategy based on plasmonic sensor incorporated by the data-efficient sensing algorithm with compression and recovery techniques. The geometry of the plasmonic coupler was modified to shape the sensor's spectral sensitivity in order to bring the multispectral imaging capability. The technique termed the band-compressive algorithmic spectrometer was incorporated in the plasmonic sensor to compress required number of bands (by minimum band selection) and successfully reconstructed high resolution spectral contents.

18:25 : A freestanding, flexible, tunable, and biocompatible super-resonator and color filter
Niloufar Raeis-Hosseini, Dasol Lee, Junsuk Rho
Pohang University of Science and Technology (Korea)

A freestanding resonator based on a natural organic polymer for flexible and biocompatible nano-optics is reported. The device has metal-insulator-metal (M-I-M) structure, which demonstrates perfect absorber and color filter. A facile lithography-free fabrication method based on solution-assisted process and a biocompatible material facilitate the realization of a cost-effective and environmentally benign large-area super absorber. The proposed resonant optical device exhibits a narrow bandwidth absorber with absorption near unity and equivalent functionalities with nano-patterned super absorbers.

16:40 - 18:45 — Room 107-108

Session 1A30

GEN1. Plasmonics and nanophotonics III

Chaired by: Erik S. Lotfi

16:40 : Invited talk
CMOS spoof-SPP optical filter for fluorescence detection
Xiaojian Fu, Yu Jiang, Hao Yu
Nanyang Technological University (Singapore)

In this work, an optical filter is designed based on spoof surface plasmon polariton resonant cavity constructed by nanoscaled metallic line array. As for fluorescence detection, the numerical results show that the 400∼450 nm excitation light is almost 100 % absorbed and the 750∼850 nm fluorescence is highly transparent. The transmission difference between 400 nm and 800 nm reaches 64dB. Thus, an on-chip high SNR fluorescence detector can be achieved by combining this filter and a high sensitive photon detector.

17:00 : Quantitative 3D phase imaging - a tool for plasmonic metasurfaces
J. Babocky, Aneta Krizova, Filip Ligmajer, Martin Hrton, Petr Dvorak, Matej Tyc, Vlastimil Krapek, Radek Kalousek, Radim Chmelik, Tomas Sikola
Brno University of Technology (Czech Republic)

We present the coherence-controlled hollographic microscopy as an ultimate tool for 3D- wide field wave imaging finding direct application in characterization of optical fields formed by metasurfaces. Proof-of-concept experiments have been performed on individual plasmonic antennas and on a specific metasurface - a focusing zone plate made of plasmonic nanodisks.

17:15 : High-Performance Metamaterial-Based Transparent Conductive Electrode Using Nano-imprint Lithography Process
Dong-Sheng Su, Ta-Jen Yen
National Tsing Hua University (Taiwan)

By applying the beauty of Drude's model, we design metallic meshes to reduce the effective plasmon frequency of metal down to near infrared range, which accomplishes a transparent metal. Due to its metallic nature, the DC conductivity of our designed metallic meshes is still superior to common ITO. Combining these two properties, we successfully realize a metamaterial-based transparent conductive electrode whose transmittance is up to 86.41 % in visible spectra and sheet resistance is down to 8.77 Ω/o.

17:30 : Infrared tunable absorbers based on electro-optically controlled conducting oxides
D. C. Zografopoulos[1], G. Sinatkas[2], Erik Lotfi[3], L. A. Shahada[3], M. A. Swillam[4], E. E. Kriezis[2], R. Beccherelli[1]
[1] *Consiglio Nazionale delle Ricerch (Italy),* [2] *Aristotle University of Thessaloniki (Greece),* [3] *Qatar University (Qatar),* [4] *The American University in Cairo (Egypt)*

A class of electro-optically tunable infrared plasmonic absorbers is designed and theoretically investigated. The spacer between a subwavelength metallic stripe grating and a ground plane is filled by a bilayer of indium-tin-oxide (ITO) and hafnium oxide (HfO2). The application of a bias voltage across the dielectric gap induces a free-carrier accumulation layer at the ITO/HfO2 that locally modulates the ITO permittivity and drastically modifies the optical response of the absorber.

17:45 : Nonperturbative theoretical description of graphene saturable absorption
Andrea Marini, Joel D. Cox, Javier F. Garcia de Abajo
ICFO-Institut de Ciencies Fotoniques (Spain)

We theoretically investigate saturable absorption in extended graphene by developing a semi-analytical nonperturbative approach and solving the electron dynamics nonperturbatively. We find a remarkably low saturation intensity along with a large modulation depth that can be electrically manipulated through an externally applied gate voltage. Our results are relevant for the development of graphene-based optoelectronic devices, as well as for application in mode-locking and random lasers.

18:00 : The dynamic of formation of clusters and Ag nanoparticles in colloidal system and polymer matrix

Alexey Leonidovich Potapov[1], **Vladimir Enokovich Agabekov**[1], **Vladimir Nikolaevich Belyi**[2]
[1] *Institute of Chemistry of New Materials of the NAS (Belarus),* [2] *B.I. Stepanov Institute of Physics of the NAS (Belarus)*

It is shown that the peak in UV-region (205-235 nm) of absorption spectrum corresponds to the scattering on clusters and nanoparticles (NPs) of Ag. For samples of sol of Ag particles at deficiency in reducing agent (0.5 % PVA) the peak at 290 nm corresponding to Ag clusters is determined. The size and dynamics of formation of clusters and Ag NPs substantially depend on such factors as UV-radiation and acoustochemical influence.

18:15 : Patch antenna enhanced graphene infrared photodetectors
Jing Zhou, Chang Long Liu, Dong Hai Zhang, Lin Wang, Xiao Shuang Chen, Wei Lu
Chinese Academy of Sciences (China)

By integrating a graphene photodetector with an optical patch antenna, the responsivity is enhanced in both optical and electrical way. At resonance, the absorption of the single layer graphene is increased by 29 times. Besides, the top patches connected with an electrode extend the graphene/contact borderline and hence enlarges the optical sensitive area. The asymmetrical distribution of the top patches over the two contacts allows a net signal under uniform flood illumination.

18:30 : 'Building Up' NanoMetamaterials Utilizing a Synthetic Biology Approach for Photonic Applications
R. Cullinan, C. Liu, P. G. Oppenheimer, T. Dafforn
University of Birmingham (UK)

Synthetic biology is a new and emerging field. Utilizing mechanisms found in nature we can reach solutions to problems such as; 'cloaking' devices, not currently found within the reaches of traditional science. Exploiting the intrinsic nature of M13, a filamentous bacteriophage, to self-assemble we have achieved tuneable 3D nanoarchitectures. Such structures have demonstrated interesting optical characteristics, where a strong non-linear dependence of light induces a resonance shift in the reflected light, and therefore the colour witnessed by you and I.

16:40 - 18:40 — Room 110-111

Session 1A31

GEN10. Metamaterial-based devices I

Chaired by: Humeyra Caglayan

16:40 : Metasurface electrode light emitting diodes for directional emission
Yeonsang Park[1], **Jineun Kim**[1], **Young-Geun Roh**[1], **Q-Han Park**[2]
[1] *Samsung Advanced Institute of Technology (Korea),* [2] *Korea University (Korea)*

Metasurfaces have attracted great attention in recent years due to their diverse properties. However, the application of metasurfaces to optical source devices has been limited by difficulties in fabrication and the inefficient coupling of unit elements to light due to their small sizes. Here, we present quantum dot light emitting diodes (QDLEDs) with metasurface-integrated electrode. By incorporating slot-groove array into the metal electrode, we show that LED emission can be directed towards a specific direction determined by metasurfaces.

16:55 : Tunable Metatronic Circuits for Biosensing
Alireza Rahimi Rashed[1], **Majid Aalizadeh**[1], **Mi Hyun Kim**[2], **Soo-Jung Kim**[2], **Sung-Hoon Hong**[2], **Humeyra Caglayan**[1]
[1] *Bilkent University (Turkey),* [2] *Electronics and Telecommunications Research Institute (Korea)*

In this work, we enhanced the functionality to metatronic nanocircuits by adding real time tunability feature. We change the surface structure of the ITO surface using nanoimprint lithography. Hence, we will obtain RLC nanocircuits which operates at NIR region. Then, we change the dielectric constant of the nano-gap region dynamically. The capacitance value and the resonance wavelength of optical nanocircuits changes when the dielectric constant of the gap region the nanoscale gap region changes.

17:10 : A New Metamaterial-based Wideband Rectangular Invisibility Cloak
S. S. Islam, M. R. I. Faruque, S. Abdullah, M. M. Hasan, M. T. Islam
Universiti Kebangsaan Malaysia (Malaysia)

A new metamaterial-based wideband electromagnetic rectangular cloak is being introduced in this study. TThe metamaterial unit cell was then applied in designing a rectangular-shaped electromagnetic cloak. The scattering reduction technique was adopted for the cloaking operation. The cloak operates in the certain portion of C-and x-band that covers more than 4 GHz bandwidth region. The experimental results were provided as well for the metamaterial and the cloak.

17:25 : Broadband and Thin Electromagnetic Absorber Based on Non-Foster Metasurface
Jinchao Mou, Zhongxiang Shen
Nanyang Technological University (Singapore)

An ultra-wideband and extremely-thin electromagnetic absorber is presented, containing a grounded magnetic sheet coated with a non-Foster metasurface. The non-Foster metasurface can tailor the dispersion property of the magnetic material for reactance neutralization and compensate the loss in the substrate for power absorption over an ultra-wide band. Experimental measurements demonstrate that a nearly decade-wide absorption bandwidth can be achieved with a total thickness of only 1/255 wavelength at the lowest frequency, effectively breaking the Rozanov limit for passive absorbers.

17:40 : Analysis of Lateral Displacement for Ultrathin Planar Loop Incorporating mu near zero Metamaterials
Lai Ly Pon[1], Sharul Kamal Abdul Rahim[1], Chee Yen Leow[1], Wai Yan Yong[1], Beng Wah Chew[2]
[1] *Universiti Teknologi Malaysia (Malaysia),* [2] *Intel Microelectronics (M) Sdn. Bhd (Malaysia)*

The aim of this paper is to investigate the relationship between lateral displacement and desired axial distance in an integrated planar loop with mu near zero (MNZ) spiral resonators on establishing sustained energy efficiency for the low power wireless energy transfer application. The proposed study is done by utilising Roger 4350 with the dielectric constant of 3.66. It can be discerned that there is potential to achieve robustness towards misalignment with MNZ metamaterials

17:55 : High-efficiency circular polarizer based on all-dielectric Huygens metasurface in microwave band
Huan Jiang, Wenyu Zhao, Yongyuan Jiang
Harbin Institute of Technology (China)

We numerically demonstrate an all-dielectric circular polarizer with high efficiency and broadband response in the microwave region by leveraging Huygens metasurface. Due to the symmetry breaking of the structure in the light propagation, right circularly polarized light can pass through freely, while left circularly polarized light is largely blocked in a broad band. The proposed structure possesses the merits of high efficiency and simple inclusions, which represent a major advance in the performance compared with previously reported circular polarizers.

18:10 : Analysis of Effects of Mobile Casing Materials on Specific Absorption Rate
M. I. Hossain[1], M. R. I. Faruque[2], M. T. Islam[2]
[1] *International Islamic University Chittagong (Bangladesh),* [2] *Universiti Kebangsaan Malaysia (Malaysia)*

The aim of this investigation is to analyze the effects of mobile casing on the specific absorption rate (SAR) in the human head. The effects were analyzed with the variation in casing materials and its thickness. The results show that the SAR values are reduced significantly after using a mobile casing at 0.9 GHz. The maximum SAR reduction can be obtained by using silicon mobile casing (97.8 $\%$ at 0.9 GHz and 24 $\%$ at 1.8 GHz).

18:25 : A parasitic resonator based diamond shape microstrip antenna for UWB applications
Md. Zulfiker Mahmud, Md. Naimur Rahman, Farhad Bin Ashraf, Dr. Mohd Fais Mansor, Mohammad Tariqul Islam
Universiti Kebangsaan Malaysia (Malaysia)

This study proposes a diamond shaped microstrip patch antenna for ultra-wideband applications. The antenna is made up of a diamond shape radiating patch, partial ground plane, and three asterisk shaped parasitic elements. The parasitic elements are positioned above the ground plane to enhance the bandwidth and gain. The proposed antenna has a compact dimension of 30 x 25 x 1.6 mm3 and achieves an overall bandwidth

(S11<-10dB) is 5.8 GHz from 2.7 GHz to 8.5 GHz.

16:40 - 18:50 — Room 113

Session 1A32

Symposium II. Recent Advances in Complex Materials and Nanophotonics V

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

16:40 : Keynote talk

Pseudo-spins and their consequences in classical waves

Che Ting Chan

Hong Kong University of Science and Technology (China)

Classical wave systems such as photonic crystals and metamaterials can exhibit pseudospin physics. The pseudospin in such systems gives rise to unique transport properties such as super-Klein tunneling. In addition, the conventional Anderson localization picture needs to be revised for waves propagating in 1D disordered systems carrying pseudospins. The localization length in such systems reaches a minimum value at a critical random strength and any additional disorder beyond this critical strength only makes the waves less localized.

17:10 : Invited talk

Self-assembled optical metamaterials

Xuan Wang, Sergio Gomez-Grana, Mona Treguer-Delapierre, Alexandre Baron, Ashod Aradian, Philippe Richetti, Philippe Barois, Virginie Ponsinet

University of Bordeaux (France)

Self-assembled metamaterials constitute a promising platform towards bulk optical materials with unusual effective properties. Reporting on several experimental systems, we show that they can reach unprecedented values of bulkiness and homogeneity figures of merit. This is achieved by assembling plasmonic nanoparticles into dense 3D structures, in which the localized surface plasmon resonances of the particles provide specific optical responses. We produce self-assembled hyperbolic metamaterials and self-assembled bulk nanocomposites presenting optical magnetism at visible wavelengths.

17:30 : Invited talk

Photonic Band Gaps in Amorphous Gyroid Structures

Marian Florescu

University of Surrey (United Kingdom)

We introduce a new class of photonic band gap materials based on amorphous gyroid networks. The amorphous gyroid networks are created using the concept of local-self uniformity that controls spatial correlations of on a wide range of length scales.

17:50 : Invited talk

Fiber-chip surface grating couplers engineered by nanophotonic sub-wavelength grating metamaterials

Daniel Benedikovic[1], Carlos Alonso-Ramos[1], Pavel Cheben[2], Jens H. Schmid[2], Shurui Wang[2], Dan-Xia Xu[2], Boris Lamontagne[2], Jean Lapointe[2], Siegfried Janz[2], Robert Halir[3], Alejandro Ortega-Monux[3], Juan-Gonzalo Wanguemert-Perez[3], Inigo Molina-Fernandez[3], Jean-Marc Fedeli[4], Milan Dado[5], Laurent Vivien[1]

[1]Paris Sud University (France), [2]National Research Council Canada (Canada), [3]Universidad de Malaga (Spain), [4]CEA-LETI (France), [5]University of Zilina (Slovakia)

We present our recent advances in the development of high-efficiency fiber-chip surface grating couplers engineered by sub-wavelength grating nano-structuration. The intriguing technological concept of sub-wavelength grating refractive index engineering affords an additional design freedom in the development of high-quality

optical coupling interfaces for sub-micrometric silicon-on-insulator technology. We present an overview of various demonstrations of high-efficiency surface grating couplers, particularly develop for applications in silicon photonics across the near-infrared wavelengths.

18:10 : Invited talk
Nonlinear plasmonics at anisotropic metal-dielectric interfaces
Ilya Razdolski[1], **Alexander L. Chekhov**[2], **Tatyana V. Murzina**[2]
[1] *Fritz Haber Institute of the Max Planck Society (Germany),* [2] *Moscow State University (Russia)*

We show sensitivity of second harmonic generation to the surface plasmon propagation direction at anisotropic Au/dielectric interfaces. The symmetry of the iron garnet enables interplay between even and odd components of the nonlinear susceptibility leading to a 95 % asymmetry of the second harmonic output. Illustrating this interplay with a simple two-component model, we discuss its applicability to nonlinear magnetoplasmonics and nanophononics.

18:30 : Invited talk
Exploiting complex media with random nanoparticles with the principle of inverse scattering
Yongkeun Park
KAIST (Korea)

We will present the applications of inverse scattering principles with digital holography. Scattering of light in complex media or biological samples can be reversed and controlled by actively controlling the wavefront of incident beams. Utilizing multiple light scattering on purpose, we demonstrate 3-D holographic microscopy, the sub-wavelength focusing and imaging, the reference-free optical phase conjugation, the reference-free holographic camera, and ultra-high definition dynamic 3D holographic display.

16:40 - 18:40 — Room 114

Session 1A33

SP14. Fano resonances in optics and microwaves: Physics and application III

Organized by: Eugene Kamenetskii and Almas Sadreev

Chaired by: Eugene Kamenetskii and Almas Sadreev

16:40 : Invited talk
Fano resonance and spontaneous emission rate of an atom near a plasmonic nanoshell
Tiago Jose Arruda[1], **Romain Bachelard**[2], **Sebastian Slama**[3], **Philippe Wilhelm Courteille**[1]
[1] *University of Sao Paulo (Brazil),* [2] *Federal University of Sao Carlos (Brazil),* [3] *University of Tubingen (Germany)*

We analytically study the spontaneous emission of a single quantum emitter in the vicinity of a plasmonic nanoshell. Using realistic material parameters, we show the luminescence enhancement factor can be tuned by the aspect ratio of the coated nanosphere and the distance between the quantum emitter and its surface. In particular, we show both the enhancement and quenching of the luminescence are associated with plasmonic Fano resonances induced by near-field interactions.

17:00 : Invited talk
Sharp Ultrafast Fano Resonances in Superconducting THz Metamaterials
Yogesh Kumar Srivastava, Manukumara Manjappa, Harish N. S. Krishnamoorthy, Ranjan Singh
Nanyang Technological University (Singapore)

Superconductor based metamaterial structures pave the way to design switchable metamaterial devices operating at terahertz frequencies.However, since metals possess very high conductivity at terahertz frequencies, the role of superconductors in exciting lossless high Q resonances remains unclear. Here, we used high-Tc superconductor YBCO to design a low asymmetry Fano resonator which supports sharp resonance at extremely low asymmetries but identical metallic meta-atom fails to support any resonance response. We also present the ultrafast switching of sharp Fano resonances in superconductors.

17:20 : Invited talk
Helical bound states in a microwave-field continuum with an embedded MDM ferrite particle
Eugene Kamenetskii
Ben Gurion University of the Negev (Israel)

We consider multiple dicrete states of magnetostatic oscillations in a quasi-2D ferrite disk embedded in a common microwave continuum. We examine the microwave transport of such a system including the apperance of Fano resonances.

17:40 : Invited talk
Resonant-state expansion in open quantum systems
Naomichi Hatano
University of Tokyo (Japan)

A novel complete set of the Hilbert space of open quantum systems is introduced. The complete set contains all possible states with discrete eigenvalues, including the resonant, anti-resonant, bound and anti-bound states. The Fano resonance is microscopically explained in terms of the interference between discrete eigenstates.

18:00 : Invited talk
Fano-resonant excitations of generalized optical spin waves
Xianji Piao, Sunkyu Yu, Minpyo Lee, Namkyoo Park
Seoul National University (Korea)

Here we show the Fano-resonant excitation of optical spin waves, for longitudinal and transverse axes with respect to the propagation direction. By implementing two linearly-polarized scattering paths to chiral materials, antisymmetric Fano resonances of longitudinal spins are derived with the handedness-dependent asymmetry. We will also introduce the realization of transverse spin guided mode and its Fano-resonant excitations.

18:20 : Invited talk
Photonic-crystal Fano structures for lasers and nonlinear optical signal processing
Yi Yu, Dagmawi Alemayehu Bekele, Elizaveta Semenova, Luisa Ottaviano, Hao Hu, Pengyu Guan, M. Galili, Leif Katsuo Oxenlowe, Kresten Yvind, Jesper Mork
Technical University of Denmark (Denmark)

We present our recent work on photonic-crystal structures based on Fano resonance. We show that the use of Fano interference in combination with optical nonlinearity can enable single-mode operation and self-pulsing in a nanolaser, as well as fast, low-energy all-optical signal processing.

16:40 - 19:00 — Room 115

Session 1A34

Symposium I. Hybrid Optically Active Nanomaterials III

Organized by: Xing Yi Ling, Jerome Plain and Alexander Govorov

Chaired by: Xing Yi Ling, Jerome Plain and Alexander Govorov

16:40 : Invited talk
Ultrafast optical responses of photoexcited electrons and excitons in hybrid nanomaterials
Gary P. Wiederrecht
Argonne National Laboratory (USA)

The ultrafast optical responses of two types of hybrid nanomaterials are described. The first is the ultrafast hot electron response of plasmonic gap mode metamaterial nanostructures, in which two plasmonic nanostructures are separated by a thin layer of semiconducting or insulating material, with impact on understanding and using energetic electrons. The second describes ultrafast exciton generation and migration in porphyrin-based self-assembled biomimetic nanomaterials, with ramifications for optical light harvesting in self-healing

structures.

17:00 : Invited talk

Observation of Isotopic Effect on Hydrogen Evolution Process using In-situ Electrochemical Surface Enhanced Raman Scattering

Hiro Minamimoto, Kei Murakoshi
Hokkaido University (Japan)

In-situ electrochemical surface enhanced Raman scattering measurements were performed for the investigation of the isotopic effect for the hydrogen evolution reactions. Using various mixed ratio of H2O and D2O, curious behavior for the heavy water was observed depending on the electrode potential. Through the analysis of the obtained SERS spectra, it was revealed that the highly ordered structures of water molecules formed at the surface of the electrode during hydrogen evolution process.

17:20 : Invited talk

Plasmonic Liquid Marbles for In-situ Monitoring of Picoliter-scale Reactions

Xing Yi Ling
Nanyang Technological University (Singapore)

In this talk, I will discuss our group's development using highly flexible plasmonic liquid marbles as picoliter analytical sensors. By using the ultrasensitive surface-enhanced Raman scattering (SERS) capability imparted by the plasmonic shell of the Ag nanoparticles of the liquid marbles, the liquid marbles are capable of quantitative examination of multiple analyte(s), even at trace level.

17:40 : Invited talk

Emergent Nanophotonic Technologies For Chemical Application

Affar S. Karimullah[1], Calum Jack[1], Ryan Tullius[1], Vincent M. Rotello[2], Graeme Cooke[1], Nikolaj Gadegaard[1], Laurence D. Barron[1], Malcolm Kadodwala[1]
[1] *University of Glasgow (United Kingdom),* [2] *University of Massachusetts (USA)*

In this talk I will discuss how near fields with chiral asymmetries, generated by light scattering from chiral nanostructures, can uniquely characterise higher order biological structure which is invisible to conventional spectroscopy. I will demonstrate how the interaction of chiral nanostructures and biomaterials can be understood using concepts from physical chemistry and atomic and molecular physics, orbital hybridisation and quantum interference phenomenon such as electromagnetic induced transparency (EIT).

18:00 : Invited talk

Fluorescence enhancement with metal, dielectric and metal-dielectric hybrid platforms

Ping Bai, Song Sun, Lin Wu, Ching Eng Png
*A*Star Institute of High Performance Computing (Singapore)*

Metallic nanoparticles, dielectric nanoparticles and metal-dielectric hybrid dimers have been investigated for fluorescence enhancement. Results show that the metallic nanoparticles have better fluorescence enhancement in high-index media (e.g. water), whereas the dielectric nanoparticles have higher fluorescence enhancement in low-index media (e.g. air). The hybrid dimers show 40 % higher electric field enhancement comparing with dielectric dimers and 30 % lower loss comparing with metallic dimers, yielding a fluorescence enhancement 30 % higher than that of the pure dielectric dimers.

18:20 : Invited talk

Macroscale ultrasharp nanocone metamaterials - optical properties and applications

M. Cordova-Castro[1], W. P. Wardley[1], M. E. Nasir[1], G. A. Wurtz[2], A. Krasavin[1], A. V. Zayats[1], Wayne Dickson[1]
[1] *King's College London (United Kingdom),* [2] *University of North Florida (USA)*

Self-assembled hyperbolic metamaterials comprised of gold nanorod arrays deposited via anodic aluminium oxide templates have received significant attention due to the broad tunability of the optical properties due to the template geometry and the scalable fabrication approach. In this work we describe a method to create ultrasharp nanocone arrays using the broad beam argon ion milling of gold nanorod metamaterials. Such materials support localized plasmonic resonances characterized by strong electromagnetic field enhancement at the cone apex.

18:40 : Invited talk

Exciton-plasmon coupling of single quantum dots and a metal nanowire

Hong Wei
Chinese Academy of Sciences (China)

We studied the coupling of single quantum dots and a metal nanowire. By exciting a single quantum dot, single surface plasmons are generated in the nanowire with the quantum efficiency dependent on the distance between the quantum dot and the nanowire. The single quantum dots can also be excited by the propagating surface plasmons in the nanowire. We demonstrate selective excitation of two quantum dots within diffraction-limited area by modulating the electric field using the interference of surface plasmons.

16:40 - 17:35 — Room 116

Session 1A35

SP39. Potential application of metamaterials III

Organized by: Tae In Choi

Chaired by: Tae In Choi

16:40 : Invited talk

Focusing electromagnetic wave with reconfigurable metasurface

Jong-Ho Choe, Jin-Soo Kim, Q-Han Park
Korea University (Korea)

In this presentation, we demonstrate an electromagnetic wave focusing using reconfigurable metasurface. We made a metasurface which can modulate microwave spatially. Each unit structure constituting the metasurface is controlled electrically. With optimization process, we could concentrate electromagnetic wave energy into a spatially localized spot.

17:00 : Invited talk

The 2D, 1D, and 0D Tightly Coupled Array Antennas

Hakjune Lee[1], **Sangwook Nam**[2]
[1] *Electronics and Telecommunications Research Institute (Korea),* [2] *Seoul National University (Korea)*

Tightly Coupled Dipole Array (TCDA) is a ultrawideband array antenna proposed by Munk. The operation principle of the TCDA is cancellation between inductive reactance of the ground plane at low frequency and capacitive reactance of coupled capacitance of neighboring element dipoles. In this paper, we present variety dimensions (2D, 1D, and 0D) TCDAs which can be used at electric warfare.

17:20 : Absorber using a split eight equal Circular Sectors Resonator

Nguyen Toan Trung, Lim Sungjoon
Chung-Ang University (Korea)

The unit cell of the metamaterial is designed with a split eight equal Circular Sectors Resonator is introduced for the polarization -insensitivity of the MM absorber. The performances are demonstrated with full-wave simulation and measurements. Under normal incidence, the fabricated absorber shows 98 % absorptivity at 9.26 GHz for all polarization angles, while for oblique incidence, the fabricated absorber maintains an absorptivity higher than 91 % for incident angles up to 70degrees for both transverse magnetic and transverse electric modes.

17:35 - 18:50 — Room 116

Session 1A36

GEN24. Fabrication and Characterization Technology

Chaired by: Augustine Urbas

17:35 : Instrumental Development of FT-IR Spectroscopy in the Meta-Material Characterization and studies

Young Sup Roh[1], Dan Wu[1], Denis Czurlok[1], Michael Joerger[2]
[1] *Bruker Korea Co., Ltd. (Korea),* [2] *Bruker Optik GmbH (Germany)*

In the field of Metamaterials research, FT-IR spectroscopy has played important roles to characterize the optical properties with wavelength dependence. We will review the recent development of our FT-IR spectrometer. We will also introduce state-of-art Instrument, hybrid FT-IR and cw-THz system, covering from 3 to 50,000 cm-1, which corresponds from Terahertz to UV region.

17:50 : Fabrication of nanoscale 3D optical metamaterials and metadevices using electron beam lithography overlay process

Inki Kim, Gwanho Yoon, Sunae So, Jungho Mun, Minkyung Kim, Junsuk Rho
Pohang University of Science and Technology (Korea)

Abstract-Nanofabrication techniques is essential for exploring nanoscience including nanophotonics, plasmonics and optical metamaterials. Recently, 3D nanofabrications have been actively investigated to make sophisticated nanoscale 3D metamaterials and metadevices, but it is still challenging to fabricate elaborate 3D nanostructures. In this work, ultra-high accurate and precise electron beam lithography overlay process is developed for fabricating elaborate nanometers-sized 3D metamaterials and metadevices. Sub-20nm alignment accuracy and over-75 % repeatability are achieved through well-defined alignmarks and specific calibrators.

18:05 : THz Metamaterials Fabricated using Electrohydrodynamic Jet Printing for Sensitive Detection of Microorganism

Ayodya Pradhipta Tenggara[1], Saejune Park[2], Hadi Teguh Yudistira[3], Yeonghwan Ahn[2], Doyoung Byun[1]
[1] *Sungkyunkwan University (Korea),* [2] *Ajou University (Korea),* [3] *Institut Teknologi Sumatera (ITERA) (Indonesia)*

We demonstrated the capability of terahertz metamaterial sensor fabricated using electrohydrodynamic jet printing for the accurate and on-site detection of microorganism (yeast). The ESRR unit structures could be printed on a large area. It was shown that the metamaterial sensor fabricated on a flexible polyimide film had higher sensitivity by more than six times, due to the low refractive index of the PI substrate and the extremely thin substrate thickness which lowers the effective index further.

18:20 : Nanoimprint-lithographically fabricated stacked 1D gratings for improved MWIR polarization detection

Boram Oh[1], Xiang En Huang[2], Deok-kee Kim[3], Jun Oh Kim[1], Sang Jun Lee[1], Augustine Urbas[4], Zahyun Ku[4], David Czaplewski[5], Il Woong Jung[5], Jong Eun Ryu[2]
[1] *Korea Research Institute of Standards and Science (Korea),* [2] *Indiana University (USA),* [3] *Sejong University (Korea),* [4] *Air Force Research Laboratory (USA),* [5] *Argonne National Laboratory (USA)*

Polarization extinction ratio of a stacked double-layer subwavelength metal grating structure was investigated. Top and bottom grating layers were fabricated with nanoimprint lithography on silicon wafer, separated by a dielectric spacer. We characterized the linear polarization extinction ratio of the stacked gold gratings (100-nm thickness) in the mid-infrared regime with various pitches of 0.4, 0.7, and 1.0 μm, whose width-to-pitch ratio and spacer thickness were 0.7 and 0.45 μm, respectively. Numerical simulations were performed to design the geometrical parameters.

18:35 : Optical Patternable Metamaterial For Nanolithography Below Diffraction Limit

Youngseop Lee[1], Sang-Gil Park[1], SeokJae Yoo[2], Minhee Kang[1], Sang Chul Jeon[3], Young-Su Kim[3], Q-Han Park[2], Ki-Hun Jeong[1]
[1] *KAIST (Korea),* [2] *Korea University (Korea),* [3] *National Nanofab Center (Korea)*

This work reports optical patternable metamaterial (OPM) for ultraviolet nanolithography below the diffraction limit. The OPM features mono-dispersed silver nanoislands (AgNs) embedded within photosensitive polymer by using solid-state embedment of AgNs into ultrathin polymer. This unique configuration simultaneously ex-

hibits both negative effective permittivity and high lithographic contrast in the ultraviolet range, which enables the superlens effect for the clear photolithographic definition of 70 nm in minimum feature size beyond the Fraunhofer distance.

16:40 - 18:35 — Room 117

Session 1A37

SP19. META-magnetism and interdisciplinary applications III

Organized by: Ilya Razdolski, David Schmool, Ko-Wei Lin and Vasily Temnov

Chaired by: Ilya Razdolski, David Schmool, Ko-Wei Lin and Vasily Temnov

16:40 : Invited talk
Ellipsometric analysis of magneto-optical effects in thin films, nanostructures and spin transport devices
Patricia Riego, Jon Ander Arregi, Andreas Berger
CIC nanoGUNE (Spain)

We investigate experimentally in how far optical property modifications change magneto-optical responses in films, multilayers and nano-structures. For this purpose, we utilize Generalized Magneto-optical Ellipsometry (GME), a technique that combines high sensitivity of small magneto-optical signal detection with the ability to simultaneously determine both optical and magneto-optical properties by means of a simple experimental setup. Application examples include the detection of magneto-optical anisotropy, optical anisotropy, including in artificial meta-materials, and the investigation of spin transport effects.

17:00 : Invited talk
Magneto-optics at atomic limit with nanoantennas and magnetic control of chiroptical plasmonic surfaces
Alexandre Dmitriev
University of Gothenburg (Sweden)

We show how the combination of optical nanoantennas and ferromagnets produces the sensitivities of the magneto-optical detection down to sub-atomic monolayer amounts of material. This combination also gives the 100 % + dynamic tunability to plasmonic surfaces by introducing the magnetically-tunable optical elements to the 2D plasmonic nanoantennas.

17:20 : Invited talk
Thin film magnetic meta materials
Vassilios Kapaklis
Uppsala University (Sweden)

Lithographically nano-patterned magnetic materials can result in fascinating behaviour exploiting the interactions between individual elements creating novel functionality. The emergent properties in such systems are distinctly different from those of their constituent components, driven by the collective dynamics of the interacting elements and respond to external stimuli such as magnetic or temperature. Further functionality can be realised exploiting the fact that the periodicity and element size in such nano-patterned magnetic arrays matches well the wavelengths of visible light.

17:40 : Invited talk
Magneto-optic enhancement in 0D-1D- and 2D magneto-plasmonic structures
Ellen Wiedemann[1], Spyridon Pappas[1], Sascha Keller[1], Christian Dautermann[2], Sandra Wollf[2], Evangelos Th. Papaioannou[2]
[1] *Department of Physics and Research Center OPTIMAS (Germany),* [2] *Nano Structuring Center (Germany)*

The magneto-plasmonic interaction is revealed in 0D, 1D- and 2D magnetic nanostructures. The magneto-optic response is examined in the presence of localized surface plasmons, of propagating surface plasmons and in the geometrical percolation limit. The role of the thickness of the magnetic layer is clarified. Finally, the

influence of surface plasmons on the magnetization dynamics is discussed.

18:00 : Invited talk
Magneto-plasmonic nanostructures and crystals
Paolo Vavassori
CIC nanoGUNE (Spain)

The rapidly developing field of magnetoplasmonics merges concepts from plasmonics and magnetism to realize novel phenomena and functionalities for the manipulation of light at the nanoscale. This talk will cover recent advances in the investigation and development of magneto-plasmonic nanostrucutres and crystals. Applications of such multifunctional optical surfaces to a variety of emerging technologies are presented as an example of their broad scientific and technological perspectives.

18:20 : A modular magneto-optical diractometer as a toolbox for the characterization of nanostructured magnetoplasmonic crystals
Emil Melander[1], Ioan-Augustin Chioar[1], Richard Rowan-Robinson[1], Tobias Dannegger[1], Sebastian George[1], Evangelos Th. Papaioannou[2], Bjorgvin Hjorvarsson[1], Vassilios Kapaklis[1]
[1] *Uppsala University (Sweden),* [2] *OPTIMAS Technische Universitat (Germany)*

We present a versatile magneto-optical diractometer, with ellipsometric capabilities,designed for investigating changes mediated by nano-engineered magnetoplasmonic crystalson the polarization state of the incident light. This facilitates a detailed characterization ofmetasurface light-tailoring as a function of wavelength and incidence angle, further enabling fundamentalstudies as well as exploring avenues for potential applications within the at-opticsframework.

16:40 - 18:20 — Room 118

Session 1A38

SP20. Nanophotonics and plasmonics for information applications III

Organized by: Haitao Liu

Chaired by: Dangyuan Lei

16:40 : Invited talk
Surface-Plasmon-Polariton Laser based on an Open-Cavity Fabry-Perot Resonator
Henri J. Lezec, Wenqi Zhu, Ting Xu, Cheng Zhang, Amit Agrawal
Center for Nanoscale Science and Technology - NIST (USA)

We demonstrate visible frequency, ultra-narrow-linewidth lasing of surface plasmon polaritons (SPPs) propagating along the floor of a metallic open-cavity Fabry-Perot resonator formed by template stripping and coated with a subwavelength-thick layer of dye gain medium. The lasing threshold is lowered by pumping the medium with an SPP standing wave, generated using a low-profile grating on the cavity floor. Transmission of the lasing SPP mode via a recessed nanoslit enables high-contrast refractive-index sensing of analytes interacting with the open cavity.

17:00 : Invited talk
Linear crossing dispersion in a multilayered structure with two kinds of single-negative metamaterials
Zhiwei Guo, Feng Wu, Haitao Jiang, Hong Chen
Tongji University (China)

We reveal a linear crossing dispersion in a multilayered structure containing two kinds of single-negative metamaterials. Distinct from the elliptical dispersion or the hyperbolic dispersion, linear crossing dispersion can bring about a variety of new phenomena such as beam splitting and negative-refraction imaging.

17:20 : Invited talk
Cavity quantum electrodynamics based on gap surface plasmons
Juanjuan Ren[1], Ying Gu[1], He Hao[1], Dongxing Zhao[1], Fan Zhang[1], Tiancai Zhang[2], Qihuang Gong[1]

[1] *Peking University (China),* [2] *Shanxi University (China)*

Plasmon nanostructures with ultrasmall mode volume can enhance light-matter interactions in nanostructure based cavity quantum electrodynamics. In the strong coupling regime, taking the evanescent mode provided by single mode nanowire as electromagnetic vacuum, we theoretically demonstrate the enhanced reversible photon-exciton interaction and fluorescence collection. In the weak coupling regime, we theoretically investigate the efficient photon emission of single emitter with metallic nanorod-coupled nanofilm structures. Furthermore, utilizing the liquid crystals, high-contrast switching of spontaneous emission is obtained.

17:40 : Invited talk
Resonant cavity modes in plasmonic nanorod and nanotube metamaterials
Junxi Zhang[1], Haojie Song[2], Junfeng Wang[2], Cheng Zhang[3], Pei Wang[3], Lide Zhang[2], Yuri Kivshar[4], Lin Zhang[5]
[1] *Chinese Academy of Sciences (China) and Aston University (UK),* [2] *Chinese Academy of Sciences (China),* [3] *University of Science and Technology of China (China),* [4] *Australian National University (Australia),* [5] *Aston University (United Kingdom)*

Plasmonic cavity resonators are designed by noble metal nanorod or nanotube metamaterials. A hybrid mode appears due to near-field coupling between plasmonic silver nanorod metamaterials and gold-film substrate. Additionally, T-L hybrid plasmonic modes resulted from the near-field coupling between transversal and longitudinal resonance modes with different order harmonics are found in gold nanotube metamaterials, performing electric fields partially localized into pores and at two ends based on extraordinary optical transmission coupling effect through inner-nanochannels of the gold nanotubes.

18:00 : Invited talk
On-chip Integrated Free-electron light source
Fang Liu, Long Xiao, Yidong Huang
Tsinghua University (China)

To generate Cherenkov radiation (CR) in natural medium, the electron energy threshold is higher than hundreds of keV. Even though various approaches were adopted, the high-energy electrons as high as tens of keV is still required in experiment. We demonstrate in hyperbolic metamaterial that the electron velocity threshold for CR is eliminated, and meanwhile, with this threshold-less CR, the first on-chip integrated free electron light source was realized.

18:20 - 18:50 — Room 118

Session 1A39

GEN8. Chiral and bianisotropic materials

Chaired by: Bumki Min

18:20 : Enhanced Circular Dichroism of Isotropic Au-core/Ag-shell Nanoparticles due to Fano Resonances
Jong-Won Park
Boston University (USA)

Optical activity of individual Au-nanospheres and Au-core/Ag-shell nanoparticles was observed in aqueous solution. Possible mechanisms are discussed, including the excitation of volume plasmons, multiple scattering, and electron spin polarization. Given the left-handedness of dipolar localized surface plasmons (LSPs) of Au-nanospheres, spherical Au-core/Ag-shell nanoparticles exhibit sign reversal. Strong positive ellipticity from core-shell nanoparticles is attributed to Fano resonances between dipolar and quadrupolar LSPs whereas negative ellipticity of dipolar LSPs originates from nonlocality. Plasmon enhancement via ligand chirality was not observed.

18:35 : Tunable, nondispersive optical activity of bi-layered chiral metamaterials
Hyun Sung Park, Jagang Park, Jaehyeon Son, Yushin Kim, Hyukjoon Cho, Bumki Min
Korea Advanced Institute of Science and Technology (KAIST) (Korea)

Here we demonstrate that mechanically-tunable, nondispersive optical activity can be achieved in quasi-planar, bi-layered chiral metamaterials where an enhanced magnetic coupling between front- and back layers is present. It is experimentally shown that the polarization state of the transmitted electromagnetic waves through the metamaterial layer is rotated by 30°, regardless of their frequencies in a broad frequency range.

Wednesday 26th July, 2017

08:45 - 10:30 — Ballroom

Session 2A1

Plenary Session II

Chaired by: Ortwin Hess

08:45 : Plenary talk
Metamaterials, anapoles and flying donuts
Nikolay I. Zheludev
University of Southampton (UK) and NTU (Singapore)

Electromagnetic toroidal multipoles can be represented as currents flowing on the surfaces of tori were recently experimentally observed in metamaterials and nanoparticles. They provide physically significant contributions to the basic characteristics of matter including absorption, dispersion, and chirality. They give rise to dynamic anapoles, illusive non-radiating charge-current configurations recently detected in matter. Toroidal excitations also exist in free space as spatially and temporally localized electromagnetic pulses propagating at the speed of light and interacting with matter in a way different from conventional electromagnetic transvers pulses. We discuss these recent findings and the role of localized and propagating electromagnetic toroidal excitations in light-matter interactions, spectroscopy and telecommunications.

09:20 : Plenary talk
Parity-Time-Symmetric Optics, extraordinary momentum and spin in evanescent waves, and the quantum spin Hall effect of light
Franco Nori
Riken (Japan)

We report PT-symmetry breaking in coupled optical resonators. We observed non-reciprocity in the PT-symmetry-breaking phase due to strong field localization, which significantly enhances nonlinearity. In the linear regime, light transmission is reciprocal regardless of whether the symmetry is broken or unbroken. We show that in one direction there is a complete absence of resonance peaks whereas in the other direction the transmission is resonantly enhanced, which is associated with the use of resonant structures.

09:55 : Plenary talk
Parity-time Symmetry Breaking Lasing and Anti-Lasing
Xiang Zhang
UC Berkeley (USA)

Optical loss is usually undesirable. Recently, judiciously designed balanced gain and loss structures, so called parity-time (PT) symmetric synthetic materials, are explored due to their extraordinary properties. In this talk I will discuss the notion of PT symmetry in optical systems. Especially I will discuss how to achieve nano-scale spectrometer by designing an anti-Hermitian light matter interactions. This will be also useful for spectrum splitting in solar applications. Finally, I will discuss a single mode lasing scheme using PT symmetric periodically modulation in a micro ring lasers, and lasing and anti-lasing in a single cavity

Coffee Break and Exhibit Inspection

Sponsored by Incheon Tourism Organization

Session 2P1

Poster Session III

10:30 - 11:10

P1: A Compact UWB MIMO Antenna with Single Ring Resonator (SRR) Metamaterial Structure for Improved Isolation

Mohannad Obaid Katie, Mohd Faizal Jamlos, Ping Jack Soh
Universiti Malaysia Perlis (Malaysia)

A compact Single Ring Resonator (SRR) metamaterial UWB MIMO antenna is proposed for UWB MIMO systems. The antenna significantly reduces mutual coupling, improving isolation and size miniaturization by the presence of SRR metamaterial. The overall antenna performances are optimized in term of reflection coefficient (S11), mutual coupling (S21) and radiation pattern. Results show that the proposed antenna is capable of operating in the entire UWB band, from 3.1 to 10.6 GHz with good isolation up to - 38 dB.

P2: A miniaturized sub-wavelength based wideband negative refractive index metamaterial for quad-band applications

M. J. Hossain, M. R. I. Faruque, M. T. Islam
Universiti Kebangsaan Malaysia (Malaysia)

In this manuscript, a new modified hexagonal unit-cell structure with wideband negative refractive index metamaterial structure is worked in microwave regime. The proposed structure is designed of two symmetrical metallic patterns printed on the both sides of an FR4 dielectric substrate. The finite-difference time-domain (FDTD) based commercially available CST microwave studio is adopted to investigate the design scattering parameters.

P3: Absorption analysis of planar double U-Îă shape left-handed metamaterial for multi-band applications

M. J. Hossain, M. R. I. Faruque, M. T. Islam
Universiti Kebangsaan Malaysia (Malaysia)

A new double U-$\amalg$ shape design, simulation, fabrication and experimental verification of unit-cell structure based on simple configuration operating in microwave spectra. The proposed structure resonators have magnetic and electric resonances that demonstrate left-handed properties at 6.89 GHz.

P4: Tree-Shape Fractal Meta-Surface with Left Handed Characteristics for Absorption Application

M. R. I. Faruque, M. M. Hasan
Universiti Kebangsaan Malaysia (Malaysia)

A tri-band fractal meta-surface absorber composed of metallic branches of a tree connected with a straight metal strip is presented in this paper for high absorption application. The proposed tree-shape structure shows resonance at C-, x-, and Ku-bands and left handed characteristics at 14.15 GHz. The designed absorber structure shows absorption above 84 %, whereas the absorber structure printed on the FR-4 substrate material.

P5: Polymeric Magneto Comb Array Antenna for Bandwidth Enhancement in Millimeter Wave Applications

Wan Asilah Wan Muhamad[1], R. Ngah[1], Mohd Faizal Jamlos[2], Ping Jack Soh[2]
[1] *Universiti Teknologi Malaysia (Malaysia),* [2] *Universiti Malaysia Perlis (Malaysia)*

A new synthesization of polymeric magneto dielectric comb array antenna is presented. The synthesized substrates of Polydimethylsiloxane (PDMS) and Ferrite III oxide (PDMS-Fe3O4) generates permeability of 1.85 to provide huge improvement bandwidth of 57.27 % compared to existing antenna. The proposed polymeric magneto antenna produced a bandwidth of between 26.823 GHz to 42.573 GHz and gain of 7.161 GHz with only as small as dimension of 19x33 mm2.

P6: Performance Enhancement of Crescent Shaped Array Antenna using Artificial Magnetic Conductor

Herwansyah Lago, Mohd Faizal Jamlos, Ping Jack Soh
University Malaysia Perlis (Malaysia)

Integration of crescent shaped array antenna into a metamaterial of single resonant Artificial Magnetic Conductor (AMC) at 9.41 GHz is proposed. AMC plane stacked with crescent shaped array has increased the gain, efficiency and bandwidth of the antenna to 9.73 dB, 97 % and 398 MHz. Moreover, the radiating surface has been reduced to 155.62 mm compared to 165.74 mm without the AMC. It is observed that the characteristics of the proposed AMC plane significantly contributed to the mentioned results.

P7: CPW-fed multiband array antenna loaded with wide range double-negative (DNG) metamaterial for wireless applications

Samir Salem Al-Bawri, Mohd. Faizal Jamlos, Syed Alwee Aljunid Syed Junid
Universiti Malaysia Perlis (Malaysia)

A miniaturized multiband coplanar waveguide (CPW) fed antenna array using a novel double negative (DNG) metamaterial unit cell for GSM900, WLAN, LTE-A and 5G Wi-Fi applications is presented in this paper. The investigated DNG structure indicates wide range of negative refractive index in the frequency span (0-3.78 and 5.65-7.2)GHz. Two categories of the proposed metamaterial plane have been applied to enhance the bandwidth up to 1.2 GHz, whereas the maximum attained gain is 6.74 dBi at 3.5 GHz.

P8: A Compact Crisscross Slotted Log Periodic Fractal Koch Antenna with AMC Metamaterial for UHF TVWS Applications

Nur Akmal Abd. Rahman[1], Mohd Faizal Jamlos[2]
[1] *Universiti Malaysia Perlis (Malaysia),* [2] *Universiti Malaysia Pahang (Malaysia)*

This paper presents a compact crisscross slotted log periodic fractal Koch antenna (S-LPFKA) with artificial magnetic conductor (AMC) surface that serves as a reflector. This S-LPFKA with AMC is designed to operate from 0.47 to 0.79 GHz with linearly polarized radiation, performing with 36.6 % size reduction compared to stand-alone S-LPFKA. With gain from 2.57 dBi to 4.75 dBi, this antenna is suitable and potential for ultra high frequency (UHF) television white space (TVWS) applications.

P9: Low Loss Metamaterials for 5G Mobile Networks

B. A. F. Esmail[1], H. A. Majid[1], Z. Z. Abidin[1], M. K. A. Rahim[2], R. Dewan[2]
[1] *Universiti Tun Hussein Onn Malaysia (Malaysia),* [2] *Universiti Teknologi Malaysia (Malaysia)*

A double C-shaped resonator (DCR) unit cell metamaterial (MTM) for 5G mobile network that operates at 28 GHz is proposed. For comparison purpose, three other common unit cells which are the S-shaped resonator, double G-shaped resonator (DGR), and Omega-shaped resonator are optimized to operate at similar operating frequency. The losses of the proposed DCR is improved and the negativity of the constitutive parameters is maintained compares to others.

P10: Suppression of Surface Modes in Metamaterial Grounded Slab

Riham Borghol, Taoufik Aguili
University of Tunis El Manar (Tunisia)

This paper investigate the technique of suppression of surface modes in the metamaterial grounded slab. This technique consists to sandwich a left-handed material layer between the air and the metamaterial slab. The purpose of this suppression is to reduce the mutual coupling between the elements of array antennas. The Transverse Resonance Method is applied in this analysis to find the effects of the left-handed material layer on the dispersion characteristics of transverse electric and transverse magnetic polarizations.

P11: Terahertz dielectric lens for super-resolution images

Alexander Vladimirovich Chernyadiev, Anna Vozianova, Mikhail Khodzitsky
ITMO University (Russia)

In this paper the dependence of the full-width at half-maximun (FWHM) of the terajet from the polarization of the incident light (TE-TM), from the orientation of the structure (two different cross-sections of the composite) is performed. S-parameters and Ey, Hz intensity distributions for TE- and TM-polarized wave was obtained in the COMSOL Multiphysics Software.

P12: Measurement of far-field to near-field transmission matrix using near-field scanning optical microscapy

Eunsung Seo[1], Joonmo Ahn[1], Wonjun Choi[1], Yonghyeon Jo[1], Q-Han Park[2], Young Min Jhon[3], Wonshik Choi[1]
[1] *Center for Molecular Spectroscopy and Dynamics (Korea),* [2] *Korea University (Korea),* [3] *Korea Institute of Science and Technology (Korea)*

Control of near-field waves is the key to going beyond the diffraction limit in imaging and manipulating target objects. We present the focusing of plasmonic waves, a type of near-field waves, by wavefront shaping of far-field waves.

P13: Early Detection of Gastric Cancer with microRNA-106a using Plasmon Coupling of Hybridized

Metal Nanoparticles
Sang-Heon Park, Jihye Lee, Jong-Souk Yeo
Yonsei University (Korea)

To detect miRNA-106a, the promising biomarker for gastric cancer, we demonstrate colorimetric sensing platform based on plasmon coupling effect. The on-chip platform with core-satellite structure is made by conjugation of complementary oligonucleotides between target miRNA-106a and probes which are pre-functionalized on gold nanoparticles, thus enabling to observe the scattering color changes and spectral shift.

P14: Anti-parity-time symmetry in optical waveguide and electric circuit structures
Youngsun Choi, Choloong Hahn, Jae Woong Yoon, Seok Ho Song
Hanyang University (Korea)

We demonstrate a spontaneous symmetry breaking and power-difference -conserving light propagation in the anti-parity-time symmetric optical waveguide structures. These optical properties are experimentally realized in the equivalent electric circuit analogy.

P15: Electronic band structures and quantum Hall effect in In0.53Ga0.47As/InP nanostructures superlattices short infrared detectors
D. Barkissy, A. Nafidi, A. Boutramine, N. Benchtaber, A. Hannour, M. Massaq
University Ibn Zohr (Morocco)

We investigate here the band structures and transport properties of In0.53Ga0.47As(d1=10 nm)/InP(d2=5 nm) lattice matched superlattice, based on the envelope function formalism. We have theoretically interpreted the photoluminescence and the quantum Hall Effect observations of Santos et al..The position of Fermi level indicates that this sample exhibits n type conductivity. The density of states shows a two dimensional electron gas. In the investigated temperature range, the cut-off wavelength is located in the short infrared region.

P16: Broadband enhancement of photocatalytic efficiency by 3D patterned light trapping structure
Yunha Ryu, Kyoungsik Kim
Yonsei University (Korea)

Here we report enhancement of photocatalytic efficiency of TiO2 by utilizing three dimensional light trapping structure which brings increased the light absorption. We successfully fabricate the 3D structures via self-assembly technique. The fabricated structures show high light absorption and large surface area which are beneficial to photocatalytic effect. Also, we combined TiO2 structures with plasmonic metal nanostructures to achieve higher light absorption and hot carrier injection.

P17: Energy Tunable Hot Carrier Generation via Surface Plasmon Polaritons for Photocatalysis
Wonmi Ahn, Daniel Ratchford, Pehr Pehrsson, Blake Simpkins
U.S. Naval Research Laboratory (USA)

Surface plasmon polaritons (SPPs) on a metal/TiO2 heterostructure enable plasmon-mediated chemical reactions in a system whose resonance may be continuously tuned simply by altering excitation source and incident angle. We found a strong excitation angle dependence and linear power dependence in the photocurrent, confirming that the photoelectrochemical reactions are SPP-driven. Applicability of the SPP system for energy-tunable hot carrier generation and hot-carrier driven solution chemistry was further investigated using refractory plasmonic materials and SP band gap structures.

P18: Exploring Different Metallic Structures Dispersion Attribute to Enhance Future Microwave Absorbing Material
Abdul Aziz Muhammad Ezanuddin, Yeng Seng Lee, Herwansyah Lago
Universiti Malaysia Perlis (Malaysia)

Not all engineered metallic structures with the same resonance can exhibit acceptable electromagnetic bandgap (EBg). In this paper, several metallic structures consisting of rectangular, deformed, slit patch and unequal divided circles (UDC) were assessed its proneness in manipulating surface wave and producing targeted EBg. Utilizing FR4 laminate, decent EBg can be achieved by using optimized structure with the correct resonance. Results shows a stable and decent EBg region can be gained from UDC specifically from 5.9 to 6 GHz.

P19: Continuous control of complex nonlinear susceptibility for harmonic generation using plasmonic metasurface
Gun-Yeal Lee, Kyookeun Lee, Yohan Lee, Hyeonsoo Park, Chulsoo Choi, Byoungho Lee

Seoul National University (Korea)

In the field of nonlinear optics, the capability of tailoring nonlinear optical properties in confined area is an important issue. Here, we propose a novel strategy for designing a metasurface that can control magnitude of nonlinear susceptibility. The continuous control of the nonlinear susceptibility is demonstrated by using x-shaped nanoantennas, which induce the third harmonic generation due to its circular symmetry. The proposed metasurface is expected to be applicable to nonlinear applications such as nonlinear holography and data storage.

P20: Practical Limits of capacitive coupling between gold nanoparticles toward self-assembled, ultra-high index optical metamaterial

Ji-Hyeok Huh, Seungwoo Lee
SKKU Advanced Institute of Nanotechnology (SAINT) (Korea)

In this work, we demonstrate self-assembly of the closely-packed plasmonic nanoparticles (NPs) superlattice that could exhibit unnaturally high-refractive-index at optical frequencies. We successfully synthesized highly uniform and smooth AuNPs, by benefitting from this unprecedented quality of AuNPs, we approached to the practical limits of the accessible minimum gap between AuNPs, self-assembled into large-area, close-packed monolayer. Thus, the effect of AuNP shape on capacitive coupling, essential for unnaturally high-refractive-index, was systematically studied.

P21: Manipulation of multipolar phenomena in dielectric optical antennas through beam engineering

Jon A. Schuller
UC Santa Barbara (USA)

Dielectric Mie resonators have emerged as exceptional optical antennas due to their low-loss resonances and combined electric and magnetic response. Traditionally, researchers have manipulated Mie resonances by engineering physical properties such as size, shape, or composition. Here, we instead engineer illuminating radiation to measure and manipulate the scattering response of dielectric optical antennas.

P22: Raman scattering of MoS2 enhanced by Ag nanoparticles

Fengkai Meng, Feng Lin
Peking University (China)

Based on localized plasmon resonances of silver nanoparticles(Ag NPs) with the size of several tenths of nanometer, we obtained a dramatic enhancement for Raman scattering of MoS2 as the Ag NPs were dispersed on the monolayer of MoS2.

P23: Light scattering by magnetic resonance of crescent-shaped split-ring resonator

Toshihiro Okamoto, Naoki Tamura, Masanobu Haraguchi
Tokushima University (Japan)

We investigated the optical scattering property of crescent-shaped split-ring resonator (SRR) fabricated by the nanosphere lithography method. The magnetic resonance of single gap SRR was able to be excited in an optical magnetic field by using the total reflection of the prism. It was clarified to contain a polarized component different from the incident light as a result of observing the scattered light from SRR.

P24: Stacked Nanogaps Exciting Strong Fano Resonances

Ye Yu[1], **Ziwei Zhou**[2], **Tobias Konig**[1], **Andreas Fery**[1]
[1] *Leibniz-Institut fur Polymerforschung Dresden e. V. (Germany),* [2] *Jilin University (China)*

In this poster we present a method of fabricating nanogap arrays via a low-cost, versatile method of colloidal lithography. Combing various deposition technologies using colloidal crystal monolayer as initial template, we show here the possibility of obtaining nanogap structures with advanced optical properties with low cost and high throughput. The simulation results show clear Fano resonances occurring because of the presence of nanogap between stacked metallic layers.

P25: Enhanced second and third harmonic signals achieved by a grating structure from magnetic metamaterials

Dongwoo Lee, Inki kim, Junsuk Rho
Pohang University of Science and Technology (Korea)

Through nonlinear crystals, second and third harmonic signals are obtained. However, such signals are limited to low efficiency as an output. Here, we introduce a new strategy how to amplify the second and third

harmonic signals via magnetic metamaterials. We theoretically and numerically show that the higher induced polarization currents with harmonic signals can be achieved by the grating structure and an actual model is suggested and performed.

P26: Optical Characterization of Chiral Photonic Crystals on Nanostructured Perfluoropolymer Films
Heetae Ahn[1], Sooyeon Bae[2], Taeguen Kim[2], Na Young Ha[2]
[1]*Ajou University (Korea),* [2]*Ajou University (Korea)*

We investigated optical characteristics of cholesteric liquid crystals (CLCs) on periodically-nanostructured perfluoropolymer films. Here, CLCs with periodic helical structures are chiral photonic crystals and nanostructured perfluoropolymer films are used as alignment layers to control orientations of cholesteric helices. The CLCs on the nanostructured films showed not specular but diffusive reflections at the specific spectral region. This nanostructured perfluoropolymer film can provide new possibility to engineer optical characteristics of the CLCs.

P27: Fabrication and Optical Characterization of All-biocompatible Photonic Crystals with Fluorescent Carbon-dots
Taeguen Kim, Chaeli Lim, Soonil Lee, Na Young Ha
Ajou University (Korea)

We fabricated biocompatible polymeric films doped with surface-modified Carbon-dots (C-dots) by drop-casting and introduced periodic nanostructures, i.e., photonic crystals on the surface of the C-dots/polymer films using a nanoimprint lithography. The nanostructured polymeric films doped with the C-dots showed strong enhancement of photoluminescence (PL) efficiencies at the specific spectral region depending on the periodicity of the nanostructured films. These nanostructured C-dots/polymer films can be new biocompatible fluorescent sources and photonic devices.

P28: Out-of-plane dispersive photonic band structure of a honey-comb photonic crystal
Jesus Daniel Valenzuela-Sau, Raul Garcia-Llamas
Universidad de Sonora (Mexico)

We present an alternative numerical method for calculating dispersive photonic band structures (DPBS). This method can be implemented considering experimental data or an approximate mathematical model for the dielectric constant and for others types of lattices and cross sections. Out-of-plane propagation is considered for a honey-comb photonic crystal given the high interest in graphene like structures.

P29: An experimental study of self-guided unidirectional waveguides by a chain of gyro-magnetic rods
Zhen Li[1], Rui-Xin Wu[2]
[1]*Nanjing Institute of Industry Technology (China),* [2]*Nanjing University (China)*

We experimentally studied the tunability of an unidirectional waveguides of magnetic photonic crystals(MPCs) which is a straight-line chain with gyro-magnetic rods. By changing the constitution parameters, we could achieve different one way transmission (OWT) characteristics. We studied the influence of normalized radius R and lattice constant a on band width and center frequency of OWT band.

P30: Plasmon-induced local heating for optically controlled nano-architectures
Marlous Kamp, B. de Nijs, Tao Ding, Sean Cormier, Oren Scherman, Jeremy Baumberg
University of Cambridge (United Kingdom)

This poster discusses new results in optically controlled nano-architectures of gold nanoparticles, prepared using the temperature responsive polymer poly(N-isopropylacrylamide) (pNIPAM). We show how assemblies can be selected according to size using local plasmonic heating. We also discuss how these assemblies relate to a type of self-limiting assemblies called actuating nanotransducers (ANTs) prepared in our lab1.

P31: Facile fabrication technique of periodically aligned faceted gold nanocrystal array
Minjung Choi, Kyuyoung Bae, Kyoungsik Kim
Yonsei University (Korea)

We demonstrate a fabrication technique of gold nanocrystals with periodic anodic aluminum oxide groove template by evaporation and high-temperature heat treatment processes. Employing diverse groove templates with different lattice constants and proper evaporation condition, we fabricated gold nanocrystal arrays with few tens of nanometer-diameter. Compare with chemically synthesized gold nanocrystals, our gold na-

nocrystals are not aggregated nor piled but periodically distributed as a monolayer in accordance with the periodicity of the groove template.

P32: Self-Assembled Hyperbolic Metamaterials in the Deep-Ultraviolet
S. Skov Campbell[1], William Wardley[1], Mazhar Nasir[1], Gregory A. Wurtz[2], Anatoly Zayats[1], Wayne Dickson[1]
[1] *King's College London (United Kingdom),* [2] *University of North Florida (USA)*

We describe a self-assembled, template-assisted approach for the fabrication of anisotropic metamaterials which exhibit dipolar plasmonic resonances in the deep ultraviolet spectral range. This technique is based on the electrochemical deposition of UV plasmonic nanorods in anodic aluminium oxide templates. Such materials exhibit dipolar plasmon resonances, related to the nanorod geometry, with the quality factor determined by the intrinsic loss of the constituent metals. This research advances many applications, including fluorescent enhancement, surface enhanced resonant Raman scattering and bio-sensing.

P33: Aluminum oxide nanowire metastructure for tailoring the absorption and radiation
Kyuyoung Bae, Kyoungsik Kim
Yonsei University (Korea)

Here we establish the fabrication method for self-collapsed aluminum oxide nanowires from anodization process. A lattice and length of nanowire bundle can be controlled readily by anodization time, wet etching, and drying conditions. With the metal or metal-oxide deposition, the optical characteristic dramatically changes to ultra-broadband absorption or selective emission. The nanowires can be transferred onto adhesive tape or polymer films for practical applications as well.

P34: Self-assembly-assisted gold nanostructure for plasmonic sensor
Eui-Sang Yu[1], Sin-Hyung Lee[1], In-Ho Lee[2], Sang Hyun Lee[1], Yong-Sang Ryu[3], Sin-Doo Lee[1]
[1] *Seoul National University (Korea),* [2] *University of Minnesota (USA),* [3] *Sensor System Research Center, Korea (Korea)*

A self-assembly of gold (Au) nanostructures was employed over a dielectric spacer and an underlying bottom Au layer for a plasmonic refractive index (RI) sensor. Its exposures to distinct surrounding media with different refractive indices result in visible color changes due to plasmonic resonance shifts in the reflectance that are attributed to the changes of the surrounding RI. The resonance absorption occurred at λ=550.3 nm, 634.7 nm, and 725.3 nm for the RI's of n=1.000, 1.343, and 1.516, respectively.

P35: A Low-cost PET-based 4x4 Butler Matrix using 3dB Hybrid Coupler with Non-Conventional Output Phase Difference
S. A. Babale[1], S. K. A. Rahim[1], M. Himdi[2]
[1] *Universiti Teknologi Malaysia (Malaysia),* [2] *University of Rennes (France)*

Butler Matrix (BM) utilizing only 3dB hybrid couplers and a crossover is presented. It is implemented on a specially coated PET substrate using a low -cost silver-nano inkjet printing technology. The results show a return loss better than -10 dB at 6.0GHz. The transmission coefficients are, and at the operating frequency. Based these results, the proposed design has a good performance in terms of amplitude and progressive phase difference at the output ports.

P36: Instant Inkjet Printed 3dB Hybrid Coupler with Non-Conventional Output Phase Difference
S. A. Babale[1], S. K. A. Rahim[1], H. A. Elmobarak[1], D. Schreurs[2]
[1] *Universiti Teknologi Malaysia (Malaysia),* [2] *KU Leuven (Belgium)*

In this paper, a design a 3-dB coupler with 450 phase difference is implemented using a low-cost instant inkjet silver-nano printing technology. The responses of the coupler show that the return loss and isolation are both below -20dB at the designed frequency. However, for the output phase difference it can be observe that there is 450 phase difference and the amplitude imbalance in dB is less than 0.05 at the center frequency.

P37: A polarimetric analysis applied to human cells
Andrea Fernandez[1], Yael Gutierrez[1], Jose Luis Fernandez Luna[2], Fernando Moreno[1], Jose Maria Saiz[1]
[1] *Universidad de Cantabria (Spain),* [2] *Hospital Universitario Marques de Valdecilla (Spain)*

We measure the image Mueller matrix (MM) of human cancerous cells. We apply three different decomposition and transforming methods (Polar decomposition, Mueller matrix transformation and differential decomposition) over these matrices in order to look for an adequate polarimetric parameter that allow us to

characterize and differentiate these tumor cells. Due to the intrinsic difficulty of applying polarimetry to these kind of samples we set out two proposals in order to enhance the sensitivity of the polarimetric parameters.

P38: Terahertz nano-metamaterials for discrimination and quantification of Avian Influenza viruses
Dong-Kyu Lee[1], Ji-Hun Kang[2], Junghoon Kwon[3], Chang-Seon Song[3], Minah Seo[1]
[1] *Korea Institute of Science and Technology (Korea),* [2] *University of California at Berkeley (USA),* [3] *Konkuk University (Korea)*

Optical characteristics of three different subtyped Avian influenza viruses were measured using nano scaled metamaterial sensing chip based terahertz (THz) time-domain spectroscopy (TDS) system. The enhanced THz field via metamaterial structures can lead to increase absorption cross section of the targeted viruses, in turn, increase the detection sensitivity. The three virus samples can be discriminated by measured optical parameters including normalized transmittance change and shifted frequency at maximum transmittance, assigning subtype of viruses.

P39: Wireless Transfer Efficiency Enhancement on Reduced Size Antenna
Mohamad Harris Misran, Sharul Kamal Abdul Rahim, Warren Yong, Kashif Nisar Paracha, Maizatul Alice Meor Said
Universiti Teknologi Malaysia (Malaysia)

Paper present a reduced size of patch loop antenna is proposed on glass-reinforced epoxy laminate sheets substrate with copper conductive as a microstrip line for wireless power transfer purpose. Single square loop antenna is designed on each of front and back FR4 layers at 13.56MHz to optimize the used of near-field communication that already embedded in almost middle and high end smartphone. An optimized antenna is able to achieve 13.9 % wireless transfer efficiency improvement with 47 % size reduction.

P40: Dual-Band Circularly Polarized Wearable Textile Antenna Slotted with Split-Ring Resonator for Off-Body LTE Applications
E. A. Muhammad[1], Hasliza A. Rahim[1], P. J. Soh[1], M. Abdulmalek[2], G. A. E. Vandenbosch[3]
[1] *Universiti Malaysia Perlis (Malaysia),* [2] *University of Wollongong in Dubai (United Arab Emirates),* [3] *Katholieke Universiteit Leuven (Belgium)*

This paper presents a dual band circularly polarized wearable textile patch antenna slotted with split-ring for WBAN application. A split-ring slot is integrated onto the top radiator. The antenna achieved a 10-dB impedance bandwidth of 3.9 % at 1.8 GHz and 15 % at 2.6 GHz, respectively. The 3-dB axial-ratio bandwidths are 3 % and 13 % at 1.8 GHz and 2.6 GHz, respectively, with a maximum gain of 4.1 dB.

P41: Application of the Mathieu's equation for an analysis of photonic crystal - supported surface electromagnetic waves: s- and p-polarization cases
Ekaterina Rostova, Serguei K. Sekatskii, Giovanni Dietler
Ecole Polytechnique Federale de Lausanne (Switzerland)

Recently, we showed that an analogy between a 1D Photonic Crystal and a structure with a sine-modulated refraction index enables to apply the Mathieu's differential equation for an anylysis of Photon Crystal - supported surface electromagnetic waves. Here we present the detailed analysis for p- and s- polarizations and show that the s-polarization is described exactly by the Mathieu's equation while that corresponding to the p-polarization gives rise to a slightly modified equation.

P42: Metamaterial-HIS for Pattern Reconfigurable Multiband Array Antenna
Raimi Dewan[1], M. K. A. Rahim[1], Mohamed Himdi[2], M. R. Hamid[1], Noor Asmawati Samsuri[3]
[1] *University Technology Malaysia (Malaysia),* [2] *Institut d'Electronique et de Telecommunications de Rennes (France),* [3] *Universiti Technologi Malaysia (Malaysia)*

Metamaterial-HIS of Electromagnetic Band Gap (EBG) incorporated onto dual band array antenna operate at 2.45 GHz (lower band) and 5.8 GHz (upper band) is proposed. The four configurations of EBG unit cells successfully realizes a dual band antenna with dedicated pattern reconfigurability. The antenna is suitable for steering the main lobe direction to intended directions.

P43: Multiband Salisbury Screen Absorber Using Double Layer Cross Dipole FSS
Fauziahanim Che Seman[1], Salleh Omar[1], Warren Y. Yong[2], Sharul K. A. Rahim[2]
[1] *Universiti Tun Hussein Onn (Malaysia),* [2] *Universiti Teknologi Malaysia (Malaysia)*

In this paper the microwave absorbing properties of multiband Salisbury screen absorber design which is

constructed using double layer FSS is investigated. The structure exhibits triple operating band where the -10 dB reflectivity bandwidth of a Salisbury screen operating at normal incidence is 36.3 %, 11.9 % and 14.5 % at the resonant frequencies of 6.16 GHz, 9.08 GHz and 15.01 GHz respectively.

P44: A CPW-Fed CSRR Loaded Inkjet Printed Filtenna on Low-Cost Flexible PET Substrate
Nurul Afiqah Remli, Sharul Kamal Abdul Rahim, Wai Yan Yong, Mursyid Idzam Sabran
Universiti Teknologi Malaysia (Malaysia)

An inkjet printed CPW loaded complementary split-ring resonator harmonic rejection filtenna designed on low-cost flexible PET substrate operates at 5.8 GHz is presented. The proposed antenna comprised of square slots built-in the rectangular patch structure. CSRR is implemented at the transmission line to suppress unwanted harmonics. The proposed antenna achieved acceptable 2nd and 3rd harmonic rejection with a minimum reflection coefficient of -4.56 dB and -3.3 dB respectively, offers efficiency up to 88.66 %.

P45: Improving MIMO Fabric Antenna Performance using AMC Octa-rift Structure
Herwansyah Lago[1], Muhamad Ezanuddin Abdul Aziz[2], Yeng Seng Lee[2], Che Muhammad Nor Che Isa[1]
[1] *University Malaysia Perlis (Malaysia),* [2] *FETech-UniMAP (Malaysia)*

A textile AMC plane with hexagonal and triangular patch antenna was proposed. The AMC is designed at 2.45 GHz to improve antenna performance. The performances of both antennas with and without AMC plane were investigated. Antennas' size remains constant while results show improvement. The AMC plane has been integrated with three different MIMO orientation and its performance investigated. In addition, the presented AMC plane and both antennas are made of fabric for the entire substrate and conducting parts.

P46: Passive Sensors using 3D Circular Frequency Selective Surfaces for Structural Health Monitoring System
Syaiful Anas Suhaimi, Saidatul Norlyana Azemi, Ping Jack Soh
University Malaysia Perlis (Malaysia)

This paper is introduced a passive sensor to detect the performance of the structure using three-dimensional (3D) Frequency Selective Surfaces (FSS). The proposed 3D Circular FSS results are proved behave as passive sensor with changing of sensitivity incident angles to be apply in Structural Health Monitoring (SHM) system. Moreover, this 3D Circular FSS capable to operate without stand to any (DC/AC) power and very low cost in term of installation and maintenance.

P47: Flexible, Ultrathin and Light-weight PET based inkjet-printed FSS for x-band Shielding
Wai Yan Yong[1], Sharul Kamal Abdul Rahim[1], Muhammad Ridduan Ramli[1], Muhammad Lokman Samingan[1], Fauziahanim Che Seman[2]
[1] *Universiti Teknologi Malaysia (Malaysia),* [2] *Universiti Tun Hussein Onn Malaysia (Malaysia)*

This paper presents a flexible x-band band-stop FSS using inkjet printing on the PET substrate. The ring slot FSS is proposed as it is easy to design and insensitive toward the change in polarisation and angle. The FSS provide attenuation up to 30 dB for both TE and TM polarisation. The proposed design provided a stable performance up to 45° at both polarisation. The proposed FSS has a -10 dB bandwidth of 38 %.

P48: Branch Line Coupler Using PDMS as Dielectric Substrate and Superstrate at 2.45 GHz
M. L. Samingan[1], S. K. A. Rahim[1], T. Peter[1], W. Y. Yong[1], D. Schreurs[2]
[1] *Universiti Teknologi Malaysia (Malaysia),* [2] *ESAT- TELEMIC (Belgium)*

This paper presents the design of a branch-line coupler (BLC) using a copper fabric sheet as conductive element, mounted on Polydimethylsiloxane (PDMS) substrate and superstrate (cover) dielectric layers. The BLC operates at the 2.45 GHz operating frequency and has a phase difference of 90°. The use of PDMS material as a dielectric layer for BLC is to add the special characteristics of PDMS on this passive microwave circuit.

11:10 - 11:40 — Ballroom

Session 2A2

GEN1. Plasmonics and nanophotonics IV

Chaired by: Stephanie Law

11:10 : Plasmon-Assisted Positive Photoconductance by Gold Nano-Gradient Structures
Jihye Lee, Jeong-Hyeon Kim, Jong-Souk Yeo
Yonsei University (Korea)

We demonstrate the electrically connected gold nano-gradient structure for investigating the positive photoconductance assisted by the plasmons. The gradient nanostructures have an optically graded colors within a visible wavelength so that the interaction of visible light and graded nanostructure shows different positive photoconductive responses depending on the coherency (coherent/incoherent) and wavelength (red, green, blue) of the incident light source. The junction of the graded nanostructure composed of carbon and gold is expected to generate hot carriers by Landau damping.

11:25 : Engineering of electronic bands structure and magneto-transport properties in a semimetallic InAs/GaSb superlattice for Terahertz detection
A. Boutramine, A. Nafidi, D. Barkissy, N. Benchtaber, A. Hannour, H. Chaib
University Ibn Zohr (Morocco)

Using the envelope function formalism, we report here on bands structure of a p-type InAs(d1)/GaSb(d2) superlattice. When the temperature T increases, the band-gap Eg(d1) indicates that the semiconductor-semimetal transition goes to lower d1. The Boltzmann magnetic-field-dependent Hall coefficient shows that the Fermi energy increases by 10 meV with T. At 141 K, the conductivity changes from p-type to n-type with a possible transition from two-dimensional to three-dimensional electron gaz. The cut-off wavelength situates this sample as a terahertz detector.

11:10 - 12:10 — Room 106

Session 2A3

SP2. Functional Materials and Devices for Acoustic and Elastic Waves I

Organized by: Guancong Ma and Yun Lai

Chaired by: Guancong Ma and Yun Lai

11:10 : Invited talk
Topological transport of sound vortices
Shubo Wang, C. T. Chan
The Hong Kong University of Science and Technology (China)

We theoretically and experimentally demonstrated the geometric phase effect for sound using a helical waveguide. We show that the geometric phase can be used to control the flow of sound vortices inside an interferometer structure, resulting in geometric-phase-based sound vortex filter.

11:30 : Invited talk
Optimal Sound-Absorbing Structures
Ping Sheng
(Hong Kong)

Causal nature of the acoustic response dictates an inequality that relates the absorption spectrum of the sample to its thickness. We use the causal constraint to delineate what is ultimately possible for sound absorbing structures, and denote those which can attain near-equality for the causal constraint to be optimal. Using acoustic metamaterial as backing to conventional porous absorbers, we present a design strategy for structures with target-set absorption spectra and a sample thickness close to the causal minimum value.

11:50 : Invited talk

Negative refraction experiments in acoustic metafluids

Thomas Brunet, Artem Kovalenko, Benoit Tallon, Olivier Mondain-Monval, Olivier Poncelet
University of Bordeaux (France)

Negative refraction is observed at ultrasonic frequencies in underwater acoustic experiments. The phenomenon is evidenced through the deflection of an ultrasonic beam emerging from a prism-shaped negative-index metafluid composed of soft porous micro-beads randomly dispersed in a water-based gel matrix. These experiments are compared with theoretical predictions based on multiple scattering theory models revealing a good agreement for various volume-fractions of particles.

11:10 - 12:10 — Room 109

Session 2A4

SP14. Fano resonances in optics and microwaves: Physics and application IV

Organized by: Eugene Kamenetskii and Almas Sadreev

Chaired by: Eugene Kamenetskii and Almas Sadreev

11:10 : Invited talk

New type of the Fano resonance in the core-level absorption spectrum of an impurity in one-dimensional superlattice

Satoshi Tanaka[1], Taku Fukuta[1], Tomio Petrosky[2]
[1] *Osaka Prefecture University (Japan),* [2] *The University of Texas at Austin (USA)*

Core absorption spectrum of an impurity embedded in a one-dimensional tight-binding chain is theoretically investigated in terms of complex spectral analysis.The spectrum shows a distinct Fano-profile only with a single intra-atomic transition.The asymmetric Fano absorption profile is attributed to the complex oscillator strength of the transitions to the discrete resonance states belonging to the extended Hilbert space.Nonlinear nature of the effective non-Hermitian Hamiltonian enhances the asymmetric Fano profile of the absorption spectrum.

11:30 : Invited talk

Metasurfaces for dark mode resonance characteristics

Elena Bochkova[1], Shah Nawaz Burokur[2], Andre de Lustrac[1], Anatole Lupu[1]
[1] *Paris Sud University (France),* [2] *Paris Nanterre University (France)*

The engineering of metasurfaces intended to obtain sharp features in their spectral response is studied. We show that in contrast to the conventional hybridization approach exploiting Fano type interference between dark and bright resonant elements, a more flexible and efficient engineering of the spectral response can be achieved by using distinctly different mechanisms for the excitation of dark modes.

11:50 : Invited talk

Tuning the directional scattering of light with silicon nanowires

P. R. Wiecha[1], A. Cuche[1], C. Girard[1], G. Colas des Francs[2], A. Lecestre[1], G. Larrieu[1], V. Larrey[3], F. Fournel[3], T. Baron[3], A. Arbouet[1], Vincent Paillard[1]
[1] *University of Toulouse (France),* [2] *Bourgogne University (France),* [3] *Grenoble-Alpes University (France)*

The interference between electric and magnetic resonances in high index dielectric nanostructures can be exploited to control the directionality of the light scattering. Usually, the directional Fano resonances occur either in spherical nanoparticles or in coupled nanostructures as silicon sphere dimers. We show theoretically and experimentally that directionality can be controlled in silicon cylindrical nanowires, even by exciting either pure electric ou pure magnetic resonances. The directionality can be further tailored using asymmetric nanowires of rectangular cross section.

11:10 - 12:10 — Room 104-105

Session 2A5

Workshop: Toroidal Electrodynamics and Toroidal Metamaterials I

Organized by: Nikolay Zheludev and Andrey E. Miroshnichenko

Chaired by: Nikolay Zheludev and Andrey E. Miroshnichenko

11:10 : Invited talk

Engineering anapole mode for the generation of toroidal dipole moment

Hui-Hsin Hsiao[1], Jia-Wern Chen[1], Yu Han Chen[1], Hui Jun Wu[2], Cheng Hung Chu[2], Mu-Ku Chen[1], Wei-Yi Tsai[1], Tsung Lin Chung[1], Din Ping Tsai[1]

[1] National Taiwan University (Taiwan), [2] Academia Sinica (Taiwan)

A novel three-dimensional plasmonic metamaterial which is able to generate a transverse toroidal dipole moment under normal illumination is presented in the optical region. In addition to the toroidal dipolar response, a non-radiating anapole mode resulting from the destructive interference between toroidal and electric dipoles is also observed. This is achieved via specifically designed and fabricated plasmonic metamaterials for the generation of both transverse toroidal dipole moments and associated anapole mode, and readily available for feasible applications.

11:30 : Invited talk

On an exact multipole expansion and the implications for dynamic toroidal multipoles

Ivan Fernandez-Corbaton[1], Rasoul Alaee[2], Carsten Rockstuhl[1]

[1] Karlsruhe Institute of Technology (Germany), [2] Max Planck Institute for the Science of Light (Germany)

To perform a multipole expansion of a charge-current distribution is a key procedure when doing research on light-matter-interaction. Usually, expressions valid only for small particles are considered. Here, we derive exact expressions for electric and magnetic multipole moments, which are valid irrespective of the particle size. We show that the usually called toroidal multipole moments emerge in higher order terms of a Taylor expansion of these exact expressions. The physical implications of this Taylor expansion are discussed.

11:50 : Invited talk

Progress in anapole metamaterials

Alexey A. Basharin

National University of Science and Technology (MISiS) (Russia)

We demostrate the progress in anapole metamaterials. We propose the promising properties of planar metamaterials, like extremely high Q-factor and strong electric and magnetic field localization, tunable toroidal metamaterials. Moreover, we demonstrate anapole excitation in dielectric metamaterials.

11:10 - 12:10 — Room 107-108

Session 2A6

SP7. Transformation Optics concept and applications I

Organized by: Shah Nawaz Burokur, Andre de Lustrac and Jianjia Yi

Chaired by: Shah Nawaz Burokur, Andre de Lustrac and Jianjia Yi

11:10 : Invited talk

Practical Realization of a Transformation Optics based Dielectric Superstrate for Patch Antenna using 3D printing

Chetan Joshi[1], Anne Claire Lepage[1], Xavier Begaud[1], Gerard Pascal Piau[2]

[1] Telecom ParisTech (France), [2] Airbus Group Innovations (France)

Transformation Optics (TO) based superstrates allow modifying radiation patterns of antennas but generally required anisotropic magnetic and dielectric materials or metamaterials. Previously, we presented a TO-based all dielectric solution which allows achieving in-plane radiation from planar antennas. In this paper, we will present the approach to design the superstrate prototype using 3D printing process and the performances achieved.

11:30 : Invited talk

Functional Metamaterial Devices for Manipulation of Waves in Microwave Region based on Transformation Optics

Kuang Zhang[1], J. Mei[2], Xumin Ding[1], Jiahui Fu[1], Guohui Yang[1], Qun Wu[1]
[1] *Harbin Institute of Technology (China),* [2] *Harbin University of Science and Technology (China)*

As an effective approach for manipulating propagation of waves, transformation optics has inspired many novel applications in past decades. In this paper, our recent efforts in metamaterial devices for manipulation of waves in microwave region are reviewed with emphasis on (1) multifunctional device with three different kinds of electromagnetic properties, (2) homogeneous illusion device exhibiting transformed and shifted scattering effect and (3) wave bending devices with homogeneous complementary material.

11:50 : Invited talk

QCTO-based lens antennas

Jianjia Yi[1], Tongyu Ding[1], Haoyu Li[2], Hailin Zhang[1], Andre de Lustrac[3], Shah Nawaz Burokur[4]
[1] *Xidian University (China),* [2] *State University of New York (USA),* [3] *Paris Sud University (France),* [4] *Paris Nanterre University (France)*

A 3D lens calculated by spatial light transformation method for electromagnetic field shaping is proposed. The lens is capable of transforming cylindrical wavefronts into planar ones, and therefore generating a directive emission. Such manipulation is simulated and analyzed by solving the Laplace's equation. A potential 3D realization with all-dielectric gradient refractive index metamaterials is presented.

11:10 - 12:30 — Room 110-111

Session 2A7

SP13. Hybrid Plasmonics with Quantum Confined Materials and Devices I

Organized by: Palash Bharadwaj and Hayk Harutyunyan

Chaired by: Palash Bharadwaj and Hayk Harutyunyan

11:10 : Invited talk

Nanogap-enhanced Electronic Trapping of Quantum Emitters and Nanoparticles

Avijit Barik, Xiaoshu Chen, Sang-Hyun Oh
University of Minnesota (USA)

We demonstrate ultralow-power dielectrophoretic trapping of quantum dots, diamond nanoparticles, and gold nanoparticles using sub-10 nm nanogap electrodes.

11:30 : Invited talk

Transient Extinction in Gold Bipyramids and Doped Oxide Nanostructures

P. Guo[1], M. S. Kirschner[1], B. T. Diroll[2], L. X. Chen[1], S. K. Gray[2], A. B. F. Martinson[1], X. M. Lin[2], R. P. H. Chang[1], R. D. Schaller[1]
[1] *Northwestern University (USA),* [2] *Argonne National Laboratory (USA)*

We investigate dynamics of three classes of plasmonic structures for applications such as ultrafast switching. Through transient extinction and finite difference time domain simulation, we analyze coherence time of mode-specific acoustic phonon distortions for a series of gold bipyramids. We probe the impact of conformally coated phase change material, VO2, on a doped oxide nanorod array for broadband infrared optical switching.

11:50 : Invited talk

Quantum and Classical Phenomena in Metal Nanostructures with Hot Spots: Coherent Transfer of Plasmons, Hot Electrons and Heat Generation
Alexander O. Govorov
Ohio University (USA)

Metal nanocrystals exhibit strong plasmon resonances and have the ability to absorb and scatter light very efficiently. This study concerns special designs of plasmonic nanostructures with electromagnetic hot spots, where the electromagnetic field becomes strongly enhanced. Overall plasmonic nanostructures with hot spots demonstrate strongly amplified optical and energy-related effects, including: (1) coherent transfer of plasmonic signals with minimal losses, (2) generation of energetic (hot) electrons and (3) localization of high photo-temperature in small volumes.

12:10 : Invited talk
Quantum Defects of Carbon Nanotubes: Room Temperature, 1.5μm Single Photon Emitters for Quantum Plasmonic Circuits
Han Htoon
Los Alamos National Laboratory (USA)

We demonstrate that exciton localization at covalently-introduced aryl sp3 defect sites in single-wall carbon nanotubes provides a route to room-T single photon emission (SPE) with ultra-high single-photon purity (99 $\%$) and the shot-noise limited emission stability. The inherent optical tunability of SWCNTs allows us to generate room-T SPE spanning over 1.3 to 1.55 μm telecom band. We integrate these novel quantum emitters with plasmonic and photonic structures toward achieving control on SPE characteristics and realization of quantum photonic/plasmonic functionality.

11:10 - 12:25 — Room 113

Session 2A8

Symposium II. Recent Advances in Complex Materials and Nanophotonics VI

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

11:10 : Invited talk
Measuring Topological Orders and Band Inversion in a Photonic Peierls Chain with Non-Hermitian Parity-Time Symmetry
Jun Jiang, Weiwei Zhu, Hong Chen, Jie Ren
Tongji University (China)

We demonstrate the photonic Peierls chain, in which couplings alternate between electric and magnetic, has different topological phases with different boundaries. Furthermore, we measure the density of states, the symmetry type of the band-edge states and the topological winding number with the aid of experimentally measured dispersion and mode characteristics. These results are powerful evidences to demonstrate the topological phases trivial or not. This is the first time to measure the winding number since the proposal of topological metamaterials.

11:30 : Invited talk
Optoelectronic metasurfaces
Jeremy Munday
University of Maryland (USA)

Metasurfaces consist of flat, ultrathin optical components that can have a functionality resembling that of much thicker optical structures, and photon detection is typically a separate process. In this talk, I will discuss the use of lossy, ultrathin film metasurfaces for the generation of hot carriers, and their subsequent collection, enabling compact polarization and wavelength selective optoelectronic components.

11:50 : Parallelization of single nanoparticle biosensors

Wolfgang Fritzsche, David Zopf, Jacqueline Jatschka, Sophie Thamm, Andre Dathe, Andrea Csaki, Matthias Thiele, Gabriele Schmidl, Gangrui Li, Ondrej Stranik
Leibniz Institute of Photonic Technology (IPHT) (Germany)

We are interested in utilizing localized surface plasmon resonances as transducing principle for biomolecular binding. We have used several approaches for the fabrication of the nanostructures such as microfluidic synthesis of anisotropic particles, double concentric structures by colloidal lithography, pyramidal structures by template stripping and colloidal lithography or by thermal annealing of thin metal layers. We have established hyper-spectral imaging combined with an microscopy system, which allows to record spectral properties of multiple particles simultaneously.

12:05 : Invited talk
Reversible Switching of Highly Confined Phonon-Polaritons with an Ultrathin Phase-change Material
Peining Li, Xiaosheng Yang, Tobias Mass, Julian Hanss, Martin Lewin, Ann-Katrin Michel, Matthias Wuttig, Thomas Taubner
Aachen University (Germany)

We use phase-change materials (PCMs) as a switchable dielectric environment for infrared antennas and surface polaritons. Specifically, we combine an ultrathin film of PCMs with a substrate hosting surface phonon polaritons and realize the all-optical, non-volatile, and reversible switching of resonators for these ultra-confined polaritons.

11:10 - 12:10 — Room 114

Session 2A9

SP25. APhoto/Thermal Conversions and Their Applications with Photonic Crystal, Plasmonics and Metamaterials I

Organized by: Qiang Li and Hui Liu

Chaired by: Qiang Li and Hui Liu

11:10 : Invited talk
Tailoring thermal emission with metasurfaces
Leo Wojszvzyk, Emilie Sakat, Ioana Doyen, Anne-Lise Coutrot, François Marquier, Jean Jacques Greffet
Paris-Saclay University (France)

We show that a periodic array of hot nanoparticles embedded in resonant plasmonic antennas can produce thermal emission with an effective emissivity approaching unity. This type of design allows to control thermal emission by designing the antennas. We expect to modulate thermal emission at a rate exceeding 10 MHz.

11:30 : Invited talk
Control over emissivity of middle infrared thermal emitters with phase changing material
Qiang Li, Kaikai Du, Yurui Qu, Min Qiu
Zhejiang University (China)

Controlling the emissivity of a thermal emitter has attracted growing interest with a view towards a new generation of thermal emission devices. So far, all demonstrations have involved sustained external electric or thermal consumption to maintain a desired emissivity. In this invited talk, I will review our recent work on control over the emissivity of a thermal emitter consisting of a phase changing material Ge2Sb2Te5 (GST) film on top of a metal film.

11:50 : Invited talk
Spatial and spectral control of thermal emission with nanoantennas
Patrick Bouchon, M. Makhsiyan, J. Jaeck, R. Haidar
ONERA (France)

We experimentally demonstrate a multispectral metasurface that exhibits controlled inhomogeneous optical

properties leading to a spatial modulation of the emissivity up to the wavelength scale in the infrared. Each antenna acts as an independent deep subwavelength emitter for a given polarization and wavelength, and their juxtaposition at the wavelength scale can encode far field multispectral and polarized images.

11:10 - 12:15 — Room 115

Session 2A10

Symposium I. Hybrid Optically Active Nanomaterials IV

Organized by: Xing Yi Ling, Jerome Plain and Alexander Govorov

Chaired by: Xing Yi Ling, Jerome Plain and Alexander Govorov

11:10 : Keynote talk
Chiral nanomaterials and their applications
Yurii K. Gun'ko[1], Finn Purcell-Milton[1], Olan Cleary[1], Alex Loudon[1], Vera Kuznetsova[1], Maria V. Mukhina[2], Ivan V. Korsakov[2], Vladimir G. Maslov[2], Anvar Baimuratov[2], Ivan Ruhlenko[2], Alexander Baranov[2], Anatoly Fedorov[2]
[1] *Trinity College Dublin (Ireland),* [2] *ITMO University (Russia)*

The main goal of our work is to develop new types of inorganic nanoparticulate materials possessing optical activity and chirality, study their properties, investigate their nature and explore their applications. We have developed new chiral nanomaterials including chiral II-VI semiconducting nanoparticles (quantum dots) and chiral nanoparticles of technologically important metal oxides. We have also demonstrated potential applications of chiral quantum dots for chiral recognition and luminescent chemo- and bio- sensing.

11:40 : Optical chirality generation and amplification in achiral plasmonic nanostructures assembled with chiral biomolecules
Dangyuan Lei
The Hong Kong Polytechnic University (China)

I will discuss our recent study on the generation and amplification of optical activity in achiral metal nanostructures assembled with chiral biomolecules. I will show how an individual plasmonic nanostructure interacts with chiral biomolecules, enabling switching and amplifying the molecular optical activity and probing the conformational evolution of the chemisorbed molecules. I will also show how a cluster of plasmonic nanostructures can be assembled with chiral molecules to produce plasmon-induced circular dichroism response in both UV and visible-NIR regions.

11:55 : Invited talk
Circularly Polarized Luminescence from Chiral Lanthanide Phosphate Nanocrystals
U. Hananel, A. Ben Moshe, Gil Markovich
Tel Aviv University (Israel)

We prepared colloidal chiral lanthanide phosphate nanocrystals using chiral molecular templates and studied their chirality through circularly polarized luminescence at the lanthanide emission lines. Some of these emission lines exhibited very large degree of circular polarization, up to $\sim$50 %. High enantiomeric purity of the nanocrystals was obtained using tartaric acid molecular templates.

11:10 - 12:20 — Room 116

Session 2A11

SP40. Innovative Metamaterials I

Organized by: Namkyoo Park and Jeong Weon Wu

Chaired by: Namkyoo Park and Jeong Weon Wu

11:10 : Keynote talk

Making Structured Metal Transparent for Ultra-Broadband Electromagnetic and Acoustic Waves

Mu Wang
Nanjing University (China)

In this talk, I will present our recent studies on making structured metals transparency for ultrabroadband electromagnetic waves and acoustic waves via surface excitations. First, I will show the effect that periodic, quasiperiodic, and disordered metallic gratings can become transparent and completely antireflective for extremely broadband electromagnetic waves at oblique incidence. Further, we develop an approach to design oblique metal gratings that are transparent for broadband electromagnetic waves (including optical waves and terahertz ones) with normal incidence. Thirdly, we demonstrate that the principles of broadband transparency for structured metals can be extended from one-dimensional metallic gratings to two-dimensional scenario. Finally we point out that similar phenomena can be observed in sonic artificially metallic structures, demonstrating transparency for broadband acoustic waves. With this series of studies we try to provide guidelines to develop novel broadband metamaterials, which are promising for applications of transparent conducting panels, antireflective conducting solar cells, broadband acoustic imaging and sensing, etc.

11:40 : Invited talk

Charge-Transfer Dynamics Controlled by Manipulating Dielectric Permittivities with Hyperbolic Metamaterial Structures as Solvent Analogues

Kwang Jin Lee[1], Yiming Xiao[1], Jae Heun Woo[1], Eunsun Kim[1], David Kreher[2], Andre-Jean Attias[2], Fabrice Mathevet[2], Jean-Charles Ribierre[1], Jeong Weon Wu[1], Pascal Andre[3]
[1] *Ewha Womans University (Korea),* [2] *Sorbonne University (France),* [3] *RIKEN (Japan)*

We demonstrate that multilayered hyperbolic metamaterial (HMM) substrates alter charge transfer (CT) dynamics by showing that both charge separation and recombination characteristic times are increased by factors of 2.4 and 1.7, respectively, resulting in longer-lived CT states. We successfully rationalize the experimental data by introducing image dipole interactions in Marcus theory to tune the driving force. The number of metal-dielectric pairs induces a non-local effect formalized in the dielectric permittivity, and is presented as an analogue to local solvent effects.

12:00 : Invited talk

Isospectral transformations for disordered photonics

Sunkyu Yu, Xianji Piao, Choonlae Cho, Namkyoo Park
Seoul National University (Korea)

We introduce isospectral transformations for disordered light-matter interactions. Exploiting supersymmetric transformation, we show a novel disorder having perfect bandgap and confined modes, and demonstrate the switching of disordered light without loss of information. We will also discuss the Householder transformation for interdimensional phase matching.

11:10 - 12:10 — Room 117

Session 2A12

SP19. META-magnetism and interdisciplinary applications IV

Organized by: Ilya Razdolski, David Schmool, Ko-Wei Lin and Vasily Temnov

Chaired by: Ilya Razdolski, David Schmool, Ko-Wei Lin and Vasily Temnov

11:10 : Invited talk
Thermal emission and radiative heat transfer of magneto-optical systems
Ricardo Martin Abraham Ekeroth[1], Antonio Garcia-Martin[1], Juan Carlos Cuevas[2]
[1] *Instituto de Microelectronica de Madrid, Consejo Superior de Investigaciones Cientificas (Spain),* [2] *Universidad Autonoma de Madrid (Spain)*

The thermal emission and the radiative heat transfer between finite objects of arbitrary shape that exhibit magneto-optical activity, is studied using a generalization of the thermal discrete dipole approximation (TD-DA).

11:30 : Invited talk
Extending Magneto-Plasmonics to the Mid IR by the use of the Magneto Refractive effect
Alfonso Cebollada, Fernando Garcia, Gaspar Armelles
IMM-Instituto de Microelectronica de Madrid (Spain)

Magnetoplasmonics combines plasmonic and magneto optic effects, making them to interact and finding great potential in sensing and telecom applications. While this has been so far restricted to the visible and Near IR, here we extend this concept to the Mid IR by substituting the magnetooptic by the magnetorefractive effect (change of refractive index due to magnetic field induced change in electrical resistivity), most effective in the 5-10 microns range. Possible applications of this idea will be introduced.

11:50 : Invited talk
Topological magneto-plasmonics of graphene-based meta-structures
Dmitry Kuzmin[1], Igor Bychkov[1], Vladimir Shavrov[2], Vasily Temnov[3]
[1] *Chelyabinsk State University (Russia),* [2] *Kotel'nikov Institute of Radio Engineering and Electronics of RAS (Russia),* [3] *University of Maine (France)*

In order to explore the non-reciprocal effects, we investigate topological magnetic nanostructures covered with graphene-based meta-surfaces, which consist of a periodic pattern of sub-wavelength stripes of graphene winding around magnetic (meta-)tube or (meta-)torus. We establish the relation between the topological and plasmonic properties in these structures. Elliptical and hyperbolic magneto-plasmonic Fabry-Perot resonances in meta-structures not only manifest the non-reciprocity but display the giant mode splitting.

Lunch and Exhibit Inspection

12:10 - 14:00

14:00 - 15:20 — Room 106

Session 2A13

SP19. META-magnetism and interdisciplinary applications V

Organized by: Ilya Razdolski, David Schmool, Ko-Wei Lin and Vasily Temnov

Chaired by: Ilya Razdolski, David Schmool, Ko-Wei Lin and Vasily Temnov

14:00 : Invited talk
Ultrafast laser control of magnetic materials
A. Donges, S. Gerlach, D. Hinzke, U. Atxitia, Ulrich Nowak
University of Konstanz (Germany)

The manipulation of the magnetization with sub-picosecond laser pulses is attractive for potential information storage device applications. Some magnetic materials can already be switched solely by the effect of a laser pulse, without any external magnetic field involved. We investigate all-optical switching theoretically exploring the spin dynamics, which is triggered by the laser pulse, and distinguishing thermal heating effects from opto-magnetic effects, such as the inverse Faraday effect.

14:20 : Invited talk

All-optical magnetic switching: making use of fundamental magnetic interactions
Andrei Kirilyuk
Radboud University (The Netherlands)

The reversal of magnetization solely with the help of femtosecond laser pulses is an expanding area of research with more and more materials that can be switched, and various mechanisms responsible for switching. Here we concentrate on switching in rare-earth - transition metal alloys, where the inter-sublattice exchange is responsible for switching, as well as magnetic garnets, where the precessional switching is driven by the local change of anisotropy.

14:40 : Invited talk
Ultrafast Magnetization Switching of Ferrimagnetic Oxides
Ilie Radu[1], Radu Abrudan[2], Martin Hennecke[1], Durgamadhab Mishra[1], Clemens von Korff Schmising[1], Thomas Ostler[3], Oksana Chubykalo-Fesenko[4], Alexandra Kalashnikova[5], Roman Pisarev[5], Stefan Eisebitt[1]
[1] *Max-Born Institute Berlin (Germany),* [2] *Helmholtz-Zentrum Berlin (Germany),* [3] *Universite de Liege (Belgium),* [4] *Instituto de Ciencia de Materiales de Madrid - CSIC (Spain),* [5] *Russian Academy of Sciences (Russia)*

We report on the latest developments in our studies on ultrafast magnetism, which reveal very intriguing spin switching phenomena by employing a novel experimental approach combining the femtosecond laser excitation with an ultrafast, element-specific X-ray probing of spins. In particular, by investigating the laser-driven magnetization dynamics in ferrimagnetic iron garnets, we observe an ultrafast magnetization switching process occurring over an extremely long lived ($>>$100 ps) transient ferromagnetic-like state. These findings challenge the current understanding of laser-driven magnetization switching phenomena.

15:00 : Invited talk
Magnetization reversal in granular FePt promoted by near-field laser enhancement
Loic Le Guyader
Stanford Institute for Materials and Energy Sciences (USA)

Using ultrafast small-angle x-ray scattering at an x-ray free-electron laser, the magnetization dynamics of FePt nanoparticles embedded in a carbon matrix after excitation by an optical femtosecond laser pulse is investigated. It is found that some individual FePt nanoparticles neither switch nor demagnetiz, the origin of which is identified as the near-field modification of the incident laser radiation around FePt nanoparticles, as demonstrated by Finite Difference Time Domain simulations.

15:20 - 15:50 — Room 106

Session 2A14

GEN13. Plasmon-enhanced photovoltaics, photocatalysis, and solar fuels

Chaired by: Naresh Das

15:20 : Enhancing Energy Transfer Upconversion in Rare Earth Doped Nano-Crystals using Plasmonic Nano-Arrays
Jon Fisher[1], Amy Hor[1], M. T. Berry[2], P. Stanley May[2], Steve Smith[1]
[1] *South Dakota School of Mines and Technology (USA),* [2] *University of South Dakota (USA)*

Spectroscopic imaging is used to investigate surface plasmon polariton enhanced energy transfer upconversion of rare-earth doped NaYF4:Yb3+,Ln3+ upconverting nano-particles on noble metal nano-structured substrates, including arrays of Au nano-pillars and nano-cavities with optical resonances coincident with rare-earth ion absorption (Yb3+) or emission (Er3+,Tm3+) energies. The mechanisms for the observed enhancement and power dependence are understood through analytical and computational models, relating the observed enhancement to kinetics of the ETU system and the photonic properties of the substrates.

15:35 : Plasmonic and Electrochemical Response of Nanostructured Au-Iron Oxide Composite Films
Naresh Das, Joshua McClure, Kyle Grew, Deryn Chu
U.S. Army Research Laboratory (USA)

We report the plasmonic resonance behavior of nano-structured iron oxide film decorated with gold nano particles. iron oxide film recently has drawn interest for electrocatalytic process including reactions that involve C-C bond breakage. We deposited iron oxide film using electron beam evaporation followed by annealing at 450 C in mixed and pure oxygen environment. We used ellipsmetric and UV-vis spectroscopy technique to characterize nano structured plasmonic film.

14:00 - 16:00 — Room 109

Session 2A15

SP14. Fano resonances in optics and microwaves: Physics and application V

Organized by: Eugene Kamenetskii and Almas Sadreev

Chaired by: Eugene Kamenetskii and Almas Sadreev

14:00 : Invited talk

Dark and bright mode hybridization in plasmonic nanostructures: from electric to magnetic Fano resonances

Andrea Cerea, Simone Panaro, Remo Proietti Zaccaria, Andrea Toma
Istituto Italiano di Tecnologia (Italy)

Strongly coupled plasmonic nano-architectures are ideal systems for promoting Fano resonance excitation. Here we analyze, both theoretically and experimentally, different trimer configurations supporting, respectively, electric and magnetic Fano modes. In particular, by controlling the dark-mode spectral position and the localized surface plasmon resonance retardation (de-phasing), we were able to clarify the role that these two parameters play in the super- and sub-radiant mode hybridization.

14:20 : Invited talk

Perturbation theory for bound states in the continuum on periodic structures

Lijun Yuan[1], **Ya Yan Lu**[2]
[1] *Chongqing Technology and Business University (China),* [2] *City University of Hong Kong (Hong Kong)*

On periodic structures with proper symmetries, guided Bloch modes could exist above the lightline, and they are examples of bound states in the continuum (BICs). Certain BICs on periodic structure are not protected by symmetry in obvious ways. Using a rigorous perturbation theory, we show that these BICs are in fact still closely related to the symmetries.

14:40 : Invited talk

Harnessing Fano resonances for optomechanics

Simone Zanotto
Istituto Nanoscienze - CNR and NEST Laboratory (Italy)

Cavity optomechanics relies on the interplay between light and mechanical resonant degrees of freedom in a micro- or nanophotonic environment. In this contribution we will explore the physics of optomechanical devices based on optical Fano resonances, with insights towards self-sustained mechanical oscillations and electro-opto-mechanical interaction in piezoelectric metasurfaces.

15:00 : Invited talk

Control of electromagnetically-induced-transparency-like effect in metamaterials for coherent storage of electromagnetic waves

Toshihiro Nakanishi, Shinji Tohi, Masao Kitano
Kyoto University (Japan)

We propose tunable metamaterials, which realize the storage and retrieval of elec- tromagnetic waves, in analogy with electromagnetically induced transparency (EIT) effect in atomic systems. The basic concepts are introduced with coupled resonator models, and we experimentally demonstrate the storage and retrieval of electromagnetic waves in microwave regions. Owing to coherent process, the phase information is also recovered in the retrieved signal.

15:20 : Invited talk
Fano-Feshbach resonance in metallic nanohole arrays
Munehiro Nishida, Y. Kadoya
Hiroshima University (Japan)

Variety of surface bound modes in thin metallic nanohole arrays produce complicated band structure. If the different branches co-exist adjacently, multiple bound modes contribute to a resonance and cause a Fano-Feshbach resonance. In this study, we show that appropriate lattice structure of nanohole array yields sharp reflection-transmission spectra. The origin of this resonance is attributed to the coupled-resonator induced transparency (CRIT) between the two surface bound modes based on the analyses using spatial and temporal coupled mode methods.

15:40 : Invited talk
Fano resonance in Bose-Fermi mixtures
M. V. Boev[1], V. M. Kovalev[1], Ivan. G. Savenko[2]
[1] *Siberian Branch of Russian AoS (Russia),* [2] *Institute for Basic Science (Russia)*

This is a theoretical study of the Fano resonance in a hybrid system consisting of spatially separated two-dimensional layers of electrons and excitons interacting by the Coulomb force and exposed to weak magnetic field and light (electromagnetic field). We investigate the conductivity of electrons in this system and show that the electromagnetic power absorption spectrum has a Fano profile. Further we phenomenologically account for the disorder in the system.

14:00 - 15:40 — Room 104-105

Session 2A16

Workshop: Toroidal Electrodynamics and Toroidal Metamaterials II

Organized by: Nikolay Zheludev and Andrey E. Miroshnichenko

Chaired by: Nikolay Zheludev and Andrey E. Miroshnichenko

14:00 : Invited talk
Optical force on toroidal nanostructures: source representation versus field representation
Xu-Lin Zhang, C. T. Chan
The Hong Kong University of Science and Technology (China)

In the electrodynamic multipole expansion, all the charge and current distributions can be expanded into a complete set of contributions from electric, magnetic, as well as toroidal multipoles. However, the radiated far field from all these three types of source can be completely described in terms of electric and magnetic multipoles only, excluding the toroidal ones. We employ optical forces to address this confusion by studying the force acting on toroidal nanostructures in both source representation and field representation.

14:20 : Invited talk
Toroidal cavity resonance in metal-dielectric-metal nanoantenna
Jun Jun Xiao
Harbin Institute of Technology (China)

We show that in judiciously designed metal-dielectric-metal (MDM) nanoantenna, the toroidal dipole resonance may arise and dominate. Furthermore, toroidal-like cavity resonances can be excited and controlled. More interestingly, it is possible to tune the coupling interactions between such cavity modes and the antenna mode, yielding significant scattering enhancement and suppression of the MDM nanoantenna. The results are interpreted as Fano-like and/or electromagnetically-induced transparency like phenomena by a coupled oscillator model.

14:40 : Invited talk
Dielectric nanoantennas: exploiting anapole modes and low-loss behavior for near-field localization of near-infrared and visible radiation

Stefan Maier
Imperial College London (United Kingdom)

We discuss avenues for near-field focusing of electromagnetic radiation in the visible and near-infrared regime of the electromagnetic spectrum. A special focus will lie on the exploitation of anapole modes - coherent superpositions of electric and toroidal dipolar modes - in order to efficiently localize electric field energy in dielectric nanostructures. Materials systems to be presented include Ge, GaP, and hybrid dielectric/metallic nanoantennas.

15:00 : Invited talk
On-chip Ultrafast Sources Based on Near-eld Anapole Lasers
Juan Sebastian Totero Gongora[1], Andrey E. Miroshnichenko[2], Yuri Kivshar[2], Andrea Fratalocchi[1]
[1] *KAUST (Saudi Arabia),* [2] *Australian National University (Australia)*

We discuss an all-dielectric integrated source of ultrafast optical pulses by finely tuning the mutual interaction and synchronization of near-eld nanolasers emitting at the anapole frequency.

15:20 : Invited talk
Steering light by tailored excitation of nano-antennas and applications to nano-metrology
Z. Xi, H. P. Urbach
Delft University of Technology (The Netherlands)

Far field methods based on the interaction of spatial mode of light with ultra-compact resonant optical antenna are proposed to measure deep subwavelength displacement. The realm of combining optical antenna theory with spatial modes will open intriguing applications in nano-metrology and provide new insights into fundamental far field subwavelength detection technique.

14:00 - 15:05 — Room 107-108

Session 2A17

SP7. Transformation Optics concept and applications II

Organized by: Shah Nawaz Burokur, Andre de Lustrac and Jianjia Yi

Chaired by: Shah Nawaz Burokur, Andre de Lustrac and Jianjia Yi

14:00 : Invited talk
Free-standing and conformable Optical Metasurfaces
Gauthier Briere[1], Peinan Ni[1], Jun Rong Ong[2], Hong Son Chu[2], Patrice Genevet[1]
[1] *Cote d'Azur University (France),* [2] *Institute of High Performance Computing (Singapore)*

We have designed and optimized freestanding silicon and GaN based metasurface deflectors for the mid-infrared and visible wavelengths. Our metasurfaces are fabrication friendly and have high transmission efficiency due to the lack of substrate and fulfillment of Kerker's conditions. We will conculde this presentation with a discussion on the concept of conformal boundary optics to engineer the transmission and reflection of light at arbitrarily-shaped interfaces.

14:20 : Detecting the spatial chirp signals by fractional Fourier lens with transformation materials
Jing Chen, Jin Hu
Beijing Institute of Technology (China)

Detecting the rate of frequency change or chirp rate (CR) of a spatial chirp signal is important in some optical applications. With the help of transformation optics, the improved fractional Fourier lens can be designed to adjust the CR as well as the focusing location of the given input chirp signals. In consequence the CR detection precision can be improved and the range of the input signals can be extended. The numerical simulations verified the design.

14:35 : Designing transformation optics devices for wave vectors manipulation
Mircea Giloan, Robert Gutt, Gavril Saplacan

Company for Applied Informatics (Romania)

The devices designed using a transformation optics approach are mainly accomplishing their functionality by inducing specific manipulations of the wave paths through coordinate transformations. In this study we analyze how the wave vectors can be manipulated as the waves propagate in transformation media derived from a specific class of coordinate transformations. We provide a powerful method for designing electromagnetic devices able to accomplish different functions by inducing proper manipulations of the wave vectors generated by appropriate coordinate transformations.

14:50 : Transformational Fluctuation Electrodynamics: Application to Thermal Radiation Illusion
Ahmed Alwakil[1], Myriam Zerrad[1], Michel Bellieud[2], Denis Veynante[3], Franck Enguehard[3], Nathalie Rolland[4], Sebastian Volz[3], Claude Amra[1]
[1]*Aix Marseille University (France),* [2]*Montpellier University (France),* [3]*Ecole Centrale Paris (France),* [4]*Lille University (France)*

We apply transformation optics to the field of thermal radiation where fluctuational electrodynamics is shown to be invariant under transformation optics. We show that thermal camouflage/cloaking can be possibly realized using the proposed theory.

15:05 - 16:05 — Room 107-108

Session 2A18

GEN1. Plasmonics and nanophotonics V

Chaired by: Masanobu Iwanaga

15:05 : Analyzing a 3D Far Field of Plasmonic Ruler Based on Double Metal Blocks
Eunso Shin, Young Jin Lee, Seokhyeon Hong, Kihwan Moon, Soon-Hong Kwon
Chung-Ang University (Korea)

In a manufacturing process, sensing a structure is challenging theme. For sensing the nano-size structure, we propose analyzing the 3D far field of plasmonic ruler which composed of two silver nanoblocks separated by 10 nm thickness of an air gap. When upper nanoblock slightly shifted to x or y-axis, it causes the considerable change of far field of the specific wavelength, which occurs plasmonic coupling, in comparison with original one. This change of far field cans simply detecting structure.

15:20 : Silver nanoparticles with many sharp apexes and edges as efficient nanoresonators for shell-isolated nanoparticle-enhanced Raman spectroscopy
Karol Kolataj, Jan Krajczewski, Andrzej Kudelski
University of Warsaw (Poland)

One of the tools which is used for investigations of various interfaces, especially in the in situ conditions, is shell-isolated nanoparticle-enhanced Raman spectroscopy - SHINERS. In this contribution we tested decahedral and prismatic silver nanoparticles containing a large number of sharp apexes and edges as nanoresonators in SERS and SHINERS measurements. We found that the SERS enhancement factors obtained in the experiments with such anisotropic nanoparticles are ca. one order of magnitude larger than in experiments with spherical nanostructures

15:35 : Nonlinear Optical Responses under Weak Excitation Regime from Embedded Quantum Dots in Semiconductors Covered by Plasmonic Metasurfaces
Masanobu Iwanaga, Takaaki Mano, Naoki Ikeda
National Institute for Materials Science (NIMS) (Japan)

We fabricated an optimized plasmoinc metasurface on bulk semiconductor of GaAs to improve extraction efficiency of photoluminescence (PL) emitted from embedded quantum dots. We found that the PL intensity is approximately square to the excitation power even under weak excitation conditions. The metal-semiconductor system is an essential nonlinear system, suggesting the potential for high-performance plasmon-merged semiconductor devices.

15:50 : Spectroscopic investigation of localized surface plasmon resonator structure by infrared nanoscopy near the plasma frequency
Yi Huang[1], Julien Vaillant[1], Franziska Barho[2], Maria Jose Milla[2], Mario Bomers[2], Fernando Gonzalez-Posada[2], Laurent Cerutti[2], Thierry Taliercio[2], Aurelien Bruyant[1]
[1] *University of Technologie de Troyes (France),* [2] *Institut d'Electronique et des Systemes (France)*

We present a nanoscopic investigation of optical modes near plasma frequency of a highly doped semiconductor structure. With a phase sensitive mid-IR s-SNOM [1], we imaged the complex field distribution of localized surface plasmonic resonators and we obtained near-field optical amplitude and phase spectrum containing precise information on the dieletric function of the sample, in agreement with simulations. Moreover, our finding corroborates a formal link between Local Density of Optical States and phase information scattered by a local emitter.

14:00 - 16:15 — Room 110-111

Session 2A19

SP23. Periodic Systems with Glide Symmetry

Organized by: Rhiannon Mitchell-Thomas and Guido Valerio

Chaired by: Simon Arthur Robin Horsley and Guido Valerio

14:00 : Invited talk
Chiral Optics of Planar Metamaterials
Eric Plum[1], Nikolay I. Zheludev[2]
[1] *University of Southampton (United Kingdom),* [2] *Nanyang Technological University (Singapore)*

Any planar structure can be superimposed with its mirror image. Despite lacking conventional chirality, planar metamaterials exhibit stronger and more diverse chiral optical effects than conventional materials. Planar chirality associated with the twist of flat spirals and mirror asymmetry introduced by the direction of illumination give rise to directional transmission asymmetries, giant linear and nonlinear optical activity, circular polarization reflectors and perfect absorbers as well as wavevector selective spectral filters.

14:20 : Invited talk
Nonsymmorphic topological photonic crystals
Ling Lu
Chinese Academy of Sciences (China)

After discussing the consequences of band dispersions of glide, screw and time-reversal symmetries, I will show examples of 2D photonic crystal waveguides and 3D photonic crystal waveguides with glide and time-reversal symmetries. At last, I will present a 3D magnetic topological photonic crystal hosting a single surface Dirac cone, protected by glide reflections. Such a gapless surface state is fully robust against random disorder of any type.

14:40 : Invited talk
Cost-effective Integrated Waveguide Circuits at High Frequencies Using Glide-Symmetric EBG Structures
Mahsa Ebrahimpouri, Oscar Quevedo-Teruel
KTH Royal Institute of Technology (Sweden)

Here, we present a cost-effective and easy method to manufacture integrated waveguide circuits at high frequencies. Glide-symmetric holey EBG structure enables us to realize gap-waveguide technology economically since it only requires drilling holes on metallic plates and larger periodicity of it with respect to the pin-type EBG at the same frequency results in higher accuracy of manufacturing at high frequencies. Introducing this method provides a way for mass production of gap waveguide technology at high frequencies.

15:00 : Invited talk
Symmetry properties of planar particle arrays and their role for non-reciprocal and one-way guiding

Yarden Mazor, Ben Zion Steinberg
Tel Aviv University (Israel)

Resonant particle arrays have been considered as waveguides for various applications. We present a general theory for analyzing the breach of geometrical symmetries required to allow for non-reciprocal guiding and optical isolation. Both, the unit cell symmetry and the properties of the particles themselves play a role in this study. The structure symmetry can be combined with specific particles properties to yield various wave phenomena. Their role in achieving non reciprocity, non-even dispersion, and one-way guiding, will be discussed.

15:20 : Invited talk
Generalized glide symmetry and topological edge states in layered media
Simon Arthur Robin Horsley
University of Exeter (United Kingdom)

In this talk I shall discuss the theory of glide symmetry andits generalization to include mixtures of translation and polarizationtransformation, or translation and time reversal. Following from thisI shall discuss the existence of edge states at the interface betweentwo such stacks of slabs, finding the relationship between theZak phase and the surface impedance of each stack.

15:40 : Invited talk
Mesoscopic Crystals with Glide Symmetry Planes for Electric Displacement Manipulation
Jonghwa Shin, Taeyong Chang, Yong-Hee Lee
Korea Advanced Institute of Science and Technology (Korea)

Mesoscopic crystals with deep-subwavelength unit cells can be designed to manipulate the effective electric permittivity tensor over a broad frequency bandwidth. Especially, crystals with glide planes can have a giant macroscopic electric displacement while the mesoscopic electric displacement field averaged over the dielectric region in a unit cell is very small. The relative magnitudes of the individual elements of the effective permittivity tensors are affected by the symmetry of the crystal.

16:00 : Symmetry protected topological states of acoustic Kagome lattices
Xiang Ni[1], Maxim Gorlach[2], Andrea Alu[3], Alexander Khanikaev[1]
[1] *City College of New York (USA),* [2] *ITMO University (Russia),* [3] *The University of Texas at Austin (USA)*

We demonstrate that an acoustic Kagome lattice formed by an array of interconnected resonant cavities exhibits a new class of topological states protected by C3 symmetry. This acoustic topological metamaterial exhibits a topological transition when a detuning is introduced between the inter-cell and intra-cell hopping amplitudes. The edge states emerge on either truncated ends of the lattice terminated by a cladding layer or at the domain walls between topologically nontrivial and trivial domains.

14:00 - 16:00 — Room 113

Session 2A20

Symposium II. Recent Advances in Complex Materials and Nanophotonics VII

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

14:00 : Invited talk
Electromechanically Tunable Metal-Air-Metal Nanocavity
Junichi Takahara
Osaka University (Japan)

We demonstrate an electromechanically tunable metal-air-metal structure based on a gold nanowire suspended on a gold substrate in visible range. By applying voltage to the nanowire, the suspended nanowire can be pull down by the electrostatic force, resulting in scattering spectral change due to Fabry-Perot resonance of a plasmonic nanocavity. Such nanocavity provides a promising route for achieving dynamical control of the

interaction between surface plasmon and inserted objects such as fluorescent molecules or quantum dots in the gap.

14:20 : Invited talk
Plasmonic Enhancement of Light-matter Interaction in Planar Materials
Hossein Taghinejad, Syed Hamed Shams, Tianren Fan, Mohammad Taghinejad, Ali A. Eftekhar, Ali Adibi
Georgia Institute of Technology (USA)

This talk is focused on the integration of 2D TMDC nanostructures with plasmonic nanostructures to considerably enhance their optical properties for enabling new devices for light emission and detection. It is shown that by using a carefully engineered plasmonic nanocavity, orders of magnitude improvement in light-matter interaction in these hybrid materials can be achieved. Supported by theoretical calculations, this technique will be experimentally presented for a variety of hybrid nanostructures.

14:40 : Invited talk
Active plasmon injection assisted negative index flat lens for noise free for sub-diffraction limited imaging
Anindya Ghoshroy, Wyatt Adams, Xu Zhang, Durdu Guney
Michigan Technological University (USA)

We illustrate an active loss compensation scheme for a non-ideal negative index flat lens (NIFL), based on the recently developed plasmon injection or PI scheme. The scheme is applied to an image spectra where, noise similar to real imaging systems, is artificially added. An external auxiliary source is used to amplify high spatial frequency features of the object. The compensation scheme improves SNR and has the potential to be extended to higher spatial frequencies.

15:00 : Invited talk
Optimizing the Growth of Strontium Molybdate Thin Films for Plasmonic and Nanophotonic Applications
Matthew Wells, Bin Zou, Brock Doiron, Andrei Mihai, Neil Alford, Stefan Maier, Peter K. Petrov
Imperial College London (United Kingdom)

Strontium molybdate thin films have been studied by means of ellipsometry, xRD, and DC resistivity measurements in order to evaluate their potential use in the advancing field of plasmonics and nanophotonics. SrMoO3 (SMO) thin films were grown by pulsed laser deposition on three types of substrate: LaAlO3, MgO, and SrTiO3. It is shown that SrMoO3 exhibits tunable plasmonic behaviour at wavelengths above 600 nm with losses comparable to those of gold.

15:20 : Invited talk
Chirality of topological gap solitons in bosonic dimer chains
Dmitry D. Solnyshkov, O. Bleu, B. Teklu, G. Malpuech
University Clermont Auvergne/CNRS (France)

We study gap solitons which appear in the topological gap of 1D bosonic dimer chains within the mean-field approximation. We find that such solitons have a non-trivial texture of the sublattice pseudospin. We reveal their chiral nature by demonstrating the anisotropy of their behavior in presence of a localized energy potential.

15:40 : Invited talk
Advantages of MDM plasmonics waveguide for Kerr nonlinearities
Stefano Palomba, Guangyuan (Clark) Li, C. Martijn de Sterke
University of Sydney (Australia)

Photonics structures are currently the leading platform for on-chip nonlinear optical application. However, limitations in compactness, interfacing with electronics and broadband operations have open the path to complementing and competing platforms such as the base based on plasmonic structures. However, we showed here how plasmonic structures perform better than any other platform by harnessing efficiently the material nonlinearities manly thanks to a slow-light effect, exhibiting a different behavior than the one in dielectrics.

14:00 - 16:00 — Room 114

Session 2A21

SP25. APhoto/Thermal Conversions and Their Applications with Photonic Crystal, Plasmonics and Metamaterials II

Organized by: Qiang Li and Hui Liu

Chaired by: Qiang Li and Hui Liu

14:00 : Invited talk
Thermal emission control by semiconductor photonic crystals
Takashi Asano, Masahiro Suemitsu, Takuya Inoue, Susumu Noda
Kyoto University (Japan)

We demonstrated mid-infrared narrowband thermal emitters by combining multiple quantum wells (MQWs) and two-dimensional photonic crystal slabs. Ultrafast modulation ($\sim$MHz) of thermal emission without changing the temperature of emitters has been also realized by changing the electron density of MQWs using applied electric field. We have also demonstrated near-infrared narrowband thermal emitters recently by using arrays of nano-rods made of intrinsic silicon, which can be utilized to increase the efficiency of thermophotovoltaic power generation.

14:20 : Invited talk
Metamaterials for Spectroscopic Infared Emitters and Sensors
Tadaaki Nagao, T. D. Dao, K. Chen, S. Ishii, T. Yokoyama
National Institute for Materials Science (Japan)

By adequately designing their size and geometry, metal nano-structures offer highly efficient light/heat absorption with desired spectral features. We report our recent study on the design, fabrication, and characterization of spectrally selective narrow-band plasmonic metamaterial perfect absorbers for the effective applications in wavelength-selective thermal emitters, infrared detectors as well as high-sensitivity bio-sensing.

14:40 : Invited talk
Tungsten based metamaterials and photonic crystals for selective thermal emitters
Alexander Petrov[1], Katrin Knopp[1], Slawa Lang[1], Elisabeth Leib[2], Jefferson do Rosario[3], Sean Molesky[4], Zubin Jacob[4], Tobias Krekeler[5], Martin Ritter[5], Michael Stormer[6], Tobias Vossmeyer[2], Horst Weller[2], Gerold Schneider[3], Manfred Eich[1]
[1] Hamburg University of Technology (Germany), [2] University of Hamburg (Germany), [3] Institute of Advanced Ceramics - TUHH (Germany), [4] University of Alberta (Canada), [5] Electron Microscopy Unit - TUHH (Germany), [6] Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (Germany)

In order to tailor thermophotovoltaic emitters to match specific photovoltaic receivers we designed spectrally selective emitters that have close to black body emission at short wavelengths and substantially reduced emission at long wavelengths. We demonstrate selective band-edge emitters based on a W-HfO2 refractive multilayer metamaterial and a ZrO2 opal monolayer on tungsten both stable up to 1000° C. Conditions for improved selectivity and higher thermal stability will be presented as well.

15:00 : Invited talk
Superradiant and superscattering in thermal and light energy conversion
Zongfu Yu
University of Wisconsin Madison (USA)

When wave effects of thermal photons become significant, thermal emitters can exhibit intriguing coherent effects. Here, we show that the superradiant emission, which was originally found in quantum emitters, can be realized in resonant thermal emitters. In addition, we will discuss superscattering of optical resonance around the Wely point in photonic crystals.

15:20 : Invited talk
Light-induced pulling and pushing by synergic effect of optical force and photophoretic force
Min Qiu, Jinsheng Lu, Hangbo Yang, Lina Zhou, Yuanqing Yang, Si Luo, Qiang Li

Zhejiang University (China)

Optical force has been widely utilized to manipulate microscopic objects, though mostly in vacuum or in liquids. Photophoretic force provides an alternative and effective way to transport light-absorbing particles in ambient gases. However, in most cases these forces work independently. Here, by employing the synergy of optical force and photophoretic force, we propose and experimentally demonstrate a configuration which can drive a micron-size metallic plate moving back and forth on a tapered fiber with supercontinuum light in ambient air.

15:40 : Invited talk
Self-assembled Three Dimensional Plasmonic Absorbers for Solar Thermal Conversion
Lin Zhou, Jia Zhu
Nanjing University (China)

Nanostructures enabled solar thermal conversion has aroused tremendous interest in the field of solar energy applications. Here we will report our progresses on the self-assembled plasmonic nanostructures assisted solar thermal conversion, which includes the design and fabrication of the most broadband plasmonic absorbers, tunability of absorption bandwidth, as well as the first plasmon enhanced solar desalination device. Our results may provide a competitive solution to the cost-effective and highly efficient solar desalination strategies for personalized applications.

14:00 - 15:40 — Room 115

Session 2A22

Symposium I. Hybrid Optically Active Nanomaterials V

Organized by: Xing Yi Ling, Jerome Plain and Alexander Govorov

Chaired by: Xing Yi Ling, Jerome Plain and Alexander Govorov

14:00 : Invited talk
Plasmonic nanostructures in thin film generated by laser induced self-organization processes
Nathalie Destouches[1], Zeming Liu[1], Jan Siegel[2], Marie Vangheluwe[1], Said Bakhti[3], Daniel Slaughter[3], Ali Belkacem[3]
[1] Lyon University (France), [2] Laser Processing Group-Instituto de Optica (Spain), [3] Lawrence Berkeley National Laboratory (USA)

Controlling plasmonic systems with nanometre resolution over large non-planar areas with high flexibility and speed is of strategic importance for spreading their use in various industrial fields. Using light to trigger self-organization processes controlled by non-linear feedback mechanisms is a unique strategy to meet this challenge. Here, we open a new route for the ultrafast laser-induced self-organization of metallic nanostructures in 3D and we characterize the self-organization processes through time-resolved polarization imaging.

14:20 : Invited talk
Compact plasmonic resonance shift sensors
Andreas Horrer, Jonas Haas, Patricia S. Blach, Valentin Henken-Mellies, Sarah El-Asfar, Viktoria Wedler, Sabrina Rau, Katrin Krieg, Kathrin Freudenberger, Lothar Leidner, Gunter Gauglitz, Dieter P. Kern, Monika Fleischer
Eberhard Karls University Tuebingen (Germany)

Different fabrication approaches for nanostructured localized surface plasmon resonance (LSPR) sensors will be presented and their sensitivities evaluated. A miniaturized setup based on gradient index lenses will be shown.

14:40 : Invited talk
Local electromagnetic flip-flop in plasmonic infrared trimer nanoantenna
Yinping Zhang[1], Guillaume Demersy[2], Davy Gerard[1], Stephanie Dodson[3], Qihua Xiong[3], Jerome Plain[1], Nicolas Bonod[2], Renaud Bachelot[1]

[1] *Universite de Technologie de Troyes (France),* [2] *Institut Fresnel (France),* [3] *Nanyang Technological University (Singapore)*

We investigated light spatial localization in an infrared nanoantenna consisting of a gold trimer. The study is based on two-photon molecular motion in azobenzene-containing photopolymers. It is shown that different electromagnetic hot spots can be tuned and controlled, on demand, with an external plane wave. 4-digit plasmonic combination was also discussed.

15:00 : Invited talk
Enhancement of the Activity of Plasmonic Photocatalysts
Jianming Zhang[1], **Jerome P. Claverie**[2], **Xin Jin**[3], **Luca Razzari**[3]
[1] *Jiangsu University (China),* [2] *Sherbrooke University (Canada),* [3] *Institut National de la Recherche Scientifique, Energie, Materiaux et Telecommunications (Canada)*

Plasmonic photocatalysts are widely popular as they permit an efficient utilization of the solar spectrum in photocatalysis. However, they usually require a noble metal component, which precludes a large scale deployment of such devices. We present here two strategies to increase their activity, and thus to reduce the amount of noble metal.

15:20 : Invited talk
Generalized Theory of Foerster-Type Nonradiative Energy Transfer in Nanostructures with Mixed Dimensionality: Confinement Dimension vs Stacking Dimension
Pedro Ludwig Hernandez Martinez[1], **Alexander O. Govorov**[2], **Hilmi Volkan Demir**[1]
[1] *Nanyang Technological University (Singapore),* [2] *Ohio University (USA)*

We report a generalized theory for the Foerster-type nonradiative energy transfer (NRET), which includes the derivation of the effective dielectric function due to the donor in different confinement geometries and the derivation of transfer rates distance dependencies due to the acceptor in different confinement geometries, including mixed dimensionality in arrays. These accounts for the transfer rates in all possible combinations of different cofinement geometries and assembly architectures. Thus, we obtain a unified picture of NRET in assembled nanostructures arrays.

14:00 - 15:40 — Room 116

Session 2A23

SP2. Functional Materials and Devices for Acoustic and Elastic Waves II

Organized by: Guancong Ma and Yun Lai

Chaired by: Guancong Ma and Yun Lai

14:00 : Keynote talk
Extreme elastic anisotropy - realization by metamaterials
Yoon Young Kim
Seoul National University (Korea)

While extreme effective material properties, such as negative or very large density and stiffness, have been explored significantly, studies on the realization of extreme anisotropy has not received much attention. Particularly for elastic media that are characterized by 4th-order tensor field, a wide spectrum of material anisotropy can be envisioned. As illustrative cases of extreme anisotropy, one can make shear modulus equal to or even larger than longitudinal modulus for which unique wave phenomena known as conical refraction or polarization anomaly can take place.

14:30 : Beating Diffraction Limit using a three-dimensional metamaterial absorber
Guancong Ma[1], **Xiying Fan**[1], **Fuyin Ma**[1], **Ping Sheng**[1], **Mathias Fink**[2]
[1] *Hong Kong University of Science and Technology (China),* [2] *ESPCI Paris Tech (France)*

A focal spot is bounded by diffraction limit, which has a dimension of half of wavelength. This limit arises through the destructive interference between converging and diverging waves, which eliminate the singularity

at the center of the focal spot, and gives rise to its sinc-function shape. We design a three-dimensional sub-wavelength absorber using acoustic metamaterial, and show with a time-reversal focusing experiments that by reducing the diverging waves, the focal spot is smaller than the diffraction limit.

14:45 : Invited talk
Tailoring locally resonant metamaterials: from local modifications to metamaterial crystals
Nadege Kaina[1], Fabrice Lemoult[1], Simon Yves[1], Romain Fleury[1], Thomas Berthelot[2], Mathias Fink[1], Geoffroy Lerosey[1]
[1] *ESPCI ParisTech (France),* [2] *CEA Saclay (France)*

Starting from the very simple example of a soda can metamaterial (an acoustic mediummade of Helmholtz resonators), we explain the propagation of waves in locally resonant mediawithout involving homogenized parameters. This allows us to highlight the importance of multiplescattering even at this deep subwavelength scale. This, in turns, permits to envisage exoticphenomena such as subwavelength control of waves, slow waves, negative refraction with a singlenegative medium or topological metamaterial crystals.

15:05 : Invited talk
Tailoring the microstructure of bubble metamaterials for super absorption or negative refraction of water-borne acoustic waves
John Hilton Page[1], Reine-Marie Guillermic[1], Maxime Lanoy[1], Anatoliy Strybulevych[1], Eric Lee[1], Fabrice Lemoult[2], Geoffroy Lerosey[2], Valentin Leroy[3], Arnaud Tourin[2]
[1] *University of Manitoba (Canada),* [2] *ESPCI ParisTech (France),* [3] *Universite Paris-Diderot (France)*

Two- and three-dimensional bubble metamaterials can be tuned to enable a variety of interesting functionalities for acoustic waves by exploiting the low-frequency Minnaert resonance of the bubbles. Here we show how a broadband coherent perfect absorber for ultrasonic waves can be created from a bubble metalayer, and how doubly negative behaviour can be realized in three-dimensional bubble metamaterials.

15:25 : Anisotropic metasolids for elastic wave control
Yong Cheng, Jiahui Huang, Hongkuan Zhang, Xiaoming Zhou
Beijing Institute of Technology (China)

We have proposed a structured metasolid, which can be homogenized into an elastic continuum with both stiffness and inertial anisotropy. Effective medium parameters have been retrieved from band structure results and have shown the orthotropic properties in elasticity and inertial mass. This anisotropic metasolid fulfills the requirement of transformation elastic mediums under some special coordinate transformations in which the Navier elastodynamic equation retains its original form. We study some elastic wave controlling examples based on the proposed metasolids.

14:00 - 16:05 — Room 117

Session 2A24

SP40. Innovative Metamaterials II

Organized by: Namkyoo Park and Jeong Weon Wu

Chaired by: Namkyoo Park and Jeong Weon Wu

14:00 : Invited talk
Charge transfer emission control by nonlocal dielectric constant near hyperbolic metamaterial structure
Kwang Jin Lee[1], Yeon Ui Lee[1], Frederic Fages[2], Jean-Charles Ribierre[1], Jeong Weon Wu[1], Anthony D'Aleo[1]
[1] *Ewha Womans University (Korea),* [2] *Aix Marseille University (France)*

Hyperbolic metamaterial (HMM) enables to manipulate nonlocal dielectric environment to control photo-induced energy and charge transfers. Here, we address how nonlocal effect of HMM modifies ICT emission spectral features in a way distinct from local effect. A 7nm blueshift is observed in intramolecular charge

emission from DCM dye dispersed into a polymer matrix, accounted for by 7 % reduction of nonlocal dielectric constant based on Lippert-Mataga formalism. Such a capability of spectral shift control opens new means of designing devices

14:20 : Invited talk
Time-resolved pump-probe measurement of optical rotatory dispersion in chiral metamaterial
Jae Heun Woo[1], Boyoung Kang[1], Minji Gwon[1], Ji Hye Lee[1], Dong-Wook Kim[1], William Jo[1], Dong Ho Kim[2], Jeong Weon Wu[1]
[1] *Ewha Womans University (Korea),* [2] *Yeungnam University (Korea)*

Transient optical rotatory power (ORP) of chiral metamaterial is measured to clarify the temporal development of ORP by exciting d-band electrons to the conduction p-band of Au using a circularly polarized light pump beam. Three distinct transient behaviors are identied, resulting from different energy relaxation processes of hot electrons that occur during a period of a few picoseconds after pumping.

14:40 : Keynote talk
Second order optical nonlinearity in metamaterials
Teruya Ishihara
Tohoku University (Japan)

By designing sub-wavelength structure, it is possible to endow a new response that is not obtained in nature. In thi spaper, various secdond order optical nonlniearities including second harmonic generation, optical rectification and electro-optic effects are discussed in the same platform for metamaterials.

15:10 : Experimental Investigation of Transparent Conducting Oxide N-CNT doped ZnO
Maryama Hammi[1], Naseem Abbas[2], Younes Ziat[1], Amine Slassi[1], Anas Benyounes[1]
[1] *University of Mohammed V (Morocco),* [2] *University of Central Punjab (Pakistan)*

CNT -ZnO and N-CNT -ZnO thin films were prepared using sol gel method, to extract their usefulness in photovoltaic applications. The optical and electrical properties have been investigated in this research. The electrical conductivity has found to be more imperative for ZnO films filled with N-CNTs. This finding is pretty explained by the electronic conduction hold by nitrogen as charge carriers within carbon nanotubes which provide higher performance to the active layer.

15:25 : Invited talk
Overlapped multiple Mie resonances in high-index dielectric structures
I. C. Seo, E. Lee, B. H. Woo, Young Chul Jun
Ulsan National Institute of Science and Technology (UNIST) (Korea)

We investigate multiple Mie resonances in high-index dielectric structures. Especially, we study spectral (Fano resonances and Superscattering) and spatial (Beam steering) features that occur in overlapped multiple Mie resonances. We also explore the possible applications of these dielectric structures in sensing and spectroscopy.

15:45 : Invited talk
Direct and quantitative measurement of far-field light scattering of a single optical nanostructure
Jinhyung Kim, Donghyeong Kim, Min-Kyo Seo
NanoCentury-KAIST (Korea)

We present for the first time the quantitative measurement of the far-field light scattering properties of a single optical nanostructure. A goniometer-based solid angle scanning enables us to overcome the limitations of the conventional back-focal-plane method and quantitatively measure the differential scattering cross-section of a single metal nanorod and its far-field distribution over the full hemisphere. We expect that the angle- and spectrum-resolved far-field measurements will be highly useful for evaluating the performances of optical nano-devices and metamaterials.

Coffee Break and Exhibit Inspection

Sponsored by POSTECH Mechanical Engineering Department

Session 2P2

Poster Session IV

16:00 - 16:40

P1: Flexible Microstrip Polymer-Conductive Fabric Grid Array Antenna for Wearable Applications
M. R. Ramli, S. K. A. Rahim, W. Y. Yong, M. I. Sabran
Universiti Teknologi Malaysia (Malaysia)

A flexible microstrip grid array antenna that established using copper conductive fabric as the conducting element deposited on the Polydimethysiloxane (PDMS) as it substrate is presented. The design is made up from a rectangular geometry which consists of 19 cells that build up by 22 radiating elements to provide a resonant frequency at 15 GHz. The proposed design managed to provide a 40 % bandwidth at -10 dB bandwidth performance with a maximum gain up to 14.6 dBi at normal condition.

P2: A Low-Profile Paper-based Inkjet Printed Frequency Selective Surface using Modified Square Loop for x-band Shielding
Wai Yan Yong[1], Sharul Kamal Abdul Rahim[1], H. A. E. Elobaid[1], Nurul Afiqah Remli[1], F. C. Seman[2], Mohamed Himdi[3]
[1] *Univerisiti Teknologi Malaysia (Malaysia),* [2] *Universiti Tun Hussein Onn Malaysia (Malaysia),* [3] *University of Rennes 1 (France)*

The paper demonstrates a contemporary, flexible and economical frequency selective surface that designed from Modified Square Loop element. The FSS is realize using inkjet printing technique to deposit silver nano-particle ink on top of paper substrate to provide a shielding of x-band signal at 10GHz with attenuation up to 30dB. The FSS manage to provide a stable performance over TE and TM polarization with angle of incident up to 45°.

P3: A Modified Theta shaped Double Negative Metamaterial for Satellite Application
Jubaer Alam, Mohammad Rashed Iqbal Faruque, Mohammad Tariqul Islam
Universiti Kebangsaan Malaysia (Malaysia)

The paper imparts the architecture of a modified theta-shaped double negative metamaterial unit cell that is felicitous for dual band of microwave frequency. To justify the performance of the proposed resonator an analogy is conferred on transmission coefficient, relative permeability, permittivity and refractive index. A correlation is made on the performance after the analysis of unit cell and array structures. Due to its auspicious design, double-negative characteristics and the proposed metamaterial has potential to be used for satellite application.

P4: Design of Anisotropic Metamaterials by Topology Optimization
Byungseong Ahn, Hyung Jin Lee, Yoon Young Kim
Seoul National University (Korea)

While the resonance mechanism has been utilized for metamaterial design, extreme anisotropy has been less explored. There is indeed a wide range of material properties including extreme anisotropy, which may not be realized without designing metamaterials. Here, we present a design method suitable for anisotropic metamaterials by topology optimization. Specific design problems in consideration are those that require the tailoring of the Equi-Frequency Contour and field polarization. As a design application, we consider the design of wave-mode converting metamaterial.

P5: Phase transitions in periodic photonic structures
Mikhail Rybin, Sergey Li, Kirill Samusev, Dmitry Filonov, Anton Nikulin, Yuri Kivshar, Mikhail Limonov
ITMO University (Russia)

We study phase transitions between metamaterials and photonic crystals by employing an inverse dispersion method that allows to construct a phase diagram for periodic structures composed of materials with high

dielectric index including silicon and Ge-Sb-Te alloys. Our theoretical results are confirmed by microwave experiments with tunable metacrystals.

P6: A Low-Cost Paper-based Inkjet-Printed Frequency Selective Surface for x-band Screening
Wai Yan Yong[1], Sharul Kamal Abdul Rahim[1], H. A. E. Elobaid[1], Nurul Afiqah Remli[1], F. C. Seman[2], Mohamed Himdi[3]
[1] *Univerisiti Teknologi Malaysia (Malaysia),* [2] *Universiti Tun Hussein Onn Malaysia (Malaysia),* [3] *University of Rennes 1 (France)*

A low-cost paper based frequency selective surface for x-band frequency shielding is presented in this paper. The proposed FSS contains the unit cell made of single ring loop element with paper as its novel substrate. The designed FSS provide a band-stop response at 10 GHz with minimum 35 dB shielding effectiveness. It also exhibits angular stability up to 45° for both TE and TM mode fields. A prototype is fabricated using inkjet printing method.

P7: Space transformation based multi-beam generation lens antenna
Rui Feng[1], Jianjia Yi[1], H. Zhang[1], A. de Lustrac[2], S. N. Burokur[3]
[1] *Xidian University (China),* [2] *Paris Sud University (France),* [3] *Paris Ouest University (France)*

A 3D flat cuboid shaped lens calculated by spatial light transformation method for electromagnetic field shaping is proposed. The lens is capable of generating multi beams by reshaping the omnidirectional emission of a monopole antenna into four or more beams. Such manipulation is simulated and analyzed by solving the Laplace's equation. The design implies a potential 3D realization with all-dielectric gradient refractive index metamaterials.

P8: Construction methods of auxetic structures with hourglass shaped units and its application to smart transformation optics
Junhyun Kim, Kyoungsik Kim
Yonsei University (Korea)

In this paper, we illustrate the methods of constructing structures with negative Poisson's ratio with rigid sliding units. By numerical evaluation we describe its mechanical properties and show structures exhibit auxetic behavior indeed. We discuss its future productivity and its application to smart transformation optics.

P9: Mue-negative metamaterials seen as band-limited non-Foster impedances for magnetic coupled systems
Jorge Virgilio de Almeida[1], Glaucio Lima Siqueira[1], Marbey Manhaes Mosso[1], Carlos Antonio França Sartori[2]
[1] *Pontifical Catholic University of Rio de Janeiro (Brazil),* [2] *University of Sao Paulo (Brazil)*

Various works have demonstrated that artificial materials called metamaterials (MTM) can synthesize u-negative (MNG) media capable of evanescent-wave focusing which largely enhances the magnetic coupling between coils, the basic mechanism of Inductive Power Transmission (IPT) systems. In this work, MTM-enhanced coupling in IPT systems is examined through analytical, numerical and experimental results. Adopting a transmission-line based approach to describe the general MTM-enhanced IPT system, it is evidenced that MNG MTMs can be interpreted as a negative impedance.

P10: Analysis of metamaterial behaviors on NiAl2O4 based flexible substrate material synthesized by sol-gel method
Md Atiqur Rahman, Mohammad Rashed Iqbal Faruque, Mohammad Tariqul Islam
Universiti Kebangsaan Malaysia (Malaysia)

In this study, a flexible metamaterial based on Nickel Aluminate (NiAl2O4) synthesized by sol-gel method is presented. The optical and microwave characterization demonstrate that the NiAl2O4 substrate is consists of a dielectric constant of 4.8, loss tangent of 0.04, and an optical bandgap of 2.8 eV. The metamaterial unit cell is fabricated on prepared flexible composite employing copper coating by magnetron sputtering. The double negative metamaterial behavior is found at a frequency of 6.05 GHz in microwave spectra.

P11: Design of a Broad Band - Stop Filter with Metamaterial as Defective Ground System
Jubaer Alam, Mohammad Rashed Iqbal Faruque, Mohammad Tariqul Islam
Universiti Kebangsaan Malaysia (Malaysia)

In this paper, a broad band-stop filter with metamaterial as defective ground system has been introduced.

The frequency of the filtering depends on the dimensions of SRR. The filter shows great commitment on X-band applications particularly on 5.9 to 11.3GHz. It has also been observed by NRW method at the filtering frequency, value of relative permeability as well as permittivity for this structure is negative that confirms the structure behaves as a Left Handed medium.

P12: Bandwidth Enhanced Metamaterial Inspired Antenna with Bent Monopole at UHF Band
N. A. Borhan, N. A. Murad, M. K. A. Rahim
University of Technology Malaysia (Malaysia)

In this paper, a design and simulation study of a bandwidth enhanced bent monopole antenna consisting a unit of CSRR, shorting via and a stub is presented. The antenna resonates at 0.75 GHz and 0.9GHz with bandwidth 32.73 %. A comparison of return loss between bent monopole and bent monopole with added CSRR is shown to prove the functional of CSRR. The proposed antenna has a moderate 1.789dB and 2.047dB gain at 0.75 GHz and 0.9 GHz respectively.

P13: Mutual Coupling Reduction for Broadband MIMO Antenna Using SRR Unit Cell Metamaterials
Mohannad Obaid Katie[1], Mohd Faizal Jamlos[1], Ping Jack Soh[1], Mohd Aminudin Jamlos[2]
[1] *Universiti Malaysia Perlis (Malaysia),* [2] *UniMAP (Malaysia)*

A broadband MIMO antenna with single ring resonator (SRR) metamaterial to reduce mutual coupling is proposed. Antenna performance is optimized in term of the reflection coefficient (S11) and mutual coupling (S21). It is notified that mutual coupling has been significantly decreased when SRRs are located in between radiators and at a T-shaped stub ground plane. Results show that the proposed antenna is capable of operating at broadband frequency from 2.8 to 4.95 GHz with good S11.

P14: 9.5GHz Metamaterial AMC reflector for x-band Applications and Operation
M. M. Gajibo, M. K. A. Rahim, N. A. Murad, O. Ayop, Raimi Dewan
Universiti Teknologi Malaysia (Malaysia)

A single layer structure consisting of a metamaterial (MTM) artificial magnetic conductor (AMC) reflector is presented in this paper. An FR4 substrate with thickness of 1.6mm was used and the incidental wave angles were varied from 0° to 66°. A peak reflection of close to 90 % was achieved at 9.5GHz by the AMC reflector for both TE and TM polarization

P15: Bifurcation of microwave propagation in a negative-permeability material triggered by high density plasma generation
Akinori Iwai[1], Yoshihiro Nakamura[1], Osamu Sakai[2]
[1] *Kyoto University (Japan),* [2] *The University of Shiga Prefecture (Japan)*

We performed a plasma generation experiment with metamaterial using 2.45-GHz microwave, and detected the electron density which decided the effective permittivity and transmitted 2.45-GHz signal at the position in the generated plasma. The transmitted signal sustainsrelatively high level with both the negative-permittivity plasma and the negative-permeability double-split-ring resonator, although each material works as reflector and absorber. This bifurcationabout the wave propagation suggests that the synthesis of the plasma and the DSRR iscompleted, which compose the negative-refractive-index material.

P16: A Compact Metamaterial Based Dual Band Patch Antenna for GPS L1/GS Applications
Md. Sobuz Samsuzzaman[1], M. Z. Mahmud[2], M. N. Rahman[2], M. T. Islam[2]
[1] *Patuakhali Science and Technology University (Bangladesh),* [2] *Universiti Kebangsaan Malaysia (Malaysia)*

A compact metamaterial based dual band antenna is presented for using GPS L1/GS communication systems. This antenna structure comprises of a radiating patch with four mender line resonant elements, and a modiïňĄed ground plane, which provides a dual band covering from 1.55 GHz to 1.64 GHz frequency. The inductances and capacitances developed due to the ground plane and patterned radiating patch leads to the behavior of the metamaterial.

P17: A Novel Modified H-Shaped DNG Metamaterial for Multi-band Microwave Application
Toufiq Md Hossain, Mohd Faizal Jamlos, Md. Imtiaz Islam, Mohd Aminudin Bin Jamlos, Rizwan Khan
Universiti Malaysia Perlis (Malaysia)

This paper highlights a modified H-shaped Double Negative (DNG) metamaterial unit cell for x- and Ku-band applications. The unit cell has been constructed with the combination of rectangular Split Ring Resonator (SRR) and H-shaped resonator. The unit cell has realized a multi-band DNG bandwidth of 845 MHz (7.615

GHz to 8.46 GHz), 605 MHz in x band (8.755 GHz to 9.36 GHz) and 4.51 GHz in Ku-band (10.49 GHz to 15 GHz) with a size of 0.792 cm2.

P18: Dynamic behaviour of a two-dimensional elastic metamaterial with eccentric local resonators
Zhengwei Li, Chen Wang, Xiaodong Wang
University of Alberta (Canada)

This article presents a two-dimensional four-component composite, which consists of coated eccentric cylinders embedded in elastic medium. The engineered composite can generate negative mass density and the multiple interaction of the local resonators has been studied using a pseudo-incident wave method. Then, the effect of the structural parameters on its dynamic behaviour has been comprehensively analyzed. This study can provide a general method to investigate periodic elastic metamaterial systems with eccentric resonators.

P19: Bandwidth Optimization of Trapped-Mode THz Filters Exploiting Adjoint Sensitivity
Ahmed Elsharabasy, Mohamed Bakr, M. Jamal Deen
McMaster University (Canada)

In this work, we present an optimization approach to reduce the bandwidth of metal mesh THz filters on thick substrates. Adjoint sensitivity analysis is exploited to provide the derivatives of the objective function for the optimizer. Through the optimization steps, the trapped-mode response has been improved with the out-of-band rejection reduced. EM simulations are carried out to illustrate the efficiency of the technique in decreasing the filter's bandwidth and enabling integration for detection and sensing applications.

P20: New controllable birefringence phase matching method for the 2nd harmonic generation
Taeyong Chang, Jonghwa Shin
KAIST (Korea)

We show that the new type of the phase matching technique, which is controllable birefringence based on the mesoscopic crystal. The polarization of the pump wave and 2nd harmonic wave can have orthogonal polarization, and the x- and y- directional linear property of the mesoscopic crystal can be independently contolled, and coherence length can be tuned.

P21: Ag/SiNx sub-10 nm gap for ultra-sensitive SERS detection
Ruhao Pan, Yujin Wang, Zhe Liu, Junjie Li, Changzhi Gu
Chinese Academy of Sciences (China)

SiNx sub-10nm nanogap is fabricated by stress induced cracking of SiNx nanobridge. The width of the gap is determined by the shape of nanobridge and Ag coating thickness. FDTD simulation shows that there is a bulk effect of the suspending nanogap, making the nanogap to be better than traditional metal gap in light confinement. Take rhodamine 6G as a probe, this structure performs very good in SERS even at an ultra-low concentration of 10-16 M.

P22: A Monolayer Graphene NIR Plasmonic Super Absorber using High-index Contrast Grating (HCG)
Parag Parashar, Wei-Ming Huang, Albert Lin
National Chiao-Tung Univeristy (Taiwan)

Quasi-guided plasmonic mode excitation based near infrared (NIR) graphene absorber using high index contrast grating (HCG) has been demonstrated. High-Q (=700) narrow-band plasmonic resonance with enhanced ($>80\,\%$) absorbance in graphene monolayer is reported without incorporating metallic mirrors. The high absorbance achieved is comparable to the magnetic resonance graphene absorption with metal gratings. Also, only a single-layer of subwavelength dielectric grating is adopted to achieve high TM NIR absorption without the use of distributed Bragg reflectors or 1D Photonic crystals.

P23: Parameterization Study of Dual Polarized Cross Bowtie Nano Antenna for Energy Harvesting Applications
Rishad Arfin, Ahmed Elsharabasy, Mohamed Bakr, Shirook Ali, Matiar Howlader
McMaster University (Canada)

In this paper, we study the performance of dual polarized cross bowtie gold nano antenna (nantenna) using COMSOL Multiphysics software for energy harvesting applications. Illuminating the bowtie nantenna with an incident plane wave results in a strong local field confinement in the gap. In this work, the electric field in the inner gap of the cross bowtie nantenna is observed and estimated for different values of the geometrical parameters of the nantenna.

P24: Demonstration of active plasmonic device on an optical fiber
Kazuhiro Yamamoto[1], Kenzo Yamaguchi[2]
[1] *Kyushu University (Japan),* [2] *Kagawa University (Japan)*

Active and reconfigurable plasmonic devices are expanding their applications. To combine such devices on optical fibers, one easily excites and detects signals from the optical element. We report the design, fabrication and demonstration of active plasmon device on fiber facets. From visible to near- infrared spectral range, we could control the transmission from the device by applying electrical signal.

P25: Observation of resonance mode in a MIM plasmonic waveguide with a rectangular resonator
Shun Kamada, Toshihiro Okamoto, Masanobu Haraguchi
Tokushima University (Japan)

We proposed a metal/insulator/metal plasmonic waveguide with a rectangular resonator for a compact pressure or refractive index sensor. Transmission spectra of fabricated structure were measured to confirm the resonance mode. Transmission dips by rectangular resonator are appeared at the fabricated structure. It is assume that the transmission dips due to resonance mode in the rectangular resonator.

P26: Numerical analysis on propagation compensation for loss in shadow of object by plasma and dielectric layer
Syuhei Yamaguchi, Alexandre Bambina, Akinori Iwai, Yuki Kabe, Shigeyuki Miyagi, Osamu Sakai
The University of Shiga Prefecture (Japan)

We proposed and evaluated a functional layer, a composite of plasma and dielectric, which compensates the propagation of electromagnetic waves for loss in the shadow of an object. The layer hides the object inside the layer from electromagnetic waves. Using the layer, we observed by numerical analyses that electromagnetic waves propagate in the shadow. This layer consists of a dielectric layer and a plasma layer, and so the structure is simpler than the invisibility cloak composed of metamaterial.

P27: Hybrid plasmonic waveguides by cladding hyperbolic metamaterials
Ruey-Lin Chern
National Taiwan University (Taiwan)

We propose a new type of hybrid plasmonic waveguides by cladding hyperbolic metamaterials, consisting of mutlilayers of metal and dielectric, on a cylindrical plasmonic waveguide. The proposed metal-dielectric-hyperbolic waveguides share the merit of hybrid plasmonic waveguides, that is, a relatively large ratio of propagation length to mode area. We analytically solve the propagation constant, the most important waveguide feature, by locating the complex roots of the multilayered anisotropic cylindrical waveguide dispersion relations.

P28: A Capacitor-Loaded Spoof Surface Plasmon Transmission Line (SSP-TL) Design for Flexible Dispersion Properties Control
Xiao-Lan Tang[1], Qingfeng Zhang[1], Sanming Hu[2], Yifan Chen[1]
[1] *South University of Science and Technology of China (China),* [2] *Southeast University (China)*

A novel implementation of spoof surface plasmon transmission line (SSP-TL) with loaded capacitors is proposed in this paper. It has been demonstrated that SSP-TL with capacitors can be an alternate candidate of flexible dispersion properties control. As an example, a smaller-line-width SSP-TL with loaded capacitors is designed and its measured performance is compared to the conventional one without capacitors but in larger-line-width configuration. The new method provides design flexibility without any geometrical dimensions modification of the SSP-TL.

P29: Control of light absorbance using plasmonic grating based metamaterials
Duc Minh Nguyen, Gwanho Yoon, Dasol Lee, Junsuk Rho
Pohang University of Science and Technology (Korea)

We demonstrate that a conventional polarization-insensitive multilayer perfect absorber can be switched to a highly polarization sensitive perfect absorber by replacing the metallic reflecting layer with a plasmonic grating. Active control of light absorption based on this concept is experimentally and numerically demonstrated for both narrowband and broadband of wavelength.

P30: Electrical control of one circular polarization in graphene integrated chiral metamaterials
Teun-Teun Kim[1], Hyeon-Don Kim[2], Sang Soon Oh[3], Hyun-Sung Park[2], Ortwin Hess[3], Bumki Min[2],

Shuang Zhang[4]
[1] *Sungkyunkwan University (Korea),* [2] *KAIST (Korea),* [3] *Imperial College London (United Kingdom),* [4] *University of Birmingham (United Kingdom)*

We experimentally demonstrate an electrical tuning of the polarization state of terahertz waves with a graphene integrated chiral metamaterial. We validated that the graphene integrated chiral metamaterial achieves a high-intensity modulation depth up to 63 % for the RCP wave at the small gate voltage with maintaining high transmission of the LCP wave up to 52 %.

P31: Single particle chirality

E. Vinegrad, D. Vestler, A. Ben-Moshe, G. Markovich, O. Cheshnovsky
Tel Aviv University (Israel)

Chiroptical activity serves as an important tool for manipulating light or for characterizing spatial arrangements in molecules, proteins (and other polymers) crystals and nanostructures. Due to the wak intensity of Circular Dichroism (CD) measurements of CD are all done on an ensemble of particles either in solurtion, in crystals, or on a large array of meta-particles on a substrate. Here we present an experiment in which trhe CD spectroscopy of individual, fabricated Gammadions were studied.

P32: Optical sensing of chiral molecules using metamaterials

SeokJae Yoo, Q-Han Park
Korea University (Korea)

We present a theory for the microscopic origins underlying the chiroptical spectroscopy using metamaterials. When optical resonators are coupled to chiral molecules, the inherent circular dichroism (CD) of chiral molecules are modified by local fields near resonators, whereas chiral molecules perturb resonant modes of the resonators. We show two origins of CD simultaneously contribute to the CD enhancement in the chiral molecule/resonator coupled system. We propose a design route for the optical resonators that enhance CD of chiral molecules.

P33: A Simple Chiral Metamaterial for Broadband Asymmetric Transmission of Linearly Polarized Electromagnetic Waves at Microwave Frequencies

Lincy Stephen[1], **Yogesh Natesan**[2], **Vasantharajan Ganesan**[1], **Subramanian Venkatachalam**[1]
[1] *Indian Institute of Technology Madras (India),* [2] *University of Madras (India)*

A chiral metamaterial (CMM) based on a complementary metal strip in a single dielectric layer is proposed for achieving broadband asymmetric transmission (AT) of linearly polarized electromagnetic waves. The proposed CMM exhibits AT efficiency of 90 % over a bandwidth of 1.11 GHz (7.79 GHz- 8.9 GHz) for forward/backward linearly polarized excitations. Surface current analysis indicates that the origin of AT effect stems from anisotropy of chiral meta-atom in which CMM lacks reflection mirror symmetry for forward and backward transmissions.

P34: Tuning spontaneous radiation of chiral molecules by asymmetric chiral nanoparticles

Dmitry V. Guzatov[1], **Vasily V. Klimov**[2], **Hsun-Chi Chan**[3], **Guang-Yu Guo**[3]
[1] *Yanka Kupala State University (Belarus),* [2] *Russian Academy of Sciences (Russia),* [3] *National Taiwan University (Taiwan)*

We have derived analytical expressions for the radiative decay rate of the spontaneous emission of a chiral molecule located near a dielectric spherical particle with a chiral nonconcentric spherical shell made of a bi-isotropic material. Our numerical analyses show that for a chiral molecule near a dielectric spherical particle with a shell made of a chiral metamaterial with simultaneously negative permittivity and permeability, the right and left enantiomers of molecules can exhibit pronounced differences between the radiative decay rates.

P35: Low-Loss Non-Reciprocity in Spatiotemporally Modulated Hybrid Dielectric-Graphene Photonic Structures

Diego Correas-Serrano[1], **Dimitrios Sounas**[2], **Andrea Alu**[2], **J. Sebastian Gomez Diaz**[2]
[1] *University of California (USA),* [2] *University of Texas at Austin (USA)*

We introduce the concept of magnet-less non-reciprocal photonic devices based on spatiotemporally modulated graphene embedded in dielectric structures. Compared to non-reciprocal graphene plasmonic devices based on similar bias schemes, graphene is used only as a perturbation of low-loss photonic modes. This approach has important benefits, including very reduced losses, much relaxed biasing requirements, and large non-reciprocal responses.

P36: Strong Coupling between the WS2 Excitons and Metallic Plasmonic Nanoholes
Xuexian Chen, Huanjun Chen
Sun Yat-sen University (China)

We demonstrated that the strong coupling between WS2 excitons and plasmonic gold nanoholes. By transferring monolayer WS2 onto the Au nanoholes fabricated by focused ion beam technique (FIB), a hybrid two dimensional optical system has been achieved. Rabi splitting was observed by measuring scattering spectra from the hybrid system. A Rabi splitting of 162 meV is observed at room temperature for this system. Furthermore, the coupling strengths can be tailored by changing the diameter of the hole.

P37: Enhanced Optical Absorption in MoS2 Layers Grown on Si Nanocone Arrays
Eunah Kim, Yunae Cho, Soyeong Kwon, Dong-Wook Kim
Ewha Womans University (Korea)

We prepared MoS2 layers on SiO2/Si nanocone (NC) arrays and investigated their characteristics. The NCs strongly concentrated incoming light at the surface and increased optical absorption of the MoS2 layers in broad wavelength range. Finite-difference time-domain simulations were performed to explain the experimental optical properties of the MoS2-NC integrated structures. The influences of the enhanced absorption on the reflection, photoluminescence, and Raman spectra were investigated.

P38: Tunable Graphene-nonlinear sensor
Rifa Jarallah El-Khozondar[1], Zeyad I. Al-Sahhar[1], Hala Jarallah El-Khozondar[2], Mohammed M. Shabat[2]
[1]Al-Aqsa University (Palestine), [2]Islamic University of Gaza (Palestine)

Graphene has many exceptional properties such as electrical and optical properties. Therefore, it has attracted attention for applications in electronics, optics and THz technology. The purpose of this work is to study the sensitivity of a composite material made of graphene sandwiched between two layers of dielectric materials. The top layer is linear dielectric and the substrate is nonlinear dielectric. The results will be presented.

P39: A unique combination of two-stepped in Syntesization of High Performance Graphene Antenna
Mohd Aminudin Bin Jamlos, Abdul Hafiizh Ismail, Mohd Faizal Jamlos, Lee Yeen Seng
Universiti Malaysia Perlis (Malaysia)

A unique two-stepped combination of chemical and microwave reduced method successfully synthesizing the high performance of graphene antenna. The antenna recorded ultra-wide band radiation frequency of 2.5 GHz until 12.2 GHz with high energy produced of 5.5dB to 14.5dB. Small dimension of 90 mm x 45 mm made the antenna suitable enough to be applied and integrated in microwave related system. Most importantly, the measured and simulated results are within in acceptable similarity.

P40: Fabricated New Polydimethylsiloxane Magnetite Substrates in Bandwidth Enhancement for Cancer Detection Using Specific Absorption Rate Measurement
Mohd Aminudin Bin Jamlos, Abdul Hafiizh Ismail, Mohd Faizal Jamlos, Lee Yeen Seng
Universiti Malaysia Perlis (Malaysia)

Fabricated Polydimethylsiloxane Magnetite graphene detector successfully detecting brain cancer using SAR measurement. Combination of fabricated PDMS Ferrite as the substrate and graphene sheet as the radiating element realize the ultra-wide band radiation (2.5 GHz-11.2 GHz) with high energy (2.5dB-11.7dB) in microwave frequency ranges. Amount of energy absorbed by the human brain indicated the present of tumor. Human brain with cancer absorbed more energy and recorded higher SAR value (3.98 W/kg) compared with brain without tumor (2.28 W/kg).

P41: Printed graphene antenna design for 5G applications
Siti Nor Hafizah Sa'don, Muhammad Ramlee Kamarudin, Mohd Haizal Jamaluddin, Fauzan Ahmad
Universiti Teknologi Malaysia (Malaysia)

In the next generation of mobile communication, fifth generation (5G) will come up with higher frequency band. However, this situation affected reducing antenna size which is more difficult to manufacture especially when using conventional copper as radiating element. Hence, conductive graphene ink is introduced for smaller antenna and screen printing fabrication is proposed. From this conductive ink and approach used, the impedance bandwidth obtained is comparable. Then the simulated gain is 2.301 dBi and antenna efficiency is 84.24 $\%$.

P42: Tip-enhanced exciton-plasmon coupled imaging and control in monolayer WSe2

Kyoung-Duck Park[1], Vasily Kravtsov[1], Tao Jiang[1], Genevieve Clark[2], Xiaodong Xu[2], Markus Raschke[1]
[1] *University of Colorado (USA),* [2] *University of Washington (USA)*

Combining tip-enhanced Raman and photoluminescence with active atomic force tip interaction, we nano-image the exciton behavior associated with defects, grain boundaries, and local strain. Based on exciton-plasmon coupling we achieve a ∼100,000-fold enhancement of photoluminescence yield. This hybrid tip-enhanced nano-spectroscopy and -imaging method also enables to probe and control neutral-, multi-, localized-, and dark-excitons at room temperature.

P43: Millimeter Wave Antennas Coated using Monolayer Graphene

Mohammed Taih Gatte, Ping Jack Soh, Mohd Faizal Jamlos, Raad Badlishah Ahmad, Mohamed Fareq AbdulMalek, Hasliza A. Rahim
Universiti Malaysia Perlis (Malaysia)

In milimeterwave applications, the conducting parts of most communication devices can easily degrade when using conventional metals like copper. Oxidation take place when such devices are operated in harsh environmental conditions. Copper in most of these devices are coated with other materials to overcome this problem. In this study, doped and non-doped monolayer graphene are employed as coating layers of conductors for millimeter-wave antennas. Results indicated that coating such antennas using monolayer graphene improves antenna performance at millimeter-wave frequencies.

P44: Modeling of Millimeter Wave Antennas' Conducting Layers using Adhesive CVD-Graphene

Mohammed Taih Gatte, Ping Jack Soh, Mohd Faizal Jamlos, Raad Badlishah Ahmad, Mohamed Fareq AbdulMalek, Hasliza A. Rahim
Universiti Malaysia Perlis (Malaysia)

A new technique based on chemical vapor deposition (CVD) graphene in the fabrication of millimeter-wave antenna is proposed in this work. This is to overcome the difficulties faced by the transfer of graphene onto dielectric substrate of antenna such as tears and cracks in their samples. This technique enables adhesion of graphene onto antenna substrate without removing the transition metal substrate from CVD sample. Modeling of antenna based on this technique shows promising results, especially when using doped graphene.

P45: The Synthesis of the Novel Fe3O4@Void@Ag Yolk-shell Nanostructures from the Fe3O4@Carbon@Ag Core-shell Nanoparticles

Di Liu, Jaebeom Lee
Pusan National University (China)

Compared with the core-shell and hollow nanoparticles, the yolk-shell nanoparticles (YSNs) with the void space between the core and shell have attracted more attention because of their appealing structures, tunable physical and chemical properties. Here, we tried to synthesize the Fe3O4@void@Ag YSNs with removing the carbon shell of Fe3O4@carbon@Ag core-shell nanoparticles (CSNs) by the calcination. The area of void space could be adjusted by the thickness of the carbon shell of the Fe3O4@carbon@Ag CSNs.

P46: A Multilayer Harvester for Acoustic Energy Transfer in Low Power Wireless Applications

Md Rabiul Awal[1], Muzammil Jusoh[1], R. Badlishah Ahmad[1], Thennarasan Sabapathy[1], Muhammad Ramlee Kamarudin[2], Mohamed Nasrun Osman[1]
[1] *Universiti Malaysia Perlis (Malaysia),* [2] *Universiti Teknologi Malaysia (Malaysia)*

This paper presents a multilayer harvester for acoustic energy transfer. A four layer cantilever conguration is used to design the harvester with Aluminum, Silicon and Zinc Oxide. The displacements of the cantilever is obtained through mathematical and simulate analysis and found 5.5e-27 mm and -7e34 mm scale from simulation and mathematical modeling. However, 1.1-4.0 mV output voltage is obtained by the cantilever from minimum nger pressing on tip in open load mode.

P47: Opening Photonic-Plasmonic Hybrid Band Gaps by Lamb Waves

Z.-T. Huang[1], J.-H. Shih[1], Tzy-Rong Lin[1], Jin-Chen Hsu[2]
[1] *National Taiwan Ocean University (Taiwan),* [2] *National Yunlin University of Science and Technology (Taiwan)*

We propose efficient generation of tunable optical band gaps through acousto-optic (AO) interaction. The optical system consists of a thin dielectric slab coupled to a metal surface with a nanoscale air gap in between and provides hybridization of highly guided photonic-plasmonic modes squeezed in the air gap. Enhanced AO interaction occurs through the disturbance of Lamb waves in the slab. As a result, wide optical band gaps are opened.

P48: Extraordinary transmission of GHz bulk acoustic waves
Thibaut Devaux[1], Hiroya Tozawa[1], Motonobu Tomoda[1], Paul H. Otsuka[1], Sylvain Mezil[1], Osamu Matsuda[1], Istvan A. Veres[2], Oliver B. Wright[1]
[1] *Hokkaido University (Japan),* [2] *Research Center for Non-destructive Testing GMBH (Austria)*

Concentrating acoustic wave energy in sub-wavelength regions is a subject of much recent interest. One method for achieving this is the principle of extraordinary transmission, in which a resonant structure is combined with an aperture to achieve greatly enhanced transmission. Here, we make use of acoustic Fabry-Perot resonances combined with surface-wave resonances in a solid-solid structure to demonstrate acoustic extraordinary transmission.We show by simulation an enhancement in the acoustic amplitude transmission efficiency up to $\sim$20 times at GHz frequencies.

P49: Metasurfaces for perfect transmission of sound from water to air
Eun Bok[1], Haejin Choi[1], Jongjin Park[1], Chungkyu Han[1], Oliver Bernard Wright[2], Samhyeon Lee[1]
[1] *Yonsei University (Korea),* [2] *Hokkaido University (Japan)*

We present the fabrication of an acoustic metasurface of thickness much smaller than the wavelength, which, placed in between the water and the air, enhances the transmission by more than two orders of magnitude. This metasurface is a two-dimensional array of unit cells, each of which consists of a thin cavity covered with five membranes. Experimentally we obtained about 40 $\%$ power transmission through the interface using the metasurface, which corresponds to over 23.5 dB transmission enhancement.

16:40 - 18:20 — Room 106

Session 2A25

SP15. Parity-Time and related symmetries in Photonics, Plasmonics, Acoustics III

Organized by: Anatole Lupu, Henri Benisty and Kin Hung Fung

Chaired by: Anatole Lupu, Henri Benisty and Kin Hung Fung

16:40 : Invited talk
PT systems with time delayed gain and loss
Yogesh N. Joglekar
Indiana University Purdue University Indianapolis (IUPUI) (USA)

In recent years, Floquet PT-symmetric systems, with time-periodic Hermitian or non-Hermitian parts, have become a topic of increasing interest. This interest is driven by their rich PT phase diagram and ability to induce PT transitions in the presence of minimal gain-loss strength. However, in all cases, the system of interest - classical or quantum - is described by a local (instantaneous) Hamiltonian.

17:00 : Stationary regimes of Fiber Ring PT laser with saturable gain
Sergey Smirnov[1], Maksim Makarenko[1], Sergey Vladimirovich Suchkov[2], Ilya Vatnik[1], Dmitry Churkin[1], Andrey Sukhorukov[2]
[1] *Novosibirsk State University (Russia),* [2] *The Australian National University (Australia)*

We propose a fiber laser composed of coupled ring cavities with gain and loss, featuring parity-time transition between symmetry-broken single-mode and bistable symmetric regimes, controllable by static phase shifters without active modulation.

17:15 : Cross/bar Switch using longitudinal gain redistribution and modified parity-time symmetry
Anatole Lupu, Henri Benisty
Paris Sud University (France)

The concept of parity-time symmetry has inspired new switch architectures. Here, we explore a 2x2 cross/bar switch architecture that mostly works by redistributing the longitudinal gain along one of the waveguides, which then features either gain in its center or at its edges. The other guide can then be of purely loss type, as occurs in plasmonic or hybrid waveguides. The advantage is to work with more stable space- and

time-averaged parameters than previous parity-time symmetric designs.

17:30 : Invited talk
Self-collimation in 2D Complex P- and PT-symmetric systems
Muriel Botey, Waqas Wasser Ahmed, Ramon Herrero, Kestutis Staliunas
Universitat Politecnica de Catalunya (Spain)

We predict the self-collimation phenomena (or equivalently, dynamical localization) in 2-dimensional P-symmetric and PT-symmetric complex potentials, with periodic modulations of both gain/loss and refractive index. Non diffractive propagation is analytically predicted and further confirmed by numerical integration of a paraxial model. The parameter space is explored to identify the self-collimation regime in crystals with different complex symmetries.

17:50 : Anomalous transmission due to topological edge modes in low-symmetry photonic systems
C. W. Ling[1], Jin Wang[2], Ka Hei Choi[1], K. F. Lee[1], Raymond P. H. Wu[1], Kin Hung Fung[1]
[1] *The Hong Kong Polytechnic University (China),* [2] *Southeast University (China)*

Low-symmetry photonic elements with most symmetries broken but other spatial-temporal symmetries maintained could support exceptional points. Periodic arrays of these units may also support different classifications of topological bands, where the local symmetries in unit cell including material permittivity and permeability tensors play crucial roles. In this talk, we discuss our recent findings on anomalous transmission associated with topological edge modes in Lorentz nonreciprocal and non-Hermitian systems.

18:05 : Floquet Topological Phases in PT Symmetric Passive Hadamard Quantum Walks
Hideaki Obuse[1], Ken Mochizuki[1], Dakyeong Kim[1], Norio Kawakami[2]
[1] *Hokkaido University (Japan),* [2] *Kyoto University (Japan)*

We theoretically study Floquet topological phases of PT symmetric non-unitary quantum walks. Especially, by considering feasibility of experiments, we focus on passive Hadamard quantum walks which have effects of only losses and whose coin operators are described by Hadamard matrices. We clarify Floquet topological phases of this quantum walk and find that after compensating the loss effect, the corrected probability corresponding to edge states exponentially increases with time due to PT symmetry breaking.

16:40 - 17:55 — Room 109

Session 2A26

SP14. Fano resonances in optics and microwaves: Physics and application VI

Organized by: Eugene Kamenetskii and Almas Sadreev

Chaired by: Eugene Kamenetskii and Almas Sadreev

16:40 : Invited talk
A Spectral Method for the Analysis of Fano-like Resonances of Nanoparticles in the Full-Retarded Regime
Carlo Forestiere, Mariano Pascale, Roberto Tricarico, Giovanni Miano
Universita degli Studi di Napoli Federico II (Italy)

In this work, we introduce a full-retarded spectral technique to identify the interfering modes responsible for the peaks and the dips of the scattered power spectrum in spherical nanoparticles. Moreover, we show that the interaction of non-orthogonal modes determines the onset of Fano-like resonances. We also investigate the role played by the material properties in enabling or preventing the interference effects behind Fano-like resonances.

17:00 : Invited talk
Magnetic interactions and transport properties of parallel coupled magnetic molecules
Seif Alwan, Juan David Vasquez Jaramillo, Henning Hammar, Jonas Fransson
Uppsala University (Sweden)

Parallel coupled quantum dots embedded in a tunnel junction is a typical system that exhibits Fano resonances. Here, we consider magnetic molecules in a similar geometry and consider the electronically mediated magnetic interactions between the localized spins as function of the gate and bias voltages as well as temperature differences between the leads. In addition to regimes of ferromagnetic and anti-ferromagnetic coupling, we show that Fano resonances give rise to vanishing exchange between the localized spins.

17:20 : Invited talk
Steering topological surface lasers
Babak Bahari, Junhee Park, Felipe Valini, Ricardo Tellez-Limon, Ashok Kodigala, Thomas Lepetit, Yashaiahu Fainman, Boubacar Kante
University of California San Diego (USA)

We demonstrated topological steering of light sources in which the phase offset to steer the beam is provided by Floquet-Bloch phase in periodic structures. It was shown that in periodic structures there exist singular states in the radiation region of the band diagram that exhibit diverging quality factor, which is useful for light source cavities. Our experimental demonstrations open new paradigm in the implementation of light steering with applications in data communications, bio imaging and sensing.

17:40 : Tuning of Fano resonances by rotation of continuum: wave faucet
Almas Sadreev, Artem Pilipchuk, Alina Lyapina
Kirensky Institute of Physics (Russia)

We consider wave transmission in a non-axisymmetric waveguide which consists of cylindrical resonator and two semi-infinite cylindrical waveguides whose axes are shifted relative to the resonator. Rotation by the azimuthal angle $\Delta\$\phi$ of input waveguide tunes the Fano resonances and respectively gives rise to an analog of a faucet. Moreover under the rotation of the waveguide numerous events of the Fano resonance collapse occur to evidence for the bound states in the continuum.

17:55 - 19:10 — Room 109

Session 2A27

GEN10. Metamaterial-based devices II

Chaired by: Boubacar Kante

17:55 : Near-field acoustic microscope for sub-wavelength imaging based on extraordinary transmission in zero-mass metamaterials
Thibaut Devaux[1], Jong Jin Park[2], Sam H. Lee[2], Oliver B. Wright[1]
[1] *Hokkaido University (Japan),* [2] *Yonsei University (Korea)*

Using the principle of extraordinary transmission through a zero-mass metamate- rial, a prototype of a near-field acoustic microscope is proposed and built for the audible frequency range. Experimental results reveal the detection of objects of sub-wavelength size ($\sim \lambda/20$) by use of a simple reflection coefficient measurement. This method allows one to work at high resolution compared to the far-field diffraction limit, and introduces new perspectives in acoustic imaging and non-destructive testing.

18:10 : Frequency Switchable Microfluidic Metamaterial-Loaded QMSIW Bandpass Filter Using a Liquid Metal Alloy
Muhammad U. Memon, Sungjoon Lim
Chung-Ang University (Korea)

Frequency-switchable metamaterial-loaded quarter-mode substrate-integrated-waveguide (QMSIW) bandpass filter is proposed. A liquid metal inside microfluidic channel is used for switching. The microfluidic channels are built using the elastomer polydimethylsiloxane (PDMS) and 3D printed channel molds. This structure has two states. Before injection of the liquid metal, the recorded fractional bandwidth and center frequency of filter are 6.80 % and 2.205 GHz, respectively. After injecting liquid metal, the frequency changes from 2.205 GHz to 2.56 GHz.

18:25 : Digit 8-Shaped Resonator Based Metamaterial for Sensor Applications
Md. Naimur Rahman, Mohammad Tariqul Islam, Md. Zulfiker Mahmud, Md. Amanath Ullah, Gan Kok Beng
Universiti Kebangsaan Malaysia (Malaysia)

This paper presents a metamaterial, based on a digit 8-shaped resonator. The resonator is encompassed by a partial ground plane and excited by a microstrip feeding transmission line. As the digit 8-shaped resonator, partial ground plane, and the feedline are all on a microstrip, the measurement can be executed by using the common laboratory facility instead of using the waveguide. The presented metamaterial is also applied in sensor applications where the simulated and measured results reveal considerable agreement.

18:40 : Chiroptical Spectroscopy Using an On-Resonance Chiral Metasurface
S. Hamed Shams Mousavi, Sajanlal R. Panikkanvalappil, Ali A. Eftekhar, Mostafa A. El-Sayed, Ali Adibi
Georgia Institute of Technology (USA)

We present a novel three-dimensional chiral metamaterial design for chiroptical spectroscopy. Utilizing the chiral light-matter interaction between the designed metamaterial and molecule that is chiral in the same wavelength range, we demonstrate chiroptical sensing at the molecular level.

18:55 : Multiband band-stop filters for spoof surface plasmon polaritons
Jiandong Li, Xiaopeng Shen, Haipeng Li, Kui Han, Chuanlei Jia
China University of Mining and Technology (China)

Band-stop filter is key component and play a very important role in various communication and radar systems. In this report, we will demonstrate a new type of multiband bandstop filters for spoof surface plasmon polaritons (SSPPs) in the microwave frequency regime. The simulated, measured, and the resonator theory calculated resonant frequencies are in good agreement.

16:40 - 17:20 — Room 104-105

Session 2A28

SP26. THz metamaterial and metasurface II

Organized by: Qiang Cheng and Qi Ye Wen

Chaired by: Qiang Cheng and Qi Ye Wen

16:40 : Invited talk
Determination of dielectric constants of thin films and liquids using terahertz metamaterials
SaeJune Park, S. A. N. Yoon, YeongHwan Ahn
Ajou University (Korea)

We suggest that terahertz (THz) metamaterials can be used to measure the dielectric constant of various dielectric materials. We successfully measure the dielectric constant of various polymers and polar liquid using THz metamaterial devices. Our experimental results were confirmed by finite-difference time-domain simulation.

17:00 : Invited talk
Reconfigurable terahertz grating with enhanced transmission of TE polarized light
J. W. He[1], Y. Zhang[1], X. K. Wang[1], Z. W. Xie[2], Y. Z. Xue[1], S. Wang[3], S. F. Feng[1]
[1] *Capital Normal University (China),* [2] *Shenzhen University (China),* [3] *Harbin Institute of Technology (China)*

We demonstrate an optically reconfigurable grating with enhanced transmission of TE polarized waves in the terahertz (THz) waveband. The grating is realized with periodical photoexcited free carriers strips on a thin Si wafer. For TE polarized THz incident wave, the strips behaviors like metal, resonances between the strips happen and cause the enhanced transmission. The frequency of the transmission peak could be tuned through changing the period and duty cycle of the photoinduced grating.

17:20 - 18:35 — Room 104-105

Session 2A29

GEN2. Metamaterials and negative index materials II

Chaired by: Alexander Petrov

17:20 : Magnetic Purcell effect in magnetic hyperbolic metamaterials
Mohammad Sajjad Mirmoosa, Sergei Kosulnikov, Constantin Simovski
Aalto University (Finland)

We study a wire medium comprising high-index wires, and uncover topological phase transition between closed and open types of dispersion for transverse-electric (TE) polarized waves. The transition results in a filamentary pattern and remarkable Purcell factor for a magnetic dipole moment oriented perpendicularly to the optical axis of the medium.

17:35 : Performance Prediction of Bundle Carbon Nanotube and Bundle Carbon Nanotube Composite Dipole Antennas
Yaseen N. Jurn[1], Mohamed Fareq AbdulMalek[2], Hasliza A. Rahim[1], Sawsen A. Mahmood[3]
[1] *Universiti Malaysia Perlis (Malaysia),* [2] *University of Wollongong in Dubai (UOWD) (United Arab Emirates),* [3] *University of Mustansiriyah (Iraq)*

The performances of bundle carbon nanotubes (BCNTs) and bundle carbon nanotubes composite (BCNTs-composite) materials for the antenna applications in the terahertz and gigahertz frequency ranges are evaluated. The performances of these bundles are compared based on the electromagnetic properties of their dipole antennas, where the cross sections of bundles are circular geometry. Furthermore, comparative studies are performed to show the size and frequency dependent of these bundles.

17:50 : Dynamics of harmonically excited irregular cellular metamaterials
Sondipon Adhikari[1], T. Mukhopadhyay[2]
[1] *Swansea University (United Kingdom),* [2] *Oxford University (United Kingdom)*

Dynamics of hexagonal cellular lattice structures with geometric and material irregularities is considered. Effective steady-state in-plane elastic properties of the system is discussed. Equivalent static elastic properties of regular cellular solids using a unit cell approach is the most common approach. However, this cannot be extended to dynamic analysis or when there are spatial irregularities in the cell geometry or material properties. A dynamic stiffness based bottom-up approach in the frequency domain is developed for this purpose.

18:05 : Enhancement of spontaneous emission in metal-dielectric structures revisited
Mikhail Kaliteevski, Azat Gubaydullin, Kostya Ivanov
Saint- Petersburg Academic University (Russia)

We have developed the procedure of the quantization of the electromagnetic field in a layered inhomogeneous media, based on the analysis of the eigenvalues of the scattering matrix (S-matrix). We present application of S-quantization for the calculation of spontaneous emission rate for different photonic structures. We study the enhancement of spontaneous emission of the dipole embedded in the layered metal-dielectric structure applying S-quantization.

18:20 : Comparison of E-field on Various Patch Split Ring Resonator for Energy Harvesting
M. S. Zainudin, M. K. A. Rahim, N. A. Samsuri
Universiti Teknologi Malaysia (Malaysia)

The energy harvesting with metamaterial structure (Split Ring Resonator) are proposed. The operating frequency is 1.3GHz. Three design are simulated by using CST software shows square patch give the highest value of absorption, which is 96.57 %. For E-field monitoring in CST, the even circle shows the lowest value of absorption frequency wavelength, but its shows that it has the highest value of E-field, which is 181,100 V/m.

16:40 - 17:25 — Room 107-108

Session 2A30

SP31. Coupling of magnetic and electric dipoles to magneto-electric resonances in nanostructures and metasurfaces

Organized by: Aurelien Cuche and Vincent Paillard

Chaired by: Aurelien Cuche and Vincent Paillard

16:40 : Surface-enhanced second harmonic generation and fluorescence using effectively lossless GaP nanoantennas in the visible regime
Javier Cambiasso, Gustavo Grinblat, Yi Li, Aliaksandra Rakovich, Emiliano Cortes, Stefan A. Maier
Imperial College (United Kingdom)

We fabricated all-dielectric gallium phosphide (GaP) nanostructures with negligible losses in the visible. Single GaP nanodisks are used to generate a second harmonic signal that has, to the best of our knowledge, the highest yet achieved efficiency in the optical region produced by a single nano-object. Furthermore, we show that GaP dimers with 35 nm gap can enhance up to 3600 times the fluorescence emission of dyes located in the gap of the nanoantenna.

16:55 : High-Q resonances in linear arrays of optically coupled dielectric nanospheres
Evgeny N. Bulgakov[1], Dmitrii N. Maksimov[2]
[1] *Siberian Airspace University (Russia),* [2] *Kirensky Institute of Physics (Russia)*

We consider light trapping by bound states in the continuum (BSCs) in linear periodic arrays of optically coupled high-index dielectric nanospheres. Using a Mie multi-scattering approach we numerically demonstrate that the BSC-related resonances in arrays of silicon nanospheres can be employed for both light guiding and light enhancement in he visible-to-near infrared range. Asymptotic behavior of the resonance Q-factor against the number of spheres is elaborated.

17:10 : Nanofabrication of silicon Mie resonators and all-dielectric colored metasurfaces
Igor Ozerov[1], Julien Proust[1], Frederic Bedu[1], Bruno Gallas[2], Nicolas Bonod[1]
[1] *Aix Marseille University (France),* [2] *Sorbonne University (France)*

Silicon Mie resonators and metasurfaces were nanofabricated using electron beam lithography followed by wet chemical alkaline etching or reactive ion etching. The fabrication process was adapted for both amorphous and monocrystalline silicon in order to obtain efficient resonant light scattering by individual silicon particles. A large palette of colors was created by tuning the size, shape and aspect ratio of the particles.

16:40 - 17:25 — Room 110-111

Session 2A31

GEN6. Materials for photonics

Chaired by: Thomas Taubner

16:40 : Topological phase transitions in the photonic local density of states
Wilton J. M. Kort-Kamp[1], Pablo Rodriguez-Lopez[2], Alejandro Manjavacas[3], Lilia M. Woods[2], Diego A. R. Dalvit[1]
[1] *Los Alamos National Laboratory (USA),* [2] *University of South Florida (USA),* [3] *University of New Mexico (USA)*

The expansion of the graphene family by adding silicene, germanene, and stanene opens a promising platform to probe the complex interplay between topology, photonics, and 2D Dirac materials. In this work we investigate the behavior of the photonic local density of states close to buckled materials and show that it can undergo various phase transitions and present topological behavior, all enabled by the rich electronic phase diagram of the graphene family.

16:55 : Ultralow-loss copper films for plasmonics: structural morphology is the key to the improve-

ment of optical properties
Dmitry I. Yakubovsky, Dmitry Yu. Fedyanin
Moscow Institute of Physics and Technology (Russia)

Plasmonics is widely considered to be a promising candidate for the next generation of chip-scale platforms. However, it is based on noble metals, which are incompatible with the industry-standard manufacturing processes. Here, we demonstrate both experimentally and theoretically that copper can efficiently substitute gold in plasmonic devices and open the prospects for commercialization of plasmonic technologies.

17:10 : Highly confined phonon polaritons in thin van der Waals crystal of orthogonal molybdenum trioxide
Zebo Zheng, Huanjun Chen
Sun Yat-Sen University (China)

Here we report the study on the surface phonon polaritons (SPhPs) in a representative layered oxide crystal, orthogonal molybdenum trioxide (α-MoO3). The ultra-confined SPhPs waves resulted from the coupling of IR light and optical phonons of α-MoO3 were launched, detected, and imaged in real space. Our results suggest α-MoO3 as a new platform for studying on novel regimes of lightâĹŠmatter interactions and the future nanophotonic devices.

16:40 - 19:10 — Room 113

Session 2A32

Symposium II. Recent Advances in Complex Materials and Nanophotonics VIII

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

16:40 : Keynote talk
Metasurfaces for in-plane plasmonic arbitrary pattern generation
Byoungho Lee
Seoul National University (Korea)

Plasmonic metasurfaces with distributed nanoslits are demonstrated to generate in-plane plasmonic arbitrary patterns based on holographic approach. Utilizing extremely anisotropic scatterings of surface plasmon polaritons (SPPs) at nanoslits, holographic reconstruction and modulation of plasmonic wavefront are achieved by designing spatial distributions and rotations of nanoslits. Polarization-dependent modulations of in-plane SPP wavefront are thoroughly studied for focusing, switching, and multiplexing in-plane plasmonic waves. Moreover, manipulation of complex plasmonic field in terms of phase and amplitude is proposed for complete control of arbitrary holographic SPP patterns.

17:10 : Invited talk
Observation of a chiral mode at the exceptional point of a polariton laser
Tingge Gao[1], G. Li[2], E. Estrecho[1], L. Pfeier[3], K. West[3], M. Steger[4], D. Snoke[4], A. Kavokin[2], A. G. Truscott[1], E. A. Ostrovskaya[1]
[1] *The Australian National University (Australia),* [2] *University of Southampton (United Kingdom),* [3] *Princeton University (USA),* [4] *University of Pittsburgh (USA)*

In this work, we demonstrate a chiral mode in the form of a charge 1 vortex in an exciton polariton condensate in a ring resonator. The ring resonator is composed of two half rings, through which we observe both the crossing-anticrossing of the energy peak and linewidth of the two modes and confirm the exceptional point. A vortex is observed through both the spatial polariton density distribution and the interference with a reference beam.

17:30 : Invited talk
Rhodium Nanocubes as building blocks for UV-plasmonics
Yael Gutierrez[1], Dolores Ortiz[1], Jose Maria Saiz[1], Francisco Gonzalez[1], Henry O. Everitt[2], Fernando

Moreno[1]
[1] *Universidad de Cantabria (Spain),* [2] *Duke University (USA)*

Nanoplasmonics in the UV-range has awaken a great interest due to applications in biological sensing, photocatalysis or spectroscopy. Recently, rhodium has been proposed as a promising candidate for this purpose. Its low tendency to oxidize overcomes the main problem with metals such as aluminum or magnesium. Also, it presents outstanding catalytic properties. As the synthesis of rhodium nanocubes has been recently reported and because of its UV-plasmonic performance interest, in this research we present an analysis of the plasmonic behaviour of Rh nanocubes aggregates.

17:50 : Invited talk

Enhancement of Electrocataytic Activity of Octahedoral Au-Core/Pt-Shell Nanoparticles by Visible Light Irradiation

Tatsuya Kameyama, K. Sato, T. Torimoto
Nagoya University (Japan)

Octahedral Au-core/Pt-shell (Au@Pt) nanoparticles were successfully prepared via a galvanic replacement of Cu monolayer underpotentially deposited on Au core with a Pt monolayer. The visible-light irradiation to Au@Pt nanoparticles-immobilized electrodes enlarged a cathodic current of oxygen reduction reaction (ORR), suggesting that the electrocatalytic activity of Pt shell layer was enhanced by the photoexcitation of localized surface plasmon resonance peak of octahedral Au-core particles.

18:10 : Invited talk

Vis and NIR nanoplasmonic active and passive materials by eutectic solidification and NanoParticle Direct Doping

Dorota A. Pawlak, Rafal Nowaczynski, Marta Kurowska, Aneta Antolik, Piotr Paszke, Marcin Gajc, Katarzyna Sadecka, Pawel Osewski, Barbara Surma
Institute of Electronic Materials Technology (Poland)

We report on developments in fabricating nanoplasmonic volumetric isotropic and anisotropic materials with plasmonic resonances at visible and infrared wavelength ranges. We demonstrate the results of utilizing the melt-based crystal growth techniques for developing novel methods as the NanoParticle Direct Doping method enabling doping dielectric matrices simultaneously with plasmonic nanoparticles and quantum dots or rare earth ions. We also demonstrate the results when using methods utilizing the self-organization mechanism as in directional solidification of eutectic composites.

18:30 : Invited talk

Three-dimensional Plasmonic Metadevices

Jia-Wern Chen[1], **Hui-Hsin Hsiao**[1], **Yu Han Chen**[1], **Hui Jun Wu**[2], **Cheng Hung Chu**[2], **Mu-Ku Chen**[1], **Wei-Yi Tsai**[1], **Tsung Lin Chung**[1], **Din Ping Tsai**[1]
[1] *National Taiwan University (Taiwan),* [2] *Academia Sinica (Taiwan)*

The resonant properties arose from the electric and magnetic interactions between the vertical split-ring resonators (VSRRs) and light are theoretically and experimentally studied. Particularly, the magnetic resonance plays a key role in plasmon coupling in VSRRs. We perform several VSRR-based metadevices for practical applications in optical communication frequency such as Fano-resonance, highly sensitive nanoplasmonic sensor, isotropic absorber etc.

18:50 : Invited talk

Surface plasmon polariton mediated light-matter interactions in monolayer molybdenum diselenide-nanoantenna hybrid structures

Geeta Sharma, Astha Singh, Parinda Vasa
Indian Institute of Technology Bombay (India)

We report a simple approach to growing large area monolayer molybdenum diselenide films on different substrates using chemical vapor deposition technique. We have investigated surface plasmon mediated light-matter interactions in monolayer molybdenum diselenide-gold nanoantenna hybrid nanostructures. Our results show significant changes in the lattice constant, bandgap energy, photoluminescence lifetime and Raman lines as a direct manifestation of the Purcell effect in MoS2-nanoantenna hybrid structures. Preliminary studies also offer indications of strong coupling in optimized sample configurations.

16:40 - 18:10 — Room 114

Session 2A33

SP25. APhoto/Thermal Conversions and Their Applications with Photonic Crystal, Plasmonics and Metamaterials III

Organized by: Qiang Li and Hui Liu

Chaired by: Qiang Li and Hui Liu

16:40 : Controlling thermal emission of phonon by magnetic metasurfaces
X. Zhang, Hui Liu, Z. G. Zhang, Q. Wang, S. N. Zhu
Nanjing University (China)

Our experiment shows that the thermal emission of phonon can be controlled by magnetic resonance (MR) mode in a metasurface (MTS). Through changing the structural parameter of metasurface, the MR wavelength can be tuned to the phonon resonance wavelength. This introduces a strong coupling between phonon and MR, which results in an anticrossing phonon-plasmons mode.

16:55 : Invited talk
Thermoplasmonic energy conversion by self-assembled aluminum oxide meta-structures
Kyoungsik Kim, Kyuyoung Bae, Yunha Ryu
Yonsei University (Korea)

We report on the thermoplasmonic energy conversion by self-assembled meta-structures of aluminum oxide nanostructures. We fabricate aluminum nanowire array, which has high optical transmission haze, and manipulate the optical characteristics by controlling sizes and morphologies. By depositing metal or metal oxide, the array structures absorb broadband light by plasmonic nanofocusing and the absorbed light is converted into the localized heat energy. The converted heat energy can be utilized for solar vapor generation and thermophotovoltaics.

17:15 : Invited talk
Functionalized Silk Fibroin Thin Films with Gold Nanoparticles as Ultrahigh Broadband Absorber
Dehui Wan
National Tsing Hua University (Taiwan)

In this paper, the phenomenon of white-light-induced heating in silk fibroin films embedded with gold nanoparticles is systematically investigated. As far as we are aware, this study is the first to employ Au NPs to develop an ultrahigh broadband absorber and also the first to use a white light source for photothermal generation. Also, the broadband absorptive film is coated on a simple Al/Si Schottky diode and displays a linear, significant, stable photo-thermo-electronic response with varying light intensity.

17:35 : Invited talk
Enhanced near-infrared Photoelectric and Photothermal Response on silicon flatform by metamaterial absorber and omni-schottky junction
Qin Chen, L. Wen
Chinese Academy of Sciences (China)

Optical absorption and electron emission/collection are two key factors for improving photoelectric response based on plasmonic hot-electron. Here, we demonstrated plasmonic hot-electron photoresponse as high as 3.3mA/W at 1500nm achieved on a silicon platform by metamaterial absorber (MA) and omni-schottky junction. Furthermore, time-resolved photoresponse shows optical energy transferred to electricity through the photothermal mechanism distinct from the photoelectric process of hot electron.

17:55 : Enhancing Near-Field Radiative Heat Transfer with Si-based Metasurfaces
Victor Fernandez-Hurtado[1], Francisco Jose Garcia-vidal[1], Shanhui Fan[2], Juan Carlos Cuevas[1]
[1] *Universidad Autonoma de Madrid (Spain),* [2] *Stanford University (USA)*

We propose a novel mechanism to further enhance near-field radiative heat transfer (NFRHT) with the use of Si metasurfaces, which is based on the broad spectral bandwidth and the high tunability of the surface-plasmon polaritons that dominate NFRHT in these structures. We have shown that by an appropriate choice

of the geometrical parameters, these metamaterials can exhibit room-temperature near-field radiative heat conductances higher than any existent or proposed structure.

18:10 - 18:45 — Room 114

Session 2A34

SP22. Near, Mid and Far Infrared Photonics II

Organized by: Artur Davoyan

Chaired by: Artur Davoyan

18:10 : Invited talk
THz hollow-core waveguide with metamaterial cladding
Shaghik Atakaramians, H. Li, R. Lwin, X. Tang, A. Argyros, S. C. Fleming, B. T. Kuhlmey
The University of Sydney (Australia)

We theoretically, numerically and experimentally demonstrate hollow core fibres with hyperbolic metamaterial cladding having more than double the single-mode bandwidth of metallic waveguides. In the THz such fibres offer a unique combination of being mechanically flexible, with low optical loss and large single-mode bandwidth.

18:30 : Highly Integrated Dual-Channel Metamaterial Thermal Detector for Mid-IR Optical Gas Sensing
Alexander Lochbaum, Yuriy Myronovych Fedoryshyn, Christian Hafner, Juerg Leuthold
ETH Zurich (Switzerland)

We demonstrate a dual-channel, CMOS-compatible metamaterial thermopile detector, exhibiting near-ideal peak absorptivity values (A=0.99), and narrowband absorption characteristics (Q=15.1 at 4.29μm). The ultra-thin metamaterial perfect absorber (MPA) makes additional blackening layers and filter elements obsolete, allowing for highly integrated, low-cost optical gas sensing systems. Employed in a non-dispersive gas sensing setup, the MPA detector leads, in comparison to a non-structured thermopile, to a 3.9-fold increase in analyte resolution, with a simultaneous 6.5-fold decrease in humidity cross sensitivity.

16:40 - 19:15 — Room 115

Session 2A35

Symposium I. Hybrid Optically Active Nanomaterials VI

Organized by: Xing Yi Ling, Jerome Plain and Alexander Govorov

Chaired by: Xing Yi Ling, Jerome Plain and Alexander Govorov

16:40 : Invited talk
Metal nanostructures characterization by digital holography: applications to thermoplasmonics and electrochemistry
Adrien Lalisse[1], Vitor Brasiliense[1], Minh Chau Nguyen[1], Pascal Berto[1], Robert Kuszelewicz[1], Frederic Kanoufi[2], Jerome Plain[3], Gilles Tessier[1]
[1] *Paris Descartes University (France),* [2] *Paris Diderot University (France),* [3] *Technological University of Troyes, (France)*

Heterodyne digital holography is a powerful tool to study optically scattering objects. It allows the reconstruction of 3D images, and the superlocalization of individual objects with 3x3x10 nm3 precision. Associated to heterodyning, it can also measure modulated phenomena like the scattering efficiency changes thermally induced by the modulated excitation of plasmonic nanoantennas. We will illustrate the possibilities of this tech-

nique to study electrochemical processes in single metallic nanoparticles, and to obtain quantitative thermal mapping in thermoplasmonics.

17:00 : Time-dynamical model for the lasing of homogeneous and core-shell plasmonic nanoparticles coupled to an active medium

Andres Cathey[1], **Alessandro Veltri**[1], **Arkadi Chipouline**[2], **Ashod Aradian**[3]
[1] *Universidad San Fransisco de Quito (Ecuador),* [2] *Technische Universitat Darmstad (Germany),* [3] *Bordeaux University (France)*

We propose a full time-dynamical and space-dependent theoretical description of the optical response of plasmonic nanoparticles coupled to gain (active medium) in two geometries homogeneous spheres immersed in a gain medium, and gain core-metal shell nanoparticles. We are able to calculate the lasing threshold and the initial stages of the lasing instability, and for the latter geometry, we solve the long-term dynamics, calculating the emission width of the nanolaser as well as exploring other relevant features of the system.

17:15 : Invited talk

Blinking surface-enhanced Raman scattering and fluorescence from polyamino acid or dye molecules on the same silver nanoaggregate

Yasutaka Kitahama
Kwansei Gakuin University (Japan)

Blinking of surface-enhanced Raman scattering (SERS) and surface-enhanced fluorescence (SEF) from the same silver nanoaggregate with poly-L-lysine or thiacarbocyanine were simultaneously observed at different wavelengths. Intensities of the SERS were plotted against those of the SEF at the same times. The SERS of poly-L-lysine was emitted while no SEF of silver atomic cluster on the silver surface was observed. This result suggests single molecule detection. We compared the blinking statistics of poly-L-lysine to that of the dye molecules.

17:35 : Invited talk

Selective Trapping and Fixation of DNAs Using Plasmonic Optical Tweezers

Yasuyuki Tsuboi
Osaka City University (Japan)

Optical manipulation of small biomolecules is an important issue in bioscience. Plasmon-based optical tweezers (POT) has attracted significant interests as a novel efficient trapping method, since it enhances a radiation force and enables us to trap smaller biomolecules.

17:55 : Invited talk

Penetration Effect in Uniaxial Anisotropic Metamaterials

K. Vytovtov[1], **Said Zouhdi**[2]
[1] *Astrakhan State Technical University (Russia),* [2] *Paris-Sud University (France)*

We consider a plane harmonic wave propagating parallel to an interface between a standard isotropic medium and an anisotropic metamaterial. It is proved analytically that part of the wave power propagates into the anisotropic metamaterial. Reflection and transmission coefficients are obtained.

18:15 : Invited talk

Nanoplasmonics for ultra-high resolution colours prints and DNA-programmable nanoplasmonics

Xiao Ming Goh[1], **Lin Xi**[1], **Gomathy Sandhya Subramanian**[1], **Ng Jia Hong Ray**[2], **Joel K. W. Yang**[1], **Shawn J. Tan**[1]
[1] *A*STAR (Singapore),* [2] *Singapore University of Technology and Design (Singapore)*

Metal nanostructures can exhibit specific plasmonic resonances in their optical reflectance spectra through the control of nanostructure material and geometry. This unique spectral control and tunability is attractive for ultra-high resolution colour printing, or for producing security elements for anti-counterfeiting. Their enhanced sensitivity can be combined with the programmability of DNA to develop active plasmonic systems. Here, economical ways of making high resolution colour prints and integrating lithographically-defined nanostructures on solid substrates with DNA will be discussed.

18:35 : Invited talk

Improving the photocatalytic water reducing activity of LaTi2O7 by tuning the crystal facets and composing with plasmonic Au

Junying Zhang
Beihang University (China)

The photocatalytic activity of La2Ti2O7 (LTO) is limited by the large band gap and poor electron mobility. These problems can be conquered by hybridization with materials with visible-near infrared (vis-NIR) light absorption and high charge carrier transport. Firstly, we synthesized a 2D composite with g-C3N4 nanosheets and nitrogen doped LTO nanosheets (NLTO).

18:55 : Invited talk
Active control of strong plasmon-exciton coupling in two-dimensional atomic semiconducting crystals
Jinxiu Wen[1], Hao Wang[2], Huanjun Chen[2]
[1] *Sun Yat-Sen University (China),* [2] *Sun Yat-sen University (China)*

We report on the strong plasmon-exciton coupling in monolayer WS2 coupled to individual plasmonic gold nanorods. Due to the high oscillator strength and larger binding energy of the 2D exciton of WS2, we have obtained large Rabi splitting energy of 91 meV $\sim$ 133 meV at ambient condition which was associated with only 5 $\sim$ 18 excitons. In addition, the strong coupling can be dynamically tuned either by electrostatic gating or temperature scanning.

16:40 - 18:20 — Room 116

Session 2A36

SP2. Functional Materials and Devices for Acoustic and Elastic Waves III

Organized by: Guancong Ma and Yun Lai

Chaired by: Guancong Ma and Yun Lai

16:40 : Invited talk
A route to acoustic Landau levels
Zhaoju Yang, Baile Zhang
Nanyang Technological University (Singapore)

Previous approaches constructing synthetic gauge field for sound predominantly relied on a periodic system, being unable to form a uniform effective magnetic field. Here we introduce strain engineering, previously developed in graphene electronics and later transferred to photonics, into an aperiodic two-dimensional acoustic structure in order to form a uniform effective magnetic field for air-borne acoustic wave propagation. Landau levels in the energy spectrum can be formed near the Dirac cone region.

17:00 : Invited talk
Production and control of acoustic orbital angular momentum (OAM) by metamaterials
Jianchun Cheng[1], Bin Liang[1], Xue Jiang[1], Likun Zhang[2], Chengwei Qiu[3]
[1] *Nanjing University (China),* [2] *University of Mississippi (USA),* [3] *National University of Singapore (Singapore)*

In this talk, I will introduce some of our latest works on production and manipulation of acoustic OAM by metamaterials. We have designed and fabricated an acoustic vortex emitter with multi-arm coiling slits that utilize diffraction effect to generate vortex beam. Based on this, we further propose a new mechanism for producing OAM by converting resonances to OAM. I will also briefly discuss the potential of OAM devices to revolutionize various applications such as in acoustic communication.

17:20 : Invited talk
Ultra-thin Acoustic Metasurface-Based Schroeder Diffuser
Yifan Zhu[1], Xudong Fan[1], Bin Liang[1], Jianchun Cheng[1], Yun Jing[2]
[1] *Nanjing University (China),* [2] *North Carolina State University (USA)*

Schroeder diffuser is a classical design that has been widely adopted in architectural acoustics. The conventional Schroeder diffuser, however, has a considerable thickness on the order of one wavelength. In this paper, a new class of ultra-thin and planar Schroeder diffusers are proposed based on the concept of acoustic

metasurface. Both numerical and experimental results demonstrate satisfactory sound diffuse reflection produced from the metasurface-based Schroeder diffuser despite it being one order of magnitude thinner than the conventional one.

17:40 : Invited talk
Topological sound in active liquid metamaterials
Vincenzo Vitelli
Leiden University (Netherlands)

Liquids composed of self-propelled particles have been experimentally realized using molecular, colloidal, or macroscopic constituents. These active liquids can flow spontaneously even in the absence of an external drive. We design metamaterials that break time-reversal symmetry using lattices composed of annular channels filled with a spontaneously flowing active liquid. Such active metamaterials support topologically protected sound modes that propagate unidirectionally, without backscattering, along either sample edges or domain walls and despite overdamped particle dynamics.

18:00 : Invited talk
Non-reciprocal acoustic systems: from sound isolation to topological propagation
Romain Fleury
EPFL (Switzerland)

We discuss the possibility to largely break Rayleigh reciprocity in compact, linear acoustic systems with broken time-reversal symmetry. These subwavelength systems can be used as building blocks to construct non-reciprocal metamaterials. Interestingly, the obtained metamaterials support one-way edge modes that are topologically protected against defects and disorder, highlighting a fruitful design strategy, from engineering non-reciprocal acoustic metamolecules to building acoustic Chern topological insulators.

16:40 - 17:20 — Room 117

Session 2A37

SP40. Innovative Metamaterials III

Organized by: Namkyoo Park and Jeong Weon Wu

Chaired by: Namkyoo Park and Jeong Weon Wu

16:40 : Invited talk
New Avenue in dielectric cavities; Transformation optics perspective
Muhan Choi[1], Yushin Kim[2], Jung-Wan Ryu[3], Inbo Kim[1], Bumki Min[2]
[1] *National University Daegu (Korea),* [2] *Korea Advanced Institute of Science and Technology (Korea),* [3] *Institute for Basic Science (Korea)*

We have proposed a new methodology based on transformation optics to manipulate mode properties of dielectric cavity such as directionality, chirality of resonance modes while maintaining High-Q values. The novel mode properties can be realized in inhomogeneous dielectric cavities which can be defined by imposing spatially-varying refractive index derived from the transformation optics theory.

17:00 : Invited talk
Metasurfaces for chiral sensing
Seok-Jae Yoo, Q-Han Park
Korea University (Korea)

Metasurfaces as ultrathin flat metamaterials induce substantial phase changes in the propagating light thereby enabling a new field of planar photonics. However, the ability of metasurfaces to create non-trivial strongly localized near fields has not received much attention. Here, we address applications of metasurfaces to the sensing chiral molecules by utilizing highly inhomogeneous near fields created by metasurfaces. We establish underlying physical theories for chiral molecule sensing and explain the role of metasurfaces in enhancing sensing signals.

17:10 - 18:50 — Room 118

Session 2A38

SP13. Hybrid Plasmonics with Quantum Confined Materials and Devices II

Organized by: Palash Bharadwaj and Hayk Harutyunyan

Chaired by: Palash Bharadwaj and Hayk Harutyunyan

17:10 : Invited talk
Broadband Second-Harmonic Generation based on Active Nonlinear Metasurfaces
Jae-Yeon Yoo, Jongwon Lee
Ulsan National Institute of Science and Technology (Korea)

Broadband second-harmonic generation based on Stark-tunable intersubband nonlinearities in multiple quantum well structures combined with plasmonic resonators was studied. Theoretically, 5 times broader second-harmonic generation wavelength compared to passive nonlinear metasurfaces and over 0.1 % of the maximum conversion efficiency were achieved.

17:30 : Invited talk
Visible-frequency Surface Plasmon Resonators and Lasers with High Quality Factors
Shawn Divitt, Wenqi Zhu, Jared Strait, Henri Lezec, Amit Agrawal
National Institute of Standards and Technology (USA)

We experimentally demonstrate novel geometries of surface-plasmon-polariton based resonators that exhibit record-high quality factors (>750) in the visible frequency range, and use them to achieve narrow-linewidth lasing.

17:50 : Invited talk
Metallic/dielectric nanoantennas for high-resolution color printing and giant enhancement of second-harmonic generation
Zhaogang Dong[1], Joel K. W. Yang[2]
[1] *A*STAR (Singapore),* [2] *Singapore University of Technology and Design (Singapore)*

The fast development of top-down fabrication has enabled investigations towards the interaction mechanism between optical fields and metallic/dielectric nanoantennas. In this talk, we will present our recent work on silicon antenna for high-resolution color printing beyond diffraction limit, where we could achieve a color gamut of more than 100 % of sRGB. In addition, we will also present our recent work on metallic nanoantenna for the giant enhancement of photoluminescence and second-harmonic generation from monolayer tungsten diselenide.

18:10 : Invited talk
Strong Coupling Between Individual Plasmonic Metal Nanostructures and Quantum Dots
Matthew Pelton
University of Maryland (USA)

Coupling between plasmons in metal nanoparticles and exctions in quantum dots can lead to novel optical phenomena. We predict that a single colloidal quantum dot can induce nearly complete transparency in the much stronger absorption and scattering of a metal nanostructure, and this induced transparency can be switched on and off with control laser pulses. For more than one quantum dot coupled to the same nanostructure, we predict that laser pulses can induce entanglement among the quantum-dot states.

18:30 : Invited talk
Polarization Dependent Light-Matter Interaction with Metal Surfaces and Metasurfaces
Pieter G. Kik[1], Chatdanai Lumdee[2], Vrinda Thareja[1], Majid Esfandyarpour[1], Mark L. Brongersma[1]
[1] *Stanford University (USA),* [2] *CREOL, The College of Optics and Photonics (USA)*

The large free charge concentration in metals enables strong light-matter interaction, allowing for nanoscale engineering of emission efficiency and radiation patterns. However, the large conductivity of metals also strongly suppresses lateral fields, reducing excitation and emission rates related to lateral polarization. Here we show that subwavelength patterning of metal surfaces can overcome the deleterious effect of lateral field

suppression, resulting a large, reproducible, and quantitatively understood enhancement of Raman scattering from graphene in close contact with a metasurface.

Thursday 27th July, 2017

08:45 - 10:30 — Ballroom

Session 3A1

Plenary Session III

Chaired by: Xiang Zhang

08:45 : Plenary talk
Towards Scalable Semiconductor Quantum Networks
Dirk Englund
Massachusetts Institute of Technology (USA)

The Internet is among the most significant inventions of the 20th Century. We are now poised for the development of a quantum internet to exchange quantum information and distribute entanglement among quantum memories (and ultimately quantum computers) that could be great distances apart. This kind of quantum internet would have a range of applications that aren't possible in a classical world, including long-distance unconditionally-secure communication, certain types of precision sensing and navigation, and distributed quantum computing. But we still need to develop or perfect many types of components and protocols to build such a quantum internet.

09:20 : Plenary talk
Optical Antennas: Spontaneous Emission Faster Than Stimulated Emission
Eli Yablonovitch
UC Berkeley (USA)

Over 100 years after the radio antenna, we finally have tiny optical antennas which can extract radiation from molecules and quantum dots. With optical antennas, spontaneous light emission can become faster than stimulated emission. Antenna physics has been poorly covered in education. It does not require plasmonics, nor the Purcell effect.

09:55 : Plenary talk
Metaoptics in the Visible
Federico Capasso
Harvard University (USA)

Metasurfaces based on sub-wavelength patterning have major potential for arbitrary control of the wavefront of light by achieving local control of the phase, amplitude and polarization and allowing greater functionality and more compact devices. We have introduced a new CMOS compatible technology based on atomic layer deposition of TiO2 which has enabled high performance metalenses, achromatic lenses, immersion objectives, axicons, vortex plates, holograms and ultracompact spectrometers for a wide range of applications.

Coffee Break and Exhibit Inspection

Sponsored by Incheon Tourism Organization

Session 3P1

Poster Session V

10:30 - 11:10

P1: Deformation Determination of Al doped ZnO Acoustic Cantilever Using Ideal Wurtzite Crystal Structure for Wireless Applications
Md Rabiul Awal[1], Muzammil Jusoh[1], R. Badlishah Ahmad[1], Thennarasan Sabapathy[1], Muhammad

Ramlee Kamarudin[2], **Mohamed Nasrun Osman**[1]
[1] *Universiti Malaysia Perlis (Malaysia),* [2] *Universiti Teknologi Malaysia (Malaysia)*

A methodology to calculate the deformation of crystal structure is presented in this paper. Al doped ZnO is used to form the acoustic cantilever in ideal wurtzite crystal structure. The expansion of the applied cantilever is calculated by the proposed methodology and presented accordingly.

P2: Experimental verification of extraordinary acoustic transmission through density near zero extremely narrow tubes

Jong Jin Park, Jun-Hyuk Kwak, Boyoung Kang, Hakjoo Lee
Center for Advanced Meta-Materials (Korea)

We experimentally verify recently developed theory of supercoupling [Phys. Rev. Lett. 111, 055501 (2013)] by researching uniform acoustic energy squeezing through an extremely narrow acoustic tubes filled with near zero density metamaterials. So, we realized extraordinary acoustic transmission based on impedance matching by installing thin membranes with a subwavelength period along the tube. Potential applications in acoustic treatment, sensing and energy harvesting.

P3: Acoustic Hologram via Decoupled Modulation of Amplitude and Phase in Acoustic Metamaterial

Yifan F. Zhu[1], **X. F. Zhu**[2], **X. D. Fan**[1], **B. Liang**[1], **J. C. Cheng**[1]
[1] *Nanjing University (China),* [2] *Huazhong University of Science and Technology (China)*

We have realized acoustic hologram via acoustic metamaterials with simultaneous controls of amplitude and phase. More importantly, the modulation of amplitude and phase is decoupled at specific points in the parameter space, leading to that all possible combinations of amplitude and phase can be accessed. Our method can stably generate hologram with high quality and high fidelity, which are unattainable with previous pure-phase approaches. Our findings will have far-reaching impacts on beam-steering, ultrasonic imaging and particle manipulation, etc.

P4: Acoustic impedance matching of water and air

Haejin Choi[1], **Eun Bok**[1], **Jong Jin Park**[1], **Chung Kyu Han**[1], **Oliver Bernard Wright**[2], **Sam Hyeon Lee**[1]
[1] *Yonsei University (Korea),* [2] *Hokkaido University (Japan)*

We present the fabrication of an acoustic metasurface of thickness much smaller than the wavelength, which, placed in between the water and the air, matches impedances of water and air. This impedance matching metasurface is a two-dimensional array of unit cells, each of which consists of a thin cavity covered with five membranes. Experimentally we obtained about 40 % power transmission through the interface using the metasurface, which corresponds to over 23.5 dB transmission enhancement.

P5: Origin of negative permittivity of metamaterials

Sam Hyeon Lee[1], **Eun Bok**[1], **Haejin Choi**[1], **Jong Jin Park**[1], **Chung Kyu Han**[1], **Oliver Bernard Wright**[2]
[1] *Yonsei University (Korea),* [2] *Hokkaido University (Japan)*

Reported methods for retrieval of wave parameters for given metamaterial structures so far have been significantly different from classical theory of dielectrics. Here we demonstrate that the classical treatment, which is familiar with wide range of scientists and engineers, can be extended to the realm of electromagnetic metamaterials for exact accounting of the effective permittivity. Our scheme not only makes the calculations easier but also provides intuitive way of understanding the origins of negative parameters.

P6: Lamb wave focusing by piezoelectric array

Pawel Kudela[1], **Zhibo Yang**[2], **Maciej Radzienski**[1], **Wieslaw Ostachowicz**[1]
[1] *Polish Academy of Sciences (Poland),* [2] *Xi'an Jiaotong University (China)*

A novel concept of A0 Lamb wave mode focusing by piezoelectric array transducers is investigated. Due to dispersive nature of A0 mode of Lamb wave precompensation of dispersion in excitation signals is performed. The designed excitation waveform for each piezoelectric transducer in the array is designed so that interference of waves occurs at desired focal point. Developed technique could be useful for damage detection purposes.

P7: Photonic Crystal Microchip Laser

Darius Gailevicius[1], **Volodimir Koliadenko**[2], **Victor Taranenko**[2], **Vytautas Purlys**[1], **Martynas Peckus**[1], **Kestutis Staliunas**[3]
[1] *Vilnius University (Lithuania),* [2] *NAS of Ukraine (Ukraine),* [3] *Universitat Politecnica de Catalunya (Spain)*

We show, theoretically and experimentally, that photonic crystals with spatial filtering functionality, inside of a microchip laser cavity, can substantially improve spatial characteristics of the emission of microchip laser. The angular divergence of the emitted beam is reduced, and the radiation brightness is increased.

P8: Purcell effect in one-dimensional disordered photonic crystals

Azat Gubaydullin[1], Kostya Ivanov[1], V. V. Nikolaev[2], Mikhail Kaliteevski[1]
[1] *Saint- Petersburg Academic University (Russia),* [2] *Ioffe Physical-Technical Institute (Russia)*

We have theoretically studied the probability of spontaneous emission rate of the emitter placed in a one-dimensional disordered photonic crystal. It is demonstrated that at high levels of disorder photonic band gap (PBG) is narrowed, and the probability of emission in the center of PBG becomes significantly different from zero, and in the PBG may occur localized states for which the spontaneous emission is significantly enhanced.

P9: Perturbed flat-band modes and anisotropic optical responses in an array of quasi-one-dimensional systems

Nojoon Myoung[1], A. Ramachandran[1], Jung-Wan Ryu[1], E. Lidorikis[2], H. C. Park[1]
[1] *Center for Theoretical Physics of Complex Systems (Korea),* [2] *University of Ioannina (Greece)*

We theoretically examine the photonic band structures of an array of quasi-one-dimensional systems where a flat band can exist. Since the interactions in the photonic lattice are not restricted to the nearest neighbor interactions, the flat bands are perturbed by coupling to the dispersive bands, resulting in the avoid crossing nature. The perturbation-induced delocalization is analyzed based on understanding of the life time of localized modes.

P10: High Quality Photonic Crystal Cavity with low index materials by using Slot Mode

Youngsoo Kim, Young Jin Lee, Seokhyeun Hong, Kihwan Moon, Soon-Hong Kwon
Chung-Ang University (Korea)

We suggest a photonic crystal cavity which confines the photons in low index material for telecommunication wavelength. The photonic crystal consists of periodic Si/SiO2/Si rods. In this cavity, the vertical losses can be reduced by low index slot mode and the horizontal losses can be reduced by photonic bandgap of square lattice photonic crystal slab. For telecommunication wavelength, we can get the highest quality factor 11200 by moving nearest neighborhoods of center defect on suggested photonic crystal structure.

P11: The role of first- and second order light scattering processes in decomposing the 3D nanostructure of butterfly wing scales

G. I. Mark[1], K. Kertesz[1], G. Piszter[1], Zs. Balint[2], L. P. Biro[1]
[1] *Institute of Technical Physics and Materials Science (Hungary),* [2] *Hungarian Natural History Museum (Hungary)*

We identified two different scattering processes characteristic of the low- and high wavelength ranges of optical reflection spectra of butterfly wing scales. Our computer simulations based on the solution of 3D Maxwell equations helps to understand the connection between the wing scale nanoarchitecture and the measured optical spectrum.

P12: Treatment of the nonconvergence of the Fourier modal method and the C method arising from field hypersingularities

Haitao Liu[1], Yanpeng Mei[1], Junda Zhu[1], Ying Zhong[2]
[1] *Nankai University (China),* [2] *Tianjin University (China)*

Perturbative approaches are reported to overcome the recently observed nonconvergence of the Fourier modal method (FMM) and the coordinate transformation method (C method) arising from field hypersingularities at lossless metal-dielectric edges. Perturbations of profile or refractive index are applied for representative examples of triangular or parallelogram (or rectangular) gratings, respectively. However, for vanishing perturbations, the converged values of the diffraction efficiency can approach a fixed value for some numerical examples but cannot for other examples.

P13: Far and near field optical properties of large scale spherical microparticle arrays

Alexey A. Shcherbakov[1], Thomas Kaempfe[2], Yves Jourlin[2]
[1] *Moscow Institute of Physics and Technology (Russia),* [2] *University of Lyon (France)*

The work is devoted to experimental and theoretical study of the far and the near field optical properties of 2D monolayer arrays of silica microspheres. In the far field results of measurements of angular dependent

diffraction are compared with simulation of realistic monolayers performed by the Generalized Source Method. In the near field simulation results are used to predict geometric parameters of microscale arrays obtained by the colloidal lithography.

P14: Simulation and Design of CMOS Terahertz Detector With Surface Plasmon Antenna
Ze Shen, Xiaoli Ji, Yiming Liao, Jingyu Peng, Qun Lou, Ruixing Wu, Biaobing Jin, Feng Yan
Nanjing University (China)

In this paper, CMOS terahertz detector integrated with surface plasmon antenna is proposed. The antenna is constructed by the doped silicon material and the simulation results show its capacity to realize strong light concentration at 650GHz.

P15: Resonance splitting in 3D Bi-flake Metamaterial
Zhe Liu, Weijia Sheng, Shuo Du, Junjie Li, Changzhi Gu
Chinese Academy of Sciences (China)

A 3D metamaterial composed of two metal flakes with supplementary angles were fabricated by ion beam induced folding technique. Due to its asymmetry configuration, trapped mode can be excited by the destructive coupling between two flakes, and the evanescent wave of surface plasmon plays a leading role. The resonance peak can be split into two peaks, and these steep resonance peaks have great potential for sensing and detecting applications.

P16: Negative refraction in vertically multilayered hyperbolic metamaterials
Sunae So, Junsuk Rho
Pohang University of Science and Technology (Korea)

Negative refraction has attracted significant interest of researchers due to its various applications including super-resolution imaging, slow light devices, and cloaking. Although it can be realized in hyperbolic metamaterial, conventional hyperbolic metamaterial has been suffered from high resistive loss and narrow working frequency. In this work, new design of hyperbolic metamaterials of vertically stacked metal-dielectric multilayer is proposed. Comprehensive comparison between two types of vertical and horizontal multilayer hyperbolic metamaterial is followed based on numerical calculation of negative refraction.

P17: Extreme absorption enhancement in ZnTe:O/ZnO intermediate band core-shell nanowires by interplay of dielectric resonance and plasmonic bowtie nanoantennas
Kui-Ying Nie, Fang-Fang Ren, Jiandong Ye
Nanjing University (China)

We explore a rational design of a hybrid structure composed of ZnTe:O/ZnO core/shell NWs with Al bowtie nanoantennas, which exhibits strong ability in tuning and enhancing broadband light response due to the interplay of NW dielectric resonance and plasmonic coupling of metallic nanoantennas.

P18: Chirality Enhancement at Simultaneous Electric and Magnetic Hotspot
Jungho Mun, Junsuk Rho
Pohang University of Science and Technology (POSTECH) (Korea)

Enhanced light-matter interaction near nanostructures have been widely investigated. Chiroptical signal can also be enhanced for a chiral molecule located at the field with enhanced optical chirality. This work investigates globally enhanced optical chirality near achiral nanostructures with simultaneous electric and magnetic resonances.

P19: High Refractive Index Nanostructures as Building Blocks for Optical Devices
Angela Inmaculada Barreda[1], Hassan Saleh[2], Amelie Litman[2], Francisco Gonzalez[1], Jean-Michel Geffrin[2], Fernando Moreno[1]
[1] *Universidad de Cantabria (Spain),* [2] *Aix-Marseille University (France)*

Here, we intend to show a review of our recent investigations in light scattering by nanostructured High Refractive Index Dielectric (HRID) materials and their possible applications for controlling the direction of the scattered light, for switching purposes and, as an alternative to metals, as low-loss near-field enhancers for sensing applications

P20: Elastic Metamaterial for Extreme Broad Stop Band at Low Frequency Ranges
Joo Hwan Oh[1], Shuibao Qi[2], Yoon Young Kim[3], Badreddine Assouar[2]

[1] *Ulsan National Institute of Science and Technology (UNIST) (Korea),* [2] *University of Lorraine (France),* [3] *Seoul National University (Korea)*

We propose and realize a new elastic metamaterial having extreme broad low frequency stop band. The stop band achieved with the proposd elastic metamaterial is from 235 to 4520 Hz. To achieve the extreme broad low frequency stop band, we developed a new idea of near-zero rotational stiffness, which is a different mechanism compared with phononic crystals or resonance based metamaterials. We expect that the proposed elastic metamaterial can open a new way in various vibration devices.

P21: Measurement and Analysis of Lamb Wave Propagating on Plates with Periodic Structures
I-Ling Chang, Guan-Hua Huang, Yun-Chun Lee
National Cheng Kung University (Taiwan)

Both experiment and numerical simulation were carried out to investigate the Lamb wave propagation behavior on phononic crystal plates. The considered periodic structures on the plate are holes and pillars. The dispersion relations of symmetric and antisymmetric Lamb waves extracted from experimental measurement agreed quite well with the numerical results. It was found that the band gaps of the phononic crystal plates with pillars was easier to observe experimentally and narrow banded, which were caused by the local resonance.

P22: Elastic metasurface for high transmission anomalous beam refraction
Hyuk Lee, Jun Kyu Lee, Yoon Young Kim
Seoul National University (Korea)

In this work, we realize an elastic metasurface capable of anomalously manipulating the refracted ultrasonic beam with almost full transmission. After the underlying mechanism involving the longitudinal elastic wave motion by the developed mass-spring model is presented, the design of the unique unit cell structure is proposed. For simulation and test, the metasurface is embedded in a thin plate and the anomalous refracting and focusing of the lowest-symmetric Lamb mode within its subwavelength thickness ($<0.5\lambda$) are demonstrated.

P23: Perfect Mode Conversion of Elastic Waves: Realization with Anisotropic Metamaterials
Joshua Minwoo Kweun, Xiongwei Yang, Yoon Young Kim
Seoul National University (Korea)

This work presents a newly-discovered elastic wave mode conversion mechanism called the transmodal Fabry-Perot resonance (TFPR) which occurs through a special anisotropic medium. When the TFPR occurs at the TFPR frequencies, an incident longitudinal wave becomes maximally transmitted to a transverse wave. The theory of the TFPR is presented and the anisotropic medium is realized by elastic metamaterials. Numerical and experimental results show the transmodal resonance that completely transmits an incident wave mode to another mode.

P24: Development of terahertz nano-gap metamaterials for low-density virus detection
SaeJune Park, GwyAm Shin, YeongHwan Ahn
Ajou University (Korea)

We developed terahertz metamaterials with micro- and nano-gaps for the sensitive detection of viruses. Redshift of resonant frequency occurs as we deposit low-density viruses such as PRD1 and MS2 on the metamaterials due to the change of the effective dielectric constant of the gap structure. Sensitivity increases as we reduce the gap size in the metamaterials, which is due to the size compatibility and the strong field confinement effect in the gap area.

P25: 3D Lantern-like metamaterial
Sha Hu, Ruhao Pan, Zhe Liu, Shengyan Yang, Junjie Li, Changzhi Gu
Chinese Academy of Sciences (China)

This work presents a 3D metamaterial based on stress induced bending of bilayer or multilayer film. Take advantage of traditional planar process, the lantern-like metamaterial contains a flat pad supported by the substrate and a number of arms connecting to the pad. By changing the number of arms, the transmission spectrum changes correspondingly, and an EIT-like resonance appears when the arm number is above 6 due to the coupling between different arms.

P26: Sharp dark modes in mirror-asymmetric metamaterials
Shengyan Yang, Chengchun Tang, Zhe Liu, B. Wang, C. Wang, Junjie Li, Changzhi Gu

Chinese Academy of Sciences (China)

We report the excitation of extremely high quality-factor (Q-factor) dark mode resonances in metamaterials composed of mirror-asymmetric split ring resonators (MASRRs) in the terahertz region. Breaking the symmetry of the mirror-arranged SRR leads to the occurrence of two distinct otherwise inaccessible ultrahigh Q-factor dark modes. The numerical simulations indicate that the highest Q-factor of the dark mode resonance was 60, which is more than one order of magnitude larger than that of conventional metamaterials.

P27: Photothermal nanojoining of metallic nanowires
Qiang Li, Hangbo Yang, Min Qiu
Zhejiang University (China)

Nanojoining of nanomaterials opens up a new emerging set of applications in transparent conductors, thin-film solar cells, nanocatalysis, cancer therapy and nanoscale patterning. Single point nanojoining is highly demanded for building complex nanostructures. In this talk, I will show the precise control of single point nanojoining of silver nanowires in depth, where the nanojoining is laser-induced through the plasmonic resonance enhanced photothermal effect.

P28: Gap-free thermophotovoltaic systems
Mohammad Sajjad Mirmoosa[1], Svend-Age Biehs[2], Constantin Simovski[1]
[1]Aalto University (Finland), [2]Carl von Ossietzky Universitat (Germany)

We investigate a gap-free thermophotovoltaic system whose engineered emitter is matched to the macroscopic layer of a particular material which has very low absorption at the operation band of the photovoltaic cell and relatively low thermal conductivity. We tailor the radiative heat transfer such that it is maximal and super-Planckian near the bandgap frequency of the photovoltaic cell, and reduced at other frequencies. Therefore, it gives rise to a high ultimate efficiency and high electric output.

P29: Resonant Thermoelectric Nanophotonics
Kelly W. Mauser, Seyoon Kim, Slobodan Mitrovic, Dagny Fleischman, Ragip Pala, Keith Schwab, Harry Atwater
California Institute of Technology (USA)

Photodetectors are typically based on photocurrent generation from electron-hole pairs in semiconductors and on bolometry for below bandgap absorption. We demonstrate subwavelength thermoelectric nanostructures designed for resonant spectrally selective absorption, which create localized temperature gradients with unfocused, spatially-uniform illumination to generate easily measureable thermoelectric voltages. We show that such structures are tunable with highly wavelength-specific detection, with responsivities up to 38 V/W, and bandwidths of 3 kHz, by combining resonant absorption at thermoelectric junctions, yielding a bandgap-independent photodetection mechanism.

P30: Thin multi-layered film of radiation cooling for heat dissipation of LED arrays
Yung-Chiang Lan, Po Jui Chiu, Bo-Han Cheng
National Cheng Kung University (Taiwan)

A three-layered compact film with heat dissipation based on the method of passive radiation cooling for light emitting diode (LED) are developed and analyzed. Electromagnetic and heat diffusion simulations are accomplished to verify that the design of proposed film can effectively decrease the temperature of LED with various input powers.

P31: High-Yield Plasmonic Nanolasers with Excellent Stability for Sensing in Aqueous Solution
Suo Wang, Bo Li, Xing-Yuan Wang, Hua-Zhou Chen, Yi-Lun Wang, Xiao-Wei Zhang, Lun Dai, Ren-Min Ma
Peking University (China)

we report a plasmonic nanolaser with excellent stability in biocompatible aqueous solution by surface passivation. The overall yield of stable operation is over 68 %. We demonstrate these passivated plasmonic nanolasers as refractive index sensors. The figure of merit (FOM) of intensity sensing is 8000.

P32: Imaging the Dark Emission of Spasers
Huazhou Chen, Jia-Qi Hu, Suo Wang, Bo Li, Xing-Yuan Wang, Yi-Lun Wang, Lun Dai, Ren-Min Ma
Peking University (China)

We directly image surface plasmon emission, an intrinsic but unrevealed feature of spasers in spatial, mo-

mentum and frequency spaces simultaneously. We demonstrate a nanowire spaser with a coupling efficiency to plasmonic modes of 74 %. This coupling efficiency can approach 100 % in theory when the diameter of the nanowire becomes smaller than 50 nm. Our results provide clear evidence of the surface plasmon amplifier nature of spasers and will pave the way for their various applications.

P33: Reduced Dispersion in Guiding Structures Utilizing Twist Symmetries
Oskar Dahlberg[1], **Rhiannon Mitchell-Thomas**[2], **Oscar Quevedo-Teruel**[1]
[1] *Institute of Technology (Sweden),* [2] *University of Exeter (United Kingdom)*

In this paper we investigate the effect of twist symmetries on guiding structures. A reduced dispersive nature of the structure can be seen when the structure possesses twist symmetry. The analysis yields that higher twist-symmetric structures can be used for low dispersive wave guiding. A promising application of this kind of structure is leaky-wave antennas, which can utilize the low dispersion of the structure.

P34: Study of propagation characteristics in a waveguide with twist-symmetric holes
Fatemeh Ghasemifard, Oscar Quevedo-Teruel
KTH Royal Institute of Technology (Sweden)

The effect of twist symmetry, a special kind of higher symmetries, in a one dimensional periodic structure has been studied. It has been shown that by adding twist symmetry, achieving less dispersive and denser materials is possible. Moreover, it has been shown that the location of bandgap is changed by adding twist symmetry or changing the degree of twist symmetry.

P35: Symmetry enhanced non-reciprocal polarization rotation in a hybrid metal-graphene metasurface
Andrea Ottomaniello[1], **Simone Zanotto**[2], **Alessandro Pitanti**[2], **Federica Bianco**[2], **Lorenzo Baldacci**[2], **Vaidotas Miseikis**[3], **Domenica Convertino**[3], **Camilla Coletti**[3], **Alessandro Tredicucci**[1]
[1] *Universita di Pisa (Italy),* [2] *NEST-Istituto Nanoscienze (Italy),* [3] *Center for Nanotechnology Innovation @ NEST (Italy)*

A monolayer graphene is able to produce a Faraday rotation of several degrees in modest magnetic field. Using a metallic metasurface of sub-wavelength optical resonators placed in proximity to graphene, an increase of the non-reciprocal effect can be achieved over a broad range of frequencies. We demonstrated via simulations that increasing the geometric symmetry of the single resonator the performances of the device improved. The studied system can constitute the prototype for sub-wavelength Faraday rotator and optical isolator.

P36: Radiative heat transfer in the extreme near-field: from nanometer to angstrom-sized gaps
Victor Fernandez-Hurtado[1], **Kyeongtae Kim**[2], **Bai Song**[2], **Woochul Lee**[2], **Won Ho Jeong**[2], **Longji Cui**[2], **Dakotah Thompson**[2], **Johannes Feist**[1], **M. T. Homer Reid**[3], **Francisco Jose Garcia-Vidal**[1], **Juan Carlos Cuevas**[1], **Edgar Meyhofer**[2], **Pramod Reddy**[2]
[1] *Universidad Autonoma de Madrid (Spain),* [2] *University of Michigan (USA),* [3] *Massachusetts Institute of Technology Cambridge (USA)*

We present a comprehensive study of radiative heat transfer in angstrom and nanometer-sized gaps from both an experimental and theoretical point of view. Our results establish the fundamental validity of fluctuational electrodynamics in modelling near-field radiative heat transfer (NFRHT) down to single-nanometer gaps. Furthermore, our work suggests that unexpectedly large thermal conductances found in previous works are due to the presence of surface contamination.

P37: Surface plasmon-polaritons in graphene - antiferromagnet layered structure
Igor Bychkov[1], **Dmitry Kuzmin**[1], **Vladimir Shavrov**[2]
[1] *Chelyabinsk State University (Russia),* [2] *Kotel'nikov Institute of Radio Engineering and Electronics of RAS (Russia)*

We have investigated surface plasmon-polaritons in graphene-antiferromagnet layered structure. We show the possibility of resonant interaction of the graphene surface plasmon-polaritons with the magnons of antiferromagnet.

P38: Ultrafast All-Optical Manipulation of Magnetization in Hybrid Metal-Ferromagnet Structures
Feng Cheng, Yongmin Liu
Northeastern University (USA)

We experimentally demonstrate all-optical helicity-dependent switching (AO-HDS) of magnetization in hybrid metal-ferromagnet thin films, showing very robust AO-HDS effect for a wide range of laser repetition rates and peak powers. The hybrid metal-ferromagnet structures exhibit smaller coercivity and smaller remanent magnetization compared with the bare ferromagnet film, which may facilitate the pronounced HD-AOS feature. This work paves a critical step towards future high-speed, low-power and high-density memory and storage technologies.

P39: Photonic noise in deep-subwavelength plasmonic structures with gain and fundamental limitations on data transfer rates

Andrey A. Vyshnevyy, Dmitry Yu. Fedyanin
Moscow Institute of Physics and Technology (Russia)

Surface plasmon amplification by stimulated emission of radiation gives the possibility to compensate for high ohmic losses in the metal and design virtually losses devices. However, stimulated emission is inevitably accompanied by spontaneous emission, which greatly reduces the signal-to-noise ratio and impairs the performance characteristics. Here, we present a comprehensive framework to evaluate noise in plasmonic structures with gain and present a strategy for noise reduction to a level sufficient for practical applications in high-density on-chip optical interconnects.

P40: PT symmetry and pseudo-unitarity of nonunitrary quantum walks

Ken Mochizuki, Hideaki Obuse
Hokkaido University (Japan)

We study PT symmetry of the nonunitary quantum walks whose parameters depend on position and time. At first, we clarify that correlations of parameters in spatial and time directions are necessary to preserve PT symmetry. Then, we numerically show that the system can have entirely real spectra even when parameters of coin operators are spatially random and PT symmetry is broken. This implies that the system possesses pseudo-unitarity.

P41: Non-Hermitian edge modes and topological winding numbers in PT-symmetric systems

Daniel Leykam[1], Konstantin Y. Bliokh[2], Chunli Huang[1], Yidong Chong[1], Franco Nori[2]
[1] *Nanyang Technological University (Singapore),* [2] *RIKEN (Japan)*

Generalizing Hermitian topological phases and edge modes to non-Hermitian systems is a pressing open problem. We study edge modes of a non-Hermitian two dimensional Dirac equation, characterizing its three distinct types of edge modes by two topological winding numbers: the Berry phase and a non-Hermitian charge carried by non-Hermitian degeneracies of the bulk spectrum. This provides an important step towards a complete topological description of non-Hermitian quantum systems and may be realized in PT-symmetric honeycomb lattices.

P42: Hybrid photonic-plasmonic crystal nanocavities sensors

Yun-Cheng Ku[1], Z. -T. Huang[1], P. -J. Cheng[2], C. -K. Chiang[1], J. -C. Hsu[3], Tzy-Rong Lin[1]
[1] *National Taiwan Ocean University (Taiwan),* [2] *Academia Sinica (Taiwan),* [3] *National Yunlin University of Science and Technology (Taiwan)*

We propose and investigate a hybrid photonic-plasmonic crystal nanocavity consisting of a silicon grating nanowire. The resonant defect mode exhibits a high quality factor of 567 and an ultrasmall mode volume of 1.9 x 10-3 (λ/n)3 . The cavity mode also reaches a sensitivity of 443 nm/RIU and a FWHM of 3.4 nm aiming at applications such as biosensing.

P43: Nonlinear Circular Dichroism from plasmonic Metasurfaces

Bernhard Reineke[1], Guixin Li[1], Shumei Chen[2], Franziska Zeuner[1], Martin Weismann[3], Ventsislav Kolev Valev[4], Kok Wai Cheah[5], Nicolae Coriolan Panoiu[3], Shuang Zhang[2], Thomas Zentgraf[1]
[1] *University of Paderborn (Germany),* [2] *University of Birmingham (United Kingdom),* [3] *University College London (United Kingdom),* [4] *University of Bath (United Kingdom),* [5] *Hong Kong Baptist University (Hong Kong)*

Circular Dichroism is the differential absorption of left or right circularly polarized light. In planar artificial structures, like metamaterials, this effect is rather weak. In contrast to that, second harmonic generation circular dichroism (SHG-CD) in artificial materials is more sensitive, than its linear counterpart. Here, we report about a near unity nonlinear circular dichroism for second- (SHG) and third- harmonic generation (THG) from specially designed plasmonic metasurfaces.

P44: Coherent all-optical information processing on metasurfaces
Eric Plum, Maria Papaioannou, Angelos Xomalis, Yongmin Jung, Iosif Demirtzioglou, Edward T. F. Rogers, Kevin F. MacDonald, Periklis Petropoulos, David J. Richardson, Nikolay I. Zheludev
University of Southampton (United Kingdom)

Exponentially growing bandwidth requirements of our information society introduce major capacity and energy challenges. We exploit coherent control of light with light on Fano-metamaterials of nanoscale thickness to demonstrate an approach promising massively parallel all-optical information processing at arbitrarily low intensities and with up to 100 THz bandwidth. We experimentally demonstrate parallel all-optical data processing, all-optical pattern recognition and image analysis as well as a fully packaged fiberized metadevice performing several logical operations at GHz bitrates.

P45: Parity control of Fano resonances and its application for signal regeneration and pulse carving
Dagmawi Alemayehu Bekele, Yi Yu, H. Hu, P. Guan, L. Ottaviano, M. Galili, L. K. Oxenlowe, K. Yvind, Jesper Mork
Technical University of Denmark (Denmark)

Parity control of Fano resonances in a photonic crystal waveguide coupled to a nanocavity is implemented by controlling the position of a partially transmitting element (PTE)in the waveguide. We experimentally demonstrate regeneration and pulse carving of optical signals by exploiting nonlinearities in the nanocavity in combination with the asymmetrical Fanoshape.

P46: Reflection-type plasmonic metasurfaces for reconfigurable wavefront modulation using phase-change materials
Chi-Young Hwang, Yong-Hae Kim, Gi Heon Kim, Jong-Heon Yang, Jae-Eun Pi, Ji Hun Choi, Kyunghee Choi, Chi-Sun Hwang
Electronics and Telecommunications Research Institute (Korea)

Reflection-type reconfigurable metasurfaces are proposed for spatial light modulation of visible light at subwavelength scale. The structure is based on a subwavelength metal grating that can couple the incident light to the gap plasmon mode and modulate it through cavity resonance. By using chalcogenide phase-change materials, the optical characteristics of the structure can be switched between two states so that it can generate the desired spatial light distributions. Numerical simulations are performed to verify the proposed structure.

P47: Anomalous extinction in lossless index-matched terahertz nanogaps
Jeeyoon Jeong[1], Dasom Kim[1], Hyeong-Ryeol Park[2], Taehee Kang[1], Dukhyung Lee[1], Sunghwan Kim[1], Young-Mi Bahk[1], Dai-Sik Kim[1]
[1] *Seoul National University (Korea),* [2] *Chungbuk National University (Korea)*

Metamaterials are capable of allowing incident wave to neither transmit nor reflect, leading to a perfect absorption. This phenomenon is usually explained in terms of simultaneous manipulation of electric permittivity and magnetic permeability to be impedance-matched to free space1. The energy absorption is conceived to occur inside the supporting dielectrics where the electric field amplitude is large, yet systematic study on the actual energy flow has barely been made.

P48: Infrared broadband absorber utilizing non-resonant metasurface for microbolometer
J. Y. Jung[1], K. Song[1], J. Lee Park[1], J. H. Jeong[1], D. P. Neikirk[2]
[1] *Korea Institute of Machinery and Materials (Korea),* [2] *The University of Texas at Austin (USA)*

We demonstrate an infrared broadband metasurface absorber that is suitable for increasing the response speed of a microbolometer by reducing its thermal mass. A large fraction of periodic patterned holes in a thin lossy metal layer can be used as a non-resonant metasurface that can be integrated with a Salisbury screen absorber to construct an absorbing membrane for a microbolometer that can significantly reduce the thermal mass while maintaining high infrared broadband absorption in the long wavelength infrared (LWIR) band.

11:10 - 12:10 — Ballroom

Session 3A2

Industrial Workshop

Organized by: Xihang Shi, Zhen Gao and Hongyi Xu

Chaired by: Xihang Shi, Zhen Gao and Hongyi Xu

11:10 : Industrial Workshop
Near-field imaging of metamaterials in physical space,reciprocal space and time domain
Xihang Shi[1], Zhen Gao[2], Hongyi Xu[3]
[1]Linbou Nearfield Technology Co.,Ltd. (China), [2]Linbou Nearfield Technology Co.,Ltd. (China) and Nanyang Technological University (Singapore), [3]Nanyang Technological University (Singapore)

Near-field imaging has become a versatile technology in metamaterial-related researches, since it not only provides direct imaging of electromagnetic/acoustic wave propagation in and around metamaterials, but also can visualize the band diagrams in reciprocal space and dynamic pulse evolution in time domain. LINBOU Nearfield Imaging Systems provide a stable, fast and economic solution to near-field imaging of electromagnetic and acoustic waves in physical space, reciprocal space and time domain, from two dimensions to three dimensions, from near-field measurements to far-field radiation patterns.

11:10 - 12:10 — Room 106

Session 3A3

SP13. Hybrid Plasmonics with Quantum Confined Materials and Devices III

Organized by: Palash Bharadwaj and Hayk Harutyunyan

Chaired by: Palash Bharadwaj and Hayk Harutyunyan

11:10 : Invited talk
Superradiance and PT symmetry with plasmonic waveguides
Ying Li, Christos Argyropoulos
University of Nebraska-Lincoln (USA)

Plasmonic waveguides exhibit an effective epsilon-near-zero operation in their cut-off wavelength and Fabry-Perot resonances at lower wavelengths. In this work, we demonstrate a plasmonic route to control coherent collective spontaneous emission effects, such as superradiance and subradiance, from emitters located inside plasmonic waveguides. Our findings will be important to optical computing systems, quantum entanglement, and efficient sensors. In addition, we will demonstrate a nanoscale parity-time symmetric nanophotonic device, designed based on gain medium embedded inside the plasmonic waveguide nanochannels.

11:30 : Invited talk
Molecular optomechanical effects in Surface Enhanced Raman Spectroscopy
Ruben Esteban, M. K. Schmidt, T. Neuman, A. Gonzalez-Tudela, G. Giedke, J. Aizpurua
Donostia International Physics Center (Spain)

We discuss a novel quantum description of Surface Enhanced Raman Spectroscopy based on the framework of quantum optomechanics. This theory allows interpreting recent experiment and predicts new effects such as unexpected non-linearities, large correlations of the emitted photons and rich control of the population of molecular vibrational states, which may open new possibilities in the study of molecules coupled with plasmonic systems.

11:50 : Invited talk
Optically Controlled Molecular Switching: Redox in Plasmonic Nanostructures
Bart de Nijs[1], Rohit Chikkaraddy[1], Felix Benz[1], Cloudy Carnegie[1], Steven J. Barrow[1], Aniello Palma[1], Ravishankar Sundararaman[2], Prineha Narang[3], Oren A. Scherman[1], Jeremy Baumberg[1]

[1] *University of Cambridge (United Kingdom),* [2] *Rensselaer Polytechnic Institute (USA),* [3] *Harvard University (USA)*

Self-assembled plasmonic structures provide enough field-enhancement for single molecule sensitivity in Surface Enhanced Raman Spectroscopy (SERS). We combine this effect with the capability of plasmonic structures to generate high-energy charge carriers to study the oxidation and reduction of single molecules in the plasmonic hot-spot, and demonstrate we can optically control the redox state of these trapped molecules.

11:10 - 12:10 — Room 109

Session 3A4

SP10. A bottom-up approach towards metamaterials and plasmonics I

Organized by: Dorota Pawlak and Virginie Ponsinet

Chaired by: Dorota Pawlak and Virginie Ponsinet

11:10 : Invited talk

Large Area Printed Flexible Hybrid Photonic-Electronic Systems

Debashis Chanda

University of Central Florida (USA)

The talk will focus on high throughput, large area and low cost fabrication of quasi-3D and 3D optical nanostructures based on various printing techniques. Based on these techniques functional devices like uncooled neural sensors, mid-IR detectors, flexible reflective color displays and others are realized.

11:30 : Invited talk

Self-organized ZnO-ZnWO4 eutectic composite doped with Al and Ga ions, as a NIR nanoplasmonic metamaterial

Pawel Osewski[1], **A. Antolik**[1], **J. Toudert**[2], **B. Surma**[1], **D. A. Pawlak**[1]

[1] *Institute of Electronic Materials Technology (Poland),* [2] *CSIC (Spain)*

We report properties of a self-organized eutectic composite made of ZnO (Transparent conducting oxide - TCO) phase precipitates embedded in ZnWO4 [1] matrix, doped with Al or Ga ions. The ZnO precipitates, with plasmonic properties, are formed as pseudo-periodically dispersed thin ($\sim$200 nm in width) layers separated by crystalline matrix. Optical properties, microstructure, chemical analysis, xRD, Raman spectra and photoluminescence will be presented.

11:50 : Invited talk

Reconfigurable plasmonic nanostructures with engineered stimuli responses

Anton Kuzyk[1], **Francesco Ricci**[2], **Masayuki Endo**[3], **Na Liu**[4]

[1] *Aalto University (Finland),* [2] *University of Rome Tor Vergata (Italy),* [3] *Kyoto University (Japan),* [4] *Max Planck Institute for Intelligent Systems (Germany)*

In this talk, I will introduce our work on DNA origami-based reconfigurable plasmonic metamolecules. The spatial configuration, and hence, the optical response of such metamolecules can be regulated by external stimuli, e.g., excess of fuel DNA strands, light, change in pH. The spatial reconfiguration is transduced into plasmonic circular dichroism change in the visible wavelength range.

11:10 - 11:45 — Room 104-105

Session 3A5

SP5. Singularity Points in Acoustic Metamaterials: Physics and Applications I

Organized by: Jie Zhu and Xuefeng Zhu

Chaired by: Jie Zhu and Xuefeng Zhu

11:10 : Invited talk
Singularity point applications of acoustic vortices
Zhenyu Hong
Northwestern Polytechnical University (China)

Single singularity point in water has been yielded by integer-order acoustic vortices, which can be used to trap, move and rotate a single particle or particle cluster. Multiple singularity points in water have been created by generating fractional-order acoustic vortices or superposing two or more first-order acoustic vortices, which can be used to manipulate two or more particles at the same time. Moreover, singularity points of acoustic vortices in air are able to levitate and rotate diverse objects.

11:30 : Ultrathin binary metalens of 1/250 lambda for sound manipulation
Hanchuan Tang, Shuaifeng Li, Xuefeng Zhu, Jianfeng Zang
Huazhong University of Science and Technology (China)

Acoustic metamaterial is extremely attractive due to its unprecedented manipulating properties of acoustic wave. Here we proposed a fiber-beads metamembrane that can cause π phase shift and maintain a 0.9 transmittance with 1/250 lambda thickness at low frequency range. Based on this, we construct a binary metalens with different arrangement modes, which can manipulate the diversity of sound and realize focusing. Meanwhile, our work lay the foundation for the following research about transformation acoustics and so on.

11:10 - 12:30 — Room 107-108

Session 3A6

SP6. Photonic topological insulators: fundamental physics and state-of-the-art devices I

Organized by: Alexey Slobozhanyuk and Andrey Miroshnichenko

Chaired by: Alexey Slobozhanyuk and Andrey Miroshnichenko

11:10 : Invited talk
Directly Measuring Photonic Band Topology in A Dimerized Designer-Surface-Plasmon Chain
Fei Gao, Yidong Chong, Baile Zhang
Nanyang Technological University (Singapore)

Photonic band topology in a dimerized chain is defined with the winding of pseudo spin along the Brillouin zone. However, no experiment has measured the winding process in any photonic system so far. Here we present the direct measurement of pseudo-spin winding in a dimerized designer-surface-plasmon chain.

11:30 : Invited talk
Building Photonic Topological Insulators with Reconfigurable Multipost Re-Entrant Meta-Cavities
M. Goryachev, Michael Edmund Tobar
University of Western Australia (Australia)

The concept of multiple post re-entrant metastructures scaling from a double post cavity to a lattice with non-trivial topological properties is considered. We demonstrate reconfigurable photonic analogues of topological insulators on a regular lattice of tunable posts. High post tunability allows dynamical in-situ change of media chirality and other properties. This provides great flexibility in choice of bulk/edge configurations. One way photon transport is demonstrated. Applications in quantum hybrid systems and fundamental physics tests are

discussed.

11:50 : Invited talk
Towards copolymer self-assembly of photonic Weyl metamaterials
Michel Fruchart, Vincenzo Vitelli
Leiden University (The Netherlands)

Block copolymers are soft materials made of different types of monomers glued together by covalent bonds. They self-assemble into highly structured phases which can replicate at the mesoscopic scale the symmetry of atomic crystals. Here, we present a bottom-up approach based on copolymer-self assembly to engineer photonic crystals with topologically protected Weyl points. These photonic metamaterials exhibit a frequency and angle selective optical response, lack of Anderson localization and chiral edge states, even in absence of time-reversal symmetry breaking.

12:10 : Invited talk
Crystalline metamaterials for topological properties at subwavelength scales
Simon Yves[1], Romain Fleury[1], Thomas Berthelot[2], Mathias Fink[1], Fabrice Lemoult[1], Geoffroy Lerosey[1]
[1] ESPCI ParisTech (France), [2] CEA Saclay (France)

The intriguing concept of topological insulators has been transposed from condensed matter to optics/acoustics. However, these photonic/phononic topological insulators are inherently physically wavelength scaled. Here, we explain how structural modifications of locally resonant metamaterials, although deep-subwavelength scaled, also induce a topological phase transition. This experimental and numerical demonstration allows to envision applications benefiting the compactness of metamaterials and the amazing potential of topological insulators.

11:10 - 12:10 — Room 110-111

Session 3A7

SP8. Advanced passive and active metasurfaces I

Organized by: Howard Lee and Din Ping Tsai

Chaired by: Howard Lee and Din Ping Tsai

11:10 : Invited talk
Epsilon-near-zero substrate engineering for ultra-thin-film perfect absorbers
Federico Capasso[1], Jura Rensberg[2], You Zhou[1], Steffen Richter[3], Chenghao Wan[4], Shuyan Zhang[1], Philipp Schoppe[2], Rudiger Schmidt-Grund[3], Shriram Ramanathan[5], Mikhail A. Kats[4], Carsten Ronning[2]
[1] Harvard University (USA), [2] Friedrich-Schiller-Universitat Jena (Germany), [3] Universitat Leipzig (Germany), [4] University of Wisconsin (USA), [5] Purdue University (USA)

The wavelength at which reflection can be fully suppressed is primarily determined by the nature of these substrates, and is pinned to particular values near plasma or phonon resonances - the former typically in the ultraviolet or visible, the latter in the infrared. Here, we explicitly identify the required optical properties of films and substrates for the design of absorbing anti-reflection coatings based on ultra-thin films.

11:30 : Invited talk
Absorption band engineering by metamaterials
Takuo Tanaka
RIKEN Metamaterials Laboratory (Japan)

Recent progresses on metamaterials absorber will be presented. As an application of IR metamaterial absorbers, high sensitive molecular detection technique using resonant coupling between metamaterial and molecule is proposed and attomole level sensitivity is demonstrated. As an application of absorption engineering by metamaterial in the visible range, ink-free full color printing with controllable color attributes like hue, brightness and saturation is also demonstrated.

11:50 : Invited talk
Ultrathin metasurfaces for wide-angle spectrum splitting
Z. Li, Z. Liu, F. Callewaert, S. Butun, Koray Aydin
Northwestern University (USA)

We present flat metasurfaces and metamaterials that enable broadband spectrum splitting and anomalous light reflection and transmission. We will also describe a phase-transition material based dynamic metasurface for beam steering.

11:10 - 12:10 — Room 113

Session 3A8

Symposium II. Recent Advances in Complex Materials and Nanophotonics IX

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

11:10 : Invited talk
Dimer and trimer nanoantennas from a transformation optics perspective
Victor Pacheco-Pena[1], Antonio I. Fernandez-Dominguez[2], Miguel Beruete[3], Yu Luo[4], Miguel Navarro-Cia[5]
[1] *University of Pennsylvania (USA),* [2] *Universidad Autonoma de Madrid (Spain),* [3] *Universidad Publica de Navarra (Spain),* [4] *Nanyang Technological University (Singapore),* [5] *University of Birmingham (United Kingdom)*

Understanding and controlling the light-matter interaction is of fundamental importance for science and technology. Scenarios involving nanoemitters and nanoantennas are nowadays routinely measured in the lab. However, interpretation of the observations is not always straightforward. We will show here how conformal transformation can be used to provide ananalytical description of the commonly used bowtie nanoantenna and its trimer counterpart.

11:30 : Invited talk
Emission properties of second-harmonic generation in AlGaAs optical nanoantennas
Lavinia Ghirardini[1], Luca Carletti[2], Valerio Gili[3], Giovanni Pellegrini[1], Lamberto Duo[1], Marco Finazzi[1], Davide Rocco[2], Andrea Locatelli[2], Costantino De Angelis[2], Ivan Favero[3], Marco Ravaro[3], Giuseppe Leo[3], Aristide Lemaitre[4], Michele Celebrano[1]
[1] *Politecnico di Milano (Italy),* [2] *University of Brescia (Italy),* [3] *Paris Diderot University (France),* [4] *Centre de Nanosciences et de Nanotechnologies (France)*

We demonstrate extremely efficient second harmonic generation (SHG) from monolithic aluminum gallium arsenide (AlGaAs) nanoantennas suspended on a transparent aluminum oxide substrate. When exciting with a pump laser centered at 1554 nm, we obtained SHG with a conversion efficiency of about 10-5 for a 1.6 GW/cm2 pump intensity.

11:50 : Invited talk
Enhancement and Inhibition of Spontaneous Photon Emission by dielectric photonic nanoantennas
Mathieu Mivelle[1], Dorian Bouchet[1], Julien Proust[2], Bruno Gallas[3], Igor Ozerov[2], Maria F. Garcia-Parajo[4], Yannick De Wilde[1], Nicolas Bonod[2], Valentina Krachmalnicoff[1], Sebastien Bidault[1]
[1] *ESPCI Paris (France),* [2] *Aix-Marseille University (France),* [3] *Sorbonne University (France),* [4] *ICFO-Institut de Ciencies Fotoniques (Spain)*

In this report, we provide the first experimental demonstration that silicon- based nanoantennas can either enhance or inhibit spontaneous emission from fluorescent molecules at the nanoscale. Using scanning probe microscopy, we analyse quantitatively the near-field interaction between a fluorescent nanosphere and silicon nanodisks in three dimensions.

11:10 - 11:45 — Room 114

Session 3A9

SP21. Metamaterial Structures for Healthcare Applications

Organized by: Themos Kallos and Panagiotis Kosmas

Chaired by: Themos Kallos and Panagiotis Kosmas

11:10 : Invited talk
Tunable Hybrid Metasurfaces for Magnetic Resonance Imaging
Alexey Slobozhanyuk
Australian National University (Australia)

Metasurfaces have become a new paradigm in the studies of artificial subwavelength structures due to their potential to overcome many challenges typically associated with metamaterials. However, a majority of demonstrated metasurface structures possess fixed properties, e.g. fixed operational bandwidth or functionality. An active control of metasurface functionalities and bandwidth is highly desirable for engineering an advanced electromagnetic and photonic devices. Here, we suggest and demonstrate experimentally a novel type of tunable metasurface capable of dramatic enhancing the image quality.

11:30 : Thin Metamaterial Antireflection Coating In-vivo Measurements to Test the Transmission Enhancement through Human Tissue
Helena Cano Garcia[1], **Shimul Saha**[1], **Ioannis Sotiriou**[1], **Panagiotis Kosmas**[2], **Efthymios Kallos**[1]
[1] *Medical Wireless Sensing Ltd (United Kingdom),* [2] *King's College London (United Kingdom)*

This paper presents for the first time experimental results of a metamaterial antireflection coating designed to work in contact with human tissue. The metamaterial performance is tested using two patch antennas operating between 59 GHz and 62 GHz that send and receive signals through a human hand. The measurements show an average of 4.4 dB enhancement in transmission when the metamaterial is added in front of the hand.

11:10 - 12:05 — Room 115

Session 3A10

Symposium I. Hybrid Optically Active Nanomaterials VII

Organized by: Xing Yi Ling, Jerome Plain and Alexander Govorov

Chaired by: Xing Yi Ling, Jerome Plain and Alexander Govorov

11:10 : Invited talk
Hybrid plasmonic-dielectric metamaterials for enhanced nonlinear response
Hayk Harutyunyan
Emory University (USA)

Nonlinear signal generation at dimensions smaller than the wavelength of light brings new challenges. These include the reduced light-matter interaction volume, the overlap of the fundamental and the nonlinear modes at the nanoscale and the outcoupling of the nonlinear signal to the far-field. Here, we develop hybrid plasmonic - dielectric metamaterials that overcome these limitations and demonstrate $\sim$10-4 nonlinear signal conversion efficiency at visible frequencies.

11:30 : Invited talk
Ultrahigh Enhancement of Electromagnetic Fields by Exciting Localized Surface Plasmon with Propagating Surface Plasmon
Shuzhou Li
Nanyang Technology University (Singapore)

We demonstrated that the localized surface plasmon resonances of a gold sphere can be excited by the extended surface plasmon of a silver thin film. The finite-difference time domain simulations have shown that the electromagnetic field enhancement in this configuration can be up to three orders higher than direct plane wave excitation. This huge enhancement has also been observed in surface-enhanced fluorescence and surface-enhanced Raman spectroscopy. These results show high potential for enhanced spectroscopic sensing and other optoelectronic application.

11:50 : Tailoring light-matter interaction in integrated silicon-organic hybrid devices for high-efficiency THz emission

Marvin Schulz[1], Jahn Hoffman[1], Adrian G.C. Rusche[1], Jingdong Luo[2], Alexander Petrov[1], Manfred Eich[2]

[1] *Hamburg University of Technology (Germany),* [2] *University of Washington (USA)*

Silicon waveguides functionalized with non-linear organic cladding material are a versatile integrated platform to provide long-range interaction of high-intensity confined light with non-linear material. Here, we show that such waveguides can be utilized for high efficiency, integrated and compact THz sources based on non-linear frequency mixing. Light-matter interaction in these systems is modelled and optimized by analytical and numerical means.

11:10 - 12:10 — Room 116

Session 3A11

SP2. Functional Materials and Devices for Acoustic and Elastic Waves IV

Organized by: Guancong Ma and Yun Lai

Chaired by: Guancong Ma and Yun Lai

11:10 : Invited talk

Vibrant times for phononic metamaterials

Johan Christensen

Universidad Carlos III de Madrid (Spain)

The boost experienced by acoustic and elastic (phononic) metamaterial research during the past years has been driven by the ability to sculpture the flow of sound waves at will. In this talk, I like to review some of the key achievements made in this field and wish to address some of the unanswered questions that might lead to a breakthrough in the future.

11:30 : Invited talk

A metamaterial approach to the cochlear wave

Matthieu Rupin, Geoffroy Lerosey, Julien de Rosny, Fabrice Lemoult

Institut Langevin (France)

We show that the physics of the inner ear, responsible for the mammalian's audition, can be modelled by a one-dimensional active metamaterial. More precisely, quarter wavelength resonators, with a gradient in their resonance frequency, side coupled to a main waveguide, give rise to the travelling wave typical of the dead cochlea. By introducing a feedback loop in each resonator, we then reproduce all of the salient non-linear properties of the living cochlea.

11:50 : Invited talk

Analytic Materials

Graeme W. Milton

University of Utah (USA)

New classes of inhomogeneous media, called analytic materials as the moduli involve analytic functions, are presented for which one can easily solve for the fields. The PDE's solved by the fields are reduced to a set of ODE's. We present explicit examples for elastodynamics and electromagnetism. This greatly expands the array of examples of exactly solvable materials that one can obtain using other techniques, such as the

transformation optics technique introduced by Dolin in 1961.

11:10 - 12:10 — Room 117

Session 3A12

SP18. Towards integrated quantum photonics: materials, designs, technologies and applications I

Organized by: Lucia Caspani and Alessandro Casaburi

Chaired by: Lucia Caspani and Alessandro Casaburi

11:10 : Invited talk

Improved single-photon sources for quantum photonic integrated circuits

Andrea Fiore[1], Maurangelo Petruzzella[1], Francesco Pagliano[1], Zarko Zobenica[1], Simone Birindelli[1], Daniele Pellegrino[1], Michele Cotrufo[1], Rob van der Heijden[1], Frank van Otten[1], Lianhe Li[2], Edmund Linfield[2]

[1] *Eindhoven University of Technology (The Netherlands),* [2] *University of Leeds (United Kingdom)*

Large-scale quantum-photonic circuits require deterministic sources of indistinguishable photons exhibiting very high efficiency. Single semiconductor quantum dots embedded in nanophotonic cavities and coupled to waveguide circuits can provide the required efficiency. We will discuss our recent progress in improving these integrated sources, including advanced tuning schemes and electrical injection into photonic crystal cavities.

11:30 : Invited talk

Infrared single-photon detection with superconducting nanowires

Robert H. Hadfield, Robert M. Heath, Nathan R. Gemmell, Alessandro Casaburi

University of Glasgow (United Kingdom)

Single photon detectors based on superconducting nanowires have emerged as a highly promising alternative for single-photon detection. These devices offer single photon sensitivity from visible to mid infrared wavelengths with high efficiency, low dark counts and tens of picoseconds timing resolution. We discuss recent advances in device design, integration and miniturized cooling. We give an overview of applications where these devices are now being deployed, including optical quantum information processing, single photon remote sensing and dosimetry for laser medicine.

11:50 : Invited talk

Frequency conversion in the single photon regime in silicon waveguides

Bryn A. Bell, C. Xiong, B. J. Eggleton

University of Sydney (Australia)

Four-wave mixing Bragg scattering in silicon waveguides is demonstrated as a low-noise frequency converter for single photon level signals. The limits to conversion efficiency due to nonlinear losses and parasitic processes are considered. Stable interference between separate input frequencies is observed, and it is shown that a birefringent phase-matching scheme can provide additional control over the unwanted processes and could lead to higher conversion efficiencies.

Lunch and Exhibit Inspection

12:10 - 14:00

14:00 - 15:00 — Room 106

Session 3A13

SP30. Alternative plasmonic materials

Organized by: Neha Sardana

Chaired by: Neha Sardana

14:00 : Invited talk
Metal Alloys as Alternative Materials for Plasmonics
Marina S. Leite
University of Maryland (USA)

We present how the alloying of metals (Ag, Au, Cu, Al) provides materials with permittivity values not found in its pure counterparts. We have developed a library of the optical properties of metal alloys. We demonstrate the use of alloyed thin films in perfect absorbers with superior performance, and we implement a scalable method for the fabrication of alloyed nanostructures. We expect alloyed metals to become a novel platform for the design of building blocks for nanophotonics.

14:20 : Invited talk
EM response of graphene oxide
Archana Thourwal[1], Arun Singh[1], Neha Sardana[2]
[1] *PEC University of Technology (India),* [2] *Institute of Nano Science and Technology (India)*

This work provides a study the shape dependent resonant properties of the graphene oxide-on FR4, FR4-Cu structures using the GO metamaterials (MMs) patterns. Such different structures are explored for low cost applications in household Wifi antennas.

14:40 : Invited talk
Plasmonic nanodisc arrays for Luminescence and Raman enhancement
Joerg Schilling[1], Neha Sardana[2], Frank Heyroth[2], Yong-Tae Kim[2]
[1] *Martin-Luther University (Germany),* [2] *Martin-Luther-University (Germany)*

Arrays of gold discs are investigated as substrates for luminescence and Raman enhancement. These nanoantenna arrays exhibit relatively sharp grating resonances leading to increased field concentration and light-matter interaction in their vicinity. This is harnessed for enhanced luminescence of colloidal nanoparticles in the IR-telecom range and surface enhanced Raman scattering in the near IR.

14:00 - 16:10 — Room 109

Session 3A14

SP10. A bottom-up approach towards metamaterials and plasmonics II

Organized by: Dorota Pawlak and Virginie Ponsinet

Chaired by: Dorota Pawlak and Virginie Ponsinet

14:00 : Invited talk
Visible-range hyperbolic dispersion and generalised Brewster extinction in copolymer-nanoparticle self-assembled composites
Xuan Wang[1], Clemence Tallet[1], Johann Toudert[1], Kevin Ehrhardt[1], Morten Kildemo[2], Alexandre Baron[1], Marc Warenghem[1], Philippe Barois[1], Ashod Aradian[1], Virginie Ponsinet[1]
[1] *Bordeaux University (France),* [2] *Physics Department - NTNU (Norway)*

Lamellar block copolymer nanostructures were self-assembled with one phase including variable amounts of plasmonic nanoparticles. The uniaxial optical properties were measured using spectroscopic ellipsometry. The presence of an extinction of the TM wave due to a generalised Brewster effect (topological darkness) is demonstrated. We also demonstrate that, within a frequency range, the effective medium made of the material

has an hyperbolic dispersion.

14:20 : Invited talk
Interband Plasmonic Materials: A promising Platform for Nanophotonics
Johann Toudert, Rosalia Serna
Instituto de Optica-CSIC (Spain)

We describe the optical properties of interband plasmonic materials and their potential for the design of active optical metamaterials for switching and sensing applications.

14:40 : Invited talk
Nanoparticle trapping, sorting, and ratcheting using light forces near photonic crystal slabs
Shao-Hua Wu, Aravind Krishnan, Ningfeng Huang, Eric Jaquay, Luis Javier Martinez, Michelle Lynn Povinelli
University of Southern California (USA)

We use the near field of a photonic crystal slab for nanoparticle manipulation. The holes of the photonic crystals form an array of optical traps. In addition to assembling regular arrays of dielectric and metallic particles, we have used this system to demonstrate nanoparticle size selection and optical ratchet motion.

15:00 : Invited talk
Plasmonic applications using air-like refractive index aerogel
Kyoungsik Kim, Dongheok Shin, Junhyun Kim, Changuk Kim
Yonsei University (Korea)

Plasmonic nano-structures have been of great interest in bio-sensing, photonic, optoelectronic, and thermos-plasmonic applications because of their ability to control the light behavior in nanoscale. Aerogels, composed of silica nano-granules with high porosity, have air-like low refractive index and allow us exotic plasmonic phenomena. I introduce our recent results about the plasmonic applications using air-like aerogels such as plasmon resonance, SERS, and so on.

15:20 : Invited talk
About Optical Games with Eutectics ZnO/ZnWO4
A. Belardini[1], P. Osewski[2], E. Petronijevic[1], D. Pawlak[2], R. Li Voti[1], G. Lehau[1], M. Centini[1], Concita Sibilia[1]
[1] *Universita di Roma La Sapienza (Italy),* [2] *Institute of Electronic Materials Technology (Poland)*

Many different optical interesting and unusual properties of eutectics ZnO/ZnWO4 are presented, ranging from linear up to nonlinear optical properties.

15:40 : Studying the properties of bottom-up meta-atoms based on their T-matrix
Martin Fruhnert, Radius Suryadharma, Aso Rahimzadegan, Carsten Rockstuhl, Ivan Fernandez-Corbaton
Karlsruhe Institute of Technology (Germany)

The T-matrix of a scatterer expresses how it couples an incident mode to a scattered mode at a given frequency. Here, we outline our recent contributions to develop methods to compute the T-matrix for arbitrary scatterers, possibly composed of many sub-elements. Based on the T-matrix, properties of these scatterers are discussed and applications are explored, e.g. scattering cancelation structures, maximal electromagnetic chiral structures, or bi-anisotropic scatterers. Emphasis is put on meta-atoms amenable for a fabrication with bottom-up approaches.

15:55 : Exploiting structural versatility and fidelity of 3D plasmonic metamolecule, self-assembled on DNA origami pegboard
Jaewon Lee[1], JiHyeok Huh[1], William M. Shih[2], Seungwoo Lee[1]
[1] *Sungkyunkwan University (SKKU) (Korea),* [2] *Wyss Institute for Biologically Inspired Engineering at Harvard University (USA)*

Tailoring optical properties of plasmonic nanoclusters (plasmonic metamolecules) has gained special interest in the field of nanophotonics. However, the difficulties in arranging plasmonic nanoparticle in deterministic way have limited the advancement of the relevant field. To address this challenge, we report a deterministic strategy for assembling 3D cluster using DNA origami as a molecular pegboard.

14:00 - 14:40 — Room 104-105

Session 3A15

SP5. Singularity Points in Acoustic Metamaterials: Physics and Applications II

Organized by: Jie Zhu and Xuefeng Zhu

Chaired by: Jie Zhu and Xuefeng Zhu

14:00 : Invited talk
Acoustic Energy Harvesting Based on Metamaterials and Metasurfaces
Badreddine Assouar, Shuibao Qi, Yong Li
University of Lorraine (France)

Acoustic energy harvesting based on acoustic metamaterials and metasurfaces are proposed and investigated. The proposed concepts are based on the idea of using plate-type metamaterial and multilateral metasurface to confine the acoustic energy, and subsequently convert it into the electrical one by a structured piezoelectric material connecting with optimized circuits. The properties of proposed acoustic energy harvesters will be presented and discussed.

14:20 : Invited talk
Topological States in Nanophononic Structures
Martin Esmann, Fabrice Roland Lamberti, Loic Lanco, Pascale Senellart, Aristide Lemaitre, Norberto Daniel Lanzillotti Kimura
Paris Sud University (France)

We report novel strategies to study topologically protected states in nanophononic systems working at frequencies around 300 GHz. We theoretically predict the existence of such modes in multilayer GaAs/AlAs structures. High resolution Raman scattering unveils features related to the maxima in the phononic local density of states associated to topologically protected states.

14:40 - 15:55 — Room 104-105

Session 3A16

SP35. Optically-assisted mechanical systems for advanced photonics and ultrahigh-precision applications I

Organized by: Jong G. Ok and Ji-Seok Lim

Chaired by: Jong G. Ok and Ji-Seok Lim

14:40 : Invited talk
Quantum manipulation and characterization of electron spin qubits in diamond
Dohun Kim
Seoul National University (Korea)

In this talk, I briefly introduce optical quantum manipulation and measurements realized using spins in diamond, We apply GST method to electron spins and discuss accuracy of the single qubit gates obtained by analyzing gate sequence data using GST. We further discuss the way toward using GST method to multiple spins and qubits.

15:00 : Invited talk
Solar Energy Harvesting based on Photosynthesis
WonHyoung Ryu
Yonsei University (Korea)

In photosynthesis of plant cells, algae, or cyanobacteria, high energy electrons are generated and transferred

in a photosynthetic electron transfer chain. The photosynthetic electrons (PEs) are either used to maintain the life of the plants or stored in a form of carbohydrates. There are multiple approaches to harvest the PEs and utilize them as a clean energy source. In this presentation, recent development of bio-solar cells based on PE harvesting will be introduced and discussed.

15:20 : Invited talk
High-throughput mechanical nanopatterning for scalable and flexible photonic and plasmonic applications
Jong G. Ok
Seoul National University of Science and Technology (Korea)

This talk will address how nanopatterns can be created at high speed and improved scalability, by utilizing continuous mechanical methods highlighted by roll-to-roll imprinting, nanoscale inscribing, and vibrational nanoindentation. Such continuous and scalable mechanical methodologies are based on simpler and cheaper principles, free from ponderous instruments, and applicable to flexible substrates, thereby enabling a big array of tangible applications particularly requiring large-area fabrication. In particular, we focus on two recent results on the plasmonic biosensors and polymer light-emitting diodes.

15:40 : Wafer-scale hyperlens device for biomolecular super-resolution imaging
Dasol Lee[1], Yangdoo Kim[2], Minkyung Kim[1], Hak-Jong Choi[2], Jungho Mun[1], Sunae So[1], Duc Minh Nguyen[1], Kyunghoon Kim[3], Jong G. Ok[4], Heon Lee[2], Junsuk Rho[1]
[1] *Pohang University of Science and Technology (Korea),* [2] *Korea University (Korea),* [3] *Sungkyunkwan University (Korea),* [4] *Seoul National University of Science and Technology (Korea)*

Hyperlens is an optical imaging method for super-resolution imaging. Due to the unique hyperbolic dispersion relation of hyperlens, sub-diffraction information of objects can be propagated to far-field. Here, we propose a new design consisting of multiple hyperlenses arranged inhexagonal arrays in large scale for high-throughput imaging. With proposed design, we report the experimental demonstration of sub-diffraction imaging on hyperlenses. Biomolecular samples are imaged by visible light through the hyperlens array with resolution down to diffraction limit.

14:00 - 16:15 — Room 107-108

Session 3A17

SP6. Photonic topological insulators: fundamental physics and state-of-the-art devices II

Organized by: Alexey Slobozhanyuk and Andrey Miroshnichenko

Chaired by: Alexey Slobozhanyuk and Andrey Miroshnichenko

14:00 : Invited talk
Dynamic long-range couplings in low-symmetry topological photonic systems
Kin Hung Fung
The Hong Kong Polytechnic University (Hong Kong)

In this talk, we will discuss the dynamic radiative long-range effects on the bands and edge modes in these low-symmetry topological photonic systems. Arrays of plasmonic nanoparticles and gyromagnetic resonators will be used as examples to illustrate the effects.

14:20 : Invited talk
Exciting Reflectionless Unidirectional Edge Modes in a Reciprocal Photonic Topological Insulator Medium
Bo Xiao[1], Kueifu Lai[2], Yang Yu[2], Tzuhsuan Ma[2], Gennady Shvets[2], Steven M. Anlage[1]
[1] *University of Maryland (USA),* [2] *Cornell University (USA)*

We demonstrate the excitation of uni-directional waves on a reciprocal topologically protected waveguide. We also show new results on a non-reciprocal photonic topological insulator, including circulator action.

14:40 : Invited talk
Experimental observation of optical Weyl points
Jiho Noh[1], Sheng Huang[2], Daniel Leykam[3], Yidong Chong[3], Kevin Chen[2], Mikael Rechtsman[1]
[1] *The Pennsylvania State University (USA),* [2] *University of Pittsburgh (USA),* [3] *Nanyang Technological University (Singapore)*

We demonstrate a laser-written photonic lattice exhibiting topologically-protected Weyl point degeneracies in its three-dimensional band structure. Probing the lattice at various wavelengths, we observe topological surface modes and conical diffraction characteristic of an anisotropic type-II Weyl point. This constitutes the first realization of a photonic Weyl point at optical frequencies, allowing further study of their novel properties in a wide class of linear and nonlinear photonic systems.

15:00 : Invited talk
Topological phase transition in acoustic systems
Yu-Gui Peng, Xuefeng Zhu
Huazhong University of Science and Technology (China)

Topological insulators have inspired analogues in acoustics, in which one-way gapless edge/surface states, featured with absence of scatterings, have been achieved via synthetic magnetic field or pseudo-spins. Varied mechanisms to realize topologically protected sound transportation have been realized, as characterized by Chern number, Z2 number as well as winding number. We present that topological phases can be tuned into trivial phases by distorting the geometry of 1D Helmholtz resonator chain or breaking the inherent symmetry of 2D resonator/cylinder array.

15:20 : Invited talk
Experiment Realization of Synthetic Weyl Points In Optical Regime
Qiang Wang[1], Meng Xiao[2], Hui Liu[1], Shining Zhu[1], C. T. Chan[2]
[1] *Nanjing University (China),* [2] *The Hong Kong University of Science and Technology (Hong Kong)*

We demonstrate that generalized Weyl points can exist in a parameter space and we report the first observation of such nodal points in one-dimensional photonic crystals in the optical range. The reflection phase inside the band gap of a truncated photonic crystal exhibits vortexes in the parameter space where the Weyl points are defined and they share the same topological charges as the Weyl points.

15:40 : Invited talk
Topological and noreciprocal sound and light in quantum well structures
Alexander V. Poshakinskiy, Alexander N. Poddubny
Ioffe Institute (Russia)

We study optomechanical effects in the laser-pumped periodic multiple-quantum-well structures. The light-sound interaction is strongly enhanced at the exciton resonance of the quantum wells and the hybrid exciton-light-phonon quasiparticles, termed as phonoritons, are formed. The phonoritons exhibit pumping-induced synthetic magnetic field in the artificial coordinate-energy space that makes transmission of left- and right-going waves different. The transmission nonreciprocity allows to use such phonoritonic crystals with realistic parameters as optically controlled nanoscale acoustic diodes and one-way lasers.

16:00 : Visualization of unidirectional electromagnetic waveguide using topological photonic crystals made of dielectric materials
Yuting Yang[1], Zhi Hong Hang[1], Xiao Hu[2]
[1] *Soochow University (China),* [2] *National Institute for Materials Science (China)*

The introduction of topology unravels a new chapter of physics, where photonic systems can also benefit from. Engineering locally in real space a honeycomb photonic crystal (PC) with double Dirac cone in its photonic dispersion, topology transition in photonic band structure is induced and a pseudospin unidirectional photonic channel is created and demonstrated by the backscattering immune electromagnetic transportation.

14:00 - 16:00 — Room 110-111

Session 3A18

SP8. Advanced passive and active metasurfaces II

Organized by: Howard Lee and Din Ping Tsai

Chaired by: Howard Lee and Din Ping Tsai

14:00 : Keynote talk

Electronically Tunable Materials and Metasurfaces: Exploring Quantum Materials and Device Designs for Dynamic Wavefront Control

Harry Atwater
California Institute of Technology (USA)

Tuning the complex dielectric function of low-dimensional materials and metasurfaces enables scientific exploration of quantum materials such graphene, phosphorene and topological insulators and, as well plasmonic and nanophotonic device applications for dynamic wavefront control including electronic phase and amplitude modulators for the near infrared (conducting oxides) and mid infrared (graphene). We discuss light-matter interactions in emerging quantum materials and report dynamically tunable metasurfaces in the near-infrared and mid-infrared with $>\pi$ phase modulation and 'perfect' absorption approaching 100 $\%$.

14:30 : Keynote talk

Flat and conformal optics with dielectric metasurfaces

Adrei Faraon, Amir Arbabi, Ehsan Arbabi, Seyedeh Mahsa Kamali, Yu Horie
California Institute of Technology (USA)

In this talk I will give an overview of our progress towards design and fabrication of flat or conformal dielectric metasurface devices with multiple functionalities.

15:00 : Invited talk

Merging Metamaterial and Optical Fiber Technologies

Nikolay I. Zheludev[1], Kevin F. MacDonald[2], Eric Plum[2], Artemios Karvounis[2], Davide Piccinotti[2], Angelos Xomalis[2], Iosif Demirtzioglou[2], Vassili Savinov[2], Behrad Gholipour[2], Yongmin Jung[2], Periklis Petropoulos[2], David J. Richardson[2]
[1] *University of Southampton (UK) and NTU (Singapore),* [2] *University of Southampton (United Kingdom)*

We will review recent advances in metamaterials research directed towards the development of switchable and tunable functional nanostructures. Metamaterials research has migrated from the study of exclusively metallic plasmonic structures to embraces a large variety of advanced material platforms, including dielectrics, semiconductors, superconductors, topological insulators and complex hybrid systems. We will discuss coherent control of metasurfaces, all-optical and electro-optical switching with reconfigurable nano-opto-mechanical and phase-change metamaterials and ways in which functional metamaterials can be integrated with optical fiber platforms.

15:20 : Invited talk

Metasurface for polarization-controllable multichannel superpositions of orbital angular momentum states

Xianzhong Chen[1], Fuyong Yue[1], Dandan Wen[1], Chunmei Zhang[1], Brian D. Gerardot[1], Wei Wang[1], Shuang Zhang[2]
[1] *Heriot-Watt University (United Kingdom),* [2] *University of Birmingham (United Kingdom)*

We propose and experientally demonstrate a facile metasurface approach to realize polarization-controllable mulitchannel superpositions of orbital angular momentusm (OAM) states at will. Four OAM beams in separate channels are observed for an incident Gaussian beam with circular polarization. By manipulating the polarization states of the incident light, arbitray control of the superpositions of various OAM states in multiple channels is realized using a single plasmonic metasurface.

15:40 : Invited talk

Exceptional points in PT-symmetric metasurfaces

Jie Luo[1], Jensen Li[2], Yun Lai[1]
[1] *Soochow Univerisity (China),* [2] *University of Birmingham (United Kingdom)*

We investigate the systems consisting of a pair of PT-symmetric metasurfaces sandwiching a slab made of metamaterials. We observe two types of exceptional points in such unique systems, at which unidirectional impedance matching is established. By using an epsilon-near-zero slab, a robust one-way cloaking phenomenon is established.

14:00 - 16:00 — Room 113

Session 3A19

Symposium II. Recent Advances in Complex Materials and Nanophotonics XI

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

14:00 : Invited talk
Au/Ni hybrid nanostructures: tuning the plasmon resonance under control
Silvere Schuermans[1], Thomas Maurer[1], Alexander O. Govorov[2], Jerome Plain[1]
[1] *Universite de Technologie de Troyes (France),* [2] *Ohio University (USA)*

We report on the fabrication of plasmonic hybrid Ni-Au nanoantennas. The optical properties of such nanostructure depend on the applied magnetic field and/or the temperature. Thus, we tune under control the plasmon resonance using external stimuli.

14:20 : Invited talk
Optical antennas - mode distributions and directionality
Niels Verellen[1], J. Li[1], A. Frolov[2], D. Vercruysse[1], D. Denkova[3], Maxim Shcherbakov[2], H. Paddubrouskaya[4], A. Fedyanin[2], V. V. Moshchalkov[4], P. Van Dorpe[1]
[1] *IMEC (Belgium),* [2] *Moscow State University (Russia),* [3] *Macquarie University (Australia),* [4] *KU Leuven (Belgium)*

To achive a high level of control over the way an optical antenna interacts with light, it is essential to obtain detailed insight in the supported modes and scattering characteristics. Especially in nanophotonics applications where every photon counts, one immediately benefits from directed photon routing for efficient photon collection.

14:40 : Invited talk
Deterministic Quantum Dot Microlenses: Building Blocks for Photonic Quantum Network
A. Thoma[1], P. Schnauber[1], S. Fischbach[1], A. Kaganskiy[1], R. Schmidt[1], S. Burger[2], F. Schmidt[2], A. Carmele[1], A. Knorr[1], A. Strittmatter[1], T. Heindel[1], S. Rodt[1], Stephan Reitzenstein[1]
[1] *Technische Universitat Berlin (Germany),* [2] *Zuse-Institut Berlin (Germany)*

We report on deterministic quantum light sources for applications in quantum communication systems. The sources are based on single quantum dot - microlenses fabricated by by in-situ electron-beam lithography. These quantum devices show close to ideal single photon purity with $g(2)(0)<0.01$, high photon indistinguishability with $V>90\,\%$, and high potential for quantum repeater networks based on entanglement distribution. Moreover, quantum dot - microlenses can be used for efficient twin-photon emission and allow for the development of stand-alone fiber-coupled single-photon sources.

15:00 : Invited talk
Engineering stimulated light-sound scattering in silicon
Peter Rakich
Yale University (USA)

Brillouin nonlinearities permit stimulated light-sound scattering through optomechanical three-wave interactions. In conventional silicon waveguides, material response and poor acoustic confinement effectively stifle Brillouin nonlinearities. However, new optomechanical waveguides-that control both light and sound-have recently transformed Brillouin interactions into the strongest and most tailorable nonlinearities in silicon. In this paper, we use theory and experiment to demonstrate a variety of stimulated light-scattering processes. We

also harness these interactions to realize light-amplification, signal filtering, and laser technologies.

15:20 : Invited talk
Time-variant metasurfaces as a frequency converting platform
Bumki Min
Korea Advanced Institute of Science and Technology (KAIST) (Korea)

Rapidly time-varying metasurfaces are proposed as a frequency converting platform. The proposed metasurface is designed for sudden merging of two distinct resonances into a single resonance upon ultrafast optical excitation. From this dispersion-engineered temporal boundary onward, the merged resonance frequency component can be radiated.

15:40 : Invited talk
Dispersion of the Nonlinear Susceptibility in Single Gold Nanoantennas
Vanessa Knittel, Marco P. Fischer, Alfred Leitenstorfer, Daniele Brida
University of Konstanz (Germany)

We compare the third harmonic generation and incoherent photoluminescence contributions to the nonlinear optical response obtained in individual gold nanoantennas upon illumination with near-IR femtosecond pulses. With this procedure we could extract the dispersion of the nonlinear susceptibility.

14:00 - 15:50 — Room 114

Session 3A20

SP4. Metasurfaces and 2D Metamaterials in microwave region

Organized by: Kuang Zhang and Shah Nawaz Burokur

Chaired by: Kuang Zhang and Shah Nawaz Burokur

14:00 : Invited talk
Omega-bianisotropic metasurfaces: from controlling radiative fields to manipulating evanescent modes
Ariel Epstein
Technion (Israel)

Omega-bianisotropic metasurfaces (O-BMSs) have been shown to be able to implement any locally power-conserving field transformation via passive lossless meta-atoms. In previous work, we have utilized this theorem to design O-BMSs realizing reflectionless refraction and beam splitting, and perfect reflection. In this talk, we propose a novel O-BMS waveguide, whose eigenmodes are quadruples of surface waves, allowing manipulation of near-field features.

14:20 : Invited talk
Inductively reconfigurable periodic structures for synchronous and wideband tuning
Yih-Dar Chen, Chienhao Liu
National Taiwan University (Taiwan)

In this research, we propose a planar reconfigurable FSS tuned continuously over a wide frequency range. Each element is composed of three metallic strips acting as an equivalent series LC resonator. By manipulating the induced surface current path on each element, the resulting variations of the equivalent inductance can shift the resonant frequency from 5.6 GHz to 7.5 GHz. In addition, a linkage mechanism can synchronously alter each element for large area applications.

14:40 : Invited talk
Active metasurface for reconfigurable reflector antennas
Badreddine Ratni[1], Andre de Lustrac[1], Gerard-Pascal Piau[2], Shah Nawaz Burokur[3]
[1] *Paris Sud University (France),* [2] *AIRBUS Group Innovations (France),* [3] *Paris Ouest University (France)*

A planar active metasurface composed of meta-atoms incorporating voltage-controlled varactor diodes, is

used as reflector for microwave antenna applications. The dispersion responses of the cells are individually tailored for reconfigurability mechanisms. The phase characteristics of a several reflectors is engineered by judiciously controlling the bias voltage of the varactor diodes on the planar metasurface.

15:00 : Invited talk
Generation of vector beams based on Field Transformation metasurface
Cheng Wang, Ke Chen, Junming Zhao, Yijun Feng
Nanjing University (China)

The microwave beam whose polarization is radially polarized is called vector beam. Because of its unique properties and potential applications, there has been a rapid increase of the number of publications on vector beams. Different approaches have been proposed to generate vector beams through these studies. Here, for the first time, we use one field transformation(FT) approach to design a metasurface which can generate vector beams. Such vector beam generation metasurface can be easily realized with 3D printer.

15:20 : Left Handed Meta-Surface Absorber for Tri Band Applications
M. R. I. Faruque, M. M. Hasan
Universiti Kebangsaan Malaysia (Malaysia)

A new tri-band perfect meta-surface absorber based on square shaped metallic resonator, where the circular rings are in the middle of the resonator is investigated in this paper. The proposed absorber structure shows a wide bandwidth and applicable for C-, x- and Ku-band applications. Due to the effective medium ratio 6.48 absorber structure compact in size and shows three absorption peaks are respectively 82 %, 67 %, and 93 %.

15:35 : Terahertz optical properties of planar all-carbon metamaterials fabricated by laser drawing
Maxim Komlenok, Sergey Lebedev, Gennady Komandin, Sergey Tikhodeev, Vitaly Konov
A. M. Prokhorov General Physics Institute RAS (Russia)

We report on the optical properties of metal-less diamond-based planar metamaterials in terahertz (THz) frequency range. A conductive 200 nm-thick graphitized layer was formed on a surface of CVD polycrystalline diamond by excimer KrF-laser. Optical properties of a diamond plate with a graphitized layer were measured and simulated according to the Drude model. A polarizer with a graphitized subwavelength grating as a prototype of metamaterial device was tested in THz range and had shown different loss for orthogonal polarizations.

15:50 - 16:20 — Room 114

Session 3A21

GEN14. Topological photonics

Chaired by: Yongmin Liu

15:50 : Topological phase transitions in QED: Casimir forces in the graphene family
Diego Dalvit[1], Pablo Rodriguez-Lopez[2], Wilton Kort-Kamp[1], Lilia Woods[2]
[1] *Los Alamos National Laboratory (USA),* [2] *University of South Florida (USA)*

The expansion of the graphene family by adding silicene, germanene, and stanene (2D allotropes of Si, Ge, and Sn) lends itself as a platform to probe Dirac-like physics in honeycomb staggered systems in the Casimir interaction. We discover Casimir force phase transitions between these staggered 2D materials induced by the complex interplay between Dirac physics, spin-orbit coupling, and externally applied fields. Furthermore, due to the topological properties of these materials, repulsive and quantized Casimir interactions become possible.

16:05 : A group theoretical route to deterministic Weyl points in chiral photonic lattices
Matthias Saba, Joachim M. Hamm, Ortwin Hess
Imperial College London (United Kingdom)

Point degeneracies in the photonic bandstructure give rise to a variety of exotic properties such as topological phases. Previously identified exceptional points are based on accidental degeneracies and subject to engi-

neering on a case-by-case basis. We here show that symmetry induced (deterministic) pseudo Weyl points with non-trivial topology and hyperconic dispersion exist at the Γ point in the Brillouin zone of chiral cubic systems. We demonstrate the universal behavior by means of interacting plasmonic spheres on a chiral cubic lattice.

14:00 - 16:00 — Room 115

Session 3A22

SP11. Active, Nonlinear, Quantum, and Reconfigurable Plasmonics and Metamaterials II

Organized by: Christos Argyropoulos and Pai-Yen Chen

Chaired by: Christos Argyropoulos and Pai-Yen Chen

14:00 : Invited talk
Non-local absorption in quantum hydrodynamictheory: application to plasmonic systems
Cristian Ciraci
Center for Biomolecular Nanotechnologies (Italy)

The quantum hydrodynamic theory is a promising method for describing microscopic details of macroscopic systems. The hydrodynamic equation is directly obtained from a single particle Kohn-Sham equation. This derivation allows to straightforwardly incorporate in the hydrodynamic equation a viscoelastic term, so that broadening of collective excitation can be taken into account, as well as a correction to the plasmon dispersion. The result is an accurate and computationally efficient hydrodynamic description of the free electron gas.

14:20 : Invited talk
Magnetic-Free Non-Reciprocal Graphene Plasmonics
Diego Correas-Serrano, J. Sebastian Gomez Diaz
University of California (USA)

We discuss recent advances in magnetic-free non-reciprocal plasmonic devices and antennas based on spatiotemporally modulated graphene. We first review the exciting properties and novel functionalities that this technology offers, focusing on achieving large non-reciprocal responses with fully integrated structures. We then address the main challenges that remain to be addressed, including limitations associated to plasmon damping and modulation speed. Finally, we explore novel routes towards optimal isolator and antenna designs.

14:40 : Invited talk
Antenna-coupled Photon Emission from Tunnel Junctions
Palash Bharadwaj[1], Markus Parzefall[2], Achint Jain[2], Lukas Novotny[2]
[1] *Rice University (USA),* [2] *ETH Zurich (Germany)*

We have studied the ultrafast conversion of electrons localized in vertical Au-hBN-Au tunnel junctions to free-space photons, mediated by resonant slot antennas. We achieve polarized, directional and resonantly enhanced light emission from inelastic electron tunneling and establish a novel platform for studying the interaction of electrons with strong electromagnetic fields.

15:00 : Keynote talk
Hybrid nanostructures for sub-wavelength imaging, nonlinear optics, and chemistry
Stefan Maier
Imperial College London (United Kingdom)

We demonstrate how controlled emission of hot electrons in plasmonic nanoantennas leads to highly localized nanochemistry. This scheme is utilized for the assembly of hybrid metallic nanoantennas consisting both of top-down fabricated elements, and nanosized colloids. The second part of the talk will show new results for dielectric and hybrid metallic/dielectric antennas, based on Si, Ge and GaP, for highly enhanced harmonic

generation and surface-enhanced sensing.

15:30 : Keynote talk
Quantum Plasmonics
Benjamin Vest[1], Marie-Christine Dheur[1], Eloise Devaux[2], Alexandre Baron[3], Emmanuel Rousseau[4], Jean-Paul Hugonin[1], Gaetan Messin[1], François Marquier[1], Jean Jacques Greffet[1]
[1]Paris-Saclay University (France), [2]Strasbourg University (France), [3]Centre de Recherche Paul Pascal - CNRS (France), [4]Montpellier University (France)

In this talk, we report experiments aiming at exploring the physics of surface plasmons in the single plasmon regime. In other words, we revisit quantum optics using surface plasmons: tests of the wave-particle duality of surface plasmons, observation of entanglement between a photon and a plasmon and two photon interference on a lossy beam splitter. In the latter case, we observe both a correlation dip and a correlation peak at the outputs of a beamsplitter.

14:00 - 16:00 — Room 116

Session 3A23

SP2. Functional Materials and Devices for Acoustic and Elastic Waves V

Organized by: Guancong Ma and Yun Lai

Chaired by: Guancong Ma and Yun Lai

14:00 : Invited talk
Topological creation of acoustic pseudospin multipoles in a flow-free symmetry-broken metamaterial lattice
Zhiwang Zhang[1], Qi Wei[1], Ying Cheng[1], Ting Zhang[1], Dajian Wu[2], Xiaojun Liu[1]
[1]Nanjing University (China), [2]Nanjing Normal University (China)

Due to the spinless nature of sound, the spin-like degree of freedom crucial to topological states in acoustic systems is commonly realized with circulating background flow or pre-set coupled resonator ring waveguides, which drastically increases the engineering complexity. Here we realize the acoustic pseudospin multipolar states in a simple flow-free symmetry-broken metamaterial lattice. Topologically protected edge states and reconfigurable topological one-way transmission for sound are further demonstrated.

14:20 : Topological subspace induced bound states in continuum
Yixin Xiao, Guancong Ma, Zhao-Qing Zhang, Che Ting Chan
The Hong Kong University of Science and Technology (China)

We propose a new kind of bound states in continuum (BIC) in systems constructed by coupling identical one-dimensional (1D) chains each with inversion symmetry. The BIC existence is enabled by a specific separation of the Hilbert space into topological and non-topological subspaces. Bulk-boundary correspondence in the topological subspace guarantees the existence of a localized interface state which can lie in the continuum of non-topological subspace, forming a BIC. Such topological BIC is observed experimentally in a coupled-acoustic-resonators system.

14:35 : Invited talk
Underwater acoustic cloak with pentamode material
Yi Chen, Mingye Zheng, Xiaoning Liu, Gengkai Hu
Beijing Institute of Technology (China)

A cylindrical underwater acoustic cloak is designed from pentamode material that mimics meta-fluid with anisotropic modulus. The machined cloak is tested in a designed 2D waveguide through transient cylinder wave experiments. Experiment results verify excellent cloaking performance over a broadband frequency range 9-15 kHz, and therefore confirm superior wave manipulating capability of pentamode metamaterial particularly for underwater acoustics.

14:55 : Invited talk
Novel Topological Concepts for Reliable Mechanical Wave-guiding
Marc Serra-Garcia, Roman Susstrunk, Osama R. Bilal, Sebastian D. Huber
ETH Zurich (Switzerland)

Guiding mechanical energy in a reliable way between two points in space is an important ingredient for many technological applications such as energy harvesting or in mechanical computing. Here, we present a new design principle for wave-guides with exactly these properties. We discuss a general formalism for the theoretical description of such topological surface modes and provide experimental implementations of two corner stones for topological wave guiding.

15:15 : Observation of topological interface state of elastic wave in a silica 1D phononic crystal
Ingi Kim, Satoshi Iwamoto, Yasuhiko Arakawa
University of Tokyo (Japan)

We demonstrate a topological interface state of elastic wave in solid-structured 1D phononic crystals (PnCs). Two PnCs with different structural parameters can possess a common phononic bandgap with different topological nature. At the interface between the PnCs, a topologically confined state of elastic wave in the bandgap appears. We observe the topologically confined mode with a quality factor of 5,650 in the transmission experiment, while no interface state exists at the interface between PnCs with the same topological characteristic.

15:30 : Experiments on asymmetric acoustic transmission devices
Thibaut Devaux[1], Alejandro Cebrecos[2], Olivier Richoux[2], Vincent Pagneux[2], Vincent Tournat[2]
[1] *Hokkaido University (Japan),* [2] *Maine University (France)*

Building architectures able to demonstrate asymmetric transmission became a real challenge in the last decades. Here, we propose two devices with capabilities of breaking acoustic reciprocity. The first device uses nonlinear conversion in granular matter meanwhile the second allows to avoid frequency conversion during the propagation process. Helping by the experimental results, the advantages and drawbacks of each architecture are compared. The possibility to break the reciprocity introduces new capabilities for information processing and for improving acoustic imaging.

15:45 : An acoustic metamaterial crystal with a graphene-like dispersion
Simon Yves, Fabrice Lemoult, Mathias Fink, Geoffroy Lerosey
ESPCI ParisTech (France)

Graphene, a honeycomb lattice of carbon atoms ruled by tight-binding interaction, exhibits extraordinary electronic properties, due to the presence of Dirac cones within its band structure. Here we explain how we induced tight-binding coupling within a locally resonant metamaterial made of mere soda cans (Helmholtz resonators) and how it allows to obtain an acoustic analog of graphene. These numerical and experimental results demonstrate the potential of crystalline metamaterials as a tabletop platform for the study of solid state physics.

14:00 - 16:15 — Room 117

Session 3A24

SP18. Towards integrated quantum photonics: materials, designs, technologies and applications II

Organized by: Lucia Caspani and Alessandro Casaburi

Chaired by: Lucia Caspani and Alessandro Casaburi

14:00 : Invited talk
Silicon photonic sources of nonclassical states of light
Daniele Bajoni
Universita di Pavia (Italy)

We review recent advances in silicon integrated quantum photonics, with particular emphasis on integrated sources of nonclassical states of light. We show how the third optical nonlinearity of silicon and silicon compatible materials can be enhanced via the use of resonators, and how this can be exploited to generate entangled states of the electromagnetic field as well as heralded single photons.

14:20 : Invited talk

On-chip frequency combs for scalable quantum state generation

Michael Kues[1], Christian Reimer[1], Piotr Roztocki[1], Benjamin Wetzel[1], Fabio Grazioso[1], Brent E. Little[2], Sai T. Chu[3], Tudor Johnston[1], Yaron Bromberg[4], Lucia Caspani[5], David J. Moss[6], Roberto Morandotti[1]
[1] *Centre Energie Materiaux Telecommunications (Canada),* [2] *Xi'an Institute of Optics and Precision Mechanics (China),* [3] *City University of Hong Kong (China),* [4] *The Hebrew University of Jerusalem (Israel),* [5] *University of Strathclyde (United Kingdom),* [6] *Swinburne University of Technology (Australia)*

Optical non-classical states are fundamental resources for applications in quantum information processing. We show that integrated frequency comb sources, operating in the quantum regime, can provide a scalable and versatile platform for non-classical state generation.

14:40 : Invited talk

High Purcell Factor Generation of Coherent, On-Chip Single Photons

Alistair J. Brash[1], F. Liu[1], J. O'Hara[1], L. M. P. P. Martins[1], R. J. Coles[1], C. L. Phillips[1], B. Royall[1], N. Prtljaga[1], C. Bentham[1], E. Clarke[1], I. Itskevich[2], L. R. Wilson[1], M. S. Skolnick[1], A. M. Fox[1]
[1] *University of Sheffield (United Kingdom),* [2] *University of Hull (United Kingdom)*

In this work we develop a high-time-resolution double π-pulse resonance fluorescence technique, allowing observation of a record Purcell factor of 35 in a low-Q (677) waveguide-coupled photonic crystal cavity. The short radiative lifetime leads to coherent single photon emission regardless of significant dephasing and an enhanced photon generation rate. Combining the strong Purcell effect with resonant excitation and electrical tuning, we demonstrate an on-chip, on-demand tunable single photon source that exhibits high purity and indistinguishability without spectral filtering.

15:00 : Invited talk

Quantum photonics for novel quantum computing and testing quantum physics foundations

Philip Walther
University of Vienna Faculty of Physics Quantum Optics (Austria)

The advantages of the photons makes optical quantum system ideally suited for fundamental quantum physics experiments and a variety of applications in quantum information processing. Here I will discuss multi-photon processing using integrated waveguides as well as experimental benchmark values for hyper-complex extensions of quantum mechanics (such as quaternions) that exploited a metamaterial. As outlook I will briefly discuss the scale-up of photonic quantum information processing by using high-efficient detectors and solid-state single-photon sources.

15:20 : Invited talk

Engineering quantum light on micro/nanophotonic chips

Qiang Lin
University of Rochester (USA)

In this talk, we will discuss our recent progress in engineering micro/nanophotonicdevice structures for producing and manipulating photonic quantum states on chip.

15:40 : Nearly 90 $\%$ collection efficiency from a single-photon source on diamond with a plasmonic nanoantenna

Ilya M. Fradkin[1], Mario Agio[2], Dmitry Yu Fedyanin[1]
[1] *Moscow Institute of Physics and Technology (Russia),* [2] *University of Siegen (Germany)*

Efficient single-photon source is a key milestone in the development of optical quantum computers and secure communication lines. Color centers in diamond and related materials are considered to be the best candidates for practical single-photon sources. However, the low quantum yield and poor collection efficiency of these emitters are a serious obstacle. Here, we present a plasmonic nanoantenna for single-photon sources on diamond which increases the radiation efficiency 30 times and enhances the collection efficiency up to 90 $\%$.

15:55 : Invited talk

Integration Technologies for Complex Photonic Circuits

Graham Sharp[1], Yifeng Song[1], Ning Zhang[1], Charalambos Klitis[1], Vera Biryukova[1], Stuart May[1], John McPhillimy[2], Manuel Reza[1], Eugenio Di Gaetano[1], Barry Holmes[1], Michael Strain[2], Marc Sorel[1]
[1] *University of Glasgow (United Kingdom),* [2] *University of Strathclyde (United Kingdom)*

Future photonic integrated chips for quantum experiments will demand several thousand of components and a number of diverse functionalities integrated on the same chip. We will discuss some of the challenges faced by the up-scaling of photonic integrated chips with a particular emphasis on robust component trimming and heterogeneous integration of III-V devices on a silicon-on-insulator platform.

Coffee Break and Exhibit Inspection

Sponsored by POSTECH Mechanical Engineering Department

Session 3P2

Poster Session VI

16:00 - 16:40

P1: Phase Gradient Silicon Nitride Nanostructures at Visible Wavelength

Jungwoo Park, Ki-Hun Jeong
KAIST (Korea)

This work reports a silicon nitride metasurface that can control the refraction angle of transmitted light at visible wavelength for high transmission efficiency. We numerically simulated the refracted wavefront transmitted through metasurface by tuning the length and the width of rectangular nanoantennas and aligning different-sized nanoantennas in a sub-array. The refraction angle can be adjusted by a unit cell size and number of element antennas in a sub-array.

P2: 2D Numerical study of Acoustic Cloaking

Md. Anzan-Uz-Zaman, Kyungjun Song, Eunjoong Lee, Shin Hur
University of Science and Technology (Korea)

It has been observed researchers use triangular bump which is generally called as baseline shape to hide objects under it using Helmholtz resonator or membrane or such kind of metamaterial for manipulating the reflected phase to cloak it. Our approach is to find the surface impedance for a shape analytically and then using it for manipulating the phase to cloak the obstacle. We have confirmed it by 2D numerical simulation.

P3: Compact Tri-band Composite Right/left-handed Patch Antenna

Ting-Yuan Chen, Fu-Chiarng Chen
National Chiao Tung University (Taiwan)

In this paper, a compact tri-band microstrip patch antenna loaded with mushroom-like composite right/left-handed structure is presented. The mushroom-like structure is composed of a mushroom with two L-shaped slots. This composite right left-handed structure can excite zeroth-order resonance (ZOR) mode and first-positive-order resonance (FPOR) mode. The first order resonance frequency can be adjusted by varying the spacing of two L-shaped slot such that the FPOR frequency can be reduced. As a microstrip upper patch stacked with the mushroom-like structure, the proposed antenna revealed triple-band behavior in 2.31 GHz, 2.92 GHz, and 3.7GHz.

P4: Self-organized silver-based eutectic metamaterial

B. Surma, K. Sadecka, D. A. Pawlak
Institute of Electronic Materials Technology (Poland)

We report on the optical properties of the Bi2O3-Ag eutectic nanocomposite with plasmonic properties, grown by the Micro pulling down method. We will present the optical response of metamaterials built from silver, bismuth, bismuth oxides and highlight the tunability in their structure and optical response. The introduction of rare-earth ions to this eutectic material should promote the enhancement of important optical properties, like photoluminescence or up-conversion processes.

P5: Design of metafluids by determining effective parameters of metamolecules-dispersed liquids
Kwangjin Kim[1], SeokJae Yoo[2], Ji-Hyeok Huh[1], Q-Han Park[2], Seungwoo Lee[1]
[1] *Sungkyunkwan University (Korea),* [2] *Korea University (Korea)*

We derive a method for calculating effective parameters of metafluids, where the rationally designed 3D metamolecules are homogeneously dispersed in liquid-phase fluid (e.g., water). Using this method, we engineer the effective parameters of solution-processable form of metamaterials by tailoring the shape and size of plasmonic nanoparticle and geometry of cluster.

P6: Tuning directional scattering through external magnetic fields in magneto-optical disordered media
Tiago Jose Arruda[1], Alexandre Souto Martinez[1], Felipe A. Pinheiro[2]
[1] *University of Sao Paulo (Brazil),* [2] *Universidade Federal do Rio de Janeiro (Brazil)*

We analytically study light scattering of normally irradiated magneto-optical coated cylinders. We show the application of an external magnetic field along the cylinder axis, consisting of silica core and InSb shell, induces a drastic decrease in absorption and negative values of scattering anisotropy. This preferential backscattering response results in an anomalous regime of multiple light scattering from a collection of magneto-optical microcylinders, in which the scattering mean free path is larger than the transport mean free path.

P7: Translation Matrix for Anisotropic Metamaterials
Konstantin Vytovtov[1], Said Zouhdi[2], E. Barabanova[1]
[1] *Astrakhan State Technical University (Russia),* [2] *Paris-Sud University (France)*

Stratified anisotropic metamaterials with N cells within a period are studied in this paper. Bandgap structure of such materials is under our consideration. The accurate analytical method of investigating is obtained for the first time. It is found that change of the arrangement of cells doesn't affect bandgap structure of metamaterials. It also is shown that boundaries between passband and stopband are resonance characteristics of plane parallel resonator.

P8: Constructing Plasmonic Soft Interfaces at the Microliter-scale for Multiplex Sensing and In-situ Reaction Monitoring
Hiang Kwee Lee, Yih Hong Lee, Xuemei Han, In Yee Phang, Xing Yi Ling
Nanyang Technological University (Singapore)

Liquid marbles have been studied extensively as isolated microreactors, as micropumps, and in sensing. However, current liquid-marble-based sensor and reactor are limited to qualitative colorimetry-based detection and ex-situ characterizations, respectively. Herein we fabricate plasmonic liquid marble1 (PLM) as a substrate-less surface-enhanced Raman spectroscopy (SERS) platform for multiplex and ultrasensitive molecular detections simultaneously across two separate phases, with detection limits as low as 0.3 fmol. PLM also serves as a multi-functional reactor for in-situ and non-invasive reaction monitoring.

P9: Đąomposite honeycomb films based on carboxylated nitrocellulose and silver nanoparticles
Viktoryia Igarauna Kulikouskaya[1], Vladimir Enokovich Agabekov[1], Nikolai Stanislavovich Kazak[2], Sergei Kozik[2], Vladimir Nikolaevich Belyi[2]
[1] *Institute of Chemistry of New Materials of National Academy of Sciences (Belarus),* [2] *Institute of Physics of National Academy of Sciences (Belarus)*

Composite materials with ordered honeycomb-patterned morphology containing Ag0 nanoparticles on the surface of carboxylated nitrocellulose matrix were fabricated by a simple solvent-evaporation method at the air/water interface. By annealing initial honeycomb composite structures, thin ordered films of silver nanoparticles were formed. The simulation of optical properties of the obtained structures was carried out and compared to measured spectra.

P10: Overcoming the constraints of high angle visible light beam bending with asymmetric nanoantenna-based titanium dioxide metasurfaces
Egor Khaidarov, Hanfang Hao, Ramon Paniagua-Dominguez, Ye Feng Yu, Yuan Hsing Fu, Vytautas Valuckas, Arseniy I. Kuznetsov
*A*STAR (Singapore)*

We propose a novel method for energy redistribution between diffraction orders in diffractive arrays of dielectric nanoantennas and demonstrate its application for visible light beam bending using subwavelength-size TiO2 nanoantenna elements. We prove this concept numerically and experimentally for medium ($\sim$45°) and

extra-high-angle ($\sim$80°) beam bending. The designed systems show highly efficient, broadband operation for green and blue frequencies, significantly surpassing the commonly used discrete phase mapping approach.

P11: Topological Distinction of Single Negative Metamaterials: from Phononics to Acoustics
Weiwei Zhu, Shanshan Hou, Hong Chen, Jie Ren
Tongji University (China)

We use a simple circuit model unifies all the different physics of different metamatieral systems, beyond electronics, ranging from phononics/acoustics to microwave photonics. We confirm from the topological band theory and further from continuous Dirac equation that the single negative phononic/acoustic metamaterials are topologically distinct. We experimentally measure the Zak phase and the relativistic Jackiw-Rebby topological solution. The analytical result of the circuit model has a good agreement with microwave experiments, which however is universal to phononics /acoustics.

P12: Topological transition in soft acoustic metamaterials
Shuaifeng Li, Hanchuan Tang, Lei Ye, Degang Zhao, Xuefeng Zhu, Jianfeng Zang
Huazhong University of Science and Technology (China)

we report a novel soft acoustic metamaterial with tunable topological phase by applied mechanical deformation. Harnessing deformation Dirac point in our acoustic system can be switched on and off, resulting in energy band inversion. Our finding offers a new approach to generate an interface state at topological domain wall. Besides, the frequency of interface state can also be tuned continuously. Importantly, we provide a general topological phase diagram to design desired tunable topological state by deforming soft acoustic metamaterials.

P13: All-dielectric metamolecules assembled using perovskite nanopaticles for low-loss magnetic resonances
Yongdeok Cho, Kwangjin Kim, Seungwoo Lee
Sungkyunkwan University (Korea)

High-refractive-index dielectric nanoparticle (NP) has been extensively viewed as one of a prominent building block for optical metamaterial. Recent progresses have been shown that a strong magnetic responses with a significantly low loss can be driven from silicon (Si) NP. However, currently available methods hinder its practical and universal application in devising all-dielectric nanoantenna and nanophotonic device. Here we report high-index-dielectric perovskite NPs by one-pot and mild method and their assembly as a practical way for efficient optical magnetism.

P14: Design of lumped resistor based broadband metamaterial structure
Tanveer Suchu, Ravi Panwar, Rajesh Khanna
Thapar University (India)

A wideband metamaterial structure (MMS) using frequency selective surface (FSS) loaded with lumped resistor has been designed in the range of 2 to 18 GHz. The MMS consists of a resistor loaded FSS, a dielectric sheet and a metallic ground. The results show that the MMA covers the wide frequency range of 5.5 GHz with reflection loss of -31.7 dB at normal incidence. The broadband absorption is mainly resulted from the strong electromagnetic (EM) resonance.

P15: Exploiting Linkage Mechanisms for Synchronously Tunable Dual-Band Frequency Selective Surfaces with Large Areas
Yih-Dar Chen, Chienhao Liu
National Taiwan University (Taiwan)

In this research, we propose a double-rocker linkage mechanism for synchronously tuning the frequency responses of the dual-band FSSs with large areas. Each unit cell is composed of a patch and a loop forming a combination of a series and parallel resonators which are connected separately with two rocker linkages, their frequency responses can be synchronously tuned by two linear driving actuators. By rotating the patches (loops) via the driving linkages, the pass-band (stop-band) was shifted 7.8 $\%$.

P16: The metamaterial based perfect light absorber for colour generation
Soo-Jung Kim[1], Hye-Won Yun[2], Mi-Hyun Kim[2], Heon Lee[1], Sung-Hoon Hong[2]
[1]*Korea University (Korea),* [2]*3D new device Research Section (Korea)*

In this work, we developed a variety of colour utilizing the metamaterial based perfect absorber based on

a coupled nanocrystals (NCs). In the corresponding results, the developed NC based absorber in visible wavelength showed the high absorption above 98 % in two absorption spectra containing a high reflectance peak, and we tuned the desired colour of varying NC type and nanostructure.

P17: Dynamic plasmonic colour display
Xiaoyang Duan, Simon Kamin, Na Liu
Max Planck Institute for Intelligent Systems (Germany)

Plasmonic colour printing based on engineered metasurfaces has revolutionized colour display science due to its unprecedented subwavelength resolution and high-density optical data storage. However, advanced plasmonic displays with novel functionalities have remained in their infancy. Here we demonstrate a dynamic plasmonic colour display technique which enables all the aforementioned functionalities using catalytic magnesium metasurfaces. Controlled hydrogenation and dehydrogenation of the constituent magnesium nanoparticles, which serve as dynamic pixels, allow for plasmonic colour printing, tuning, erasing, and restoration of colour.

P18: Carbon Nanotubes Composite Materials for Dipole Antennas at Sub Terahertz Frequency Band
Yaseen Naser Jurn[1], Mohamed Fareq Abdulmalek[2], Hasliza A. Rahim[1]
[1] *University Malaysia Perlis (UniMAP) (Malaysia),* [2] *University of Wollongong in Dubai (United Arab Emirates)*

This paper aims to present two types of carbon nanotubes composite materials (CNTs-composite) for antenna applications within sub terahertz (THz) frequency band. These materials consist of CNTs coated by copper and silver separately to construct CNTs-copper and CNTs-silver composite materials. The scientific comparisons between the dipole antennas of these structure materials with CNTs and copper dipole antennas are presented to exhibits the performance evaluation of presented dipole antennas. The mathematical modeling of CNTs-composite material is presented in this paper.

P19: Metamaterial Based Frequency Reconfigurable Antenna for 5G Communication
Md. Mehedi Hasan, Mohammad Rashed Iqbal Faruque, M. T. Islam
Universiti Kebangsaan Malaysia (Malaysia)

A metamaterial based frequency reconfigurable antenna is presented for 5G communication. It is composed of a straight feed-line monopole with two double split-ring resonators (DSRR). The DSRR is developed by an outer and the inner split ring resonators with inverse E-shape metal strips of copper are connected with the outer ring resonator. The performance of the proposed reconfigurable antenna is analysed by activate or deactivate the DSRR. However, the designed metamaterial shows the left handed characteristics and miniaturised size.

P20: A Super Wideband Reconfigurable Antenna for Millimeter Wave Application
Md. Mehedi Hasan, Mohammad Rashed Iqbal Faruque, M. T. Islam
Universiti Kebangsaan Malaysia (Malaysia)

In this paper, a super wideband microstrip patch antenna based on reconfigurable metamaterial is proposed. The ground plane of the proposed super wideband antenna is modified with the designed metamaterial structure to obtain the reconfigurable characteristics. The antenna has a zig-zag shape on the patch and the metamaterial structure consists of a ring resonator with two switching configurations.

P21: EMI Shielding Based on MWCNTs/Polyester Composites
Yeng Seng Lee[1], F. H. Wee[1], Y. K. You[2], Z. Liyana[1], F. Malek[3], M. A. Jamlos[1], A. A. M Ezanuddin[1]
[1] *Universiti Malaysia Perlis (Malaysia),* [2] *Universiti Teknologi Malaysia (Malaysia),* [3] *University of Wollongong in Dubai (United Arab Emirates)*

The shielding effectiveness (SE) and complex permittivity of Multi-walled carbon nanotubes and polyester (MWCNTs/PE) composites were investigated in the microwave frequency region from 8.2 to 18 GHz. A rectangular waveguide transmission line method was used to measure the complex permittivity and SE properties of MWCNTs (0-20 %) composites. In the microwave range, composite samples with highest conductivity have the greater SE. The results show SE of the composites increased as the amount of the CNTs increased.

P22: Development of a compact roll-to-roll nanoimprinting system equipped with a resin airbrushing module for continuous and high-speed nanopatterning towards large-area and flexible applications in photonics and metastructures
Sungkwan Koo[1], Sung Ho Lee[2], Jeong Dae Kim[1], Jeongsoo Lee[1], Jihun Lee[1], Dong Kyo Oh[1], Seung-

bum Nam[1], Sungil Cho[1], Yongsu Jo[1], Minseok Go[1], Jae Hyuk Lee[1], Seungjo Lee[1], Jung Goo Hong[2], Hyoung Won Baac[2], Moon Kyu Kwak[2], Jong G. Ok[1]
[1] *Seoul National University of Science and Technology (Korea),* [2] *Kyungpook National University (Korea)*

We developed a compact desktop-sized Roll-to-Roll nanoimprinting system equipped with an airbrushing module for high-speed and uniform resin coating. A diluted resin can be smoothly airbrushed on a continuously moving substrate. The resin-coated substrate then makes conformal contact with a roll bearing a flexible nanopattern mold, where the nanopattern is continuously stamped on a substrate as the rolling proceeds. The system enables the control of initial resin film thickness as well as the residual layer thickness of imprinted pattern.

P23: Quantitative analysis of e.coli L-asparaginase in pico-liter droplets
Eikhyun Cho[1], Youwhan Lee[2], J. Lim[2]
[1] *Yonsei University (Korea),* [2] *Yeungnam University (Korea)*

Screening for enzymatic activities at the single cell level is of particular importance to find variants with specific desired activities, either in the natural diversity or in synthetic libraries obtained through mutagenesis. Droplet-based microfluidics offers promising platforms for the automation and miniaturization of assays, usable for single cell analysis. We demonstrate here a complex coupled assays for the measurement of the enzymatic activity of the bacterial asparginase.

P24: Fabrication of all glass bifurcation microfluidic chip for blood plasma separation
Hyungjun Jang, Muhammad Refatul Haq, Jonghyun Ju, Youngkyu Kim, Seok-Min Kim, Jiseok Lim
Chung-Ang University (Korea)

An all-glass bifurcation microfluidic chip for blood plasma separation was fabricated by a cost-effective glass molding process using an amorphous carbon (AC) mold, which in turn was fabricated by the carbonization of a replicated furan precursor. To compensate for the shrinkage during AC mold fabrication, an enlarged photoresist pattern master was designed, and an AC mold with a dimensional error of 2.9 $\%$ was achieved.

P25: Facile fabrication of 3D LSPR nanoarchitectures comprising double-bent gold strips on transparent nanogratings via roll-to-roll nanoimprinting and angled metal deposition
Jung-Sub Wi[1], Seungjo Lee[2], Sung Ho Lee[3], Dong Kyo Oh[2], Jae Hyuk Lee[2], Jeong Dae Kim[2], Kyu-Tae Lee[4], Inkyu Park[5], Moon Kyu Kwak[3], Jong G. Ok[2]
[1] *Korea Research Institute of Standards and Science (Korea),* [2] *Seoul National University of Science and Technology (Korea),* [3] *Kyungpook National University (Korea),* [4] *University of Illinois at Urbana-Champaign (USA),* [5] *KAIST (Korea)*

A more facile nanoarchitecturing methodology for localized surface plasmon resonance (LSPR), particularly securing scalable and cost-effective fabrication procedure, is called for. We develop 3D plasmonic nanoarchitectures comprising the double-bent Au strips (DAS) integrated on transparent nanogratings, which can be continuously fabricated via roll-to-roll nanoimprint lithography along with inclined Au deposition. We also demonstrate the DAS shape can be tuned for optimal LSPR performance simply by controlling the Au deposition angles, towards flexible and transparent plasmonic sensors with high sensitivity.

P26: Design of a flexible metamaterial superlens system for large-area nano patterning
Jinhyung Lee, Changsu Park, Shinill Kang
Yonsei University (Korea)

We propose a method to design a flexible superlens system for large area nano patterning. The superlens structure including silver layer, silicon oxide layer and chrome grating was designed through FDTD simulation and fabricated on silicon substrate. PDMS was spin coated onto the chrome grating to achieve a flexible superlens substrate. After silicon etching, the flexible superlens structure was fabricated. Using the flexible superlens structure, we demonstrated that large-area nanopatterns with 60nm half-pitch were achieved at 365nm wavelength.

P27: Large-scale fabrication of multilayer dielectric gratings for multiple fiber laser beams combining
Inki Kim[1], Kwang Hyun Lee[2], Jungho Mun[1], Sunae So[1], Junsuk Rho[1]
[1] *Pohang University of Science and Technology (POSTECH) (Korea),* [2] *Agency for Defense Development (ADD) (Korea)*

In this abstract, I will discuss our efforts in design and experimental demonstration of multilayer dielectric gratings (MLDG), which is composed of HfO2 and SiO2multilayers. Rigorous coupled wave analysis (RCWA)

and Finite-difference in time-domain (FDTD) are used in optimization of parameters and designing the device. Laser interference lithography (LIL) set-up is used in the device manufacturing. Through LIL set-up large-scale MLDG device (35mm x 35mm) is fabricated on a thick fused silica substrate (20mm).

P28: High signal to noise enhanced fluorescence substrate with micro/nano hierarchy structure
Xun Lu, Jonghyun Ju, Mohsin Ali Badshah, Naseem Abbas, Seok-Min Kim
Chung-Ang University (Korea)

A micro/nano hierarchy structure was fabricated by UV-nano imprinting process and glancing angle deposition (GLAD) technique to improve the signal noise ratio of GLAD metal-enhanced fluorescence (MEF) substrate. Since the metallic nanorod structure formed only on the top of micropillar structure (Spotting area), the non-spot region shows lower background signal than the full metallic nanorod structure substrate, which improve the signal to noise ratio of enhanced fluorescence substrate.

P29: Fabrication of glass micromixer with high chemical resistance
Muhammad Refatul Haq, Youngkyu Kim, Seok-Min Kim
Chung-Ang University (Korea)

A glass micromixer with high chemical resistance was fabricated by glass molding process with vitreous carbon (VC) mold. A VC mold was fabricated by carbonization of replicated furan precursor. The effects of molding temperature and pressure on the replication quality were examined to optimize the glass molding process. The channel shape changes of glass chip during the mixing process with organic solvent as a working fluid were measured and compared with the conventional PDMS chip.

P30: Variable stiffness using electromagnetic force in acoustic metamaterials
Dongwook Kim, Junsun Yoo, No-Cheol Park
Yonsei University (Korea)

The narrow band gap of elastic materials is an obstruction for practical applications. In this study, we proposed a method of changing band gaps through variable stiffness of the proposed lattice structure. We used attractive force between ferromagnetic materials and electromagnets that works like a spirng. Electromagnetic circuit was designed to make variable stiffness of the stuctures. The dispersion equation and attenuation factor of this system was derived.

P31: A Study of Band Gap Effect of Seismic Metamaterials using Leaf Springs
Joo Young Yoon, Sang Jeung Lee, No-Cheol Park
Yonsei University (Korea)

Elastic metamaterials that have negative effective properies have been investigated to prevent acoustic or seismic waves. In this study, seismic metamaterials were developed using leaf springs to achieve negative effective properites. We fabricated reduction model of seismic metamaterials and investigated effect of shock absorption using vibarion exicter. Finite element model about reduction model was constructed and was verified validity of simulation results. Using similarity analysis, effect of shock absorption of real-size seismic metamaterials was investigated about seismic waves.

P32: Characteristics of diffusive transport with use of metasurfaces for spatial resolution of fNIRS
Zeshan Shoaib, Junhyun H. Kim, H. Choi, M. Y. Jeong
Pusan National University (Korea)

Functional near-infrared spectroscopy(fNIRS) is an emerging brain imaging technique. We proposed to use metasurfaces and optical antennas to control the absorption and scattering of light which are the major factors of attenuation of light in the current fNIRS system. Furthermore, with use of metasurface, we can not only detect the ballistic component but also the diffusive and snake components which in result will enhance the receiving signal intensity of the light.

P33: Effects of micro patterns on negative refractive index of planar surface
Junhyun H. Kim, Zeshan Shoaib, H. Choi, M. Y. Jeong
Pusan National University (Korea)

The metasurfaces which don't appear properties in nature have many interesting properties. Among many properties of metasurfaces, the enhancement of optical signals become more important for optical and electromagnetic field.In this paper, we changed the optical signal by using micro patterned planar surface which can control the permittivity and permeability.

P34: Single-exposure quantitative phase imaging in color-coded LED microscopy
Wonchan Lee, Daeseong Jung, Chulmin Joo
Yonsei University (Korea)

Here, we demonstrate a strategy for single-shot quantitative phase imaging in color-coded LED microscopy. We employ a circular LED illumination pattern that is trisected into subregions with equal area, assigned to red, green and blue colors, respectively. We also describe computational model and single-shot quantitative phase imaging capability of our method by presenting phase images of calibrated phase sample and dynamics of cells.

P35: In vivo optical coherence tomography imaging of penetration and dissolution characteristics of hyaluronic acid microneedles in human skin
Seungri Song[1], Jung-Hyun Bae[2], Soocheol Kim[1], Jung-Dong Kim[2], Hong-Kee Kim[2], Chulmin Joo[1]
[1] *Yonsei University (Korea),* [2] *Raphas - Inc (Korea)*

We present in situ imaging and analysis of the penetration and dissolution characteristics of hyaluronic acid based MNs (HA-MN) with various needle heights in human skin in vivo. We measured the actual penetration depths of the HA-MNs by considering the experimentally measured refractive index of HA in the solid state. For the dissolution dynamics of the HA-MNs, structural alteration of the MNs could be clearly visualized, and the volumetric changes of the MNs were measured.

P36: 3D position tracking confocal microscope based on single-photon-counting for spin resonance experiment in diamond
Donghyuck Lee, Ji-Won Yun, Dohun Kim
Seoul National University (Korea)

In this study, we introduce the development of a single-photon-counting three-dimensional position tracking confocal microscope, which mainly aims at quantum information optical experiment of Diamond NV center. Combined with single photon counting and software lock-in modulation, motion tracking in a single molecule level can be performed in real time. As performance verification we show an example of measuring magnetic resonance of single NV center in bulk diamond over several days at a signal to noise ratio of 20:1.

P37: Experimental realization of ITO based mode-multiplexed nanophotonic modulators
Heonyeong Jeong, Inki Kim, Junsuk Rho
Pohang University of Science and Technology (Korea)

Photonic and optical devices have been improved using the state of the art nanofabrication techniques. Also, photonic modulators have been affected by the nanotechnology, so we has already theoretically designed mode-multiplexed modulator using indium-tin-oxide (ITO) pattern which can distinguish one modes from waveguide modes. Thus this research is to verify that the device can modulate two wave modes by fabricating and experiment the designed structure. The results improve waveguide system multiplying functionality-per-area.

P38: Interaction mechanisms in ensembles of planar meta-atoms
Moritz Wenclawiak, Christian Derntl, Karl Unterrainer, Juraj Darmo
TU Wien (Austria)

In this contribution we demonstrate the substantial influence of meta-atoms in the terahertz regime on the radiation efficiency when being arranged in a confined environment. The meta-atoms, as the elementary structures of a metasurface, are thereby arranged in separated super cells with varying element density. For such meta-atom ensembles we find a radiative lifetime effect comparable to that known for an ensemble of excited atoms in a sub-wavelength volume.

P39: Photoelectric Properties of CdSe/ZnS Quantum Dot/Graphene Thin Films Enhanced by Silver Nanowire
Sin-Yi Wang, Kuan-Han Wu, Bo-Tau Liu
National Yunlin University of Science and Technology (Taiwan)

In this study, we used reduced graphene oxides (rGOs) and CdSe/ZnS QDs to fabricate rGO-QD-rGO sandwich-structure films. The sandwich structure is willing to alleviate the deterioration of QDs in surroundings by virtue of the covering of graphene. We found that the optoelectronic conversion efficiency of the QD-graphene system was significantly improved by incorporating silver nanowires (AgNWs) into the QD layer.

P40: Designing plasmonic nanostructure based on two-step organothiol-assisted growth
Hyo-Yong Ahn, Hye-Eun Lee, Yoon Young Lee, Ki Tae Nam
Seoul National University (Korea)

We developed two-step organothiol-assisted nanoparticle growth system, which is capable to direct morphology of plasmonic nanoparticle in solution. Rationally designed organothiols incorporated in growth process of nanoparticle and induce a distinctive interfacial interaction at the gold nanoparticle surface. We achieved novel nano-morphology control ranging from simple polyhedron to concave rhombic dodecahdron and chiral 432-symmetry structures, which show characteristic extinction, SERS enhancement, and chiroptical property.

P41: Programmable Chiral Plasmonic Nanoparticles with Giant Optical Activity
Hye-Eun Lee[1], Hyo-Yong Ahn[1], Yoon Young Lee[1], Jungho Mun[2], Junsuk Rho[2], Ki Tae Nam[1]
[1] *Seoul National University (Korea),* [2] *Pohang University of Science and Technology (POSTECH) (Korea)*

We fabricated unprecedented three dimensional chiral plasmonic nanostructures by integrating organic-inorganic interaction in nanoparticle growth. Depending on the functional group in organic molecule, binding energy onto gold surface was modulated and we use this control over shape to address fabrication of asymmetric structure with nanometer controllability. Fabricated chiral gold nanoparticle exhibited extremely high dissymmetry factor at visible range ($\sim$0.2 at 622 nm) superior to any other structures produced by bottom-up approaches and showed macroscopic color transformation even in random dispersion.

P42: Surface waves guided by metamaterials with rotational disorder
T. Gric[1], O. Hess[2]
[1] *Vilnius Gediminas Technical University (Lithuania),* [2] *Imperial College London (UK)*

The analytical analysis of the metamaterial boundary with the rotational disorder reveals both bound and leaky surface plasmon (SP) modes. The dispersion relations of SPs propagating on a surface of these metamaterials are presented along with the propagation lengths. The rigorous modeling and analysis of surface waves at the boundary of two metamaterials possessing rotational disorder are presented.

P43: Emergent and Nonlinear Properties of Macroscopic Quantum Superconducting Metamaterials
Melissa Trepanier, Daimeng Zhang, Edward Ott, Thomas Antonsen, Steven M. Anlage
University of Maryland (USA)

The analytical analysis of the metamaterial boundary with the rotational disorder reveals both bound and leaky surface plasmon (SP) modes. The dispersion relations of SPs propagating on a surface of these metamaterials are presented along with the propagation lengths. The rigorous modeling and analysis of surface waves at the boundary of two metamaterials possessing rotational disorder are presented.

P44: Enormous Nonresonant THz Field Enhancement with Nanoslits
Om Krishna Suwal, Dai-Sik Kim
Seoul National University (Korea)

Transmission of Terahertz (THz) electromagnetic wave through a substrate is encumbered because of scattering, multiple reflections, absorption, and Fabry-Perot effects when the wave interacts with the substrate. To exclude the undesired interaction of electromagnetic wave with substrates, we investigated THz transmission through a substrate-free nanoslits.

P45: Application of microchip laser for high resolution 3D printing
D. Perevoznik, K. Kurselis, R. Kiyan, B. N. Chichkov
Laser Zentrum Hannover e.V. (Germany)

Application of Q-switched microchip laser for 3D printing by two-photon polymerization is reported. With optimized laser configuration and photo-resist high resolution high throughput 3D printing of polymer is achieved

P46: Quantum states and transport in PT-symmetric quasi-one-dimensional lattices
Jung-Wan Ryu, Nojoon Myoung, Hee Chul Park
Institute for Basic Science (Korea)

We study quantum transport in PT-symmetric quasi-one-dimensional lattices in which complex band structures appear. Quantum transport in the lattice is measured only in the unbroken PT-symmetric phases in the energy band but not in the broken PT-symmetric phases. We devise a mechanism for reconfiguration of quantum states that is related to PT-phase transition between regions of broken and unbroken PT-symmetry.

P47: Combinational Analysis of 2D metamaterials using AFM-IR and s-SNOM
Eoghan Dillon[1], **Hyuk Woo Jun**[2]
[1] *Anasys Instruments (USA),* [2] *Scinco (Korea)*

This poster will discuss two techniques (1) AFM-based infrared spectroscopy and (2) scattering scanning near field optical microscopy (s-SNOM). Both of these techniques overcome the diffraction limit, providing the ability to measure and map chemical and optical properties with nanometer scale spatial resolution. This talk will focus on the applications of both AFM-IR and s-SNOM to the characterization of a variety of 2D materials, including, nanoantenna arrays and 2D metasurfaces.

P48: Dispersion-free Tunable Beam Splitter with Gate-controlled Graphene Metadevices
Soojeong Baek, Hyeon-Don Kim, Kanghee Lee, Jagang Park, Bumki Min
Korea Advanced Institute of Science and Technology(KAIST) (Korea)

In this study, we propose a broadband tunable beam splitter, where metamaterials and graphene are hybridized to modulate the splitting ratio in a electrically tunable manner.

16:40 - 17:40 — Room 106

Session 3A25

GEN1. Plasmonics and nanophotonics VII

Chaired by: Romain Fleury

16:40 : On-chip optical isolator enabled by adiabatic propagation following an enclosed path in non-Hermitian parametric space
Choloong Hahn[1], **Youngsun Choi**[2], **Jae Woong Yoon**[2], **Seok Ho Song**[2], **Pierre Berini**[1]
[1] *University of Ottawa (Canada),* [2] *Hanyang University (Korea)*

We show that nonreciprocal light propagation occurs following an adiabatic evolution of the parametric path that encircles an exceptional point. Moreover, a device architecture for the nonreciprocal transmission over a broad spectral range is presented. The device is designed for chip-scale operation, and therefore can be applied to a wide range of integration-compatible active photonic devices.

16:55 : Plasmonic Trapping and Antitrapping of Nanoparticles
Aliaksandra Ivinskaya, Mihail Petrov, Andrey Bogdanov, Pavel Ginzburg, Alexander Shalin
ITMO University (Russia)

Optical tweezers performance is investigated when the Gaussian beam is focused on the metal substrate with nanoparticle. When the beam is focused above the substrate optical force increases about an order of magnitude due to evanescent field of surface plasmon. Novel effect of repulsion from Gaussian beam (anti-trapping) is obtained when the beam waist is moved below the substrate which is confirmed by both the analytical approach and finite element simulation.

17:10 : Exploring light scattering response by phase diagram
Jeng Yi Lee, Ray-Kuang Lee
National Tsing-Hua University (Taiwan)

By applying power conservation law, allowable scattering coefficients for any passive electromagnetic scatterers are shown in a phase diagram regardless of geometry, structures, material dispersion and extrinsic operating frequency. This phase diagram not only provides a complete information for energy assignments through radiation loss (scattering cross section) and dissipation loss (absorption cross section), but also offers a clear understanding of all possible extrinsic states. Based on this diagram, we propose a systematic method to design field-controllable devices at subwavelength scales.

17:25 : Thermal effects in optical plasmonic waveguides
V. I. Zakomirnyi[1], **A. E. Ershov**[1], **V. S. Gerasimov**[1], **L. Rasskazov**[2], **S. V. Karpov**[1]
[1] *Siberian Federal University (Russia),* [2] *University of Illinois at Urbana-Champaign (USA)*

We have studied thermal effects occurring during excitation of optical plasmonic waveguide in the form of linear chain of spherical Ag nanoparticles by pulsed laser radiation. Universal comprehensive physical model which combines mechanical, electrodynamical and thermal interactions at nanoscale has been developed as a tool for investigations. It was shown that heating and subsequent melting of the first irradiated particle in a chain can significantly deteriorate the transmission effciency of OPW.

16:40 - 17:15 — Room 109

Session 3A26

SP10. A bottom-up approach towards metamaterials and plasmonics III

Organized by: Dorota Pawlak and Virginie Ponsinet

Chaired by: Dorota Pawlak and Virginie Ponsinet

16:40 : Invited talk
3D bulk material with isotropic magnetic permeability at optical frequencies
S. Gomez-Grana[1], A. Le Beulze[1], S. Mornet[1], E. Duguet[1], V. Ponsinet[1], P. Richetti[1], A. Baron[1], D. Torrent[1], P. Barois[1], J. Leng[1], J.-B. Salmon[1], V. G. Kravets[2], A. N. Grigorenko[2], M. Treguer-Delapierre[1]
[1] *University of Bordeaux (France),* [2] *University of Manchester (France)*

Controlling the magnetic permeability m of artificial materials is expected to offer an unprecedented control of the flow of light in optical devices. Unfortunately, the magnetic response of natural materials is negligible at optical frequencies. A rational design of nano-composites SiO2@Agn enables here the operational extension of the concept of magnetic permeability to visible light. Up to now, artificial optical magnetism has been observed in anisotropic structures thinner than the wavelength of light as a non-local effect which is too complex to be described by an effective magnetic permeability tensor, hence precluding the use of the usual laws of reflection and refraction.

17:00 : Optically active metastable defects in NBP:nAg,Er3+ nanoplasmonic material
B. Surma, M. Gajc, D. A. Pawlak
Institute of Electronic Materials Technology (Poland)

We report on the optical properties of the NBP glass nanocomposite doped with silver nanoparticles, nAg, and erbium ions, grown by the NanoParticle Direct Doping (NPDD) method. We observe formation of optically active metastable defects that we interpret as a result of the interaction of the glass matrix ions with the dangling bonds at the surface of silver particles and with erbium ions. Optical features of the defects were explained by using coordinational coordinate model, CC. Additionally we show that the presence of the silver particles leads also to the decreasing the free-OH absorption in boron-phosphate glass.

16:40 - 17:30 — Room 104-105

Session 3A27

SP35. Optically-assisted mechanical systems for advanced photonics and ultrahigh-precision applications II

Organized by: Jong G. Ok and Ji-Seok Lim

Chaired by: Jong G. Ok and Ji-Seok Lim

16:40 : Invited talk
Fabrication of Glass Microfluidic Devices via Glass Imprinting using a Vitreous Carbon Stamp
Hyungjun Jang, Pyoung-hwa Oh, Muhammad Refatul Haq, Jonghyun Ju, Youngkyu Kim, Seok-Min

Kim, Jiseok Lim
Chung-Ang University (Korea)

This study reports a cost-effective method of replicating glass microfluidic chips using a vitreous carbon (VC) stamp. A glass replica with the required microfluidic microstructures was synthesized without etching. The replication method uses a VC stamp fabricated by combining thermal replication using a furan-based thermally-curable polymer with carbonization.

17:00 : Gate set tomography on electron spin qubits in diamond
Ji-Won Yun, Donghyuck Lee, Dohun Kim
Seoul National University (Korea)

In this study, we used gate set tomography(GST) to characterize the gate fidelity of electron spin qubit formed by a nitrogen-vacancy center in diamond. We briefly introduce photo physics of NV centers and GST, and we discuss the accuracy of the single qubit gates we apply to nitrogen-vacancy centers that was obtained using GST. We further discuss the characteristics of main noise source due to nuclear spin bath in diamond, which is deduced from analyzing quantum processes using GST.

17:15 : Graphene quantum dot based nanohybrid material for photoluminescence with surface plasmonic
Byeongho Park, Seung Won Cho, Seong Chan Jun
Yonsei University (Korea)

We made graphene quantum dot (GQD) and Au nanocompound as an innovative fluorescent material. Such sample showed high photoluminescence characteristics and new emission peak in the visible range, since the strong light confinement obtained from the Au nanoparticles as an antenna remarkably enhace the light absorption. Our material with nanosphere structure provided bluish-green emission after the hybridization of GQD and Au (GQD/Au). It exhibited a photoluminescence quantum yield of up to 26.9 %, which is better than twice of GQD's.

16:40 - 17:20 — Room 107-108

Session 3A28

SP6. Photonic topological insulators: fundamental physics and state-of-the-art devices III

Organized by: Alexey Slobozhanyuk and Andrey Miroshnichenko

Chaired by: Alexey Slobozhanyuk and Andrey Miroshnichenko

16:40 : Invited talk
Three-Dimensional All-Dielectric Photonic Topological Metacrystal
Alexey Slobozhanyuk[1], S. H. Mousavi[2], Xiang Ni[1], Daria Smirnova[2], Yuri Kivshar[3], Alexander Khanikaev[1]
[1] *ITMO University (Russia),* [2] *City College College of New York (USA),* [3] *Australian National University (Australia)*

We demonstrate that a symmetry protected topological (SPT) state can be engineered in a three-dimensional (3D) all-dielectric metacrystal where the electromagnetic duality between electric and magnetic fields is ensured by the meta-atoms design. Magneto-electric coupling results in a complete topological photonic bandgap and an emergence of spin-polarized surface states with conical Dirac dispersion on 2D topological domain walls.

17:00 : Invited talk
The effect of topology on quantum photonic states in silicon
Andrea Blanco Redondo[1], Bryn A. Bell[1], Mordechai Segev[2], Benjamin J. Eggleton[1]
[1] *The University of Sydney (Australia),* [2] *Technion (Israel)*

We study the effect of topology on quantum walks using on-chip generated correlated photon pairs in an array of silicon waveguides. By using single-photon measurements and simulations we demonstrate the transition

between the characteristic path entanglement in random quantum walks and topological localization of the quantum states. Further, we show the robustness of that topological localization to disorder.

16:40 - 17:20 — Room 110-111

Session 3A29

SP8. Advanced passive and active metasurfaces III

Organized by: Howard Lee and Din Ping Tsai

Chaired by: Howard Lee and Din Ping Tsai

16:40 : Invited talk

Manipulating the Polarization State of Smith-Purcell Emission by Metasurfaces

Zuojia Wang[1], **Kan Yao**[1], **Hongsheng Chen**[2], **Yongmin Liu**[1]
[1] *Northeastern University (USA),* [2] *Zhejiang University (China)*

Smith-Purcell emission is far-field radiation of light from swift electrons when electrons move closely above a periodic structure. Here we show that designer metasurfaces composed of C-aperture resonators can control the polarization state of Smith-Purcell emission on demand with high efficiency, which is very difficult to achieve via traditional gratings. These findings open up new opportunities to manipulate electron-beam-induced emission, and to develop compact, tunable and efficient light sources and particle detectors.

17:00 : Invited talk

Nonlinear optics at the nanoscale with metallic, dielectric, and hybrid nanostructures

Stefan Maier
Imperial College London (United Kingdom)

We discuss different schemes for the enhancement of nonlinear processes such as second and third harmonic generation, as well as four wave mixing, focusing on plasmonic, dielectric, and hybrid materials systems. For dielectric systems, anapole modes in Ge disks are shown to allow for maximizing electric field concentration in the material, leading to highly enhanced conversion efficiencies. GaP nanopillars enable localization throughout the visible regime under low-loss conditions.

16:40 - 17:40 — Room 113

Session 3A30

Symposium II. Recent Advances in Complex Materials and Nanophotonics XII

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

16:40 : Invited talk

Hot Carrier Extraction with Plasmonic Broadband Absorbers

Charlene Ng[1], **Jasper J. Cadusch**[2], **Svetlana Dligatch**[2], **Ann Roberts**[2], **Timothy J. Davis**[2], **Paul Mulvaney**[2], **Daniel E. Gomez**[3]
[1] *Melbourne Centre for Nanofabrication (Australia),* [2] *The University of Melbourne (Australia),* [3] *RMIT University (Australia)*

Hot charge carrier extraction from metallic nanostructures is a very promising approach for applications in photocatalysis, photovoltaics, and photo-detection. Here we demonstrate that a monolayer of Au nanoparticles can be assembled on a multi-stack layered configuration to achieve broadband, near-unity light absorption. We show that this enhanced light absorption leads to a 40-fold increase in the photon-to-electron

conversion efficiency in photo-electrochemical cells.

17:00 : Invited talk
High-throughput nanoscale optical positioning of single quantum dots for high-performance single-photon generation
Jin Liu[1], Yuming He[2], Luca Sapienza[3], Kumarasiri Konthasinghe[4], Sebastian Maier[2], Monika Emmerling[2], Stefan Gerhardt[2], Jose Vinicius De Miranda Cardoso[5], Jin Dong Song[6], Antonio Badolato[7], Christian Schneider[2], Sven Hofling[2], Marcelo Davanco[5], Kartik Srinivasan[5]
[1] Sun Yat-Sen University (China), [2] Universitat Wurzburg (Germany), [3] University of Southampton (United Kingdom), [4] University of South Florida (USA), [5] National Institute of Standards and Technology (USA), [6] Korea Institute of Science and Technology (Korea), [7] University of Rochester, Rochester (USA)

We present a wide-field, high-throughput optical technique for locating solid-state quanutm emitters with less than 10 nm accuracy, and apply it in the creation of micropillar sources with near-optimal single-photon emission.

17:20 : Invited talk
Dyakonov plasmons in mid-IR
Andrey Bogdanov[1], Osamu Takayama[2], Evgeniy Shkondin[2], Mohammad Esmail Aryaee Panah[2], Kirill Golenitskii[3], Pavel Dmitriev[1], Taavi Repan[2], Radu Malureanu[2], Pavel Belov[1], Flemming Jensen[2], Andrei Lavrinenko[1]
[1] ITMO University (Russia), [2] Technical University of Denmark (Denmark), [3] Ioffe Institute (Russia)

In this work, we theoretically analyze Dyaknov surface plasmons (DPs) and bulk plasmon waves in CMOS compatible hyperbolic metamaterial slab. The slab consists of alternate layers of Si and aluminium-doped ZnO (AZO). We have shown that the dispersion and directivity of the analyzed waves can be eciently tailored in the mid-IR by change of geometrical parameters of the structure and doping level of AZO layers.

16:40 - 17:20 — Room 114

Session 3A31

SP24. Advances in Nanolasers I

Organized by: Ren-Min Ma and Mercedeh Khajavikhan

Chaired by: Ren-Min Ma and Mercedeh Khajavikhan

16:40 : Invited talk
Dynamics of nanolasers and nanoscale light emitters
Yeshaiahu Fainman, S. H. Pan, Q. Gu, A. El Amili, F. Vallini
University of California (USA)

This paper discusses nanoscale engineered metal-dielectric-semiconductor resonant gain geometries confined in all three dimensions used to create a new type of nanolasers and light emitters. When these emitters are driven in a pulsed regime, dynamic hysteresis is observed and characterized.

17:00 : Invited talk
Semiconductor Microlasers with Curve-Side Polygon Resonators
Yong-Zhen Huang, Hai-Zhong Weng, Zhi-Xiong Xiao, Yue-De Yang, Jin-Long Xiao, Yun Du
Chinese Academy of Sciences (China)

Semiconductor microlasers with curve-side polygon are proposed and demonstrated for enhancing mode Q factors and controlling lasing spectra. Numerical and experimental results are presented for the deformed square and hexagon AlGaInAs/InP microlasers.

16:40 - 17:35 — Room 115

Session 3A32

SP11. Active, Nonlinear, Quantum, and Reconfigurable Plasmonics and Metamaterials III

Organized by: Christos Argyropoulos and Pai-Yen Chen

Chaired by: Christos Argyropoulos and Pai-Yen Chen

16:40 : Invited talk
Nonlinear optics of epsilon near zero material using CdO
Ting S. Luk[1], Yuanmu Yang[1], Domenico de Ceglia[2], Michael Scalora[3], Kyle Kelley[4], Jon-Paul Maria[4], Gordon A. Keeler[1], Salvatore Campione[1]
[1] *Sandia National Laboratories (USA),* [2] *AEgis Technologies Group (USA),* [3] *U.S. Army RDECOM (USA),* [4] *North Carolina State University (USA)*

The banner of strong field confinement using plasmonic material has been waved for quite some time. In many cases, strong field confinement comes with high loss which has hampered many potential applications. In this paper we show two remarkable examples of nonlinear effects of plasmonic material: third harmonic generation and p-polarization reflectance modulation, using high mobility doped semiconductor of CdO where high absorption and strong field confinement can co-exist.

17:00 : Invited talk
2D materials polaritons
Tony Low
University of Minnesota (USA)

I will review recent progress in the study of polaritons (plasmons, phonons and excitons) in 2D materials, its state-of-the-art experiments, survey the vast library of polaritonic modes in 2D materials, their optical spectral properties, figures-of-merit and application space. Taken together, the emerging field of 2D material polaritonics and their hybrids provide enticing avenues for manipulating light-matter interactions across the visible, infrared to terahertz spectral ranges, with new optical control beyond what can be achieved using traditional bulk materials.

17:20 : Frequency conversion in THz metal-insulator-metal disk resonators coupled to semiconductor quantum wells
Christian Derntl, Moritz Wenclawiak, Karl Unterrainer, Juraj Darmo
TU Wien (Austria)

We present our investigations of asymmetric quantum wells in the THz regime. The combination with 3D full wave simulations and measurements of modified circular patch resonators allows us to study efficient nonlinear frequency conversion when the resonators are coupled to intersubband transitions in asymmetric quantum wells. The flexible tuning of the eigenmodes and the wide range of quality factors (13-40) allow to optimize the internal nonlinear conversion process as well as the in- and out-coupling of light.

16:40 - 17:20 — Room 117

Session 3A33

SP16. Plasmonic Nanocircuits: Fundamentals and Devices I

Organized by: Hong Wei

Chaired by: Hong Wei

16:40 : Invited talk
Control of Emission Photon Statistics from a Single Quantum Dot Using Plasmonic Nanostructures

Sadahiro Masuo
Kwansei Gakuin University (Japan)

One of the important emission behavior of semiconductor nanocrystal quantum dots (NQDs) is the emission photon statistics, i.e., single-photon emission and multiphoton emission. Generally, the emission photon statistics of the NQDs are governed by the multiexciton dynamics based on the quantum confinement depending on the size, shape, and atomic composition of NQDs themselves. We demonstrated that the emission photon statistics from a single NQD could be controlled by the interaction with the plasmonic nanostructures.

17:00 : Invited talk

Multimodes and their hybridization in plasmonic nanostructures

Ru-Wen Peng[1], Qing Hu[1], Kun Zhang[1], Wen-Bo Shi[1], Yue Xu[1], Nicholas x. Fang[2], Xian-Rong Huang[3], Mu Wang[1]
[1]*Nanjing University (China),* [2]*Massachusetts Institute of Technology (USA),* [3]*Argonne National Laboratory (USA)*

In this work, we study the multimodes and their hybridization in several plasmonic nanostructures. First, we present multimodes in a plasmonic nanowire and the applications on plasmonic circuits. Second, we show the multiple hybrid polariton bands in organic-dye-doped plasmonic nanostructures. Third, we explore hybrid strong coupling between multiple photonic modes and excitons in an organic-dyeattached photonic quasicrystal. Our investigations may inspire related studies on hybrid light-matter interactions, and achieve potential applications on multimode polariton lasers and optical spectroscopy.

Conference Dinner

Departure by bus from the Convention Center entrance at 17:30

18:00 - 20:30

Friday 28th July, 2017

09:00 - 10:10 — Room 106

Session 4A1

SP27. Acousto-elastic metamaterials and phononic crystals I

Organized by: Marco Miniaci and Yoon Young Kim

Chaired by: Marco Miniaci and Yoon Young Kim

09:00 : Invited talk
Graded arrays of resonators: focusing, detouring, rainbow trapping and mode conversion of waves with elastic metasurfaces
Andrea Colombi, Richard Craster
Imperial College London (United Kingdom)

Metamaterial designs combining graded arrays of resonators and elastic wave excitation are opening new possibilities to broadband control the propagation of mechanical waves in solid media. In this presentation we report on the recent development of a graded metasurface that supports a variety of phenomena including wave focusing, re-routing, rainbow trapping and mode conversion. Applications of this metamaterial can be envisaged in several fields and lengthscales.

09:20 : Invited talk
Anisotropic Surface Acoustic Waves in Tungsten / Lithium Niobate Phononic Crystals
Jia-Hong Sun, Yuan-Hai Yu
Chang Gung University (Taiwan)

Phononic crystals (PnC) were known for acoustic band gaps and applied as filters and reflective gratings for acoustic waves. In this paper, another important property of PnCs, the anisotropic propagation, was studied. A PnC made of circular tungsten films on a lithium niobate substrate was analyzed. Dispersion curves and equal frequency contours of surface acoustic wave were calculated to show the anisotropy. Then negative refraction of group velocity can be observed and used to suppress diffraction of surface waves.

09:40 : Asymptotic analogies for closely packed photonic and phononic crystals
Alice Lucie Vanel, Ory Schnitzer, Richard Craster
Imperial College London (United Kingdom)

Mechanical waves through periodic mass-spring lattices have long acted to gain qualitative intuition about waves through continua containing periodic arrays of inclusions. Techniques based upon matched asymptotic expansions use the narrow gap between the inclusions as a natural small parameter and allow us to replace a photonic crystal by an effective mass-spring lattice for the acoustic band and extend these ideas to higher branches, ultimately a versatile semianalytic methodology is developed for general shapes and illustrated by numerical simulations.

09:55 : Nonlinear Magneto-Granular Phononic Metawaveguides
Florian Allein, Vincent Tournat, Vitali Gusev, Georgios Theocharis
Maine University (France)

We report on the design and operation of magneto-granular phononic structures in two different configurations, line and Γ shaped waveguides. Experimental results reveal the existence of coupled transversal-rotational (TR) modes and conversion from longitudinal to TR modes. In addition, nonlinearity originated from contact deformations gives rise to nonlinear processes such as amplitude dependent transmission, filtering and conversion to second harmonic frequency.

09:00 - 10:20 — Room 109

Session 4A2

SP18. Towards integrated quantum photonics: materials, designs, technologies and applications III

Organized by: Lucia Caspani and Alessandro Casaburi

Chaired by: Lucia Caspani and Alessandro Casaburi

09:00 : Invited talk
Photonic circuitry with quantum dots
Leonardo Midolo, Peter Lodahl
University of Copenhagen (Denmark)

The recent advances in building scalable photonic quantum devices based on semiconductor quantum dots in Gallium Arsenide are reported. The excellent properties of quantum dots as efficient and coherent single-photon resources in this platform allows us to explore novel functionalities by combining them with photonic integrated circuits. Recent results include methods for the efficient out-coupling of single photons to optical fibers and the on-chip electro-optical routing of single quantum dot emission with sub-μs speed.

09:20 : Invited talk
Integrated photonic circuits for time-bin encoded quantum information systems
Hiroki Takesue, Takuya Ikuta, Hsin Pin Lo, Nobuyuki Matsuda
NTT Corporation (Japan)

Integrated quantum photonics is now drawing attention as a way to realize scal-able quantum information systems using photons. We review the recent progress of integratedphotonic devices based on silica, silicon and lithium niobate waveguides for quantum information and communication systems based on time-bin qubits and qudits.

09:40 : Invited talk
Femtosecond laser writing of 3D integrated quantum photonic circuits
Roberto Osellame
National Research Council (IFN-CNR) (Italy)

The use of integrated photonics in quantum optics experiments has introduced dramatic improvements in terms of stability and scalability of the experiments. In particular, femtosecond laser direct writing of photonic circuits enabled the manipulation of polarization-encoded single photons and the realization of 3D photonic circuits. These unique capabilities opened the door to advanced quantum simulation and computation tasks.

10:00 : Invited talk
Quantum Emitters in Flatland
Igor Aharonovich
University of Technology (Australia)

Engineering solid state quantum systems is amongst grand challenges in engineering quantum information processing systems. While several 3D systems (such as diamond, silicon carbide, zinc oxide) have been thoroughly studied, solid state emitters in two dimensional (2D) materials have not been observed. 2D materials are becoming major players in modern nanophotonics technologies and engineering quantum emitters in these systems is a vital goal.

09:00 - 10:30 — Room 104-105

Session 4A3

SP33. Recent progress in novel functionalities of plasmonic and metamaterial structures II

Organized by: Kazuaki Sakoda and Teruya Ishihara

Chaired by: Kazuaki Sakoda and Teruya Ishihara

09:00 : Keynote talk
Chiral plasmonic nanostructures
Peer Fischer
Max Planck Institute (Germany)

How can one see gold nanoparticles in strongly absorbing blood? I will describe that this is possible with plasmonic nanohelices. Moreover, I will show that record local plasmon resonance (LSPR) sensitivities can be achieved when plasmonics and chirality are combined. We use a general fabrication scheme to rapidly grow chiral nanostructures from plasmonic and magnetic materials, in a way that lets us tailor their dielectric function. We thereby realize metafluids whose optical properties can be tuned and dynamically switched.

09:30 : Invited talk
Bi-anisotropic response in three-dimensional split ring resonators fabricated by a self-folding method
Yuto Moritake, Takuo Tanaka
RIKEN Center for Advanced Photonics (Japan)

We experimentally demonstrated infrared metamaterials composed of three-dimensional split ring resonators (3D-SRRs) fabricated by a metal-stress-driven self-folding method we developed so far. The self-folding method enables to mass and easy fabrication of 3D SRRs operating in the infrared region due to self-organized nature of the process. By using this method, bi-anisotropic response in 3D-SRRs was controlled, which realizes 3D magnetic materials in the infrared region.

09:50 : Invited talk
Active terahertz metamaterials utilizing π-conjugated polymers
Tatsunosuke Matsui
Mie University (Japan)

We demonstrate active tuning of the resonant response of metamaterials utilizing organic π-conjugated materials in terahertz (THz) frequency ranges. Electrochemically grown heavily-doped polypyrrole (PPy) film was used as a linear actuator to slightly shifting relative position of stacked two layers of split-ring resonator (SRR) array. We also show that a stacked closed-ring resonator (CRR) array is also effective to obtain relatively large spectral shift with a small lateral shift.

10:10 : Invited talk
Symmetry Classification of Topological Photonic Crystals
Max Lein, Giuseppe De Nittis
Tohoku University (Japan)

As a first step to understand topological effects in photonic crystals via photonic bulk-boundary correspondences, we have adapted the Altland-Zirnbauer classification scheme and obtained a classification of topological photonic crystals. Our classification justifies the name Quantum Hall Effect for light, and suggests that the Chern number quantifies the net number of edge modes traveling from left to right. Furthermore, we identify dual symmetric materials as a second candidate for exhibiting novel topological effects.

09:00 - 10:40 — Room 107-108

Session 4A4

SP16. Plasmonic Nanocircuits: Fundamentals and Devices II

Organized by: Hong Wei

Chaired by: Tigran V. Shahbazyan and Christian A. Nijhuis

09:00 : Invited talk
Modal plasmonic logic gates
Upkar Kumar[1], Sviatlana Viarbitskaya[1], Aurelien Cuche[1], Alexandre Bouhelier[2], Gerard Colas des Francs[2], Jadab Sharma[1], Christian Girard[1], Erik Dujardin[1]
[1] *Universite Federale de Toulouse (France),* [2] *Universite de Bourgogne (France)*

Two dimensional colloidal plasmonic cavities spatially and spectrally shape the near-field. By designing these two degrees of freedom, transduction function can be implemented in single cavities that perform Boolean logic functions. The wealth of available plasmonic modes allow to implement complex logic functions without the need of concatenating building blocks but rather by redesigning the transfer function.

09:20 : Invited talk
Graphene based plasmonic modulator
Tao Li, Yulin Wang, S. N. Zhu
Nanjing University (China)

We proposed a plasmonic modulator design with a graphene covered groove-structured metasurface, which show excellent modulation performance on plamsonic waves. For comparison, several types of graphene-based modulators on dielectric waveguides, planar and wedge surface plasmons are theoretically investigated in detail. The results indicate great advantage of our proposed design and promise potential applications in compact optical circuits.

09:40 : Invited talk
Towards atto-Joule efficient Electro-optic Modulators
Z. Ma, R. Armin, Volker J. Sorger
The George Washington University (USA)

Here we report the optical and electrical concepts to achieve atto-joule per bit efficient and compact on-chip electro-optic modulators. We show that the interplay between the active material and the optical mode properties define the modulator performance. Based on physical tradeoffs, we find combinations of bias, material, and optical-mode that yield efficient phase or amplitude modulation with acceptable insertion loss. Furthermore, we show how material properties in the epsilon near zero (ENZ) regime enable reduction of device-length by 15x.

10:00 : Invited talk
Integrated graphene waveguide modulators based on low-loss plasmonic slot waveguides
Sanshui Xiao
Technical University of Denmark (Denmark)

Graphene based electro-absorption modulators involving dielectric optical waveguides have been recently explored, suffering however from weak graphene-light interaction. Surface plasmons polaritons enable light concentration within subwavelength regions opening thereby new avenues for strengthening graphene-light interactions. I present novel integrated plasmonic waveguide modulators showing high modulation depth and low insertion loss, thus giving a promising way to miniaturize the device without jeopardizing the performance of the device.

10:20 : Invited talk
Chiral Plasmonic Nanoparticles with Chiroptical Activity Engineerable in the UV-visible region
Zhifeng Huang
Hong Kong Baptist University (Hong Kong)

In this talk, the author will present that when plasmonic nanoparticles (NPs) are sculptured in a (hidden) helical shape using, e.g. glancing angle deposition, the NPs exhibit chiroptical activity intrinsically originating from the spiral structures. The chiroptical activity can be flexibly controlled in the UV-visible regime, by engineering the

plasmonic material, handedness, and helical dimensions. Numerical and analytical simulations are operated to understand the chiroptical activity of the chiral plasmonic NPs.

09:00 - 10:40 — Room 110-111

Session 4A5

SP8. Advanced passive and active metasurfaces IV

Organized by: Howard Lee and Din Ping Tsai

Chaired by: Howard Lee and Din Ping Tsai

09:00 : Invited talk
Tunable Conducting Oxide Epsilon-Near-Zero Metasurface as Broadband Perfect Absorbers
Aleksei Anopchenko, Long Tao, Ho Wai Howard Lee
Baylor University (USA)

We present our recent development on the use of tunable transparent conducting oxides to demonstrate an electrically tunable metasurfaces that can tune the optical phase and amplitude for on-chip beam steering devices and perfect absorbers. We find that ultrathin epsilon-near-zero (ENZ) conducting oxide multilayers absorb $>95\,\%$ of light in 1-1.5 mm wavelength range with field-effect tunability.

09:20 : Invited talk
Transformation behind equivalent metamaterial chains for caustic generation
Fan Zhong[1], Hui Liu[1], Shining Zhu[1], Jensen Li[2]
[1] *Nanjing University (China),* [2] *University of Birmingham (United Kingdom)*

We establish a metric interpretation to generate plasmonic caustic using one-dimensional chain of metamaterial atoms with variable orientation profile. Such an approach can be straight-forwardly applied to generate caustic with an arbitrarily given shape. We also explore the relationship of the metric interpretation of caustic to motion in curved space-time using a Lorentz-like transformation between equivalent trajectories with experimental realizations.

09:40 : Invited talk
Low-Loss and Tunable Huygens-Source Optical Metasurfaces
Adam Ollanik, Yaping Ji, David Bar-Or, Nathaniel Kurtz, Matthew D. Escarra
Tulane University (USA)

This work reports on the development of low-loss , dynamically tunable Huygens-source optical metasurfaces composed of arrays of elliptical nanoantennas patterned into dielectric and phase-change materials.

10:00 : Invited talk
Reconfigurable beam steering using gate-tunable metagratings
Ragip A. Pala, Ghazaleh K. Shirmanesh, Ruzan Sokhoyan, Yao-Wei Huang, Ho Wai Howard Lee, Harry Atwater
California Institute of Technology (USA)

We experimentally demonstrate gate-tunable metasurfaces that enable electrical-control of the phase of the plane wave reflected from the metasurface. Our design utilizes field-effect modulation of the complex refractive index of ITO layers incorporated into metasurface antenna elements in reflectarray geometry1. We measured a phase shift $>$180o by analyzing the reflection phase from the metasurface elements at 1550nm using Michelson Interferometry. We also show possibility of controllable beam-steering up to 40° by applying independent bias on individual antenna elements.

10:20 : Invited talk
A three-dimensional negative index medium and a miniature surface plasmon polariton amplitude modulator
Ta-Jen Yen[1], Ting-Tso Yeh[1], Tsung-Yu Huang[1], Cheng-Wei Chang[1], Chu-En Lin[2], Chih-Jen Yu[3]

[1] *National Tsing Hua University (Taiwan),* [2] *National Chin-Yi University of Technology (Taiwan),* [3] *Chang Gung University (Taiwan)*

In this talk, I introduce two metadevices.

09:00 - 10:20 — Room 113

Session 4A6

Symposium II. Recent Advances in Complex Materials and Nanophotonics XIII

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

09:00 : Invited talk

Optimized nanostructures via direct laser writing: physical and chemical approaches

Erik Hagen Waller, Julian Hering, Georg von Freymann
University of Kaiserslautern (Germany)

We present recent advances in direct laser writing (DLW) of 3D nanostructures. These require on the one hand sophisticated control of all optical parameters in a DLW system, especially the excitation mode, on the other hand detailed knowledge of the photosensitive material and the structure formation process within this material. Here, we introduce our recent efforts on both: the optics side, including automated aberration correction and stimulated-emission-depletion DLW, the material side, encompassing proximity effect characterization and direct additive metal printing.

09:20 : Invited talk

Extreme nonlinear optics from graphene plasmons

Joel D. Cox, F. J. Garcia de Abajo
ICFO - The Institute of Photonic Sciences (Spain)

The large incident electric field intensities required to achieve extreme nonlinear optical phenomena can be realized through plasmonic near-field enhancement in doped graphene nanostructures. Here we show that the combination of strong local fields and a pronounced intrinsic nonlinearity can result in efficient broadband high-harmonic generation and a dramatic modulation in the optical absorption associated with plasmon resonances in graphene, paving the way for compact ultraviolet and ultrafast light sources and all-optical switching in nanophotonic devices.

09:40 : Invited talk

Non-reciprocal optical effects in nanostructured materials

Thierry Verbiest, Tom Swusten, Ward Brullot
University of Leuven (Belgium)

We will discuss nonreciprocal optical effects that we have observed in (chiral) nanostructured materials composed of Au, Ag and Fe3O4 nanoparticles.

10:00 : Invited talk

Nanostructured Si photonics for applications in the near- and mid-infrared

Carlos Alonso Ramos[1], **Diego Perez-Galacho**[1], **Dorian Oser**[1], **Xavier Le Roux**[1], **Daniel Benedikovic**[1], **Florent Mazeas**[1], **Weiwei Zhang**[1], **Samuel Serna**[1], **Vladyslav Vakarin**[1], **Elena Duran-Valdeiglesias**[1], **Laurent Labonte**[2], **Sebastien Tanzilli**[2], **Pavel Cheben**[3], **Delphine Marris-Morini**[1], **Eric Cassan**[1], **Laurent Vivien**[1]
[1] *Paris Sud University (France),* [2] *University of Cote d'Azur (France),* [3] *National Research Council (Canada)*

We report our advances in the development of subwavelength engineered structures for on-chip photonics circuits, including Si membrane waveguides for sensing applications in the near- and mid-infrared, and high pump-rejection filters for quantum photonics.

09:00 - 10:35 — Room 114

Session 4A7

SP24. Advances in Nanolasers II

Organized by: Ren-Min Ma and Mercedeh Khajavikhan

Chaired by: Ren-Min Ma and Mercedeh Khajavikhan

09:00 : Invited talk
Manipulating the dispersion characteristics of SPP Nanolasers
Yu-Hsun Chou[1], Kuo-Bin Hong[1], Yi-Cheng Chung[2], Chun-Tse Chang[1], Tzy-Rong Lin[2], Tien-Chang Lu[1]
[1] National Chiao Tung University (Taiwan), [2] National Taiwan Ocean University (Taiwan)

Surface plasmon polariton (SPP) nanolasers have recently emerged as a promising candidate to generate coherent light source in nanophotonics integration circuit. The properties of SPP nanolaser such as group velocity, mode area, modulation speed and threshold performance are able to manipulated by the dispersion relation. In this paper we have investigated the characteristics of SPP nanolaser and managed to approach the limit of surface plasmon amplification by stimulated emission radiation (SPASER).

09:20 : Invited talk
Controlled Multi-modal Nanolasing from Plasmonic Superlattices
Teri Odom
Northwestern University (USA)

This talk will describe how to engineer different combinations of nanolasing modes by controlling the structural parameters of the multi-scale plasmonic nanoparticle arrays.

09:40 : Room Temperature Ultralow Threshold Plasmonic Nanolasers with Unusual Scaling Laws
Suo Wang[1], Xing-Yuan Wang[1], Bo Li[1], Hua-Zhou Chen[1], Rupert Oulton[2], Ren-Min Ma[1]
[1] Peking University (China), [2] Imperial College London (United Kingdom)

we report a room temperature plasmonic nanolaser with threshold on the order of 10 KW cm-2 corresponding to a pump density in the range of modern laser diodes. We find unusual scaling laws that allow plasmonic lasers to be more compact, faster, lower threshold and power consumption than photonic nanolasers when the cavity size approaches or surpasses the diffraction limit.

09:55 : Invited talk
High Performance Photonic and Plasmonic Lasers Based on Semiconductor Nanowires
Qing Zhang
Peking University (China)

Surface plasmon lasers offer strong light-matter interaction possibilities and many advanced applications in nanophotonics, biology and information technology. However, due to large intrinsic metal Ohmic losses, plasmonic laser suffers from either high threshold or low operation temperature, which limits the practical applications. Here firstly a room-temperature ultra-violet surface plasmon laser using GaN nanowires will be introduced. The lasing threshold is $\sim$3.5 MW/cm2. Furthermore, we demonstrate a method based on intrinsic self-absorption of semiconductor to tune plasmonic nanowire lasing wavelength.

10:15 : Invited talk
Optimization of Nanowire Based Light Sources and Their Applications for Super Resolution Imaging
Qing Yang[1], Xiaowei Liu[1], Pengfei Xu[1], Chenlei Pang[1], Yuanpeng Wu[1], Chao Meng[1], Jiabei Li[1], Zongyin Yang[2], Delong Wang[1], Tawfique Hasan[2], Michael Geoffrey Somekh[3], Xu Liu[1]
[1] Zhejiang University (China), [2] University of Cambridge (United Kingdom), [3] Hong Kong Polytechnic University (China)

Key parameters including wavelength, polarization and emission efficiency were optimized for the NW-based light sources.Wide-field, far-field label-free super resolution imaging was achieved by using the nanowire (NW) emission as a localized source.

09:00 - 10:40 — Room 115

Session 4A8

SP11. Active, Nonlinear, Quantum, and Reconfigurable Plasmonics and Metamaterials IV

Organized by: Christos Argyropoulos and Pai-Yen Chen

Chaired by: Christos Argyropoulos and Pai-Yen Chen

09:00 : Invited talk
Efficient broadband Huygens sources made of spherical nanoclusters
Romain Dezert, Philippe Richetti, Virginie Ponsinet, Olivier Mondain-Monval, Philippe Barois, Alexandre Baron
University of Bordeaux (France)

We present spherical nanoclusters made of spherical inclusions which act as efficient and broadband Huygens sources. The system is versatile enough that several materials may be used as inclusions and different bands may be targeted by varying some of the parameters. They may serve as the basic building blocks of Huygens metasurfaces and are particularly suited to bottom-up fabrication and self-assembly. We also investigate how these sources interact with ultra-short pulses of light.

09:20 : Invited talk
Ultrafast Spontaneous Emission Sources Based on Plasmonic Nanoantennas
Gleb M. Akselrod
Intellectual Ventures (USA)

For optical interconnects, a need exists for sources of spontaneous emission (LEDs) that rival or exceed the modulation speeds possible with stimulated emission sources (lasers). The fundamental limitation to the modulation speed of LEDs is the slow spontaneous emission lifetime of typical semiconductors ($\sim$1 ns or more). In this talk I will show how plasmonic nanoantennas can be used to dramatically modify the radiative properties of luminescent emitters, pointing towards LED sources with 100 GHz modulation rates.

09:40 : Invited talk
Strong couplings of many-body quantum emitters in plasmonic metal nanocavities
Aeshah Muqri, Jae Yong Suh
Michigan Technological University (USA)

We report Rabi splitting in the optical reflection and emission spectra from different types of quantum emitters interacting with metal nanostructures in periodic arrays. Metal-insulator-metal (MIM) nanodiscs show two localized surface plasmon flat bands as well as surface lattice (SLR) resonances, which is dipolar particle-particle interactions along the diffraction order. The strong coupling between the SLR and quantum emitters observed in MIM nanocavities exhibits both the narrow line-width and enhanced local fields.

10:00 : Invited talk
Plasmons in superlattices of graphene on hexagonal boron nitride
Jeil Jung
University of Seoul (Korea)

Recent experiments have shown the presence of strong of moire superlattice features in the electronic structure of graphene on hexagonal boron nitride. Our analysis shows that the moire superlattices formed at the graphene-hBN interface offer a rich platform for plasmonics where control of the plasmon modes can be introduced both through carrier doping and twist angle control.

10:20 : Invited talk
Nonreciprocal Metasurfaces with Temporal Modulation
Xingjie Ni
Pennsylvania State University (USA)

We demonstrated a distinct class of active metasurfaces with temporal modulation that truly breaks the Lorentz reciprocity of light propagation. The technique would pave a viable way to realize practical magnetic-free

compact nonreciprocal optical components that could enable numerous applications.

09:00 - 10:20 — Room 116

Session 4A9

SP41. Applications of nanophotonics and metamaterials in bio-imaging I

Organized by: Wonshik Choi

Chaired by: Wonshik Choi

09:00 : Invited talk
Wide-field high-resolution fluorescence imaging using wavefront control through a random metasurface
Mooseok Jang, Atsushi Shibukawa, Yu Horie, Andrei Faraon, Changhuei Yang
California Institute of Technology (USA)

The advanced spatial light modulator technology typically offers controllable degrees of freedom up to ∼106, but it is still bounded to the trade-off between the modulation's spatial extent and bandwidth. Here we challenge the traditional limitation using an ultrathin random metasurface as a static spatial frequency mixer rendering the ability to arbitrarily control optical wavefronts over their highest possible spatial bandwidth (i.e. the reciprocal of half-wavelength). We furthermore apply this technique for wide-field high-resolution imaging of fluorescence samples.

09:20 : Invited talk
Hyperbolic metamaterials and imaging
Junsuk Rho
Pohang University of Science and Technology (POSTECH) (Korea)

With proposed hyperlens array, we show the first bio-sample imaging experimental result of super-resolution imaging on hyperlenses by combining to conventional microscopy system for imaging biomolecules. Hippocampal neuron cells are imaged by visible light through the hyperlens array with resolution down to 150 nm, beyond the diffraction limit. The super-resolution imaging result of neuron at sub-diffraction size shows that hyperlens can be used as a useful imaging tool in biology, pathology, medical science and nanotechnology.

09:40 : Invited talk
Wavefront engineering for high resolution in-vivo deep tissue imaging
Jung-Hoon Park
UNIST (Korea)

Multiple scattering of light is a general phenomenon that occurs in all types of tissue. In this work, we describe methods to control the wavefront of the incident beam to enable subcellular resolution imaging deep inside living animals.

10:00 : Invited talk
Image delivery from far-field waves to the surface plasmon polaritons using a disordered array of nanoholes
Wonshik Choi[1], Y. Jo[1], J. Ahn[1], E. Seo[1], Q-H. Park[2], Y. M. Jhon[3]
[1] *Center for Molecular Spectroscopy and Dynamics (Korea),* [2] *Korea University (Korea),* [3] *Sensor System Research Center (Korea)*

We present an on-chip plasmonic switching device consisting of a two-dimensional disordered array of nanoholes that can provide multiple-input and multiple-output channels for transferring information from a photonic to an electronic platform. In this device, the surface plasmon polaritons (SPPs) generated at individual nanoholes become uncorrelated on their way to the detection channel due to random multiple scattering. We exploited this decorrelation effect to increase the channel capacity, and demonstrated wide-field optical image to SPP output channels.

09:00 - 10:25 — Room 117

Session 4A10

SP12. New concepts for energy harvesting and photon management I

Organized by: Mohamed Farhat and Fahhad H. Alharbi

Chaired by: Mohamed Farhat and Fahhad H. Alharbi

09:00 : Invited talk
A two-resonance tapping cavity for an optimal light trapping
Jordi Martorell, Quan Liu, Pablo Romero-Gomez, Paola Mantilla-Perez, Silvia Colodrero, Johann Toudert
ICFO-Institut de Ciencies Fotoniques (Spain)

A two-resonance tapping cavity is proposed and implemented to obtain an effective broadband light trapping in the absorber layer of thin-film solar cells. When this new optical cavity is applied to high performance polymer cells, an optimal light harvesting enhancement is achieved. This leads to a $\sim$20 % increase in power conversion efficiency, corresponding to a record performing polymer cell.

09:20 : Invited talk
Near-field Imaging of Confined Excitons in Monolayer Semiconductors
Jeongyong Kim
Institute for Basic Science (Korea)

Excitons predominate optical properties of monolayer transition dichalcogenides (1L-TMDs) due to their two-dimensional confined nature. Nanoscale spatial emission profiles of excitons, trions and defect-bound localized excitons in monolayer tungsten disulfide obtained by using near-field imaging, revealing a close correlation between local charge population and the formation of trions.

09:40 : Keynote talk
A New Type of Heat Engine, Using LED's as Refrigerators
Eli Yablonovitch
UC Berkeley (USA)

Very efficient light emitting diodes (LED's), surprisingly, do actually become cold as they operate, since LED light carries away entropy. This cooling requires superb LED efficiency. Of course, we now know that the photovoltaic cell and the LED are really the reciprocal of one another. The slogan: A great solar cell has to be a great LED has led to all the new solar cell efficiency records.

10:10 : High Refractive Index dielectric nanoparticles as enhancers of energy harvesting in solar cells: Geometry considerations
Angela Inmaculada Barreda, Francisco Gonzalez, Fernando Moreno
Universidad de Cantabria (Spain)

High Refractive Index Dielectric (HRID) nanoparticles have shown to be an alternative to metallic ones. Here, we analyze the possibility of using them for improving the performance of thin film solar cells by studying their Scattering Directionality Conditions (SDCs) as a function of their shape. We demonstrate that cylinders and cubes are the most promising geometries for redirecting the incident radiation into the photosensitive substrate

Coffee Break and Exhibit Inspection

Sponsored by Songdo Convensia

Session 4P1

Poster Session VII

10:30 - 11:10

P1: Performance Enhancement of Integrated Light Emitting Diode and Wi-Fi Antenna Using Stacked Microstrip

Hamizan Yon, Aziati H. Awang, M. T. Ali, S. Subahir
Universiti Teknologi MARA (Malaysia)

The integrated stacked antenna with Light Emitting Diode (LED) for Wi-Fi application is presented in this paper. Wi-Fi antenna simulated to resonate at 2.45 GHz using Computer Simulation Technology. The LED placed on the top substrate behaves as parasitic element to the antenna design. Radiating patch on second layer while aperture coupled feeding network on first layer. The antennas are reasonable well matched at their corresponding frequency. The antenna was measured using Vector network analyzer and anechoic chamber.

P2: Design of New Plasma Antenna for Wi-Fi Wireless Coverage

Musfirah Hilmi[1], Mohd Tarmizi Ali[1], Idnin Pasya Ibrahim[1], Mohammad Tariqul Islam[2]
[1] *Universiti Teknologi MARA (Malaysia),* [2] *Universiti Kebangsaan Malaysia (Malaysia)*

This paper presents the design of plasma antenna array for Wi-Fi application, operating at 2.4 GHz. In this experiment, four pieces of a commercially available fluorescent tube function as a plasma antenna, with same length and diameter was used. The proposed antenna is simulated using CST Microwave Studio to study its performance. The measured return loss, radiation pattern and signal propagation of this proposed antenna is also presented. The experimental and analysis of this study are discussed.

P3: Exceptional Points in Plasmonic Nanostructures

Ashok Kodigala, Thomas Lepetit, Boubacar Kante
University of California at San Diego (USA)

We present evidence of the existence of exceptional points (EPs) in three-dimensional (3D) plasmonic nanostructures. The systems are composed of coupled plasmonic nanoresonators and can be judiciously driven to EPs by controlling symmetry-compatible modes.

P4: A Model for Calculating the Far-Field Polarization Response of a Plasmonic Metasurface at UV Wavelengths

Matthew Scott Davis[1], J. Strait[2], Wenqi Zhu[2], J. K. Lee[3], S. Blair[4], H. J. Lezec[2], A. Agrawal[2]
[1] *University of Maryland (USA),* [2] *Center for Nanoscale Science and Technology (USA),* [3] *Syracuse University (USA),* [4] *University of Utah (USA)*

UV plasmonic technology has enabled many advanced applications however, the design and implementation of UV interactive metasurfaces remains challenging. To aid in the design of such metasurfaces we demonstrate a model accurately describing the far-field response of a chiral structured metasurface at UV wavelengths. This model is applicable to any arbitrary shape and significantly reduces the reliance on FDTD calculations required to characterize a plasmonic device.

P5: Resonance-coupling Effect On Broad Band Gap Formation And Sound Absorption In Locally Resonant Sonic Metamaterials

Meng Chen, Heng Jiang, Yuren Wang
Chinese Academy of Sciences (China)

Sonic metamaterials have important applications in both military and commercial fields such as noise control, and acoustic communication. To broaden the resonant band gap and sound-absorbing spectrum, Woodpile structure was introduced into sonic metamaterials. Calculations suggest that Woodpile LRSMs have wider band gaps, which are adaptable to all types of vibration polarizations. Using vibration modes and a mass-spring model, strong coupling effect is confirmed between the orthogonal resonances at the upper edge of the band gap. Moreover, considering viscoelasticity of materials, woodpile LRSMs can implement strong sound-absorbing effect in a wide range.

P6: Microstrip Patch Antenna Loaded with Reactive Impedance Surface

Amira Nur Suraya, Thennarasan Sabapathy, Muzamil Jusoh
Universiti Malaysia Perlis (Malaysia)

An investigation on the use of reactive impedance surface (RIS) for wearable antenna is presented. The investigation is conducted with wearable patch antenna that design using RIS at different frequency of unit cells, namely 1.8GHz, 2.45GHz and 5.12GHz. The aim of this project is to observe the miniaturize of antenna if it integrates with RIS. This antenna operates at 2.45 GHz.

11:10 - 11:40 — Room 106

Session 4A11

SP27. Acousto-elastic metamaterials and phononic crystals II

Organized by: Marco Miniaci and Yoon Young Kim

Chaired by: Marco Miniaci and Yoon Young Kim

11:10 : Bio-Inspired Hierarchical Dissipative Phononic Crystals and Acoustic Metamaterials for Low Frequency Attenuation

Marco Miniaci[1], **Anastasiia Krushynska**[2], **Federico Bosia**[2], **Bruno Morvan**[1], **Nicola Maria Pugno**[3]
[1] *University of Le Havre (France),* [2] *University of Turin (Italy),* [3] *University of Trento (Italy)*

Many biological systems show extremely efficient structural as well as dynamic properties achieved through their structure, which is often hierarchical. In this study, a hierarchical architecture is introduced in ordinary phononic crystals (PCs) and acoustic metamaterials (AMMs) to investigate modifications of the dispersion diagrams due to increasing structural complexity at different scale levels.

11:25 : Omnidirectional Source Illusions of Guided Elastic Waves in Plates using Metasurfaces

Yongquan Liu[1], **Zixian Liang**[2], **Fu Liu**[1], **Owen Diba**[1], **Alistair Lamb**[1], **Jensen Li**[1]
[1] *University of Birmingham (United Kingdom),* [2] *Shenzhen University (China)*

We demonstrate source illusion devices to manipulate guided elastic waves using metasurfaces. A source shifter, a transformer and a splitter are proposed, then measured to be broadband and robust against change of source positions. The approach is potentially useful for non-destructive testing, ultrasonography and advanced signal modulation.

11:40 - 12:10 — Room 106

Session 4A12

GEN3. Photonic crystals I

Chaired by: Sergey Sekatskii

11:40 : Applying the Kagome Lattice to 2D Photonic Crystals

Jeremy Upham[1], **Sebastian A. Schulz**[1], **Liam O'Faolain**[2], **Robert W. Boyd**[1]
[1] *University of Ottawa (Canada),* [2] *Cork Institute of Technology (Ireland)*

Slow light photonic crystal (PhC) waveguides tightly compress propagating light and increase interaction times, yet their practical application is largely limited to moderate group indices (ng $<$100). This limitation persists because nearly all research has focused on a single lattice type: the triangular lattice. Here, we present kagome lattice waveguides with an intrinsically high group index for slow light away from the band edge. We experimentally observe ng $>$150 and reduced propogation losses compared to traditional PhC waveguides.

11:55 : An Investigation of Surface Plasmon Effects on Metallic Photonic Crystals in H Polarization

Khee Lam Low[1], **Mohd Zubir Mat Jafri**[2], **Sohail A. Khan**[2]
[1] *KDU Penang University College (Malaysia),* [2] *Universiti Sains Malaysia (Malaysia)*

The band structure graph is the only graph that can be used to explain the characteristics of photonic crystals. In this work the band structure graph has been used to describe these characteristics, which include the surface plasmon effect of photonic crystals and reports the effect of surface plasmons when the relative permittivity is changed from band structure graphs. The numerical results show the magnetic field distribution of waves on the photonic crystals added for each frequency.

11:10 - 12:10 — Room 109

Session 4A13

SP3. Nanophotonics on Silicon Platform I

Organized by: Jian Wang

Chaired by: Jian Wang

11:10 : Invited talk
High efficiency, fast graphene microheater on silicon
Siqi Yan[1], Xiaolong Zhu[1], Lars Hagedorn Frandsen[1], Sanshui Xiao[1], N. Asger Mortensen[1], Jianji Dong[2], Yunhong Ding[1]
[1] *Technical University of Denmark (Denmark),* [2] *Huazhong University of Science and Technology (China)*

We demonstrate an ultra-high efficiency and fast graphene microheater on silicon photonic crystal waveguide. By taking advantage of slow-light effect, a tuning efficiency of 1.07 nm/mW and power consumption per free spectral range of 3.99 mW. A fast rise and decay times (10 % to 90 %) of only 750 ns and 525 ns are achieved. The corresponding figure of merit of the device is 2.543 nW·s, one order of magnitude better than results reported in previous studies.

11:30 : Invited talk
Experimental investigation of ultra-compact Si-GST hybrid photonic devices
Linjie Zhou, Hanyu Zhang, Liangjun Lu, Jianping Chen
Shanghai Jiao Tong University (China)

We report our recent progress on hybrid silicon photonic devices based on the phase change of GST. The Si-GST hybrid waveguide loss is extracted from the measurement of straight waveguides and ring resonators. A MZI switch enabled by the electrically-driven GST is realized. Experimental results reveal that the GST can undergo repeatable phase change induced by electrical pulses, giving rise to a switching extinction ratio variation of 5 dB.

11:50 : Invited talk
A flat-top bandpass mode order convertor based on two dimensional Bragg gratings
Yuechun Shi, Rulei Xiang, Xiangfei Chen
Nanjing University (China)

We propose a new scheme for forward mode order conversion in a multimode waveguide based on cascaded two Bragg gratings. Two Bragg reflections along with twice mode conversions are employed to achieve a flat-top bandpass and forward convertor with a compact size. In addition, the improved convertors can be obtained by carefully designing grating profiles, such as apodizaion structure for rectangle shape conversion spectrum. We believe the proposed scheme may provide a new method for high-performance mode order converter.

11:10 - 11:50 — Room 104-105

Session 4A14

SP33. Recent progress in novel functionalities of plasmonic and metamaterial structures III

Organized by: Kazuaki Sakoda and Teruya Ishihara

Chaired by: Kazuaki Sakoda and Teruya Ishihara

11:10 : Invited talk
Chiral metasurfases and photonic crystals for compact sources of circularly polarized light

Sergei G. Tikhodeev
M. V. Lomonosov Moscow State University (Russia)

Embedding chiral metasurfaces or photonic crystal slabs into semiconductornanostructures and/or microcavities allows to create compact sources of circularlypolarized light including lasers. The mechanisms tocontrol the circular polarization of light emission by chiral structuring are discussed.

11:30 : Invited talk
Near-Field Visualization of Plasmons in Single Gold Nanotriangles
K. Imaeda, S. Hasegawa, K. Imura
Waseda University (Japan)

We studied static and dynamic characteristics of plasmons excited in single gold nanotriangles by scanning near-field optical microscope. Near-field transmission images observed near plasmon resonances showed oscillating patterns depending on the observation wavelengths. The observed spatial characteristics are well reproduced by spatial features of eigen functions of a particle confined in a triangular potential well.

11:10 - 12:10 — Room 107-108

Session 4A15

SP16. Plasmonic Nanocircuits: Fundamentals and Devices III

Organized by: Hong Wei

Chaired by: Thomas Zentgraf

11:10 : Invited talk
BoseâĂŞEinstein Condensation in a Plasmonic Lattice
T. K. Hakala, A.I. Moilanen, A. I. Vakevainen, R. Guo, J.-P. Martikainen, K.S. Daskalakis, H. T. Rekola, A. Julku, P. Torma
Aalto University School of Science (Finland)

We experimentally demonstrate a BoseâĂŞEinstein condensate (BEC) of surface plasmon polaritons in lattice modes of a metal nanoparticle array combined with dye molecules. Our systems constitute of periodic arrays of gold nanoparticles on a glass substrate. Metal nanoparticle lattices support bosonic hybrid modes called surface lattice resonances (SLRs). Providing strong spatial confinement of fields, the SLR modes efficiently interact with fluorescent molecules residing on top of the array.

11:30 : Invited talk
Plasmonic-Electronic Transducers Based on Tunneling
Christian A. Nijhuis
National University of Singapore (Singapore)

This paper describes highly efficient plasmonic-electronic transducers based on tunneling. The plasmons are excited and detected via plasmon assisted tunneling. By electrically detecting the plasmon, the plasmon excitation efficiencies can be estimated which are 1000 times higher than estimates based on photon out coupling efficiencies.

11:50 : Invited talk
Quantum plasmon resonance and plasmon-enhanced photocatalytic activity of gold nanoparticles
Si-Jing Ding, Da-Jie Yang, Li Zhou, Qu-Quan Wang
Wuhan University (China)

We demonstrate the nonmonotonous surface plasmom resonance (SPR) red-shift caused by resonant electron transitions and photocatalytic activity enhanced by the quantum plasmon resonance of colloidal gold nanoparticles. A maximal SPR wavelength and the largest photocatalytic activity are observed in the quantum regime for the first time for the gold nanoparticles with a diameter of 3.6 nm. Theoretical analysis based on a quantum-corrected model reveals the evolution of SPR with quantized electron transitions and well explains the observations.

11:10 - 12:10 — Room 110-111

Session 4A16

SP8. Advanced passive and active metasurfaces V

Organized by: Howard Lee and Din Ping Tsai

Chaired by: Howard Lee and Din Ping Tsai

11:10 : Invited talk
Tunable quantum metasurface
Yuzhe Xiao, Haoliang Qian, Zhaowei Liu
University of California (USA)

We propose new kinds of tunable metasurfaces based on multilayers of gold quantum well. By changing the laser intensity, the tunability is implemented through the ultrahigh Kerr nonlinearity of gold quantum well that we experimentally demonstrated recently.

11:30 : Invited talk
Hot Electron Enhanced Thermionic Emission (HEETE) converters for all-metal optical power generation
N. Hogan, S. Wu, Matthew Sheldon
(USA)

We report on photo-induced charge transport from nanostructured metal metasurface absorbers. In particular, we outline how the remarkable thermal and optical energy concentration provided by plasmonic resonances can enable a new thermodynamic power cycle whereby photo-excited 'hot' electrons and resonant photothermal heating provides a dual excitation mechanism for electron emission. Because this process is closely related to purely thermionic emission, we label an optical power-converting device based on this mechanism a Hot Electron Enhanced Thermionic Emission (HEETE) converter.

11:50 : Invited talk
Nonlinear Scattering and Time Resolved Nonlinear Properties of Metasurfaces and Plasmonic Materials
Augustine Urbas
Air Force Research Lab (USA)

In this presentation, we focus on the design of multipolar characteristics of metasurface elements in order to engineer the nonlinear response both spectrally and directionally. This drives a need for in depth study of the nonlinear response of metasurface component materials and we conduct time resolved studies of thin film materials and structures to investigate their response. This leads to practical metasurfaces engineered for nonlinear applications.

11:10 - 12:10 — Room 113

Session 4A17

Symposium II. Recent Advances in Complex Materials and Nanophotonics XIV

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

11:10 : Invited talk
Refractory Plasmonic Core-shell Nanostructures
Mugahid Ali, Fumin Huang
Queen's University Belfast (United Kingdom)

We present experimental and numerical investigation of core-shell plasmonic nanostructures composed of noble metals and refractory oxides. A variety of nanostructures of different geometries, including nanospheres, nanospheroids, and nanodisks, and a range of oxides, such as SiO2, Al2O3, ZrO2 and TiO2, were investigated, which exhibit tunable optical properties across broad ranges of wavelengths and significantly enhanced chemical and thermal stability. The results provide important insight for developing effective optical nanodevices for applications in high-temperature environment.

11:30 : Invited talk
Magneto-plasmonic nanostructures with broken symmetry for effective magneto-optical response
A. N. Kalish, V. I. Belotelov
Russian Quantum Center (Russia)

The work is devoted to the development of the novel design of magnetoplasmonic nanostructures for improvement of magneto-optical properties. Namely, we propose (1) magneto-plasmonic crystals with broken symmetry for obtaining the Kerr effects at normal incidence, and (2) magneto-plasmonic quasicrystals with the broadband magneto-optical response.

11:50 : Invited talk
Chemical modification of plasmonic nanostructures for biosensing
Sebastian Mackowski[1], Joanna Niedziolka-Jonsson[2]
[1] *Nicolaus Copernicus University (Poland),* [2] *Institute of Physical Chemistry Polish Academy of Sciences (Poland)*

The key point in constructing biosensors based on metallic nanostructures concerns proper modification of their surfaces with defined (bio)receptors. This important tasks involves not only reproducible synthesis of homogenous nanostructures, but also establishing reliable methods for functionalization of the nanostructures that would enable efficient exploitation of plasmonic interactions in such a hybrid system. In the presentation we describe several architectures where successful control of biosensor activity of metallic nanostructures has been demonstrated.

11:10 - 12:20 — Room 114

Session 4A18

SP24. Advances in Nanolasers III

Organized by: Ren-Min Ma and Mercedeh Khajavikhan

Chaired by: Ren-Min Ma and Mercedeh Khajavikhan

11:10 : Invited talk
Room temperature operation of a Silicon nanobeam laser integrated with a 2D monolayer molybdenum ditelluride
Y. Z. Li, J. X. Zhang, D. D. Huang, H. Sun, F. Fan, J. B. Feng, Z. Wang, C. Z. Ning
Tsinghua University (China)

This talk will begin with a summary overview of recent efforts in achieving lasing operation using a monolayer of transition metal dichalcogenides. We will then present our recent results in demonstrating the first room temperature laser operation using a monolayer molybdenum ditelluride integrated with a silicon photonic-crystal nanobeam structure. We will show that room temperature lasing can be achieved at very low threshold under a continuous wave laser pumping.

11:30 : Narrow beam emission in PT-axisymmetric lasers
Waqas Waseem Ahmed, Ramon Herrero Simon, Muriel Botey Cumella, Kestutis Staliunas
Universitat Politecnica de Catalunya (Spain)

We study the field enhancement in lasers with spatial modulations showing PT- and axial symmetry including a central defect. The merge of these two symmetries created by the modulation of the complex index, strongly directs light to the central point obtaining important localization effects. The concentration capabilities of these

potentials is implemented in a simple VCSELs model to generate very narrow and bright beams when a central defect is included to avoid field saturation given by the nonlinearities.

11:45 : Fundamental Scaling Laws of Nanophotonics: Case Laser
Ke Liu[1], Arka Majumdar[2], Volker J. Sorger[1]
[1] *The George Washington University (USA),* [2] *University of Washington (USA)*

Here we report on an analysis show scaling laws for optoelectronic devices, and how various types of optical cavities directly influence the performance of three classes of photonic devices, namely laser sources, electro-optic-modulators, and photodetectors. The device-underlying optical cavities show Purcell factor maxima as a function of cavity length exceeding 1000, 20, and 200 for a micro ring resonator, Fabry Perot, or plasmonic nanocavity, respectively highlighting the physical tradeoff between optical loss management and field confinement.

12:00 : Invited talk
Carrier Dynamics in Nanoscale Light-Emitting Diodes
Bruno Romeira, Victor Dolores-Calzadilla, Aura Higuera-Rodriguez, Simone Birindelli, Francesco Pagliano, P. J. van Veldhoven, E. Smalbrugge, Lachlan E. Black, W. M. M. Kessels, Dominik Heiss, Meint K. Smit, Andrea Fiore
Eindhoven University of Technology (The Netherlands)

Nanoscale light sources operating efficiently at low powers are required for future optical interconnects. Here, we present, both theoretically and experimentally, the carrier dynamics in metal-dielectric cavity nanopillar light-emitting diodes. The nanoLEDs operate at telecommunications wavelengths, featuring tens of nanoWatt waveguide-coupled powers and GHz-range modulation bandwidths. Furthermore, an extremely low surface recombination velocity of 260 cm/s in passivated InGaAs nanopillars is reported, a result of crucial importance for the development of efficient nanoscale optoelectronic devices for nanophotonic integrated circuits.

11:10 - 12:10 — Room 115

Session 4A19

SP11. Active, Nonlinear, Quantum, and Reconfigurable Plasmonics and Metamaterials V

Organized by: Christos Argyropoulos and Pai-Yen Chen

Chaired by: Christos Argyropoulos and Pai-Yen Chen

11:10 : Invited talk
DNA-mediated self-assembly of plasmonic nanocavities
Mauricio Pilo-Pais[1], F. Nicoli[1], C. Argyropolous[2], A. Hogele[1], T. Liedl[1]
[1] *Ludwig-Maximilians-Universitat (LMU) (Germany),* [2] *University of Nebraska-Lincoln (USA)*

In this talk, I will discuss our current progress toward assembling DNA-mediated plasmonic nanocavities incorporating single quantum emitters. DNA complementarity allows the controllable placement of individual colloidal quantum dots or fluorescence molecules within closely-spaced metallic nanoparticles. Using this pre-programmable approach, we greatly enhance the emission, and the coupling strength of individual emitters with plasmonic modes. The rational engineering of these self-assembled systems are ideally suited to study plasmon-single exciton interactions.

11:30 : Invited talk
Spatio-temporal dynamics of strongly-coupled emitters with multiple plasmonic modes
Angela Demetriadou[1], Joachim M. Hamm[1], Yu Luo[2], John B. Pendry[1], Jeremy J. Baumberg[3], Ortwin Hess[1]
[1] *Imperial College London (United Kingdom),* [2] *Nanyang Technological University (Singapore),* [3] *University of Cambridge (United Kingdom)*

Plasmonic nano-cavities provide the ideal conditions to realize light-matter strong-coupling at room tempe-

rature. However, they support multiple types of modes that can be spectrally degenerate, but with different radiative behaviour and field profiles. We demonstrate that quantum emitters simultaneously couple to all modes in plasmonic nano-cavities, a process dominating the spatio-temporal dynamics of the Rabi-oscillations.

11:50 : Invited talk
Laser processing of VO2 for metamaterials applications and THz devices
Alberto Pique, Nicholas Charipar, Heungsoo Kim, Scott Mathews, Kristin Charipar, Raymond Auyeung
Naval Research Laboratory (USA)

Vanadium dioxide (VO2) undergoes a metal-insulator transition (MIT) whereby its electrical resistivity changes by several orders of magnitude. The combination of fast switching times and response to a broad range of external stimuli make VO2 an ideal material for a variety of novel devices and sensors. In this talk, we will present details of laser processed VO2 films and their application for metamaterial devices such as THz emitters and THz modulators.

11:10 - 12:20 — Room 116

Session 4A20

SP41. Applications of nanophotonics and metamaterials in bio-imaging II

Organized by: Wonshik Choi

Chaired by: Wonshik Choi

11:10 : Invited talk
Imaging Photonic Structures at Micro and Nano Scales
Ki-Hun Jeong
Korea Advanced Institute of Science and Engineering (KAIST) (Korea)

Micro and nanophotonic structures allow miniaturization of imaging systems. Spherically arranged microlenses mimic insect's eyes and provides wide FOV imaging, fast motion detection, and enhanced image resolution. Binocular microprisms also enable an ultrathin stereoscopic camera in the visible range. Furthermore, optically patternable metamaterial simply defines polymer patterns below the diffraction limit and also subwavelength silicon hole arrays can serve as a planar silicon lens. In this work, we overview diverse photonic structures for broadband compact imaging systems.

11:30 : Invited talk
Measurement of Optical Anisotropy for Living Cells
Taeseok Daniel Yang, Kwanjun Park, Beop-Min Kim, Youngwoon Choi
Korea University (Korea)

We demonstrated the measurement of optical anisotropy, which is called birefringence, of living cells. Multiple images were taken by using a 3D phase microscopic method and then processed into an enhanced 2D or a volumetric 3D image. Quantitative analysis was also presented.

11:50 : High-resolution reflectance endomicroscopy free from back-reflection noise occurring at ultrathin imaging probes
Changhyeong Yoon, M. Kang, Y. Choi, W. Choi
Korea University (Korea)

We present a high-resolution endoscopic microscope free from back-reflection noise generated at an ultrathin image bundle fiber. To eliminate the back-reflection noise, we illuminate a sample through single individual core fibers in the bundle and detect the reflected signal from the sample by the other core fibers. The transmission matrix method is used for the pixelation-free sample image reconstruction. We confirm that our method enhances the signal to noise ratio of imaging 3.2 times better than conventional illumination-detection scheme.

12:05 : Aberration Correction of an Optical System for High-resolution Synthetic Aperture Imaging

Changsoon Choi, Kyung-Deok Song, Sungsam Kang, Wonshik Choi
Korea University (Korea)

Short working distance of objective lenses often limits high-resolution imaging of targets located deep within a tissue. Condenser lens supporting high numerical aperture and long working distance can be a good alternative, but strong aberrations induced by the lens causes strong image distortion. Here we propose a method that can eliminate aberrations of condenser lens up to the numerical aperture of 1.2, and demonstrate high-resolution synthetic aperture imaging of biological cells and c. elegans.

11:10 - 12:05 — Room 117

Session 4A21

SP12. New concepts for energy harvesting and photon management II

Organized by: Mohamed Farhat and Fahhad H. Alharbi

Chaired by: Mohamed Farhat and Fahhad H. Alharbi

11:10 : Invited talk
Nanophotonics for Light Management in Luminescent Solar Concentrators
Vivian Ferry
University of Minnesota (USA)

This talk will discuss strategies to improve the performance of luminescent solar concentrators to harvest both direct and diffuse sunlight. We will discuss the combination of nanophotonic light management strategies with different types of luminophores based on their spectral overlap and quantum yield, and show experimental strategies that maintain high quantum yield of nanocrystals in polymer matrices.

11:30 : V2O5-Sn bilayer thin film mesh electrode for polymer solar cells
Kovendhan Manavalan[1], Sowri Babu Kotikala[2], Paul Joseph Daniel[2]
[1] *National Taiwan University (Taiwan),* [2] *National Institute of Technology (India)*

Electrode modification with suitable metal oxides or metal buffer layer is an important strategy to improve light harvesting ability of organic and polymeric solar cells. In this work, square regions of tin (Sn) metal layer over V2O5 islands are thermally evaporated onto ITO substrate. The deposited V2O5-Sn is expected to act as plasmonic layer improving the carrier collecting ability. Structural, optical and electrical properties of modified electrode are explored and the performance is studied by fabricating polymer solar cells.

11:45 : Invited talk
Time-Delayed Interaction of an Excitonic Dimer System with Phonons: non-Markovianity through Memory Effects
Mohamed Farhat[1], Sabre Kais[2], Fahhad H. Alharbi[1]
[1] *Hamad Bin Khalifa University (Qatar),* [2] *Purdue University (USA)*

We utilize a modeling of non-Markovian open quantum systems, consisting of an excitonic dimer system that displays memory effect due to time delayed interaction with a bath of phonons. We, thus study the effect of delay in the interaction on photosynthetic coherence and excitons dynamics in the time domain investigated experimentally (few hundred femtoseconds). In particular, we show that for high time delays, the coherence is maintained for longer periods.

Lunch and Exhibit Inspection

12:10 - 14:00

14:00 - 14:55 — Room 106

Session 4A22

SP32. Novel photonic and plasmonic structures: theory and applications

Organized by: Fangfang Ren and Qingguo Du

Chaired by: Fangfang Ren and Qingguo Du

14:00 : Invited talk
Nonlinear polarization rotation of polarization-structured beams through isotropic Kerr nonlinearities
Bing Gu, Bo Wen, Guanghao Rui, Yiping Cui
Southeast University (China)

We report a theoretical investigation of the spatial self-phase modulation (SSPM) effect and nonlinear ellipse rotation of both hybridly polarized vector beams and elliptically polarized vector beams through isotropic Kerr nonlinearities. It is demonstrated that the SSPM intensity pattern, the distribution of state of polarization, and the spin angular momentum (SAM) flux of a hybridly polarized vector beam could be manipulated by tuning the magnitude of the isotropic optical nonlinearity.

14:20 : Invited talk
Application of Surface Plasmon Antenna to CMOS Terahertz Detectors
Xiaoli Ji, Jingyu Peng, Y. Liao, Z. Shen, R. Wu, F. Yan
Nanjing University (China)

On chip surface plamon antenna used for CMOS THz detectors is demonstrated. Unlike the traditional metal antenna, it is designed with heavy-doped silicon material, backed with a silica layer to prevent radiation from going inside the lossy silicon substrate. By optimizing the antenna pattern using a frenquency domain slover, HFSS, surface plasmon polaritions are excited in the antenna and can propagate THz signals to receievers. A CMOS THz detector integrated with the proposed antenna at 0.65THz is fabricated in 0.18um standard CMOS technology. The measurement results show the detector can boost the voltage response by 200 % due to the increased local electrical field. The transmission-mode image of the metal blade using the detector is further exhibited. The results demonstrated that the designed surface plasmon antenna has a high performance to THz radiation comparable with the conventional radio-wave one.

14:40 : Zero-admittance all-dielectric planar structures for giant field enhancement
Myriam Zerrad, Fabien Lemarchand, Aude Lereu, Michel Lequime, Claude Amra
Aix Marseille University (France)

An analytical method to design optical coatings for giant field enhancement under total internal reflection will be presented. Enhancements of several decades can now be localized at arbitrary altitudes within a multi-dielectric component and for different wavelengths.

14:00 - 15:15 — Room 109

Session 4A23

SP3. Nanophotonics on Silicon Platform II

Organized by: Jian Wang

Chaired by: Jian Wang

14:00 : Invited talk
Towards chip-scale light manipulation on silicon platform
Jian Wang
Huazhong University of Science and Technology (China)

Silicon photonics provides a promising integration platform facilitating chip-scale light manipulation. We review

recent research progress in the fabrication of silicon nanophotonic devices and their applications in chip-scale light manipulation: 1) fabrication of various silicon nanophotonic devices (ridge/slot/hybrid plasmonic waveguides, couplers, gratings, microring resonators, photonic crystal nanocavities, comb filter/interleaver, plasmonic/dielectric metasurfaces), 2) chip-scale optical interconnects (terabit-scale signaling), 3) chip-scale photonic signal processing (wavelength conversion, signal regeneration, optical computing), 4) chip-scale spatial light modulation (generation of orbital angular momentum beams).

14:20 : Purcell effect in low-dimensional photonic structures
Mikhail Limonov[1], Alexander Pevtsov[1], Sergei Mingaleev[2], Yuri Kivshar[3], Mikhail Rybin[1]
[1] *Ioffe Institute (Russia),* [2] *Belarus Hi-Tech Park (Belarus),* [3] *ITMO University (Russia)*

We analyze the Purcell eect in a waveguide with a side-coupled microcavity and demonstrate that it can be considered as an interference phenomenon. Also we describe a growth of photoluminescence intensity at the low-frequency edge of the band-gap in a photonic crystal composed of alternating amorphous hydrogenated silicon with carbon and silica layers and attribute this with the Purcell eect. We suggest that Green's function calculated by the transfer-matrix method allows describing the Purcell eects in low-dimensional photonic structures. Indexing

14:35 : Invited talk
Silicon-Photonics-Based Optical Phased-Array
Kyoungsik Yu, Hyo-Hoon Park
KAIST (Korea)

We present the structures and performances of silicon-photonics-based optical phased-arrays (OPAs) to achieve wide beam-forming angles for LiDAR applications. Beam-forming and steering are experimentally demonstrated with 1x16 OPAs in which power splitters, phase shifters, and radiators are integrated on a silicon photonics platform. For wide transversal steering over 45degrees, two radiator types are examined, the grating- and photonic crystal-based structures. We will compare the detailed performances and tradeoffs for such structures.

14:55 : Invited talk
3D Integrated Optical Vortex Devices
Xinlun Cai
Sun Yat-Sen University (China)

Here, we demonstrate a 3D integrated OAM multiplexer, which can be used to combine or multiplexing up to four OAM modes. The device consists of two layers of silicon microring resonator with angular grating embedded in the innerwall. The 3D structure is fabricated through a wafer bonding process.

15:15 - 16:00 — Room 109

Session 4A24

GEN3. Photonic crystals II

Chaired by: Khee Lam Low

15:15 : Ultrasensitive optical bio- and gas- sensors based on Photonic Crystal Surface Waves
Serguei K. Sekatskii
Ecole Polytechnique Federale de Lausanne (Switzerland)

We report our recent results on development of ultrasensitive optical bio- and gas- sensors based on a properly designed Photonic Crystal supporting the propagation of bounded Electromagnetic Surface Waves along the Ptotonic Crystal - medium to be studied interface. In particular, extremely narrow magnetoplasmonic resonances have been observed, and kinetics of interaction of certain antibodies with the surfaces of intact living bacteriais studied.

15:30 : Fabrication of optical field concentrators based on 3D chirped photonic crystals by direct laser writing technique

Vygantas Mizeikis[1], **Zeki Hayran**[2], **Hamza Kurt**[2], **Darius Gailevicius**[3], **Mangirdas Malinauskas**[3], **Saulius Juodkazis**[4], **Kestutis Staliunas**[5]
[1] *Shizuoka University (Japan),* [2] *TOBB University of Economics and Technology (Turkey),* [3] *Vilnius University (Lithuania),* [4] *Swinburne University of Technology (Australia),* [5] *Institucio Catalana de Recerca i Estudis Avancats (Spain)*

We describe a class of passive optical devices based on chirped photonic crystals that have structural properties are gradually varied along one direction, and are capable to localize and enhance local intensity of the incident light. We have addressed the challenge of realizing 3D chirped photonic crystals by using Direct Laser Write lithography, and report properties of the fabricated prototype structures for infrared spectral range.

15:45 : On-chip all-optical amplifier on 2D photonic crystal nanocavities
Teanchai Chantakit[1], **Surasak Chiangga**[2], **Preecha Yupapin**[2]
[1] *Kasetsart University (Thailand),* [2] *Ton Duc Thang University (Vietnam)*

We have designed the passive all-optical amplifier in free space by using the 2D photonic crystal (PhC) nanocavities. By introducing controllable nanocavity parameters for a selective resonance frequency, the amplification can be achieved. The obtained results have confirmed an occurrence of amplified electric field from cavities interaction.

14:00 - 15:10 — Room 104-105

Session 4A25

SP19. META-magnetism and interdisciplinary applications I

Organized by: Ilya Razdolski, David Schmool, Ko-Wei Lin and Vasily Temnov

Chaired by: Ilya Razdolski, David Schmool, Ko-Wei Lin and Vasily Temnov

14:00 : Keynote talk
Functionatized Hybrid Nanomagnets: New Materials for Innovations in Energy Storage and Medical Theranostics
Michael Farle
University Duisburg-Essen (Germany) and Baltic Federal University (Russia)

I will highlight state-of-the-art experimental technologies that allow us to understand microscopic properties and interactions in relation to electronic structure changes caused by changes in size, shape, and composition of nanomaterials. Several examples will be presented, including the formation of above-room-temperature ferromagnetic interface layers between low-temperature antiferromagnetic layers and the evolution of lattices of magnetic textures (skyrmions) in confined dimensions.

14:30 : Invited talk
Magnetic Properties of Nanolaminated Magnetic MAx Phases
Ruslan Salikhov, Ulf Wiedwald, Dieter Weller, Johanna Rosen, Michael Farle
University of Duisburg-Essen (Germany)

We report on magnetic properties of a new class of inherently nanolaminated materials: magnetic MAx phases. Hexagonal atomically layered MAx phases show exclusive mechanical properties and anisotropic thermal and electrical conductivities. These systems are parent materials of graphene-like transition metal carbides, known as Mxenes, which are predicted to be future 2D magnetic materials extending the unique properties of graphene. Magnetic properties of new magnetic MAx phases are presented: magnetic ordering temperature, spin structure, saturation magnetization, magnetocrystalline anisotropy and magnetoresistance.

14:50 : Invited talk
Structural disorder induced magnetization in FeAl and FeRh: The perspectives for laterally patterned magnetic metamaterials
Anna S. Semisalova[1], **R. Bali**[1], **S. Wintz**[1], **C. Barton**[2], **T. Thomson**[2], **G. Hlawacek**[1], **C. Fowley**[1], **J. Ehrler**[1],

R. Bottger[1], **K. Potzger**[1], **J. Lindner**[1], **J. Fassbender**[1]
[1] *Helmholtz-Zentrum Dresden (Germany),* [2] *The University of Manchester (United Kingdom)*

The possibilities of fabrication of magnetic nanostructures using ion irradiation will be exampled with the recent achievements in FeAl and FeRh. Magnetization of both alloys at room temperature is highly sensitive to the structural state (ordered or disordered). This opens a way for lateral patterning of nanoscale ferromagnets embedded in paramagnetic (FeAl) or antiferromagnetic (FeRh) ordered matrix and studying the effect of planar geometry of magnetic interfaces.

15:10 - 15:40 — Room 104-105

Session 4A26

GEN5. Acoustic metamaterials

Chaired by: Xiaoming Zhou

15:10 : Design of a double-negative flexural elastic metamaterial
Keisuke Inagaki, Motonobu Tomoda, Vitalyi E. Gusev, Osamu Matsuda, Oliver B. Wright
Hokkaido University (Japan)

We present an elastic metamaterial for flexural waves with both negative density and elastic modulus. Nanoscale L-shaped holes are periodically drilled through a Au/Al/Au sandwich-structure plate of micrometer thickness. The structure is shown to have a double-negative frequency band at 500 GHz for flexural waves by means of finite-element simulations. We calculate the dispersion relation, effective density and effective modulus of the structure, and demonstrating negative refraction of flexural waves in the double-negative band in a prism-shaped geometry.

15:25 : Mimicking metamaterial functionalities in an immersive laboratory with exact boundary conditions
Miguel Moleron, D. J. van Manen, J. O. A. Robertsson
ETH Zurich (Germany)

This contribution presents an immersive wave propagation laboratory for the study of wave interactions with complex materials. The approach makes use of exact boundary conditions to link a physical experiment to a numerical environment in which a complex material is virtually implemented. This approach makes it possible to mimic exotic wave propagation properties without physically building complex materials.

14:00 - 15:40 — Room 107-108

Session 4A27

SP16. Plasmonic Nanocircuits: Fundamentals and Devices IV

Organized by: Hong Wei

Chaired by: Paivi Torma and Erik Dujardin

14:00 : Invited talk
Phase Control and Nonlinear Holography in Composite 3d Metamaterials
Yehiam Prior, Euclides Alneida
Weizmann Institute of Science (Israel)

The accurate control over the phase and amplitude response of nanoantennas, offers a wide range of opportunities for linear and nonlinear shaping of light beams. Optimization of the nonlinear response and generation of nonlinear holograms have been demonstrated, We introduced a new methodology for the fabrication of 3D multilayer metamaterials, and implemented them for phase controlled holography. Composite multispectral

elements such as an RGB lens which is chromatic-aberration-corrected over the visible range will be presented.

14:20 : Invited talk
Plasmonic Nanostructures with Strong Circular Dichroism Effects for Chirality Sensing
Wenjing Zhao[1], Rongyao Wang[1], Hong Wei[2], Xiaochun Wu[3], Xiangdong Zhang[1]
[1] *Beijing Institute of Technology (China),* [2] *Chinese Academy of Sciences (China),* [3] *National Center for Nanoscience and Technology (China)*

We report here the plasmon-based chiroptical nanosensors 1-5 for discriminating the enantiomeric pair of chiral molecules, quantifying enantiomeric purity of the chiral analytes, and recognizing homochiral/heterochiral zwitterionic interactions in solutions with different pH values. The plasmonic CD spectroscopy provides a new strategy of chiral analyses, which may find important applications in bioscience and biomedicine.

14:40 : Invited talk
Surface-assisted carrier excitation in plasmonic nanostructures
Tigran V. Shahbazyan
Jackson State University (USA)

We present a quantum-mechanical model for surface-assisted plasmon decay into electron-hole pairs (Landau damping) in metal nanostructures of arbitrary shape. The surface absorbed power and scattering rate are highly sensitive to local field polarization relative to the surface. Our model can be used for efficient calculations of plasmon-induced hot carrier generation rates in photovoltaics.

15:00 : Invited talk
Simple autocorrelation function for analysis of collective and quantum effects in radiation from nanocavities and plasmonic nanostructures
Igor E. Protsenko[1], Emil C. Andre[2], Martijn Wubs[2], Alexander V. Uskov[1], Jesper Mork[2]
[1] *Lebedev Physical Institute of RAS (Russia),* [2] *Technical University of Denmark (Denmark)*

Analytical expression for fourth-order autocorrelation function of laser field shows strong influence of collective effects to laser coherency and helps to identify parameters for coherent, incoherent (thermal), sub- and associated with superradiance super-thermal lasing. Below-, above- and thresholdless lasing of micro- and nano-lasers are analyzed in the model without adiabatic elimination of active medium polarization. We show that collective effects reduce beta-factor and number of photons below the threshold.

15:20 : Invited talk
Nonlinear imaging with plasmonic metasurfaces
Thomas Zentgraf[1], Christian Schlickriede[1], N. Waterman[1], Bernhard Reineke[1], Philip Georgi[1], Guixin Li[2], Shuang Zhang[3]
[1] *University of Paderborn (Germany),* [2] *Southern University of Science and Engineering (China),* [3] *University of Birmingham (United Kingdom)*

Tailoring the beam propagation is crucial in nonlinear optics. Here we will demonstrate a nonlinear meta-lens that works in a nonlinear way by simultaneously converting the collected light in a second harmonic wave while performing an imaging of the object. We demonstrate the concept by imaging fundamental beams in the infrared wavelength region into a second harmonic image.

14:00 - 15:45 — Room 110-111

Session 4A28

SP8. Advanced passive and active metasurfaces VI

Organized by: Howard Lee and Din Ping Tsai

Chaired by: Howard Lee and Din Ping Tsai

14:00 : Invited talk

Polarization anomalies of plasmonic singular fields

Yuri Gorodetski[1], **Pierfrancesco Zilio**[2], **Denis Garoli**[2], **Francesco De Angelis**[2]
[1] *Ariel University (Israel),* [2] *Istituto Italiano di Tecnologia (Italy)*

We experimentally demonstrate an anomalous polarization state emitted by a propagating singular plasmonic field from an adiabatically tapered nano cone. This phenomenon is attributed to the specific 3D geometry of the system allowing the increase and the full transfer of the intrinsic transverse plasmonic spin to the far-field. Our model is numerically tested and experimentally verified in this work.

14:20 : Invited talk

Passive, Active, and Nonlinear Chiral Metasurfaces

Wenshan Cai
Georgia Institute of Technology (USA)

Metasurfaces can be designed to exhibit extraordinarily strong chiral responses. Here we present a set of photonic metasurfaces that possess pronounced chiroptical features in both the linear and the nonlinear regimes. These structures are further exploited for chiral-selective two-photon luminescence from quantum emitters and a photon-drag effect with helicity-sensitive generation of photocurrent. Finally, we report a noticeable shift in the chiroptical responses under a modest level of excitation power.

14:40 : Invited talk

Chirality-dependent surface plasmon meta-coupler and transmission -type photonic Spin hall effect with nearly 100 % efficiency

Shulin Sun, Weijie Luo, Jingwen Duan, Huijie Guo, Qiong He, Lei Zhou
Fudan University (China)

Recently, Pancharatnam-Berry (PB) metasurfaces exhibit strong abilities to control spin-polarized light. However, low frequency issue becomes a great challenge in their realistic applications. Here, we propose theoretical criterions of high-efficiency PB devices, that guide us realizing several novel effects in microwave regime. These findings can inspire the high efficiency spin-dependent wave-front manipulations in other frequency domains.

15:00 : Silicon metasurfaces for beam bending and high NA flat lenses

Ye Feng Yu, Ramon Paniagua-Dominguez, Yuan Hsing Fu, Egor Khaidarov, Xinan Liang, Reuben M. Bakker, Han Fang Hao, Vytautas Valuckas, Arseniy I. Kuznetsov
*A*STAR (Singapore)*

In the present work, we demonstrate large angle, optical beam bending using dielectric metasurfaces based on asymmetric, silicon nano-structures. The largest bending angle exceeds 82°. Based on the bending results we design and demonstrate an ultra-high numerical aperture (NA) flat lens, which has a NA around 0.99 at the working wavelength of 720 nm.

15:15 : Negative refraction of highly squeezed polaritons in graphene-boron nitride heterostructures

Xiao Lin[1], **Yi Yang**[2], **Nicholas Rivera**[2], **Josue J. Lopez**[2], **Yichen Shen**[2], **Ido Kaminer**[2], **Hongsheng Chen**[2], **Baile Zhang**[1], **John D. Joannopoulos**[2], **Marin Soljacic**[2]
[1] *Nanyang Technological University (Singapore),* [2] *Massachusetts Institute of Technology (USA)*

It is fundamental to achieve negative refraction of highly squeezed polaritons, such as plasmon polaritons in graphene and phonon polaritons in BN with their wavelengths squeezed by a factor over 100, because this could enable many unique nanoscale applications. However, this still remains challenging. We reveal that graphene-BN heterostructures provide a versatile platform to flexibly tune the sign of the group velocity of hybrid plasmon-phonon-polaritons, enabling negative refraction between graphene plasmons, BN's phonon polaritons and their hybrid polaritons.

15:30 : Topological Line Wave based on Impedance Surfaces

Dia'aaldin Bisharat[1], **Daniel Sievenpiper**[2]
[1] *City University of Hong Kong (China),* [2] *University of California (USA)*

Analogous to surface wave formation at the interface of two semi-infinite spaces, we show a one-dimensional mode at the line interface of two semi-infinite planes that are characterized by complementary surface impedances. The proposed mode possesses singular field enhancement, tunable spatial confinement, extensive bandwidth, and robust wavevector-locked propagation, which may advance topological photonics applications. Here, we specify criteria for the line wave existence and present implementations using metasurfaces

and graphene that are suitable for microwave, terahertz and optical applications.

14:00 - 16:00 — Room 113

Session 4A29

Symposium II. Recent Advances in Complex Materials and Nanophotonics XV

Organized by: Konstantin Vytovtov

Chaired by: Konstantin Vytovtov

14:00 : Invited talk

Broadband polarization-independent antireflection coatings for solar cells from Mie resonators in silicon metasurfaces

Xiaoou Mao[1], **Michael Cada**[1], **Efthymios Kallos**[2]
[1] *Dalhousie University (Canada),* [2] *Metamaterial Technologies Inc. (Canada)*

Mie-type leaky mode resonances supported by Semiconductor nanowires (NWs) can produce an antireflective response for certain polarization and wavelengths of light. This paper presents the design and simulations of 3D silicon nano pillars as Mie resonators canceling reflection from a silicon substrate, which offers a broadband (400-600nm) near unity transmission and an average reflectivity in the visible range (400-800nm) as low as 2.2 $\%$ under unpolarized illumination. The results are of interest to the solar cell community.

14:20 : Invited talk

Bound states in the continuum with high orbital angular momentum in dielectric rod with periodically modulated permittivity

Evgeny Bulgakov, Almas Sadreev
Kirensky Institute of Physics (Russia)

We consider bound states in the radiation continuum (BSC) in single dielectric rod with with periodically modulated permittivity. Because of rotational and translational symmetries the BSCs are classified by orbital angular momentum m, Bloch wave vector beta directed along the rod and the polarization. The BSCs with high orbital angular momentum and mixed polarizations constitutes the most interesting class of the BSCs because of high localization of EM fields near surface of the rod.

14:40 : Invited talk

Quantum dots interfaced with alkali atoms: filtering, delaying and quantum interfering single photons

H. Vural, S. L. Portalupi, M. Muller, J. Weber, J. Maisch, S. Kern, M. Widmann, R. Low, J. Wrachtrup, M. Jetter, I. Gerhardt, P. Michler
Universitat Stuttgart (Germany)

We present recent results in the field of hybrid quantum systems. Single photons generated by the resonant pumping of a semiconductor quantum dot are interfaced with alkali atoms in order to realize an efficient variable delay up to a record value of 28 ns. After delaying, two successive single photons are used to perform quantum interference measurements: when only one photon is delayed the indistinguishability is fully conserved while when both are delayed the two-photon interference visibility further increases.

15:00 : Invited talk

Analysis of of gravity-like interactions induced by fluctuating random fields

Jorge Luis-Hita[1], **Manuel I. Marques**[2], **Victor Jose Lopez Pastor**[2], **Nuno de Sousa**[3], **Luis S. Froufe-Perez**[4], **Frank Scheffold**[4], **Juan Jose Saenz**[3]
[1] *Departamento de Fisica de la Materia Condensada (Spain),* [2] *Departamento de Fisica de Materiales (Spain),* [3] *Donostia International Physics Center (Spain),* [4] *University of Fribourg (Switzerland)*

The gravitational-like interactions induced by radiation are analyzed analytically a numerically for the particular case of two electric dipoles illuminated with a fluctuating random field.

15:20 : Invited talk

Integrated III-V Photonic Crystal - Si waveguide platform with tailored Optomechanical coupling
Victor Tsvirkun, Alessandro Surrente, Fabrice Raineri, Gregoire Beaudoin, Isabelle Robert-Philip, Remy Braive
Paris Sud University (France)

The optomechanical response of a heterogeneously integrated two-dimensional photonic crystal defect cavities on top of silicon-on-insulator waveguides is investigated and evidences an optomechanical coupling involving both dispersive and dissipative mechanisms. By controlling the optical coupling between the constituting elements, we were able to vary and understand the relative strength of these couplings. This scalable platform allows for unprecedented control on the optomechanical coupling mechanisms, with a potential benefit in cooling experiments, and for optomechanical circuits for optomechanically-driven signal-processing applications.

15:40 : Invited talk
Hybrid Chiral Plasmonic Structures for Sensing
Affar S. Karimullah, M. Kadodwala
University of Glasgow (United Kingdom)

We have developed new hybrid structures that display unique optical properties such as large optical rotation and plasmonic induced transparency. The optical properties are dependent on the strong coupling between individual components of the structures and are used to develop new sensing paradigms for biomolecular structure and surface orientation not perceivable by classical spectroscopic techniques. Here in we will describe the unique high-throughput fabrication method of these structures, their optical properties and their applications to chiral plasmonic sensing.

14:00 - 15:30 — Room 114

Session 4A30

SP35. Optically-assisted mechanical systems for advanced photonics and ultrahigh-precision applications III

Organized by: Jong G. Ok and Ji-Seok Lim

Chaired by: Jong G. Ok and Ji-Seok Lim

14:00 : Long-term stability enhancement of dynamic spectro-ellipsometry
Daesuk Kim, V. Dembele, I. Choi
Chonbuk National University (Korea)

This paper describes a long-term stability enhancement of dynamic spectro-ellipsometry by which we can measure spectral phase difference between p- and s-polarization of the reflected wave from a periodic nano pattern or a thin film with extreme high stability. Long-term stability enhancement scheme is provided for a thin film object by analyzing the spectral ellipsometric parameter stability.

14:15 : Enhanced mechanical reliability of anti-reflective nanostructured polymer films prepared by sequential heat treatment process
Doo-In Kim, N. E. Yeo, M. Y. Jeong
Pusan National University (Korea)

Characterization of Anti-reflection(AR) performance showed that the reflectance and transmittance of the prepared nanopatterned polymeric nanostructured AR film were significantly damaged by the scratch and has poor anti-scratch performance. In this study, the various thermal imprint process with heat treatment process were proposed and the effect of process on the anti-scratch performance were evaluated. It was found that the flat pressing under an elevated temperature higher than a glass transition temperature followed by an immediate cooling improves anti-scratch performance.

14:30 : Highly Sensitive Enhanced Fluorescence DNA Microarray for Diagnosis of Atopic Dermatitis
Mohsin Ali Badshah, Jonghyun Ju, Xun Lu, Naseem Abbas, Seok-Min Kim, Seong Jun Seo

Chung-Ang University (Korea)

Metal-enhanced fluorescence DNA microarray analysis has been demonstrated using glancing angle deposited (GLAD) nanorods substrate for diagnosis of atopic dermatitis. To maximize the fluorescence enhancement factor, effects of nanorod length on fluorescence signal were examined. To examine the feasibility of the proposed highly sensitive DNA microarray for real application, a DNA screening chip for diagnosis of Atopic dermatitis was prepared using fabricated GLAD substrate and performance of the chip was tested using the real blood sample from the patient.

14:45 : High-throughput and scalable micro- and nanopatterning by continuous mechanical inscribing and its application in photonic devices
Seungjo Lee, Dong Kyo Oh, Jaekyu Park, Jeong Dae Kim, Jae Hyuk Lee, Jong G. Ok
Seoul National University of Science and Technology (Korea)

We perform the designing, constructing, and operating of the high-throughput and scalable micro- and nanopatterning system that utilizes continuous mechanical inscribing of a well-cleaved rigid pattern mold edge over a compliant substrate. By controlling the mold shape, inscribing force and speed, and processing temperature, many diverse small-scale patterns including 1D grating and 2D mesh, can be continuously created on any commercial polymer films at high speed. We also demonstrate the applications of such flexible micro- and nanopattern films.

15:00 : Graphene based nanohybrid material for photoluminescence enhancement with surface plasmon
Byeongho Park, Seung Won Cho, Seung Chan Jun
Yonsei University (Korea)

We made graphene based metal nanocompounds as an innovative fluorescent material. Such sample showed high photoluminescence characteristics and new emission peak in the visible range, since the strong light confinement obtained from the metal nanoparticles as an antenna remarkably enhace the light absorption. Our material with nanosphere structure provided broad emision after the hybridization between materials. It exhibited a photoluminescence quantum yield of ~ 25 %, which is better than twice of graphene's.

15:15 : A smartphone multi-contrast microscope using a color-coded LED illumination
Daeseong Jung, Jun-Ho Choi, Soocheol Kim, Suho Ryu, Jong-Seok Lee, Chulmin Joo
Yonsei University (Korea)

We demonstrated cLEDscope on a smartphone platform. Integration of microLED array as an illuminator and smartphone lens as an objective transformed a smartphone into multi-contrast microscope capable of BF, DF and DPC imaging in a single shot. Its multi-contrast imaging capability was demonstrated by visualizing structures of transparent biological specimens. This method may be utilized for educational purposes as well as diagnostic imaging tool of biological specimens in resource-limited settings.

14:00 - 15:15 — Room 115

Session 4A31

SP28. Metamaterials in Communication Systems

Organized by: Yue Li, Zhi Ning Chen and Wei Liu

Chaired by: Yue Li, Zhi Ning Chen and Wei Liu

14:00 : Invited talk
Dynamic parameter control of magnet-less non-reciprocal metamaterial (MNM) for adaptive electromagnetic material
Toshiro Kodera
Meisei University (Japan)

Adaptive electromagnetic response control of metamaterial is quite attractive for realizing environment adaptive metamaterial. The magnetic loss of magneto-less non-reciprocal metamaterial (MNM) corresponds to

Q-factor of resonant particle and it can be dynamically controlled by the bias condition of the unidirectional active component. In this talk, a precise Q-factor evaluation of MNM is presented and its results are compared to actual prototype device.

14:20 : Invited talk
Translation of Metamaterial Concepts to Low-Profile Broadband Microwave Antenna Technology
Zhi Ning Chen[1], Wei Liu[1], Xianming Qing[2]
[1] *National University of Singapore (NUS) (Singapore),* [2] *Institute for Infocomm Research (Singapore)*

This paper updates the progress in the applications of metamaterials in the designs of low-profile and broadband microwave antennas. First, the development of metamaterials-based antenna technologies is introduced in the designs of artificial magnetic conductor (AMC) loaded substrate-integrated Fabry-Perot cavity antenna, AMC-loaded ultra-high frequency (UHF) radio frequency identification (RFID) reader antenna, high-permittivity meta-slab loaded high gain antenna arrays for 2.5G/3G/LTE cellular base-stations. Then, as an example, the design of a metamaterial-based broadband low-profile mushroom antenna is presented in detail.

14:40 : Invited talk
Modal Dispersions and Propagation Losses along Silver Nanowires Covering Optical Communication Wavelengths
Hung-Chun Chang, Hsuan-Hao Liu, Hsiang-Peng Chen, Pin-Ho Wang, Hsin-Mao Hsu
National Taiwan University (Taiwan)

Characteristics of surface plasmon modes, in particular the leaky modes, propagating on dielectric-substrate supported silver nanowires of circular and pentagonal cross-sections are numerically investigated using a finite-element method over the wavelength range covering the optical communication band. Leaky modes are with electric-field guided mainly at the top air-silver interface and with field leakage in the substrate, which are clearly revealed based on high-resolution numerical analysis.

15:00 : Virus detection with silver nanowires
Justyna Katarzyna Grzelak[1], Adam Lesniewski[2], Ewa Roznieckа[2], Lukasz Richter[2], Marcin Los[3], Aneta Voss[1], Martin Jonsson-Niedziolka[2], Katarzyna Kwasniecka[3], Sebastian Mackowski[1], Joanna Niedziolka-Jonsson[4]
[1] *Nicolaus Copernicus University (Poland),* [2] *Polish Academy of Sciences (Poland),* [3] *University of Gdansk (Poland),* [4] *Institute of Physical Chemistry Polish Academy of Sciences (Poland)*

Fluorescence microscopy provides simple recipe to specific virus detection. Functionalized silver nanowires (AgNWs) with antibodies specific for T7 bacteriophage can be well seen in an optical microscope. By correlating fluorescence images of marked viruses with optical image of the silver nanowires we can efficient and easy define the presence of specific virus in a sample. The fluorescence will be concentrated around the viruses if the virus binds to the antibody-modified nanowires. Otherwise it will be distributed over the sample.

15:15 - 16:00 — Room 115

Session 4A32

GEN9. Plasmonics-based devices

Chaired by: Sang Jun Lee

15:15 : Treble-resonance nanohole array structure for selected surface-enhanced Raman scattering substrate
Zhengqing Qi, Jie Yao, Chengjun Zhu, Yiping Cui, Changgui Lu
Southeast University (China)

Here we design a new SERS-active plasmonic nanostructure. Selected enhancement of Raman signals is achieved by this device. We found that the SERS enhancement factor corresponding to the resonant frequency exhibit about one magnitude larger than the enhancement factor mismatched with the resonant frequency.

15:30 : 1D subwavelength gratings-dielectric-T2SL detector: Highly improved performance of MWIR polarization detection

Jehwan Hwang[1], Daehyeon Ku[1], Jun Oh Kim[1], Eun Kyu Kim[2], Augustine Urbas[3], Zahyun Ku[3], Sang Jun Lee[1]

[1] Korea Research Institute of Standards and Science (Korea), [2] Hanyang University (Korea), [3] Air Force Research Laboratory (USA)

We propose and analyze a novel detector structure for linear polarization detection in the mid-infrared regime. 1-dimensional subwavelength grating atop a dielectric layer offers enhanced transmission for transverse magnetic polarized light, thereby enabling a higher extinction ratio as compared with conventional structure. Numerical simulations based on a finite integration technique were used to find the optimized geometric parameters for the structure. Our work can pave the way for practical, easy-to-fabricate detectors, which are highly useful for polarimetric imaging applications.

15:45 : Surface Plasmonic - Cavity System

Jiyeon Jeon[1], Khagendra Bhattarai[2], Deok-Kee Kim[3], Jun Oh Kim[1], Jiangfeng Zhou[2], Augustine Urbas[4], Zahyun Ku[4], Sang Jun Lee[1]

[1] Korea Research Institute of Standards and Science (Korea), [2] University of South Florida (USA), [3] Sejong University (Korea), [4] Air Force Research Laboratory (USA)

This paper is focused on analyzing the effect of a two-dimensional metal hole array structure and metal mirror back plane in a surface plasmonic-cavity system. Simulation results clearly show anti-crossing behavior resulting from interaction between the surface plasmon resonance and the Fabry-Perot resonance, depending on the thickness of the dielectric spacer. The simulation method detailed in this paper provides a generalized approach to optimize the design of any type of couplers integrated with backside-illuminate IR devices.

14:00 - 16:15 — Room 116

Session 4A33

SP17. Classical and Quantum Applications using Fast and Slow Light Photonics

Organized by: Sebastian Schulz, William Whelan-Curtin and Khaled Mnaymneh

Chaired by: Sebastian Schulz, William Whelan-Curtin and Khaled Mnaymneh

14:00 : Invited talk

Slow-light enabled photonic integrated microwave filter

S. Combrie[1], J. Bourderionnet[1], D. Martin[1], A. De Rossi[1], Z. Han[2], X. Checoury[2], M. Gay[3], L. Bramerie[3], C. Peucheret[3], J-C. Simon[3]

[1] Thales Research and Technology (France), [2] Universite Paris-Saclay (France), [3] University of Rennes 1 (France)

A recongurable multi-tap microwave filter is demonstrated on a silicon-on-insulator platform. Compactness and low-power operation are achieved owing to slow-light in photonic crystals. As an example, a microwave band-pass and a stop-band filters are obtained. Channel equalization is also demonstrated on an unitary filter cell.

14:20 : Invited talk

Demonstration of broadband slow light in genetically optimized Silicon based coupled-cavity waveguides with group-index bandwidth product exceeding 0.45

Yiming Lai[1], Mohamed Abdel-Aliem Sabry[2], Momchil Minkov[2], Boshen Gao[1], Robert W. Boyd[1], Vincenzo Savona[2], Romuald Houdre[2], Antonio Badolato[3]

[1] University of Rochester (USA), [2] Ecole Polytechnique Federale de Lausanne (Switzerland), [3] University of Ottawa (Canada)

State-of-the-art, photonic crystal (PhC)-based slow light devices suffer from limited bandwidth, group velocity dispersion, and non-flat transmission. Here, we report on the experimental measurements on structures, based on genetically optimized PhC coupled cavity waveguide (CCW) design, with largest bandwidth and the

highest group-index bandwidth product. CCWs of length ranging between 50 and 800 cavities were measured with a very homogeneous flat-top transmission profile and losses value below 67 dB/ns.

14:40 : Invited talk
Soliton pulse propagation in the presence of disorder-induced multiple scattering in slow-light photonic crystal waveguides
Nishan Mann, S. Hughes
Queen's University (Canada)

We describe a new coupled mode theory to model nonlinear Schroedinger equations for counter-propagating Bloch modes that include disorder-induced multiple scattering effects on nonlinear soliton propagation in photonic crystal waveguides. Our numerical simulations of nonlinear pulse propagation are in excellent qualitative agreement with recent experiments and provide fresh insight into how disorder inhibits soliton propagation and other nonlinear propagation effects in photonic crystal waveguides.

15:00 : Invited talk
Photonic crystal waveguide designs for optimised chiral light-matter interactions at polarisation singularities
Daryl M. Beggs[1], Ben Lang[2], Ruth Oulton[2]
[1] *Cardiff University (United Kingdom),* [2] *University of Bristol (United Kingdom)*

Slow-light photonic crystal waveguide designs that support chiral C-point polarisation singularities are shown. Using FDTD simulations, we have confirmed spin-photon entanglement with a correlation $>99\,\%$ for a quantum dot placed at a C-point. Photonic crystal waveguide designs that optimise the chiral light-matter interaction are provided, with a factor 8.6 enhancement of the local optical density of states found. The existence and location of C-points in the waveguide is confirmed to be remarkably robust to disorder in the waveguide.

15:20 : Invited talk
Coherent optical storage using acoustic phonons in chips
Moritz Merklein[1], Birgit Stiller[1], Khu Vu[2], Stephen Madden[2], Benjamin Eggleton[1]
[1] *University of Sydney (Australia),* [2] *Australian National University (Australia)*

Here we present an on-chip photonic memory based on a coherent transfer of optical data pulses to acoustic phonons and vice versa. We show that this process is fully coherent by encoding different phase states. The ultra large Brillouin gain in our photonic chips allows us to reach GHz bandwidth. We furthermore show storage of different amplitude levels, which increases the capacity of our memory even further.

15:40 : Invited talk
Co- and counter-propagating slow light and their applications
Toshihiko Baba, K. Kondo
Yokohama National University (Japan)

Optical nonlinearity allows various control of light, while their effects is usually small. Si photonic crystal waveguides enhance the nonlinearity on a chip, thanks to the strong optical confinement and slow-light effect. Here, we present co-/counter-propagating slow-light systems, in which two slow-light pulses propagate simultaneously and exhibit unique interactions. The enhanced nonlinearity as well as engineered group-delay and dispersion in slow light gives unique functions such as adiabatic wavelength conversion, fast delay tuning, pulse compression, Doppler shift and auto-correlation.

16:00 : Cavityless plasmonic nanoresonator
Ilya Fradkin, Dmitry Fedyanin
Moscow Institute of Physics and Technology (Russia)

Optical resonators are one of the most critical components in optoelectronics owing to their ability to strengthen light-matter interaction. Here, we demonstrate a cavityless nanoresonator based on an extremely slow mode of the metal-insulator-metal plasmonic waveguide. Its operating principle does not rely on the geometric resonances, and thus the device characteristics are almost independent of the structure dimensions. This feature makes such a resonator attractive for diverse applications at the deep-subwavelength scale, where accurate fabrication is still a challenge.

14:00 - 14:50 — Room 117

Session 4A34

SP12. New concepts for energy harvesting and photon management III

Organized by: Mohamed Farhat and Fahhad H. Alharbi

Chaired by: Mohamed Farhat and Fahhad H. Alharbi

14:00 : Increasing of light absorption in perovskite thin film by utilization silicon nanoparticles
Alexandr Vasilievich Chebykin[1], Ekaterina Yurievna[1], Artur Ishteev[2], Elena Vladimirovna Ushakova[1], Anastasia Sergeevna Zalogina[1], Anton Nikolaevich Tsypkin[1], Dmitry Aleksandrovich Zuev[1], Sergey Vladimirovich Makarov[1], Anvar Abdulahadovich Zakhidov[3]
[1] *ITMO University (Russia),* [2] *MISiS (Russia),* [3] *Texas University at Dallas (USA)*

We have demonstrated experimentally and theoretically that one can use silicon nanoparticles to significantly enhance light absorption in thin perovskite films. We have compared the cases with nanoparticles embedde into the layer and deposited on the perovskite surface. According to our results, absorption in the film with silicon nanoparticles can be increased up to 39 $\%$ comparing to the film without nanoparticles. Our results are promissing for development and fabrication highly effective perovskite based optoelectronic devices.

14:15 : Measuring and Exploiting Optical Anisotropies in Nanophotonic Device Architectures
S. J. Brown, R. A. DeCrescent, Jon A. Schuller
UC Santa Barbara (USA)

Nanophotonic architectures provide an attractive approach for enhancing light-matter interactions. A little-discussed feature of photonic architectures is strong anisotropies in the electromagnetic field enhancements. These anisotropies are of particular importance in relation to nanostructured materials that possess intrinsic structure-dependent optical anisotropies. In this talk, we describe a novel class of momentum-resolved spectroscopies that provide new insight into structure-dependent optical properties of thin-film material and discuss approaches to exploit these effects in photovoltaic devices that incorporated nanophotonic enhancements.

14:30 : Invited talk
Efficient Hot-Electron Harvesting by Hyperbolic Metamaterials
Pai-Yen Chen[1], Mohamed Farhat[2]
[1] *Wayne State University (USA),* [2] *Hamad Bin Khalifa University (Qatar)*

In this talk, I will present a new hyperbolic metamaterial structure, as a vertically-integrated hot-electron device, for efficiently coupling light into plasmonically-excited hot electrons, which can be efficiently collected with high external quantum efficiency approaching the physical limit. I will also discuss how to experimentally realize this metamaterial-based optoelectronic device with nanofabrication techniques and 2D materials. Results presented here may shed some light on designing energy-efficient photodetectors and energy harvesters beyond the bandgap spectral limit.

14:50 - 16:05 — Room 117

Session 4A35

GEN11. Metasurfaces and flat optics

Chaired by: Junsuk Rho

14:50 : Plasmonic metasurfaces for subwavelength mathematical operations
Yongsop Hwang[1], Timothy J. Davis[2], Xiao-Cong Yuan[1], Jiao Lin[1]
[1] *Shenzhen University (China),* [2] *University of Melbourne (Australia)*

We experimentally demonstrated 2-dimensional subwavelength detection of optical phase differences using

a metasurface consists of an array of plasmonic nanostructures. The metasurface is fabricated from arrays of coupled gold nanorods where each group of three rods form the circuit to perform the difference operation in one-direction of the xy-plane. This metasurface at subwavelength scale can be applied to optical signal processing, ultrafast computing, and biosensing.

15:05 : The SNOM observation of surface plasmon modes from different chiral plasmonic structures
Feng Lin
Peking University (China)

Au nanostructures can be fabricated to intentionally guide the propagation of surface plasmon polaritons (SPPs), which leads to the varying of propagation directions for the SPP beams, and thus generates the orbital angular momentum of SPPs. Here we investigated the coupling of such plasmonic orbital AM with optical spin AM, and found that the chiral characteristics of Au nanostructures impose great effects on the electromagnetic modes of SPPs under this spin-orbit interactions.

15:20 : Ultrathin linear optical logic gates based on a metasurface beam deflector
Shota Kita, Akihiko Shinya, Kenta Takata, Kengo Nozaki, Masaya Notomi
NTT Nanophotonic Center (Japan)

We propose all-optical AND gates based on a 120-nm thick metasurface beam deflector. The binary contrast can be maximized up to 9.5 dB by introducing an additional bias input. The insertion loss is also evaluated as 1.5 dB with use of silver at the wavelength of 633 nm. As far as we know, this is the thinnest linear optical logic gate satisfying the better performances. It could be effective to configure lower latency optical computing circuits.

15:35 : Complex Electromagnetics Based on Hybridized Simple Nanoplasmonics in Optical Metasurfaces
Atefeh Fazel Najafabadi, Tavakol Pakizeh
K. N. Toosi University of Technology (Iran)

Electromagnetic coupling of nanoparticles in plasmonic nanostructures leads to effective hybridization and modification in optical properties of the metasurfaces in visible region. Here, we study the outstanding optical properties of nanodimers and nanotrimers composed of Ag nanorods in terms of the circular dichroism (CD) and the electromagnetically induced transparency (EIT)-like response. It is shown that breaking symmetry of this configurations boost these optical properties. Therefore, these arrangements can be considered as building blocks for proposing novel optical metasurfaces.

15:50 : Rectangular holey glide-symmetric metasurfaces for ultra-wideband anisotropy
Basudev Majumder[1], Guido Valerio[2], Oscar Quevedo-Teruel[3]
[1] *Indian Institute of Technology (India),* [2] *Pierre et Marie Curie University (France),* [3] *KTH Royal Institute of Technology (Sweden)*

Metasurfaces have recently gained popularity for designing lens antennas. Particularly, fully metallic metasurface lens antennas present low losses and are ideal for space applications. In this work, we present a novel asymmetric unit cell that can be employed for the design of anisotropic lenses. The unit cell consists of two glide-symmetric layers. A rectangular hole is edged at the bottom layer, which is periodically mirrored and translated in the top layer.

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