META'14 - Singapore

The 5th International Conference on Metamaterials, Photonic Crystals and Plasmonics

Program

May 20 – 23, 2014
Singapore

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The 5th International Conference on Metamaterials, Photonic Crystals and Plasmonics

Edited by

Said Zouhdi | Paris-Sud University, France
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Jing Hua Teng | A*STAR, Singapore

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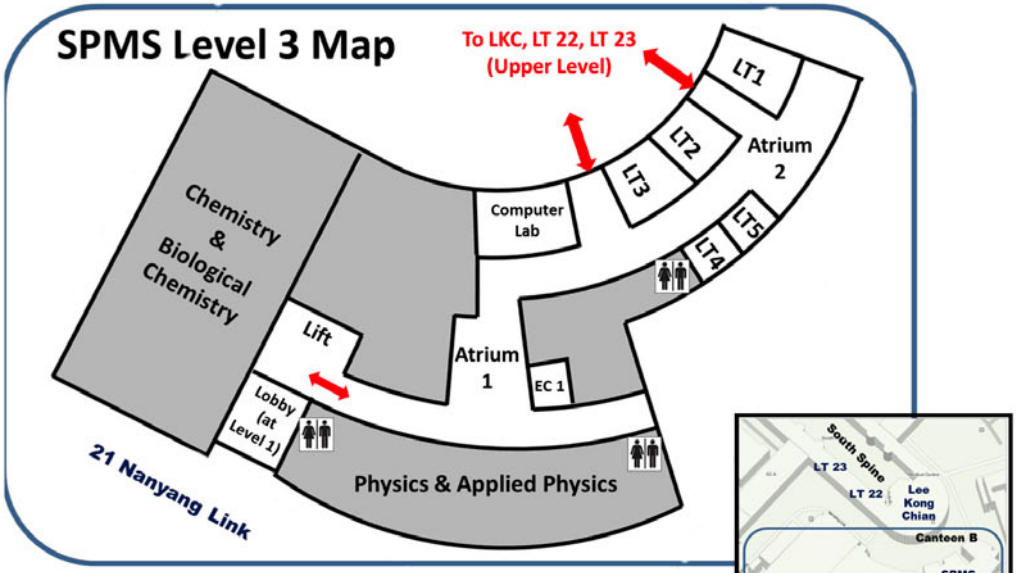
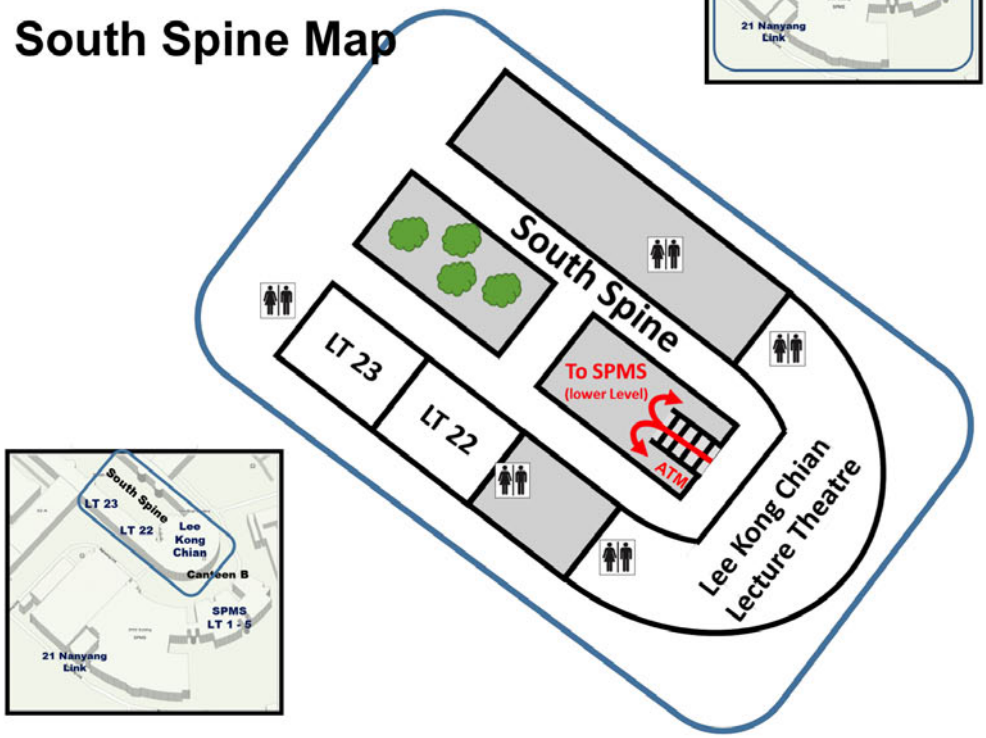
We wish to thank the following institutions, exhibitors and sponsors for their contribution to the success of this conference :

META'14 VENUE

META'14 will be held on May 20-23, 2014, at the School of Physical and Mathematical Sciences (SPMS) inside the campus of Nanyang Technological University (NTU).

Venue Layouts





Getting to Conference Venue

From Official Conference Hotels
Chartered buses will be available to participants staying at one of the Official Conference Hotels* to and from the conference venue. Please meet in your hotel lobby at the scheduled time for boarding. Participants staying at the other hotels may wish to hire a taxi or commute via train (MRT) and bus.

Official Conference Hotels :

- Bayview Hotel Singapore, 30 Bencoolen Street, 189621, Singapore ;
- Ibis Singapore on Bencoolen, 170 Bencoolen Street, 189657, Singapore ;
- Traders Hotel, 1A Cuscaden Road, 249716, Singapore ;
- Grand Park City Hall, 10 Coleman St, 179809, Singapore ;
- Shangri-La Hotel, 22 Orange Grove Road, 258350 Singapore.

By Taxi
There are eight taxi companies operating in Singapore. Dial a Cab at 6342 5222. Taxi ride from Downtown Singapore to the conference venue will take approximately between 30 to 40 minutes, subject to traffic conditions. Estimated taxi fare from Central Singapore to NTU are S$20-S$30 off-peak hours and S$30-S$40 during peak hours. Most taxi drivers are conversant in English and would be able to get you to the conference venue if you you simply quote them the following address :

Nanyang Technological University (NTU)
School of Physical and Mathematical Sciences (SPMS)
21 Nanyang Link
637371 Singapore

By Metro (MRT) and Bus
The nearest train stations to NTU are Boon Lay (EW27) and Pioneer (EW28) on the East West Line (Green).

— From Boon Lay Station : make your way to the adjacent bus interchange. Service 179 will take you in to NTU. Alight at Innovation Centre stop.

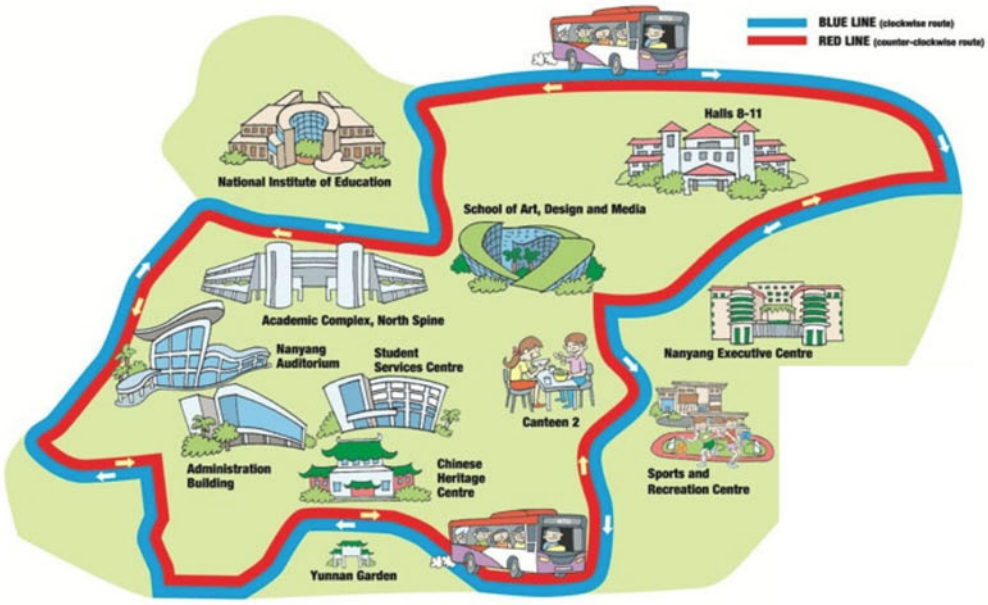
— From Pioneer Station : exit from Exit B and hop on the Service 179 in front of block 651A. Alight at Innovation Centre stop.

Bus service ply from 06 :00 - 24 :00 on weekdays and Saturdays, and from 06 :30 - 00 :20 on Sundays and Public Holidays.

NTU Campus Shuttle Bus
The NTU shuttle bus services help you move around NTU's sprawling garden campus. Just hop onto the bus, there is no need for any tickets or payment on board.

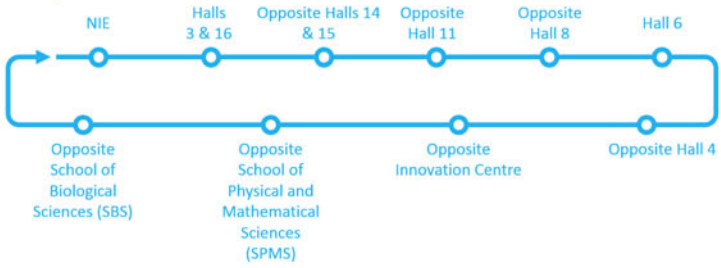
The Campus Loop (Blue and Red Lines) takes you around the campus in both directions.

Cash Machine
The nearest cash machine located in South Spine directly below the Lee Kong Chian lecture theatre, in front of the Eight Flags Computer Store (see South Spine map).

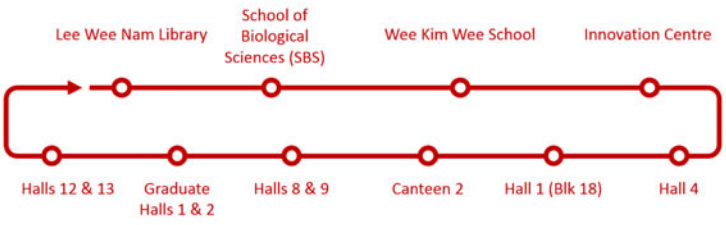


	Operational Hours	Frequency (mins)
Mon - Fri	0800-1030 1030-2100 2100-2300	8-10 15-18 18-20
Sat, Sun & Pub Holidays	0800-2300	20-25

Campus Blue Line



Campus Red Line



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 presentation are 15 mn for regular, 20 mn for invited presentations, 40 mn for plenary talks, and 30 mn for keynote 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 panel, A1 size (841 x 594mm), will be available for each poster. Pins or thumbtacks are provided to mount your posters on the board. All presenters are required to mount their papers one hour before the session and remove them at the end of their sessions.

PROGRAM OVERVIEW

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
08:00		REGISTRATION 8:00 AM - 9:00 AM			
08:15					
08:30					
08:45					
09:00			PLENARY SESSION III 8:30 AM - 9:50 AM	TECHNICAL SESSIONS 8:30 AM - 10:00 AM	TECHNICAL SESSIONS 8:30 AM - 10:00 AM
09:15					
09:30		OPENING CEREMONY PLENARY SESSION I 9:00 AM - 10:50 AM			
09:45			NETWORKING BREAK		
10:00			POSTER SESSION III	NETWORKING BREAK	NETWORKING BREAK
10:15			9:50 AM - 10:30 AM	POSTER SESSION V	POSTER SESSION VI
10:30				10:00 AM - 10:45 AM	10:00 AM - 10:45 AM
10:45		NETWORKING BREAK			
11:00		POSTER SESSION I			
11:15		10:50 AM - 11:50 AM	TECHNICAL SESSIONS 10:30 AM - 12:30 PM		
11:30				TECHNICAL SESSIONS 10:45 AM - 12:45 PM	TECHNICAL SESSIONS 10:45 AM - 12:45 PM
11:45		PLENARY SESSION II 11:50 AM - 12:30 PM			
12:00					
12:15					
12:30		LUNCH BREAK 12:30 PM - 2:00 PM	LUNCH BREAK 12:30 PM - 2:00 PM		
12:45				LUNCH BREAK 12:45 PM - 2:15 PM	LUNCH BREAK 12:45 PM - 2:15 PM
01:00					
01:15					
01:30					
01:45					
02:00		TECHNICAL SESSIONS 2:00 PM - 4:00 PM	TECHNICAL SESSIONS 2:00 PM - 4:00 PM		
02:15				TECHNICAL SESSIONS 2:15 PM - 4:15 PM	TECHNICAL SESSIONS 2:15 PM - 4:15 PM
02:30					
02:45					
03:00					
03:15					
03:30					
03:45					
04:00		NETWORKING BREAK	NETWORKING BREAK		
04:15		POSTER SESSION II	POSTER SESSION IV	NETWORKING BREAK	NETWORKING BREAK
04:30		4:00 PM - 4:45 PM	4:00 PM - 4:45 PM	4:15 PM - 4:30 PM	4:15 PM - 4:45 PM
04:45					
05:00					
05:15					
05:30		TECHNICAL SESSIONS 4:45 PM - 6:30 PM	TECHNICAL SESSIONS 4:45 PM - 6:30 PM	FREE TIME	TECHNICAL SESSIONS 4:45 PM - 6:30 PM
05:45					
06:00					
06:15					
07:30				BANQUET	

REGISTRATION (MONDAY)

REGISTRATION (TUESDAY)

EXHIBITION (TUESDAY)

REGISTRATION (WEDNESDAY)

EXHIBITION (WEDNESDAY)

EXHIBITION (THURSDAY)

EXHIBITION (FRIDAY)

TECHNICAL PROGRAM

Sunday 18th May, 2014

Registration

Nanyang Technological University

15:00 - 18:30

Monday 19th May, 2014

Registration

Hotel Ibis Singapore on Bencoolen

15:00 - 18:30

Tuesday 20th May, 2014

Registration

Nanyang Technological University

08:00 - 17:30

Opening ceremony

Lee Kong Chian

09:00 - 09:30

09:30 - 10:50 — Lee Kong Chian

Session 1A1

Plenary Session I

Chaired by: Eli Yablonovitch

09:30 : Plenary talk
Quantum amplification by superradiant emission using metamaterials
Marlan Scully

A laser generates light through stimulated emission of radiation and requires population inversion. Quantum interference can yield lasing with inversion, but still requires some atomic population in the excited state. In recent work we have demonstrated a new kind Quantum Amplification by Superradiant Emission of Radiation (QASER) which does not need any population in the excited state. We here show that QASER operation can be facilitated by metamaterials.

10:10 : Plenary talk
Toward fJ/bit optical communication inside a chip
Masaya Notomi

Toward fJ/bit optical communication inside a chip.

Coffee Break and Exhibit Inspection

Session 1P1

Poster Session I

10:50 - 11:50

P1: Left handed mode propagating In coplanar isolator based on Yittrium Iron Garnet (YIG)
Eric Verney, Souad Kirouane, Ouzer-Nabil Adam

A hybrid structure of coplanar isolator, based on a YIG slab with a down ground plane, exibits a left-handed propagation mode around 10 GHz. The dependance of this effect to the slab permittivity tensor and its dimensions and to the appearance of magneto-static waves is questionned.

P2: Tailoring spoof particle plasmon resonances with groove symmetry
Thomas Constant, Alastair Hibbins, Roy Sambles

Super-subwavelength resonators offer an appealing route to antenna miniaturization. In the realm of visible-frequency plasmonics, the most basic type of these super- sub-wavelength scatterers is perhaps the plasmonic nano- particle, which scatter greatly due to the support of localised surface plasmons. In this presentation, we show preliminarily results into the design of a microwave-regime equivalent to the localised surface plasmons: the spoof particle-plasmon.

P3: Electromagnetic characteristics of Hilbert curve based metamaterials
Ruirui Chen, Sucheng Li, Chendong Gu, Shahzad Anwar, Bo Hou, Yun Lai

By employing Hilbert fractal curves, we have investigated a deeply subwavelength magnetic resonance which is related to the fractal topology of the metallic structures and exhibits the wavelength-to-size ratio more than 20. The significantly subwavelength magnetic resonance supported by Hilbert curves will be beneficial to realize high-performance metamaterials.

P4: Frequency selective terahertz emission from metamaterial structures via the photo-Dember effect
Jan Wallauer, Christian Grumber, Markus Walther

We present frequency dependent terahertz emission from metamaterial structures on semiconductor substrates. By illuminating a gallium arsenide substrate with a short laser pulse the induced diffussion currents (photo-Dember effect) represent a radiating dipole which can couple to the resonator's near field distribution and excite it. Our simulations and experiment show that strength and frequency of the emitted radiation strongly depends on the illumination point. This approach can be applied as a complementary method for imaging electric near-fields of metamaterials.

P5: Low index metamaterial covers over a subwavelength aperture
Humeyra Caglayan, Bilal Barut, Arda Simsek

In this project, we investigate subwavelength apertures covered with low index materials. Enhanced transmission and beaming was obtained and optimized through subwavelength apertures.

P6: Multiband asymmetric transmission of linear polarization via polarization conversion through split-ring resonator
Song Han, He-Lin Yang, Meng-Ding Chen, Hua-Yan Xia, Yu-Tian Peng

We have proposed a kind of bilayered metamaterial to demonstrate multiband asymmetric transmission (AT) effect for linearly polarized electromagnetic (EM) waves propagating forwardly and backwardly. The calculated transmission coefficient txy reaches 0.75 at 4.07 GHz, and tyx reaches 0.91 at 8.29 GHz, 0.94 at 10.624 GHz, 0.81 at 15.27 GHz and 0.72 at 16.43 GHz, respectively. Their asymmetric parameters are 0.54/-0.54, 0.82/-0.82, 0.88/-0.88, 0.64/-0.64 and 0.47/-0.47 at each transforming frequency.

P7: Complementary electric-LC resonator antenna for WLAN applications
Bashir D. Bala, Mohamad Kamal B. A. Rahim, Noor Asniza Murad

In this paper, a metamaterial antenna based on complementary electric-LC (CELC) resonator is proposed. The antenna consists of slot loaded ELC on the ground plane as the main antennas radiating element and excited by a microstrip line. The peak realized gain and efficiency of 2.63 dB and 86 % are obtained respectively at resonance frequency. Simulation and measurement results are presented to validate the design. The antenna is suitable for WLAN applications (2.39 GHz-2.48 GHz).

P8: Interaction of Bessel light beams with epsilon-near-zero metamaterials
Svetlana Kurilkina, Mohammed A. Binhussain, Vladimir Belyi, Nikolai Kazak

A possibility of generation of new type of field - Bessel plasmon polaritons (BPPs) with super narrow cone angle - in a epsilon-near-zero metamaterial, surrounded by semi-infinite dielectric media, are established. The main features of this field are described analytically and analyzed numerically. It is grounded that interaction of Bessel light beam with epsilon-near-zero metamaterial can be used for formation of diffraction-free needle-like field from Bessel light beam with wide angular spectrum.

P9: Reconfigurable wideband to narrowband antenna using tunable EBG structure
Huda Majid, Mohamad Rahim, Mohamad Hamid, Osman Ayop

In this paper, frequency reconfigurable EBG structure integrates with a wideband antenna is proposed. The EBG structure consists of a circular patch shorted to the ground plane and a parasitic ring connected to the circular patch. The EBG structure is then placed underneath the feed line of a wideband antenna. The antenna is capable to reconfigure to three different frequency bands.

P10: Nanoscale conducting oxide plasmonic slot waveguide modulator
Ho W. Howard Lee, Georgia Papadakis, Stanley Burgos, Krishnan Chander, Arian Kriesch, Ragip Pala, Ulf Peschel, Harry Atwater

We demonstrate an ultra-compact plasmonic field-effect modulator based on a transparent conducting oxide active region. We combine, for the first time, the TCO material into plasmonic slot waveguides to produce modulators with high dynamic range (2 dB/μm) and low waveguide loss (0.4 dB/μm) at the telecommunication wavelength via field- effect dynamics. We also found that resonant interference between the waveguide mode and the localized mode in stub nanocavity can increase the modulation strength to more than 30 dB/μm.

P11: Composite thin film materials on the basis of silver nanostructures on polymer matrix by methods of chemical metallization and self-assembling
Evgeniy Skoptsov, Vladimir Agabekov, Mohammed Binhussain, Dmitriy Egorov, Piotr Ropot

The techniques of creation of thin metallic coatings by deposition of silver nanoparticles from solutions onto glass and silicon surfaces modified by polyelectrolytes were developed. The possibilities of deposition both separate nanoparticles and continuous films on the surface were showed. The transmission, absorption and reflection spectra of created coatings were investigated. Relatively simple and cheap methods of producing nanostructures suitable for creating metamaterials were demonstrated.

P12: A canonical filter network model of the Veselago-Pendry superlens
Ravi S. Hegde, Yew-Li Hor, Wolfgang J. R. Hoefer

A canonical filter network model of the Veselago-Pendry Superlens is derived, and closed-form expressions for the values of its elements are given in terms of the lens geome- try and its wave properties. Low material losses are added through perturbation of the lossless case. A full-wave time- domain TLM simulation validates the network model.

P13: Interaction of surface plasmon polaritons and semiconductor excitons confined in quantum dots
Fernando de Alencar Sobreira, Rodrigo Pereira, Euclydes Marega Jr.

In the present work we intend to show results obtained using a theoretical model involving the interaction of Surface Plasmon Polaritons generated in a plasmonic nanowire of gold over a GaAs substrate where that contains a chain Quantum Dots. The model is well known from Cavity Quantum Electrodynamics and employs a quantum model for the SPPs that interact with quantum dots. The dispersion of these SPPs and localized states of the QDs give rise to new quantum collective modes.

P14: Equivalent circuit model of Jerusalem cross FSS using vector fitting
Payal Majumdar, Zhiya Zhao, Ruopeng Liu, Chunlin Ji

We present the analysis and modeling of Jerusalem cross FSS adopting an efficient vector fitting procedure . The simulations are performed with CST Microwave Studio on single-substrate for different physical parameters. Then circuit model is extracted, developed and implemented in a circuit simulator enabling both time and frequency analyses along with effect of polarization and angle of incidence. ADS SPICE is used for verifying developed circuit models. The developed model is within 1 % of average deviation against reference.

P15: Dynamic effective medium theory for two-dimensional periodic metamaterials
Efthymios Kallos, Ioannis Chremmos, George Palikaras, Emmanuel Paspalakis

We present a new formulation for the effective medium properties of infinitely periodic two-dimensional (2D) metamaterial structures beyond the static and quasi-static limit. We utilize the multipole expansions, where the polarization currents associated with the supported Bloch modes are expressed via the electric dipole, magnetic dipole, and electric quadrupole moments per unit length. The results are useful for the homogenization of nanorod- type metamaterials which are frequently used in optical applications.

P16: Some properties of 2-D dielectric-based ENG/MNG material parameters extracted using the S-parameter method
Yunqiu Wu, Samel Arslanagic

This work presents a systematic investigation of material parameters for two-dimensional epsilon-negative (ENG) and mu-negative (MNG) materials as obtained by the scattering parameter method. The unit cell consists of infinite dielectric cylinders, their sizes and permittivities are chosen to enable the ENG and MNG behaviors. For the both configurations, the permittivity and the permeability is reported. Influence of several effects on the extracted material parameters is examined, including the loss inside the cylinders and the size of the unit cells.

P17: Steering free-electron beams for single-photon generation with nanocircuitry: A theoretical study
Nahid Talebi

By means of a particle-in-cell numerical approach, the interaction of a single electron beam with a hybrid system of plasmonic nanoantennas and an optical slab waveguide is investigated. It will be shown that this system can be efficiently utilized for generation of few photons and in situ controlling the propagation of the photons in the optical waveguide.

P18: Investigation of surface roughness influence on hyperbolic metamaterial performance
Serge Kozik, Mohammed Binhussain, Andrei Smirnov, Nikolai Khilo, Vladimir Agabekov

Introducing surface roughness in the model of structure in such numerical simulation method as FDTD requires correct choice of grid step, subgrid algorithm was used for minimization of errors and time consumption. Reflection and transmission spectra from test structures consisted of rectangular array of silver rods in dielectric medium has been analyzed with different grid steps and roughness parameters. Influence of roughness amplitude and spatial spectra on effective refractive index of hyperbolic metamaterial has been recovered.

P19: Short duration solitonic and non-solitonic pulse propagation through optical meta-materials
Kaisar Khan, M. F. Mahmood, Anjan Biswas

A finite element analysis of left-handed waveguides has been done and results shows the dispersion characteristics of waveguide with DNG material. Higher order dispersion have been computed for the bulk DNG materials and use this in our theoretical analysis to treat the pulse propagation in negative index materials. Negative index materials attract interest in the nonlinear domain as it enhances the nonlinearity due to confining electric field in a small region. Numerical results also intended to explain other nonlinear processes.

P20: Characterization of blade bragg grating modeling with different incident angle profiles for strain sensor applications
Niparat Cheamanunkul, Keerayoot Srinuanjan, Preecha P. Yupapin

This paper presents the properties of blade bragg gratings model, coated with a poly (methyl methacrylate)(PMMA). The proposed model consists of alternated periodic slabs waveguide with inclined angle is analyzed by using the principle of multilayer transfer matrix for photonic crystal. By varied the incident angle, the slabs angle, the proposed model is simulated for all of the parameters, regarding to the sensor applications. According to the simulation results, this model can be used for sensitive stain sensor applications.

P21: Two-color light routing using bi-directional nanoantennas on waveguides
Manuel Decker, Rui Guo, Isabelle Staude, Dragomir Neshev, Yuri Kivshar

We introduce the novel concept of Fano nanoantennas that allows for directional scattering of light in two

opposite directions depending on the wavelength of light. We furthermore show that this antenna can be used as a two-color bi-directional waveguide coupler.

P22: Tuning the dispersion relation of a plasmonic waveguide via graphene contact
Yu Zhou, Cheng Wang, Di-Hu Xu, Ren-Hao Fan, Ru-Wen Peng, Qing Hu, Mu Wang

We have designed a plasmonic slab waveguide that is compatible with silicon technology, and we have demonstrated theoretically and experimentally that the dispersion relation of this plasmonic waveguide can be tuned via graphene contact. Two kinds of plasmonic modes were experimentally observed, and the FDTD simulations fit the experiment results very well.

P23: Plasmonic properties of two-dimensional nanoparticle arrays
Fumin Huang, Matthew Millyard, Jeremy Baumberg

We report systematic investigation of the plasmonic properties of two-dimensional nanoparticle arraysA wide variety of Au nanoparticle arrays were fabricated through self-assembly, ranging from very low-density films of well-isolated individual nanoparticles to near close-packed high-density mats. Optical properties and functionalities of such nanoparticle arrays are found to be crucially dependent on particle density, which shows a higher sensitivity and a more complicated behavior in plasmonic sensing than those of individual nanoparticles or dimers.

P24: High signal-to-noise ratio and high efficient broadband grating coupler with metal reflector
Md Asaduzzaman, Masuduzzaman Bakaul, Stan Skafidas, Md Rezwanul Haque Khandokar

A CMOS compatible grating coupler based on gold reflection layer has been designed for coupling light between dimension mismatch waveguides with high coupling efficiency (90 %) and higher bandwidth (3-dB 40 nm) which provides high SNR (24 dB) of the propagating signal.

P25: Control of surface enhanced secondary radiation (SERS and SEF) in plasmonic oligomers carefully designed by AFM-nanoxerography
Pierre Moutet, Ana-Maria Gabudean, Noelia Vilar-Vidal, Miguel Comesana-Hermo, Serge Ravaine, Simion Astilean, Laurence Ressier, Renaud Vallee, Cosmin Farcau

Metallic nanoparticles covalently grafted on the external surface with fluorescent dyes have been synthesized by chemical routes. They have then been assembled in oligomers by AFM nanoxerography. We show, on the single oligomer level, that the spectral shifts and fluorescence rates can be finely controlled, owing to the carefully designed geometry of the small NP assembly. Furthermore, we show that the oligomer plasmonic resonances also have a strong influence on the amplitude and polarization of the dyes Raman bands.

P26: Short metal wires loaded split ring resonators as tunable metamaterial components
Qiang Zhao, Xuan Zhao, Qiye Wen, Wanli Zhang

Transmission through split ring resonator (SRRs) structures loaded with short metal wires in the gap region between concentric square rings is investigated numerically. Magnetic resonance frequency is observed to shift to lower frequencies when short metal wires are mounted to the SRRs structure. The amount of change in magnetic resonance frequency depends strongly on the length, width and the gap of short metal wires. Our design offers a new method to lower the resonant frequency while the size of the SRRs remains.

P27: Flexible Ag nanoparticle electrode for quantum dot light-emitting diode
Jing Chen, Zhi Li, Jiangyong Pan, Qingguo Du, Wei Lei

Flexible quantum dot light-emitting diodes (QD-LEDs) have been a promising candidate for high-efficiency and color-saturated displays. Here, we report a simply solution-processed white QD-LED using Ag nanoparticles coated on polyethylene terephthalate (PET) substrate as the flexible electrode replaced of indium-tin-oxide (ITO) coated on PET substrate. The QD-LED with Ag electrode is demonstrated with decreased leakage current, improved luminous efficiency, low turn-on voltages, and saturated emission exhibiting the Commission Internationale de l'Eclairage (CIE) coordinates of (0.59, 0.40).

P28: Surface-enhanced Raman scattering of inorganic microcrystals
Elena Shabunya-Klyachkovskaya, Sergey Gaponenko, Svetlana Vaschenko, Vyacheslav Stankevich

This work demonstrates the systematic effect of surface-enhanced Raman scattering for relative large micrometers size crystallites. Several types of nanoparticles and Si/Ge-nanostructures were used like SERS-active substrates. Obtained results can be considered as the extension of traditional surface enhanced Raman spectroscopy towards bigger inorganic probes.

11:50 - 12:30 — Lee Kong Chian

Session 1A2

Plenary Session II

Chaired by: Masaya Notomi

11:50 : Plenary talk
Device applications of metafilms and metasurfaces
Mark Brongersma

Many conventional optoelectronic devices consist of thin, stacked films of metals and semiconductors. In this presentation, I will demonstrate how one can improve the performance of such devices by nano-patterning the constituent layers at length scales below the wavelength of light.

Lunch and Exhibit Inspection

12:30 - 14:00

14:00 - 16:00 — LT22

Session 1A3

Symposium: Resonant Dielectric Nanostructures and Metamaterials I

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Boris Luk'yanchuk and Yuri Kivshar

14:00 : Invited talk
Why Physics could and should be more applied?
Serguei Beloussov

Overview of which interesting problems require science to get to solutions calling for MetaMaterials, Nano photonics or Quantum Technology and what could be the market opportunity, and current state of the art. Some examples are Fast, cheap and small MRI, Quantum Privacy and Communication, Dense AND Fast Storage, Quantum and New Computers, Ultra-long Power Sources, True Telepresence - (would be more by the time of the event). Quick overview of how to do spinoff and what are the funding/incubation could bring.

14:20 : Invited talk
Resonant dielectric nanostructures
Arseniy Kuznetsov

Resonant high-refractive index dielectric nanostructures are novel objects in nanophotonics, which may substitute plasmonic particles for multiple applications in the nearest future. In this talk, I will review our recent

results on resonant effects in single high-refractive index nanoparticles and nanoparticle arrays. Such resonant dielectric metasurfaces may have a huge promise for design of novel low-loss flat optics. Applications of these unique optical properties of resonant dielectric nanostructures to design of novel low-loss nanophotonic devices will also be discussed.

14:40 : Invited talk
Fano resonance in an individual semiconductor nanostructure
Mark Brongersma

In this work, we will demonstrate that a single Si nanobeam with a rectangular cross section can exhibit an asymmetric spectral line-shape in its scattering resonance, a signature of an optical Fano resonance that has been studied extensively in plasmonic structures yet commonly considered challenging to observe in dielectric structures.

15:00 : Invited talk
Looking through magnetic glass: controlling nanoparticles scattering via Kerker's conditions and fano resonances
Andrey Miroshnichenko

In this talk I'll overview the importance of the coexistence of magnetic and electric dipole resonances in both dielectric and plasmonic nanostructures for the shaping light scattering via Kerker's conditions and Fano resonances.

15:20 : Invited talk
Optical resonances of Si-nanoparticles
Andrey Evlyukhin, Urs Zywietz, Carsten Reinhardt, Boris Chichkov

In this work we discuss the origin of the magnetic dipole resonance in dielectric nanoparticles. Theoretical and experimental results concerning the resonant optical properties of differently shaped Si nanoparticles are presented. A new theoretical approach allowing multipole analysis of light scattering by arbitrary-shaped nanoparticles located on flat substrate surface is demonstrated. This approach is applied to investigations of light and surface plasmon polariton (SPP) scattering by Si nanoparticle structures.

15:40 : Invited talk
Mapping the scattering profiles of dielectric nanostructures
Steven Person, Manish Jain, Juan Jose Saenz, Gary Wicks, Lukas Novotny

High index dielectric nanostructures have directional scattering properties but without the losses inherent in similar plasmonic structures. One example of this effect, GaAs pil- lars with no backscattering, is discussed. To further map the scattering profile an alternate imaging geometry using an ellipsoidal mirror is proposed.

14:00 - 16:05 — LT23

Session 1A4

Metasurfaces at Terahertz, Infrared and Optical Frequencies I

Organized by: Tahsin Akalin

Chaired by: Tahsin Akalin

14:00 : Keynote talk
Metasurfaces for wavefront and waveguiding control
Federico Capasso, Francesco Aieta, J. Balthasar Mueller

In our previous works we introduced a new class of optical components based on inhomogeneous arrays of

optical resonators with subwavelength separation, dubbed metasurfaces. By accurately designing the properties of each element of the array, the wavefront of scattered light can be reshaped and redirected at will depending on the design.

14:30 : Invited talk
Beam shaping and surface plasmon excitation with metasurfaces
Thomas Zentgraf, Holger Muhlenbernd, Lingling Huang, Xianzhong Chen, Hao Zhang, Shumei Chen, Benfeng Bai, Qiaofeng Tan, Guofan Jin, Kok-Wai Cheah, Cheng-Wei Qiu, Jensen Li, Shuang Zhang

Plasmonic metasurfaces offer great flexibility in modifying the propagation of light. Here, we will demonstrate how the spatial arrangement of plasmonic nanoantennas can lead to a topological phase for the modification of the wave front of light. The potential of this approach will be discussed at several examples including a dual-polarity metalens.

14:50 : Invited talk
A plasmonic lens for terahertz Bessel beamforming
Yasuaki Monnai, Withawat Withayachumnankul, Hiroyuki Shinoda

We propose a THz Bessel beamformer based on plasmonic waveguide scattering. Surface-waves excited on a leaky plasmonic waveguide made of metal corrugation are launched into free-space as a pair of symmetrically tilted plane-waves that define a Bessel beam along the symmetry axis. We present numerical simulations to demonstrate the concept. The proposed structure could replace conventional bulky axicon lenses with a thin planar structure enabling integrated THz systems.

15:10 : Broadband light control in near infrared and visible regimes with ultrathin metasurface based on degenerated image dipole array
Lei Zhang, Jiaming Hao, Huapeng Ye, Swee Ping Yeo, Min Qiu, Said Zouhdi, Joel K. W. Yang, Cheng-Wei Qiu

To realize light manipulation with high efficiency in visible and near infrared regimes, we report a new concept of degenerated image dipole array constructed with a moderate thickness of intermediate metallic layer sandwiched by ultrathin planar plasmonic nanostructure. By tuning the mutual coupling between dipole array and its image dipole array, a robust broadband transparency is realized. Furthermore, we also demonstrate anomalous light bending with high efficiency covering almost the entire visible range.

15:25 : Invited talk
Terahertz property of nearly perfect self-complementary checkerboard patterns
Yoku Tanaka, Keisuke Takano, Abdallah Chahadih, Abbas Ghaddar, Xiang-Lei Han, François Vaurette, Tahsin Akalin, Fumiaki Miyamaru, Masanori Hangyo

We investigated the critical property of electromagnetic responses of metallic checkerboard patterns fabricated by electron-beam lithography. The nearly perfect self-complimentary checkerboard pattern shows less frequency dependent response compared with those with slight deviation from it. Possible explanations of the flat-frequency response are discussed.

15:45 : Invited talk
Plasmonic nanostructures for terahertz emission enhancement
Shang-Hua Yang, Christopher W. Berry, Mohammad R. Hashemi, Mona Jarrahi

Photoconduction is one of the most promising and commonly used means of terahertz generation, due to availability of high power, wavelength tunable, and compact optical sources with pulsed and continuous-wave operation required for broadband and narrowband terahertz generation, respectively. Here, we present an overview of recent advances in photoconductive terahertz emitters that utilize plasmonic nanostructures to significantly enhance optical-to-terahertz power conversion efficiency by enhancing light-matter interaction at nanoscale.

14:00 - 16:00 — LT1

Session 1A5

Photonic Crystals - Theory and Applications I

Organized by: Gandhi Alagappan and Du Qingguo

Chaired by: Alagappan Gandhi and Png Ching Eng Jason

14:00 : Invited talk
Broad-linewidth and high-efficiency second harmonic generation in cascaded photonic crystals
Fang-Fang Ren, Hai Lu, Hark Hoe Tan, Chennupati Jagadis

We present a method to broaden the spectral window of high-efficiency second harmonic generation in a one-dimensional photonic crystal by using cascaded cavities. Simulation results reveal that the spectrum of second harmonic can be re-shaped to a hump-like profile by controlling the joint layer based on mode splitting effects, which suggests this method results in the relaxation of stringent requirements for ultrahigh-Q microcavities in practical applications

14:20 : Invited talk
Focus engineering of radial-variant vector fields
Bing Gu, Jia-Lu Wu, Yang Pan, Yiping Cui

We generate a new kind of localized linearly-polarized vector fields with distributions of states of polarization (SoPs) describing by the radius to the power p and explore its tight focusing, nonparaxial focusing, and paraxial focusing properties. By tuning the power p, we obtain a controllable longitudinal bi-focusing spots and needle-like focal field with hybrid SoPs. Experimentally, we demonstrate both the intensity distributions and the polarization evolution of the focal field by paraxial focusing the generated vector field.

14:40 : Keynote talk
3D chiral photonic crystal inspired by butterfly wings
Min Gu

Chiral photonic crystals have recently much attention because they provide a platform to manipulate optical circular dichroism. Here we demonstrate a novel class of 3D photonic microstructures inspired by a recent finding in butterfly wing-scales and show that these nano-engineered 3D gyroid structures have the ability to redirect circularly polarized light as a chiral beamsplitter. If these nano-structures are coated with metals, they become 3D chiral metamaterials.

15:10 : A band structure calculation method for one-dimensional photonic crystals based on time integration and matrix-exponential decomposition
Xiao-Xing Su, Chuanzeng Zhang, Yue-Sheng Wang

By incorporating the Floquet-Bloch boundary conditions into the time integration scheme and the matrix exponential decomposition technique, a time-domain method for calculating the band structure of one-dimensional (1D) photonic crystals is proposed. Mathematical details are given. Numerical results show that, although the proposed method is still conditionally stable, the time-step with which the method runs stably can be much smaller than the Courant-Friedrichs-Lewy lower bound.

15:25 : Optimization of band gap in 2D and 3D photonic crystal structures
Satish Inamdar

Photonic crystals are periodic dielectric structures. These crystals are designed to prevent propagation of electromagnetic waves. Photonic crystals having large bandgap are to be designed in this work using a modified optimization approach. Thus the end objective is to maximize the bandgap for transverse magnetic field in two dimensional photonic crystals. The optimized structures prefer a piece-wise constant dielectric distribution in photonic crystal.

15:40 : Invited talk
Phyllotaxy-based optical black hole
Haitao Dai, Yufeng Liao, Yang Yang

In this paper, we present one planar optical black hole with graded photonic quasicrystals implemented with phyllotaxy structures (PSPQ). The PSPQs are composed with discrete dielectric cylinders, which radius are determined by the index profile of optical black hole and Maxwell-Garnett effective medium theory. Numerical simulations are performed to characterize the absorption feature of the PSPQs-based optical black hole. The simulation results show that the PSPQs-based optical black hole have advanced properties than square lattice-based optical black hole.

14:00 - 16:00 — LT2

Session 1A6

Technologies and Applications I

Chaired by: Christophe Fumeaux

14:00 : A mechanically flexible, angularly robust metasurface for lab-on-fibre
Peter Reader-Harris, Andrea Di Falco

We present a free standing and mechanically flexible metamaterial that performs as an angularly robust filter. Such a pliant membrane is well suited for use in lab-on-fibre applications as it can make good contact with the facet, and is potentially replaceable. We demonstrate the design of such a filter, which is angularly tolerant to over 8 degrees, and demonstrate its use on the end of a fibre facet.

14:15 : Coherent perfect absorption: Breaking 50 % limit on ultrathin films
Sucheng Li, Jie Luo, Shahzad Anwar, Shuo Li, Yun Lai, Bo Hou

It is well known that an ultrathin conductive film has the maximal 50 % electromagnetic absorption. We show that the coherent perfect absorption, induced solely by the cooperative incident waves and involving no extra additions of surface structures or substrates, brings the ultrathin film absorbance up to 100 % in a frequency-independent manner. The absorption enhancement over the whole microwave regime may enable novel ultrabroad band applications.

14:30 : Invited talk
Spoof surface plasmon devices and circuits
Tie Jun Cui, Xiaopeng Shen, Hui Feng Ma

In the microwave and terahertz frequencies, artificial structures have to be used to produce spoof SPPs(LSPs). In this presentation, we introduce a planar plasmonic metamaterial which support propagation and localization of spoof SPs (LSPs) on a textured metallic stripe (disk) at microwave frequencies. And we will also present an efficient conversion between the guided waves and the SPP modes. Based on the conversion and spoof SPP/LSP devices, we proposed integrated spoof SPP/LSP circuits to realize a series of functionalities.

14:50 : Invited talk
Sub-10-nm lithography in nanoplasmonics
J. K. W. Yang, Y. M. Wang, Z. Dong, D. Zhu, S. J. Tan, X. M. Goh, M. Bosman, W. Du, C. A. Nijhuis, Y. Gu, L. Zhang, C. W. Qiu, H. Duan

Nanotechnology has enabled the rapid progress in plasmonics and metamaterials. With advanced lithographic techniques such as electron-beam lithography, photolithography, and focused ion beam, one is able to fabricate novel devices that exploit the advantages of metal optics. These structures typically have critical dimensions in the order of tens to hundreds of nanometers.

15:10 : Invited talk
Integrated in-plane plasmonics for terahertz quantum cascade lasers
Fung Yu, Guozhen Liang, Emmanuel Dupont, Saeed Fathololoumi, Zbigniew R. Wasilewski, Dayan Ban, Siu Fung Yu, Lianhe H. Li, Alexander Giles Davies, Edmund H. Linfield, Hui Chun Liu, Qi Jie Wang

We report the planar integration of tapered terahertz (THz) frequency quantum cascade lasers (QCLs) with spoof surface plasmon (SSP) structures. The resulting surface-emitting THz beam profile is highly collimated with a divergence as narrow as 4x10. Since the complete structure is in-plane, this scheme provides a promising platform in which well-established surface plasmon techniques can be employed to engineer the emitted THz QCL beam controllably and flexibly.

15:30 : Keynote talk
Bottom-up crystal-growth-based manufacturing of bulk nanoplasmonic materials and metamaterials
Dorota Pawlak, Marcin Gajc, Katarzyna Sadecka, Karolina Korzeb, Pawel Osewski, Andrzej Klos, Barbara Surma, Alessandro Belardini, Grigore Leahu, C. Sibilia

Two novel bottom-up manufacturing methods of nanoplasmonic materials and metamaterials will be presented utilizing the crystal growth techniques: directional solidification of eutectic composites, and direct doping of dielectric matrices with plasmonic nanoparticles (NanoParticles Direct Doping - NPDD)...

14:00 - 16:00 — LT3

Session 1A7

Numerical Modeling Techniques for Metamaterials I

Organized by: Ozlem Ozgun and Mustafa Kuzuoglu

Chaired by: Ozlem Ozgun and Mustafa Kuzuoglu

14:00 : Invited talk
Atomically thin isolation based on nonreciprocal graphene metamaterial
Xiao Lin, Zuojia Wang, Fei Gao, Baile Zhang, Hongsheng Chen

We demonstrate the thinnest possible nonreciprocal isolation for circularly polarized waves by using graphene metamaterial under an external magnetic field, without external bulky resonating structure and polarizers. When some practical loss is introduced, isolation with nonreciprocal graphene metamaterial still possesses good performance in a broad bandwidth. Our work shows the first analytical study on the extreme limit of thickness for optical isolation, and may opens up new possibilities for further innovations in graphene based functional ultrathin optics.

14:20 : Invited talk
Automated synthesis of transmission lines loaded with complementary split ring resonators (CSRRs) through aggressive space mapping
Jordi Selga, Ana Rodriguez, Marco Orellana, Vicente Boria, Ferran Martin

This paper is focused on the application of space mapping optimization to the automated synthesis of transmission lines loaded with complementary split ring resonators (CSRRs) and open complementary split ring resonators (OCSRRs). These structures are of interest for the implementation of resonant-type metamaterial transmission lines, and for the design of planar microwave circuits. The paper presents a method to generate the layouts of CSRR- and OCSRR-loaded microstrip lines from the elements of their equivalent circuit models.

14:40 : Invited talk
Chiral metamaterials: From negative index to asymmetric transmission
Ekmel Ozbay

Chiral metamaterials are attractive for their intriguing properties such as negative refractive index, optical activity and circular dichroism, and asymmetric transmission. We have designed and numerically and experimentally characterized several chiral metamaterials structures. Such structures can be promising for and employed in security and defense applications, such as RF signature reduction (by control of anisotropy), infrared signature control (cloaking), imaging and sensing applications, radar and satellite applications, and remote sensors.

15:00 : Invited talk
Controlling phase and power flow with electromagnetic metamaterials
Gurkan Gok, Anthony Grbic

We describe how to design a 2D inhomogeneous,anisotropic medium that supports desired spatial distributions of the wave vector and Poynting vector direction. Plane-wave relations in anisotropic media are used to get her with an impedance matching process to find the required material parameters. The method allows arbitrary control of electromagnetic fields within a 2D medium. Such spatial control of phase and power flow allows one to mold the phase and amplitude of an aperture field.

15:20 : Invited talk
Force tracing versus ray tracing
Alireza Akbarzadeh, Cheng-Wei Qiu, Aaron J. Danner

Combining eikonal equations with the Lorentz force, we present a new method, force tracing, to trace direction and magnitude of the bulk and surface force fields along ray trajectories in both isotropic and anisotropic media. This general method can be invoked as a good estimation of the force distribution within graded-index media, and with less amount of calculations in comparison with the full-wave analysis. Through examples of isotropic and anisotropic cases we evaluate the validity of the proposed method.

15:40 : Invited talk
Metasurface synthesis using momentum transformation
Mohamed Salem, Christophe Caloz

A systematic and novel approach to synthesize metasurfaces is introduced. For a specified field incident upon a metasurface, and a desired transmitted field, an equivalent momentum boundary condition is established based on light momentum conservation. This relation forms a transform relation that defines the amplitude, phase and field rotation changes to be induced by the metasurface. This approach, named the momentum transformation approach, enables synthesizing metasurfaces that can completely control the transmitted field.

14:00 - 15:45 — LT4

Session 1A8

Hyperbolic Metamaterials

Organized by: Allan Boardman

Chaired by: Allan Boardman

14:00 : Invited talk
New frontiers in hyperbolic metamaterials
Zubin Jacob

We develop the fluctuational electrodynamics and macroscopic quantum electrodynamics of hyperbolic media and show that it gives rise to new frontiers of application for the field.

14:20 : Invited talk
Preparation and characterization of thin film hyperbolic metamaterials

Michael Stormer, Slawa Lang, Hooi Sing Lee, Alexander Petrov, Martin Ritter, Manfred Eich

Magnetron sputtering was used to synthesize one-dimensional hyperbolic metamaterials to accomplish a transition to the hyperbolic regime in the near infrared.

14:40 : Highly directional spontaneous emission enhancement through bulk polariton propagation in hypergrating-based optical HMMs
S. Kandammathe Valiyaveedu, Antonio De Luca, Giuseppe Strangi

We report the fabrication of a hyperbolic metamaterial (HMM) based on Au/TiO2 multilayers to demonstrate the modification of spontaneous emission for dye molecules embedded in a polymer layer placed on the top of the HMM structure. The proposed HMM shows a hyperbolic dispersion at optical frequencies, above 548nm wavelength. Using a hypergrating-based configuration, SPPs and BPPs are excited and probed through the grating coupling technique, by fabricating a properly designed one-dimensional metallic diffraction grating on top of the HMM.

14:55 : Hyperbolic metamaterials for nanophotonics
Vladimir Drachev, Arkadii Krokhin, Satoshi Ishii, Alexander Kildishev

We discuss the enhanced Purcell factor for the fluorophore spontaneous emission due to high density of states of the hyperbolic metamaterials. Our experiments and analysis show that the main limiting factor is the effect of metamaterials on the nonradiative decay rate and a ratio between bound and leaky modes of the surface plasmon polaritons.

15:10 : Hyperbolic metamaterials for super-resolution imaging and deep sub-wavelength cavities
Jun Suk Rho, Xiang Zhang

This talk will discuss recent progress in hyperbolic metamaterials, whose applications include super-resolution hyperlens imaging and nanoscale cavities and. It will cover the basic physics, design principle, experimental results and materials selection.

15:25 : Invited talk
Linear and Nonlinear waves in Cylindrical Metal-dielectric Multilayers
Guy Bartal

We present a semi-analytical modeling of wave propagation in cylindrically-symmetric sub-wavelength metal-dielectric multilayers. Utilizing a Cylindrical Transfer Matrix Method, we compute the Amplitude Transfer Function of Cylindrical Hyperlens, simulate the exact field distribution and propagation for a given source and compare it to that in Effective Hyperbolic Medium.

14:00 - 16:00 — LT5

Session 1A9

Hybrid Quantum Systems and Metamaterials I

Organized by: Didier Felbacq and Alexandre Zagoskin

Chaired by: Didier Felbacq and Alexandre Zagoskin

14:00 : Invited talk
Giant enhanced field in metamaterial slab close to a bound state
Vito Mocella, Silvia Romano

We illustrate a controlling mechanism that allows the stabilization of the field amplification in a thin layer lattice with low contrast dielectric. It is given an example of simple structure that exhibit an extremely large

field enhancement, as large as 700 times the amplitude of the incident wave.

14:20 : Invited talk
Layout of metallic sectors in nanoring for efficient magnetic field pulse generation from light
Guillaume Vienne, Xiaoye Chen, Ching Ping Ooi

Here we show that carefully designing the sectors of the nanoring allows for generating a higher magnetic field while reducing the lattice temperature and propose a symmetric structure made of four metallic sectors.

14:40 : Invited talk
Light-matter coupling in hyperbolic and epsilon-near-zero metamaterials
Alexander Poddubny, Alexander Chebykin, Alexey Orlov, Alexey Slobozhanyuk, Ivan Iorsh, Yuri Kivshar, Pavel Belov

Electromagnetic metamaterials, artificial media created by subwavelength structuring,exhibit many unusual properties that are rarely or never observed in nature. Here, we present a general overview and original results for the light-matter coupling effects in hyperbolic metamaterials — one of the most unusual classes of electromagnetic metamaterials. They display hyperbolic (or indefinite) dispersion, which originates from one of the principal components of their electric or magnetic effective tensor having the opposite sign to the other two principal components.

15:00 : Invited talk
Optical trapping and sensing with hybrid plasmonic particle-microcavity structures
Haixi Zhang, Yanyan Zhou, Xia Yu, Feng Luan, Jianbin Xu, Hock-Chun Ong, Ho-Pui Ho

We have investigated the optical trapping and sensing characteristics of a hybrid particle-microcavity scheme. Resonant plasmonic nanoparticle placed inside a microcavity with high Q-factor results in an interesting situation whereby (i) the far-field extinction has large variations caused by refractive index changes around the nanoparticle and (ii) near-field around the nanoparticle remains almost constant. Therefore one can have highly sensitive sensors an highly stable optical trapping simultaneously. We have evaluated two typical cases based on gold and silver nanoparticles.

15:20 : Invited talk
Quantum metamaterials with quantum dots inside nanowires
Emmanuel Rousseau, Didier Felbacq

This paper presents numerical results about quantum metamaterials made with quantum dots embedded inside nanowires . We first consider the absorption properties of nanowires in different geometries: nanowires in vacuum, nanowires above a dielectric plane, nanowires in periodic configuration. Then we consider the emission properties of the quantum dot embedded inside the nanowire.

15:40 : Invited talk
Strong coupling and coherence in disordered semiconductors near metals
J. Bellessa, S. Aberra Guebrou, C. Symonds, J. Laverdant, J. C. Plenet

During this talk, I will describe the properties of organic materials strongly coupled to surface plasmons and the intramolecular coupling induced by the plasmon. The strong coupling can coherently couple independent molecules leading to in-phase emission of emitters separated by several microns, showing the formation of a macroscopic coherent state. The extension of this state over a large number of molecules could lead to energy transfer over micrometer scale mediated by the plasmon.

14:00 - 15:00 — MAS EC1

Session 1A10

Metamaterials and Negative Index Materials I

Organized by:

Chaired by: Baile Zhang

14:00 : Modal decomposition of meta-atom dynamics
David Powell

The modes of meta-atoms are a natural basis for describing their excitation and interaction, however many structures of practical interest are too complex to find their modes analytically. It is shown here how they can be found by solving for the singularities of an integral equation operator. These modes are used to construct simple yet highly accurate models, which are applied here to scattering problems. The proposed technique is implemented in a freely available open source code.

14:15 : Design of terahertz wave path-length lens based on phase control by oblique metal slit array
Takahisa Togashi, Hideaki Kitahara, Keisuke Takano, Masanori Hangyo, Mamoru Mita, John Young, Takehito Suzuki

The need for high-performance terahertz optical devices is showing rapid growth. This paper presents the design of a terahertz wave path-length lens based on phase control using an oblique metal slit array. An oblique slit array with convex configuration can produce a focusing effect. Full wave analysis using ANSYS HFSS confirms the focusing effect.

14:30 : Conception of a metamaterials based coupler operating at 90 GHz for astrophysical applications.
Alassane Sidibe, Frederique Gadot, Benoit Belier, Guillaume Bordier, Davide Cammilleri, Adnan Ghribi, Andrea Tartari, Michel Piat, Joseph Martino, Francois Pajot, Faouzi Boussaha

Designed for astrophysical applications, this coupler must be as small as possible to be integrated in a low temperature superconducting detection chain. By using metamaterials, dimensions can be reduced compared to a conventional coupler.

14:45 : Resonances and anti-resonances in the material parameters of 2-D dielectric ENG, MNG, and DNG materials
Yunqiu Wu, Samel Arslanagic

The resonant/anti-resonant behavior of parameters extracted by the S-parameter method for two-dimensional epsilon-, mu- and double-negative (ENG, MNG, DNG) materials is investigated. The unit cells consist of infinite dielectric cylinders supporting electric dipole, magnetic dipole, or both. It is shown that the extraction procedure yields one resonant material parameter, and one anti-resonant material parameter in MNG and ENG configurations. However, both parameters display an over-all resonant response in DNG configurations where electric and magnetic dipole modes are excited simultaneously.

15:00 - 16:05 — MAS EC1

Session 1A11

Plasmonics and Nanophotonics II

Chaired by: Ashod Aradian

15:00 : Invited talk

Enhanced photoluminescence emission from organic molecule interacting with metal nanoparticles
Ryoko Shimada, Megumi Kimura, Naoki Tarutani, Masahide Takahashi, Sanjay Karna, Arup Neogi

The optical properties of anthracene-doped polyphenylsiloxane glass films containing silver nanoparticles (AgNPs) were studied for the understanding the mechanism of photoluminescence (PL) enhancement from anthracene molecules. The PL emission from anthracene molecules was resonantly coupled to the localized surface plasmon (LSP) mode. The energy transfer from the localized excitons to the LSP modes and electrostatic Coulomb effects of on the excitons in the presence of AgNPs all resulted in a significant enhancement of PL emission.

15:20 : Enhancement of light emission from an InGaN/GaN quantum well through localized surface plasmon coupling with single Ag nanoparticles
Gintautas Tamulaitis, Darius Dobrovolskas, Juras Mickevicius, Horng-Shyang Chen, Chun-Han Lin, Che-Hao Liao, Chieh Hsieh, Yean-Woei Kiang, Chih-Chung Yang

This study of spectrally and spatially resolved photoluminescence in InGaN/GaN multiple quantum wells covered by silver nanoparticles is focused on the investigation of the enhancement of light emission due to the resonant coupling of the optical transition in the well with the localized surface plasmon in single silver nanoparticles. Confocal microscopy and SNOM techniques were used. Enhancement by the factor of more than 3 is observed in the vicinity of a single Ag nanoparticle.

15:35 : Quantum emitters as nanoreporters of the plasmo-photonic resonance modes in complex hybrid structures
Simona Ungureanu, Pierre Fauché, Branko Kolaric, Renaud Vallee

Hybrid plasmo-photonic crystals have been designed to study the weak and strong coupling regimes between quantum emitters and the plasmo-photonic modes of the structure. Such plasmonic structures appear to be particularly relevant for fluorescence-based sensing devices in the weak coupling regime. In the strong coupling regime, we anticipate that such fundamental studies will be very usefull for potential applications in active nano-photonics.

15:50 : Funneling of light and field enhancement in metal-insulator-metal resonators under focused beams
Paul Chevalier, Patrick Bouchon, Riad Haidar, Fabrice Pardo

Thanks to an energetic analysis, we investigate the funneling mechanism of light and the energy dissipation in various combinations of metal-insulator-metal resonators. Along with a total funneling of light, a strong field intensity enhancement is observed. This study highlights the possibility of photon sorting in omnidirectional devices.

Coffee Break and Exhibit Inspection

Session 1P1

Poster Session II

16:00 - 16:45

P1: Meta-fluidic-materials with microfluidic systems
W. M. Zhu, Q. H. Song, W. Zhang, R. F. Huang, S. K. Ting, A. Q. Liu

We demonstrate a multilayered microfluidic system with a flexible substrate, which has tunable optical chirality within THz spectrum range. The optical properties of the multilayered microfluidic system can be tuned by either changing the liquid pumped into each layer or stretching the flexible substrate. Furthermore, the tuning resolution can be well controlled due to the fine refractive index change of the liquid with different concentrations.

P2: Negative index chiral metamaterial based on C3-symmetric meta- atoms arranged in hexagonal lattice
Mircea Giloan, Robert Gutt, Gavril Saplacan

Nanostructures made of two layers of metallic nanoelements arranged in hexagonal lattice separated by a dielectric layer are theoretically analyzed as chiral metamaterial slabs. Transmitted and reflected electromagnetic field of normally incident circularly polarized plane waves are computed using a tri-dimensional (3D) finite-difference time domain (FDTD) algorithm.

P3: Electromagnetic waves through metamaterial-dielectric photonics crystal waveguide structure
Hala El-Khozondar, Rifa El-Khozondar, Mohammad Shabat

Photonic crystals (PCs) are a revolutionary science that has a great impact on the field of photonics. In purpose of extend the applications of PCs, we introduce a new photonic structure which is composed of alternating lamellae of MTMs and Dielectric. The electromagnetic waves propagating through photonic crystal structures are numerically investigated. Results show improvement in the characteristics of the photonic crystal

P4: Interaction of the surface plasmon polaritons and magnetic cavity modes in plasmonic magnetophotonic crystals
Nkolai Khokhlov, Darja Sylgacheva, Vladimir Belotelov, Dmitry Bykov, Vladimir Berzhansky, Alexandr Shaposhnikov, T. Mikhailova, A. Prokopov, A. Karavainikov, Yuri Kharchenko

We investigate optical and magneto-optical properties of the structures combining an magnetophotonic crystal and a 1D plasmonic grating. We have found the enhancement of the magneto-optical effects in these systems up to 40 times respect to the with respect to bare magnetophotonic crystals.

P5: Frequency tunable directive emission by two-dimensional ferromagnetic photonic crystals
Ruixin Wu, Da-Yong Zou, Zhong-Hao Sha, Yin Poo

We study the radiation of a line source embedded in a ferromagnetic photonic crystal (MPC) in external magnetic fields. It is found the ferromagnetic photonic crystal not only has a strong capacity to direct the source radiation, but also makes the radiation frequency tunable in the external magnetic field. By optimizing the parameters of photonic crystal, high directivity is obtained and the effect of PC size is discussed.

P6: Study on modulating properties of magnetic defect in photonic crystal in terahertz region
Hui Zhang, Xian-Feng Xu, Shengjiang Chang, Cuiping Jia, Zhiyong Jiao

The resonance mode properties of ferrite defect in photonic crystal in terahertz region are studied. The results indicate that the resonance modes of the point defect change in large frequency domains(1.14THz-0.91THz or 0.99THz-0.9THz) when the permeability of ferrite material changes with external magnetic field . Furthermore, the transmission spectra show that the central frequency of the defect mode spectra with narrow bandwidth (about 0.017THz).

P7: Topology optimization of two-dimensional phoxonic crystals
Hao-Wen Dong, Yue-Sheng Wang, Tian-Xue Ma

We perform the multi-objective optimization of the two-dimensional phoxonic crystals by using the non-dominated sorting-based genetic algorithm II. The optimized Pareto-optimal solutions with simultaneously maximal and complete photonic and phononic bandgap widths can be obtained.

P8: Numerical study on the structural color of blue birds by a disordered porous photonic crystal model
Tsuyoshi Ueta, Garuda Fujii, Gen Morimoto, Kiyoshi Miyamoto, Akinori Kosaku

We consider the air rod photonic crystal to which disorder is introduced into the translation vectors and the radius as a model of the structural color of red-flanked bushrobin, and the optical property of the model is numerically analyzed and is compared with that of the structural color.

P9: Single-zero materials composed of dielectric photonic crystals
Jie Luo, Yun Lai

We theoretically demonstrate that single-zero materials with either permittivity or permeability near zero at certain frequencies can be realized based on two-dimensional dielectric photonic crystals. The zero value parameter leads to interesting phenomena such as tunneling effect, bending waveguide, and wave tailoring behaviors. In all of the above results, the numerical simulations perfectly match with theoretical predictions from the effective medium analysis.

P10: Optics and mechanics of stretchable DBR balloons
Gen Kamita, Jeremy J. Baumberg, Ullrich Steiner

Elastically-deformable Distributed Bragg Reflector (DBR) membranes are Rubbery mirrors that can be reversibly colour-tuned across the full visible spectrum by stretching, compressing, inflating into a balloon or any other kind of deformation that changes the thickness of the membrane. Starting from an initial bilayer consisting of two rubbers, the multifolding Origami manufacture process multiplies the number of layer stacks, leading to an enhancement of reflectance at a wavelength set by the layer thicknesses.

P11: Application of teaching learning based optimization in antenna designing
Surabhi Dwivedi, Vivekanand Mishra, Yogesh Kosta

Numerous optimization techniques are studied and applied on antenna design to optimize various performance parameters. Multiple Attributes Decision Making(MADM) is used here. The methods of MADM include, Weighted Sum Method (WSM), Weighted Product Method (WPM), technique for order preference by similarity to ideal solution (TOPSIS), Analytic Hierarchy Process (AHP), ELECTRE, etc. Analytic Hierarchy Process (AHP) is explained in detail and compared with WSM and WPM. Authors look forward to use Teaching-Learning-Based Optimization (TLBO) technique, a novel method for constrained antenna design optimization problems.

P12: Engineering of the metamaterial based cut-band filter
Alassane Sidibe, Frederique Gadot

Metamaterials based cut-band filters are realized by combining either Split Ring Resonators (SRR) close to a microstrip line or Complementary Split Ring Resonators (CSRR) under this line. The study of this paper focuses on the influence of the association of different arrays of SRR especially on the bandwidth of the cut-band filter.

P13: Generating globally enhanced chiral field using negative-index metamaterials
Seok Jae Yoo, Minhaeng Cho, Q-Han Park

We demonstrate that negative-index metamaterials generate globally enhanced chiral field. Achiral negative-index metamaterials shows a 3.5-fold enhancement of the volume-averaged optical chirality in comparison with circularly polarized plane waves. Generated electromagnetic field possess the same handedness of the optical chirality, and thus it forms globally enhanced chiral field.

P14: Gigahertz acoustic modulation of optical split-ring resonators
Yuta Imade, Ronald Ulbricht, Motonobu Tomoda, Osamu Matsuda, Gediminas Seniutinas, Saulius Juodkazis, Oliver Wright

Split-ring-resonators (SRRs), for example those made up of U-shaped structures, form elements of metamaterials for control of the magnetic permeability. In this work, we investigate how laser-generated GHz acoustic resonances modulate the optical properties of nanoscale SRRs by means of a pump-probe technique. In particular, we demonstrate the effect of changing the polarization and wavelength of probe laser pulses.

P15: Extraordinary transmission of GHz surface acoustic wave
Kazuki Chonan, Motonobu Tomoda, Osamu Matsuda, Paul Otsuka, Istvan Veres, Sam Hyeon Lee, Oliver Wright

we have simulated the extraordinary transmission of GHz surface acoustic waves in Si slabs containing resonator structures. Periodic arrays of our unit cell should prove useful in applications in GHz ultrasonics, for example in the field of surface acoustic wave filters.

P16: Phase modulation by metasurfaces composed of metal-insulator-metal nanoresonators
Junda Zhu, Haitao Liu

In this talk, we report that by designing a metasurface composed of a nonperiodic array of the metal-insulator-metal nanoresonators, the phase change of reflected light can cover nearly a full range from 0-to-2p. This provides a full control of the wavefront of the reflected light, such as beam focusing or bending.

P17: Finite element simulation for cylindrical invisibility cloaking using linear transformation optics
Karim Atallah, Kareem El Assy, Xue-feng Zhu

In this paper we will shed the light on the different cloaking techniques, specially the Transformation Optics (TO). There will be a comparison between linear and high-order TO, especially third order and fifth order, physically in terms of impedance mismatch, with FEM simulation and mathematical derivation.

P18: Dirac points in the transmission spectra of periodic dielectric structures with metamaterials: generalities and applications
Yury Bliokh, Valentin Freilikher, Franco Nori

Similarities and distinctions between Maxwell and Dirac equations and between the corresponding boundary conditons are studied. It is shown that some of the exotic properties of the charge transport in graphene superlatticies can be reproduced in the propagation of light through samples built of alternating layers of normal dielectrics and metamaterials.

P19: Broadband light coupling to dielectric slot waveguides with tapered plasmonic nanoantennas
Ivan S. Maksymov, Yuri S. Kivshar

We propose an efficient approach for broadband coupling between incident light and on-chip dielectric slot waveguides by employing tapered plasmonic nanoantennas. We demonstrate the coupling efficiency up to 20 % by employing numerical simulations.numerical simulations.

P20: Nonlinear chiroptical effects in plasmonic meta-surfaces
Ventsislav Valev, Jeremy Baumberg, Nuno Braz, Jan Mertens, Claire Blejean, Paul Warburton, Victor Moshchalkov, Nicolae-Coriolan Panoiu, Thierry Verbiest

We present an unexpected direct association between an important linear optical property (superchiral light) and a nonlinear one (second harmonic generation). By varying the dimensions in our meta-molecules, we tune the superchiral light and identify optimal material dimensions for enhanced nonlinear optical response. We then construct such optimized meta-surfaces and use their enhanced response to expose a fundamental physical property, i.e. non-reciprocity with respect to space-time reversal.

P21: Spectral Tuning of Localized Surface Phonon Polariton Resonators for Low-Loss Mid-IR Applications
Y. Chen, Y. Francescato, J. D. Caldwell, V. Giannini, T. Maß, O. J. Glembocki, F. J. Bezares, T. Taubner, R. Kasica, M. Hong, S. Maier

The presented study is of great importance in understanding the spectral tuning of localized SPhP and the coupling mechanisms, which are fundamental in applications such as surface-enhanced spectroscopy, mid-IR nanophotonics, thermal radiation engineering and metamaterial designs.

P22: Propagation characteristics of Plasmonic waveguides
Padmaja Bhanu Bandaru, R. Shevgoankar, A. Chandorkar

Propagation characteristics of plasmonic metal-insulator-metal wave guide (MIM) and dielectric-metal-dielectric (DMD) wave guide have been investigated. Waveguide dispersion of both the structures was studied. It was observed that asymmetric and symmetric modes get coupled in the both the structures. With increase in thickness of the core beyond 120nm surface waves get decoupled and tend towards photonic modes in MIM waveguide.

P23: Strong fano resonance in a plasmonic nanoparticle-in-cavity nanoantenna array
Zhendong Zhu, Benfeng Bai

A three-dimensional plasmonic gold nanoparticle-in-cavity (GPC) consisting of a super-radiative dipolar gold nanoparticle coupled with a sub-radiative cavity mode is theoretically and experimentally studied. The plasmonic properties show electromagnetic response of Fano resonance and the nanoparticle interacting with the extended nanocavity. The GPC nanostructure acts as effective light concentration originating from coupling enhancement near the bottom of the nanoparticle. The local field enhancement is demonstrated by surface enhanced Raman scattering with a 108 enhancement factor.

P24: Plasmon-assisted tunneling demonstrated with atomic precision
Shu Fen Tan, Lin Wu, Joel Yang, Ping Bai, Michel Bosman, Christian Nijhuis

We combine recently developed experimental and theoretical methods to directly demonstrate quantum tunneling between two plasmonic resonators. Our experimental results directly demonstrate the occurrence of charge transfer across the cavity between two separated plasmonic nanoparticles. Quantum-corrected optical simulations confirm this interpretation and further underline that our fabrication method provides control over the frequency of the tunneling charge transfer, which we could establish by tuning one of the fabrication parameters.

P25: Highly collimated broadband emission from plasmonic nanowire embedded in fiber
Behrad Gholipour, Venkatram Nalla, Paul Bastock, Khouler Khan, Chris Craig, Dan Hewak, Nikolay Zheludev, Cesare Soci

Optically pumped gold nanowire, 330 nm in diameter embedded into silicate optical fiber produces broadband, highly collimated radiation (in the range 470-900 nm) with divergence of less than 4 mrad.

P26: Spoof plasmonic analogue of 2D topological insulator
Fei Gao, Zhen Gao, Baile Zhang

Much experimental effort has been directed towards realizing 2D photonic topological insulators with dielectric waveguide or resonator arrays. Here we would like to further extend Topological Insulators into plasmonics, and proposed a practical scheme to realize with Spoof SPP resonator arrays. Our simulation results unambiguously show the edge state in a bulk array, which is the unique property of topological insulators.

P27: Effective medium theory for anisotropic acoustic crystals
Xiujuan Zhang, Ying Wu

We present effective medium theories for two-dimensional anisotropic acoustic crystals in the long wavelength limit. The anisotropy originates from two sources, one is anisotropic lattice structure and the other is anisotropic scatterers. Both the multiple-scattering theory and coherent potential approximation are used to derive the effective medium parameters. It is seen that the effective bulk modulus are still isotropic while the effective mass density becomes anisotropic. The validity of the theories is verified by band structure simulations.

P28: Transformational acoustic metamaterials based on pressure gradients
Carlos Garcia Meca, Sante Carloni, Carlos Barcelo, Gil Jannes, José Sanchez-Dehesa, Alejandro Martinez

By applying a homogenization process to the veloctity potential acoustic wave equation, we connect current metafiuid technology with the properties prescribed by ana- logue transformation acoustics. A careful analysis un- veils the difference between metamaterials designed via potential- and pressure-based transformational approaches. An example concerning a periodic array of cylinders em- bedded in a fluid is presented in detail. Our results show the potential of metafiuids based on pressure gradients both for building transformation

media and for achieving super- sonic propagation speeds.

16:45 - 18:15 — LT22

Session 1A12

Symposium: Resonant Dielectric Nanostructures and Metamaterials II

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Mark Brongersma and Arseniy Kuznetsov

16:45 : Keynote talk
Photonic topological insulators
Mordechai Segev, Mikael C. Rechtsman, Yonatan Plotnik, Yaakov Lumer, Julia M. Zeuner, Alexander Szameit

The first experimental demonstration of a photonic topological insulator will be reviewed, along with recent progress on linear and nonlinear waves there in, and a variety of new phenomena.

17:15 : Invited talk
Full control over the coupling strength in a hybrid plasmo-dielectric metamaterial
A. Lovera, E. Descorvi, P. Mandracci, F. Giorgis, Olivier Martin

Using a hybrid plasmo-dielectric metamaterial that supports both optical Bloch surface waves and localized plasmon resonances, we show that the coupling strength between these two optical modes can be controlled and continuously tuned by simply modifying the illumination conditions.

17:35 : Invited talk
New TiN-based metamaterials
Vladimir Shalaev, U. Guler, G. Naik, B. Saha, M. Shalaginov, A. Lagutchev, A. Kildishev, M. Ferrera, N. Kinsey, A. Boltasseva

Titanium nitride (TiN) is a plasmonic material having optical properties resembling gold. Unlike gold however, TiN is CMOS-compatible, mechanically strong, and thermally stable at higher temperatures. Additionally, TiN can be grown in smooth, ultra-thin crystalline films, which are useful in constructing many plasmonic and metamaterial devices including hyperbolic metamaterials, solar thermo-photovoltaic elements, optical interconnects, and efficient single-photon emitters. Recent progress in developing a family of new plasmonic devices based on TiN will be discussed.

17:55 : Invited talk
Quantum Spectroscopy of Plasmonic Nanostructures
Dmitry Kalashnikov, Zhenying Pan, Arseniy Kuznetsov, Leonid Krivitsky

We use frequency entangled photons, to measure the spectral response of an array of gold nanoparticles exhibiting Fano-type plasmon resonance. Refractive index sensing of a liquid is performed by measuring the shift of the array resonance. This method is robust in excessively noisy conditions compared with conventional broadband transmission spectroscopy. Detection of a refractive index change is demonstrated with a noise level 70 times higher than the signal, which is shown to be inaccessible with the conventional transmission spectroscopy.

16:45 - 17:45 — LT23

Session 1A13

Metasurfaces at Terahertz, Infrared and Optical Frequencies II

Organized by: Tahsin Akalin

Chaired by: Tahsin Akalin

16:45 : Invited talk
Three-dimensional metasurface holography
Lingling Huang, Benfeng Bai, Xianzhong Chen, Holger Muhlenbernd, Hao Zhang, Shumei Chen, Qiaofeng Tan, Guofan Jin, Kok-Wai Cheah, Cheng-Wei Qiu, Jensen Li, Thomas Zentgraf, Shuang Zhang

The emerging field of metasurfaces has offered unprecedented functionalities for shaping wave fronts. Here, we realize three-dimensional holography by using metasurfaces with oriented metallic nanorods. As the phase can be continuously controlled in subwavelength unit cell by the monolayer rod orientation, metasurfaces represent a great advantage over other conventional methods such as CGH with spatial light modulators or diffraction optical elements.High-resolution 3D holograms with a wide field of view and elimination of undesired multiple diffraction orders are achieved.

17:05 : Invited talk
Terahertz periodic leaky-wave antennas with metamaterial scatterers
Withawat Withayachumnankul, Yasuaki Monnai, Miguel Navarro Cia, Tahsin Akalin

A periodic leaky-wave antenna design is proposed for operation in the terahertz regime. The antenna is made of a microstrip periodically loaded with metamaterial resonators. By controlling the period of the resonator array, the phasefront of the radiated wave can be tilted accordingly. Simulation with realistic material parameters and geometry demonstrates a highly directional terahertz beam. This advancement will serve as infrastructure for short-range ultrafast terahertz communications in the near future.

17:25 : Invited talk
Controlling surface electromagnetic waves with metamaterials
Willie Padilla, W.-C. Chen, J. J. Mock, D. R. Smith, T. Akalin

Metamaterials permit fabrication of surfaces which support surface electromagnetic waves (SEWs) also called plasmons. We experimentally demonstrate metamaterials which absorb a specific narrowband range of electromagnetic radiation supported by a broadband planar Goubau line (PGL). In another study we show that SEWs are supported on a metamaterial absorber and responsible for the striking off-normal performance for TM polarized waves.

17:45 - 18:25 — LT23

Session 1A14

Plasmonics and Nanophotonics I

Chaired by: Mikhail Lapine

17:45 : Invited talk
Forming of gold nanoparticles utilizing photothermal effects in perfect metamaterial absorbers
Min Qiu, Xi Chen, Yiting Chen, Hanmo Gong, Yuanqing Yang, Xingxing Chen, Ding Zhao, Min Yan, Qiang Li

Here we review our recent efforts on forming ordered gold nanospheres and nanocrystals on substrate, with the help of enhanced photothermal effects in perfect metamaterial absorbers. We also show that a large number of nanospheres can be transferred from one substrate to another, while transferred nanoparticles exhibit good

size uniformity.

18:05 : Invited talk
Highly doped metal oxides for active and infrared plasmonics and metamaterials
Otto Muskens

We demonstrate that highly doped metal oxides are interesting materials for plasmonic and metamaterials applications. By combining indium-tin oxide (ITO) with gold plasmonic nanostructures, tunable and nonlinear devices can be obtained. We demonstrate antennas and metamaterials fabricated using ITO which show strong optical resonances in the mid-infrared. Such materials are of interest for applications in molecular fingerprinting and infrared spectroscopy.

16:45 - 18:25 — LT1

Session 1A15

Photonic Crystals - Theory and Applications II

Organized by: Gandhi Alagappan and Du Qingguo

Chaired by: Alagappan Gandhi and Du Qingguo

16:45 : Invited talk
Toward the realization of a temporal photonic crystal in the microwave regime
Jose Roberto Reyes Ayona, Peter Halevi, Juan Sabino Martinez Romero

It is shown that a periodically modulated dynamic transmission line behaves in the same way as a temporal photonic crystal characterized by a periodic permittivity.

17:05 : Invited talk
Narrow band parametric processes in dispersion engineered GaInP photonic crystal waveguides
Gadi Eisenstein

We describe a detailed model and a series of experiments of narrowband parametric amplification in a semiconductor (GaInP) photonic crystal waveguide.

17:25 : Photoluminance intensity of CdSe/ZnS quantum dots on different-sized gold nanoparticles
Yusheng Zhai, Qilong Wang, Jing Chen, Qianqian Huang

In the paper, the photoluminance intensity of CdSe/ZnS core-shell quantum dots on different sized Au nanoparticles is investigated. A strong correlation between the PL intensity and the size of gold nanoparticles was observed. And the effects of localized surface plasmon resonance (LSPR) of Au nanoparticles have been discussed.

17:40 : Photonic crystals for slow light
Gandhi Alagappan

The paper describes novel photonic crystal systems that allow mutimode slow light

17:55 : Transparent conductor of aluminum thin film with two-dimensional hexagonal nanohole arrays
Qingguo Du, Chan Hin Kam, Xiao Wei Sun

Both of the electrical and optical properties are optimized for two-dimensional nanohole patterned aluminum thin film. With proper design of hole filling ratio and lattice constant, low sheet resistance and high

transmittance in the visible range are achieved simultaneously.

18:10 : Non-reciprocal transmission of terahertz waves through a photonic crystal cavity with graphene
Yu Zhou, Ye-Qing Dong, Ru-Wen Peng, Qing Hu, Mu Wang

We have theoretically investigated cavity enhanced tunable non-reciprocal transmission and band structure of THz waves through graphene. Under magnetic field, 2D conductivity of graphene is asymmetric which leads to the failure of reciprocity. Right circularly polarized waves propagating in two directions have different transmission spectra and field intensity distributions. Tuning the magnetic field intensity and Fermi level of the graphene, one can tune the band structure, transmission spectrum and field intensity distribution of the structure.

16:45 - 18:20 — LT2

Session 1A16

New Materials for Plasmonics and Photonic Metamaterials

Chaired by: Satoshi Kawata

16:45 : Invited talk
Coherent modulation of single photons using graphene and plasmonic metamaterials
Thomas Roger, Julius Heitz, Niclas Westerberg, Genevieve Gariepy, Eliot Bolduc, John Jeffers, Jonathan Leach, Charles Altuzarra, Stefano Vezzoli, Christophe Couteau, Cesare Soci, Nikolay Zheludev, Daniele Faccio

Recent advances in light-matter interaction have demonstrated the possibility to coherently absorb and modulate light with sub-wavelength, partially absorbing thin films. Metamaterials and graphene are natural choices to perform complete ON-OFF modulation of light interaction, thus enabling a series of applications ranging from simple switching to novel interaction geometries for nonlinear optics. An exciting perspective still to be explored is interaction at the quantum level: our measurements in the single photon regime describe the modulation mechanism.

17:05 : Design of ultracompact electroabsorption based on novel CMOS-compatible plasmonic materials
Shiyang Zhu, Guo-Qiang Lo, Dim-Lee Kwong

A novel ultracompact EA modulator is proposed based new plasmonic materials of ITO and TiN. The thin ITO layer behaves as a semiconductor whose electron concentration can be modified by a voltage applied between Cu and TiN layers to modulate its permittivity. For a Cu/3-nm ITO/5-nm HfO2/5-nm TiN/220-nm Si modulator, the propagation loss at 1550 nm increases from ~1.4 dB/mm to ~27 dB/mm by a 4-V voltage with high speed of ~56 GHz.

17:20 : Graphene plasmons for couplers and hyperbolic metamaterials
Ilya Shadrivov, Daria A. Smirnova, Ivan V. Iorsh, Andrey V. Gorbach, Ivan S. Mukhin, Pavel A. Belov, Yuri S. Kivshar

We study propagation of electromagnetic waves in two closely spaced graphene layers and demonstrate that this double-layer graphene waveguide can operate as an optical coupler for both continuous plasmons and spatial plasmon-solitons. We further study multilayer graphene structures and show that they are good candidates for realizing hyperbolic metamaterials for THz frequencies. We show theoretically that tuning from elliptic to hyperbolic dispersion in such structure can be achieved with an external gate voltage.

17:35 : Ultrafast broadband modulation of plasmonic topological insulator
Giorgio Adamo, Zilong Wang, Jun Yin, Venkatram Nalla, Stefano Vezzoli, Azat Sulaev, Lan Wang, Handong Sun, Cesare Soci, Nikolay Zheludev

We study the optical properties of Bi2-xSbxTe3-ySey single crystal by ultrafast and broadband infrared spectroscopy (~1-15 um), support them by first-principle calculations, and discuss applications of topological insulators as ultrafast switchable broadband plasmonic materials.

17:50 : Magnetic hybrid metamaterials
Simon Gregory, Gavin Stenning, Alberto Sposito, Graham Bowden, Thorsten Hesjedal, Robert Eason, Nikolay Zheludev, Peter de Groot

Magnetic materials have been coupled to conventional metamolecule structures to create magnetic hybrid metamolecules, with new opportunities. This approach brings the rich array of nonlinear effects found in magnetic materials into metamaterials, and has proven successful in adding functionalities such as magnetic tunability. We present broadband, planar, magnetic hybrid systems incorporating (i) yttrium iron garnet, (ii) NiFe and (iii) CoFe, each with their own advantages, consequently bringing different functionalities into the hybrid systems.

18:05 : Plasmonic nanostructures for polarisation-sensitive colour printing
Xiao Ming Goh, Yihan Zheng, Shawn Tan Junhao, Joel Yang Kwang Wei

Metal nanostructures can be designed to exhibit specific plasmonic resonances in their optical reflectance spectra through the control of nanostructure material and geometry. Here, we engineer polarisation-sensitive plasmonic colour pixels that exhibit distinctly different colours under orthogonal polarisation states of the incident illumination. We will show that by appropriately designing these nano- pixels, multiple images can be embedded within a single colour print.

16:45 - 18:20 — LT3

Session 1A17

Numerical Modeling Techniques for Metamaterials II

Organized by: Ozlem Ozgun and Mustafa Kuzuoglu

Chaired by: Ozlem Ozgun and Mustafa Kuzuoglu

16:45 : Approximation of transformation media-based reshaping action by genetic optimization
Ozlem Ozgun, Mustafa Kuzuoglu

Reshaping action is achieved by concentric layers, each of which has simpler constitutive parameters, designed over the object to be reshaped. The material parameters are determined by the Genetic Optimization algorithm in such a way that the concentric layers coated over the object mimic the behavior of the reshaping medium designed by the transformation electromagnetics. In this way, the reshaping action can approximately be realized by simpler and natural media (such as isotropic, uniaxial, etc).

17:00 : Invited talk
Modified transfer matrix method for the problems of nonlinear scattering by periodic and quasi-periodic layered structures
Oksana Shramkova, Alexander Schuchinsky

The generic semi-analytical approach based on the Transfer Matrix Method and Harmonic Balance Method has been devised for the self-consistent modelling of combinatorial frequency generation by the nonlinear layered structures illuminated by a pair of incident pump waves. The method implementation is discussed for the cases of the stacks of the binary nonlinear layers arranged in the periodic and quasi-periodic (Fibonacci and Thue-Morse) order.

17:20 : Invited talk
Scattering analysis of anisotropic chiral objects with volume integral equation method

Pasi Yla-Oijala, Johannes Markkanen, Seppo Jarvenpaa, Ari Sihvola

A volume integral equation based approach combined with broadband multilevel fast multipole algorithm is developed for the electromagnetic scattering analysis of arbitrarily shaped three-dimensional anisotropic chiral objects. The method is applied to study scattering properties of chiral objects with respect to the chirality parameters.

17:40 : Invited talk
Wave propagation phenomena in metamaterials: a platform for effective parameters retrieving
Andrei V. Lavrinenko

We proposed to utilize a phenomenological approach for parameters retrieving just by observing (numerically) propagation of waves in structured materials. The major point here is that we do not restrain the analysis within a unit cell of a metamaterial, but rather investigate properties of light guiding in a number of unit cells sufficient to ensure the retrieving of bulk properties of the metamaterial if such homogenization is valid.

18:00 : Invited talk
Design of 2D and 3D isotropic transformation media for light management
Carlos Garcia-Meca, Alejandro Martinez

We present a novel method for designing isotropic transformation media in two and three dimensions (2D and 3D). It relies on a special kind of shape-preserving mappings based on Green coordinates (GC). In 2D the method always provides a conformal mapping at the expense of a slight deformation of the final domain. In 3D, the combination of this method with an optimization algorithm enables completely 3D transformation media with minimized anisotropy, which can be neglected for sufficiently smooth transformations.

16:45 - 18:00 — LT4

Session 1A18

Nonlinear Metamaterials

Organized by: Allan Boardman

Chaired by: Allan Boardman

16:45 : Dark solitons in PT-symmetric coupled waveguides
Yuliy Bludov, Vladimir Konotop, Boris Malomed

We construct dark solitons in the recently introduced model of the nonlinear dual-core coupler with the mutually balanced gain and loss applied to the two cores, which is a realization of parity-time symmetry in nonlinear optics. The modulational stability of the continuous-wave background, which supports the dark solitons, is studied analytically, and the full stability is investigated ina numerical form. Stability regions are thus identified in the parameter space of the system and verified in direct simulations.

17:00 : Invited talk
Magneto-elastic tuning of narrow-band resonant transmission via intrinsic rotation in metamaterials
Tatsunosuke Matsui, Mingkai Liu, David Powell, Ilya Shadrivov, Yuri Kivshar

We demonstrate magneto-elastic tuning of narrow-band resonant transmission analogous to the electromagnetically induced transparency (EIT) in tri-resonator system consisted of two split-ring resonators (SRRs) and one closed-ring resonator (CRR). To tune the resonant transmission, intrinsic rotation of one of the SRRs due to the near-field interaction between SRRs was utilized. Our findings may open the way to access to the time-domain response of the system by optical means via magneto-elastic metamaterials.

17:20 : Invited talk
Novel opportunities for nonlinear metamaterials
Mikhail Lapine

In this talk, I will (i) provide a brief general overview of how the field of nonlinear metamaterials has emerged and progressed over the past decade, and (ii) introduce the most recent concepts in nonlinear metamaterials, with a particular emphasis on the optomechanical feedback and on the nonlinear optical bridges.

17:40 : Invited talk
Second harmonic generation in transition metamaterials
Zhaxylyk Kudyshev, Ildar Gabitov, Andrei Maimistov, Natalia Litchinitser

Until recently, most of the studies of nonlinear optical phenomena in metamaterials have been focused on light propagation in uniform refractive index structures and across sharp interfaces between positive and negative index materials. Here, we show that resonant field enhancement of obliquely incident light in a quadratically nonlinear metamaterial with refractive index gradually changing from positive to negative values enables efficient second harmonic generation at significantly reduced input intensities.

16:45 - 17:45 — LT5

Session 1A19

Hybrid Quantum Systems and Metamaterials II

Organized by: Didier Felbacq and Alexandre Zagoskin

Chaired by: Didier Felbacq and Alexandre Zagoskin

16:45 : Invited talk
Quantum metamaterial based on superconducting qubits
Pascal Macha, Gregor Oelsner, Jan-Michael Reiner, Michael Marthaler, Stephan André, Gerd Schön, Uwe Huebner, Hans-Georg Meyer, Evgeni Il'ichev, Alexey Ustinov

Manipulating the propagation of electromagnetic waves through sub-wavelength sized artificial structures is the core function of metamaterials. Resonant structures, such as split ring resonators, play the role of artificial atoms and shape the magnetic response. Superconducting metamaterials moved into the spotlight for their very low ohmic losses and the possibility to tune their resonance frequency by exploiting the Josephson inductance. Moreover, the nonlinear nature of the Josephson inductance enables the fabrication of truly artificial atoms. Arrays of such superconducting quantum two-level systems (qubits) can be used for the implementation of a quantum metamaterial. Here, we perform an experiment in which 20 superconducting flux qubits are embedded into a single microwave resonator. The phase of the signal transmitted through the resonator reveals the collective resonant coupling of up to 8 qubits. Quantum circuits of many artificial atoms based on this proof-of-principle experiment offer a wide range of prospects, from detecting single microwave photons to phase switching, quantum birefringence and superradiant phase transitions.

17:05 : Invited talk
Designing Huygens interfaces at the nanoscale
Patrice Genevet, Jiao Lin, Federico Capasso

Conventional optical components such as lenses and holograms rely on gradual phase shifts accumulated during light propagation to shape light beam. With the advent of nanophotonics, we have witnessed the development of new types of optical interfaces to manipulate light for example by introducing phase jumps along the propagation. Allying concepts of nanophotonics with the principle of detour-phase holography, we propose instead a new type of interface that control phase amplitude and polarization over a significant spectral region.

17:25 : Invited talk
Heat superdiffusion in plasmonic metamaterials
Philippe Ben-Abdallah

Heat transport mediated by the near-field interactions in netwoks of plasmonic structures is shown to be governed by a superdiffusive transport mechanism. Plasmonic metamaterials opens the way to the design of a new generation of materials able to transport heat faster than the normal diffusion process in solids. We describe here the basic physical mechanisms responsible for this anomalous thermal behavior.

17:45 - 18:30 — LT5

Session 1A20

Metamaterials and Negative Index Materials II

Chaired by: David A. Powell

17:45 : Broadband impedance-matched electromagnetic metamaterial in the MHz range
Laura Parke, Ian Youngs, Alastair Hibbins, Roy Sambles

A high refractive-index metamaterial is fabricated that experimentally demonstrates broadband impedance-matching to free-space. The refractive index of the metamaterial is 9.5 for normally incident radiation up to 70 MHz for a single polarization. Such material properties provide a route for antenna miniaturisation and transformation optics devices.

18:00 : Controllable phaseonium metamaterials
Raymond Ooi, Mahdieh Hashemi

Metamaterials that can be controlled by external fields would be interesting and useful not only for manipulating images but for enhancement of signal. We study the optical properties of a 2D array metamaterials composed of phaseonium material created by controlling external laser fields. We analyze the field distributions especially in the regions of negative effective refractive index.

18:15 : Experimental comparison of electromagnetically induced transparency-like characteristics between silver and aluminum metamaterials at visible wavelengths
Ryohei Hokari, Yoshiaki Kanamori, Kazuhiro Hane

Fabrication of plasmonic metamaterials having electromagnetically induced transparency (EIT)-like characteristics with clear spectral responses is a challenging task for optical device applications at visible wavelengths. EIT-like effects in silver and aluminum metamaterials consisting of dipole resonators and quadrupole resonators were demonstrated at visible wavelengths. At wavelengths longer than around 650 nm, the silver metamaterials had better EIT-like features. At wavelengths shorter than around 650 nm, on the other hand, the aluminum metamaterials showed promising EIT-like results.

16:45 - 17:50 — MAS EC1

Session 1A21

The Strong Light-Matter Interaction in Photonic Crystals and Plasmonics

Organized by: Ran Hao, Min Qiu and Jian Wang

Chaired by: Jian Wang

16:45 : Graphene nanoplasmonic active circuits and logic devices
Kelvin J. A. Ooi, Hong Son Chu, Lay Kee Ang

The remarkable optical properties of graphene have provided a potential platform to design various interesting graphene-based nanoplasmonic active circuits and logic devices. Owing to the large confinement property of graphene plasmons, it is possible to miniaturize graphene plasmonic devices by one-order wavelengths or more. In addition, the highly-configurable optical conductivity of graphene has led to efficient designs of active plasmonic devices ranging from active circuits, splitters to logic devices.

17:00 : Tunable graphene plasmonic nanodimers for nanoparticle sorting
Mohammad Danesh, Er-Ping Li, Cheng-Wei Qiu

In nano-sciences, sorting nanoparticles is of great interest. However, implementing this idea via an electronically controllable platform faces many challenges, particularly when the nanoparticles have similar sizes. Here, assemblies of graphene nanodimers are designed to exploit graphene's tunable plasmons and their sensitivity to their surrounding material. The huge gradient electromagnetic forces induced by the strong light matter interaction in the gap modes, facilitate an electronically tunable sorting mechanism for nanoparticles as small as 10nm based on their refractive index.

17:15 : Extraordinary localization of TE-waves on graphene
Yuliy Bludov, Daria Smirnova, Yuri Kivshar, Nuno Peres, Mikhail Vasilevskiy

We analyze the propagation of electromagnetic waves along the surface of a nonlinear dielectric medium covered by a graphene layer. We reveal that this system can support and stabilize nonlinear transverse electric(TE) plasmon polaritons. We demonstrate that these nonlinear TE modes have a subwavelength localizationin the direction perpendicular to the surface, with the intensity much higher than that of an incident wave which excites the polariton.

17:30 : Invited talk
Recent progress in passive and active hybrid plasmonic devices
Jian Wang

Hybrid plasmonic devices feature promising characteristics of simultaneous long propagation range and sub-wavelength mode confinement. In this work, we review our recent progress in design, modeling, fabrication and applications of passive and active hybrid plasmonic devices. Long-range hybrid plasmonic slot (LRHPS) waveguide, tunable ultra-compact plasmonic microresonator, ultra-compact active hybrid plasmonic resonator for sub-wavelength lasing applications, and fabricated hybrid plasmonic waveguides for terabit ultrahigh-bandwidth data transmission are discussed.

Wednesday 21st May, 2014

08:30 - 09:50 — Lee Kong Chian

Session 2A1

Plenary Session III

Chaired by: Marlan Scully

08:30 : Plenary talk
The challenge of using optical antennas to accelerate spontaneous emission
Eli Yablonovitch

For more than 50 years, stimulated emission has been stronger and far more important than spontaneous emission. Indeed spontaneous emission has been looked down upon, as a weak effect. Now, a new science of enhanced spontaneous emission is emerging, that will make spontaneous emission faster than stimulated emission. This new science depends upon the use of optical antennas to assist the spontaneous emission. The overall enhancement in spontaneous emission rate could be 3 orders of magnitude, or more. This technology emerges at the present time owing to our ability to create metallic structures at the nano-scale, which can act as antennas for atoms, molecules and semiconductors. The latest experimental results will be presented for spontaneous emission enhancement from antennas on semiconducting quantum dots.

09:10 : Plenary talk
Metastructures at the extreme
Nader Engheta

With possibility of tailoring material parameters in metamaterials, we can explore metastructures with extreme parameters, such as very high phase velocity, very low energy velocity, extremely thin (one-atom-thick metasurfaces), subwavelength nonreciprocal vortexes, extreme anisotropy, giant nonlinearity in phase-change dynamics, static optics, and more. Such materials at the edge will provide us with unprecedented features and functionalities in classical and quantum wave physics and engineering. I will discuss some of our ongoing work on these topics.

Coffee Break and Exhibit Inspection

Session 2P1

Poster Session III

09:50 - 10:30

P1: Near-field spectroscopy of single spheroids to few particles gold nanoaggregate
Mohammad Hossain, Kitajima Masahiro, Kohei Imura, Hiromi Okamoto

Near-field scanning optical microscopy was used to visualize confined electromagnetic (EM) field occurred at the interstitial of gold nanoaggregates through two-photon-induced photoluminescence imaging. Confined optical signal of TPI-PL excitation observed at the dimer and well-defined nanoaggregatein fact reflects the existence of confined electric field at the corresponding interstitials. Subsequent surface-enhanced Raman scattering (SERS) enhancement was also observed in such condition providing an evidence of hot site mechanism. Finite different time domain analysis was carried out to illustratethe results.

P2: Self-referenced nanoplasmonic sensors through polarization
Carl Wadell, Christoph Langhammer

We present a simple but yet very effective way to achieve a -self-referenced- plasmonic sensor by simultaneous readout of two light polarization signals. The strength of the self-referencing method presented here is that the actual measurement and the reference measurement can be carried out at the same time, in the same run and on the same spot on the sample. This is achieved through careful sample design and the use of a polarizing beam splitter.

P3: Mode converter with silver strips for nano plasmonic integrated circuits
Dong Hun Lee, Jung-Han Son, Myung-Hyun Lee

A waveguide-typed plasmonic mode converter (WPMC) with silver strips is presented at a wavelength of 1.55 μm.A waveguide-typed plasmonic mode converter (WPMC) with silver strips is presented at a wavelength of 1.55 μm. The WPMC is composed of a 4.5 μm-wide input insulator- metal-insulator-metal-insulator waveguide (IMIMI-W) and a 2.0 μm-wide output metal-insulator-metal waveguide connected by a laterally tapered IMIMI-W with lateral silver mirrors. The ~5.8 μm x 4.9 μm input Ss 0 mode is converted to a ~1.1 μm x 0.5 μm output G-s0 mode. The total loss for the 16.25 μm-long WPMC is ~6.973 dB.

P4: Magneto-optical effect in passive and gain-assisted plasmonic chains
Denis Baranov, Alexey Vinogradov, Alexander Lisyansky

We study enhancement of the magneto-optical effect in subdiffraction plasmonic chains. We show that in a periodic chain made of plasmonic nanoparticles embedded in a magneto-optical medium, propagation of a guided mode is accompanied by rotation of field polarization. Angle of rotation is greater than that in the same bulk magneto-optical medium. Influence of Ohmic losses can be reduced by gain in composite core-shell nanoparticles. Modes propagating in such array show high values of Faraday rotation and propagation length.

P5: Wide-angle polarization-insensitive transparency of a continuous opaque metal film for near-infrared light
Zhengyong Song, Baile Zhang

Here we propose an alternative approach to make acontinuous (apertureless) metal film optically transparent on a substrate for wide-angle and polarization-insensitive incidence of near-infrared light by depositing periodic metal patches on top ofthe metal film.

P6: Ultra-compact CMOS compatible plasmonic modulator
Viktoriia Babicheva, Nathaniel Kinsey, Gururaj Naik, Marcello Ferrera, Andrei Lavrinenko, Vladimir Shalaev, Alexandra Boltasseva

We propose and investigate a layout for a planar ultra-compact plasmonic modulator. Our device utilizes alternative plasmonic materials which are potentially CMOS compatible. The modulation is obtained by varying the carrier concentration of the transparent conducting oxide layer. Our analysis show that an extinction ratio of 46 dB/μm can be achieved, allowing for a 3-dB modulation in just 65nm of propagation length at the telecommunication wavelength. Our structure is particularly convenient for integration with existing semiconductor-based hybrid photonic/electronic circuits.

P7: Retroreflection of light from nanoporous InP
Sergey Prislopski, Elena Naumenko, Ion Tiginyanu, Lidia Ghimpu, Eduard Monaico, Lilian Sirbu, Sergey Gaponenko

Pronounced retroreflection behavior is reported for a fishnet nanoporous strongly absorbing semiconductor material. Retroreflection appears with diffusive specular reflection for all angles of incidence. Retroreflection is apparent by the naked eye with day light illumination and exhibits no selectivity with respect to wavelength and polarization of incident light. The primary model includes light scattering from strongly absorptive and refractive super-wavelength clusters existing within the porous fishnet structure. We found that retroreflection vanishes for wavelength where absorption becomes negligible.

P8: Highly nonparaxial spin hall effect and its enhancement by plasmonic structures
Girish Agarwal, Svend-Age Biehs

We show the existence of a very large spin Hall effect of light (SHEL) in single photon plasmonics based on spontaneous emission and the dipole-dipole interaction initiated energy transfer (FRET) on plasmonic platforms. The FRET is mediated by the resonant surface plasmons and hence we find very large SHEL. We present explicit results for SHEL in bulk metal and metal films. We study how the splitting of the surface plasmon on a metal film affects the SHEL.

P9: Stretch tunable nanoparticle mats with SERS applications
Matthew G. Millyard, Daniel Sigle, Fumin Huang, Richard White, Elisabetta Spigone, Jani Kivioja, Jeremy Baumberg

Self-assembled arrays of close-packed metal nanoparticles show dynamic optical changes when they are stretched on elastomeric substrates. This is due to the changes in ~1nm interparticle separation of these nanoparticles under strain. Anisotropy arises when the mat is stretched uniaxially, due to contraction of the film perpendicular to the stretch axis decreasing the distance between particles. Such arrays of nanoparticles have potential uses as sensors, particularly as surface enhanced Raman spectroscopy substrates.

P10: Gold cross-nanoantennas for high-efficiency and broadband plasmonic meta-hologram
Wei Ting Chen, Kuang-Yu Yang, Chih-Ming Wang, Yao-Wei Huang, Greg Sun, Shulin Sun, Lei Zhou, Ai Qun Liu, Din Ping Tsai

We report the demonstration of the first reflective type, dual image and high-efficiency plasmonic meta-hologram consisted of 130-nm-thick gold mirror coupled with 50-nm-thick gold cross nano-antennas. The meta-hologram works under board incident angle illuminated by coherent laser as well as incoherent light source. Making use of the characteristics of meta-materials, these optical properties of proposed meta-hologram can be transferred to arbitrary electromagnetic frequency region, and extend the functionalities of holography-related applications.

P11: Serological diagnosis of dengue infection in blood plasma using long-range surface plasmon waveguides
Wei Ru Wong, Oleksiy Krupin, Shamala Devi Sekaran, Faisal R. Mahamd Adikan, Pierre Berini

We present the detection of dengue-specific IgM antibody in patient blood plasma using a compact, cost-effective, label-free, real-time biosensor. We demonstrate the ability of our sensor to detect this antibody in several samples of patient blood plasma and the results are of greater quality than those collected by conventional MAC-ELISA. The surface preparation approach that we report here was found to be the simplest and most effective technique reported so far to minimize non-specific binding in complex blood samples.

P12: Controlling subnanometer gaps in plasmonic Dimers using graphene
Jan Mertens, Anna Eiden, A. C. Ferrari, Jeremy J. Baumberg

Subnanometer gaps in plasmonic dimers are created using monolayers of graphene. Graphene enables us to form a stable, robust, and controlled junction between individual gold nanoparticles and a gold substrate. Having the ability to compress the gap to separations below 0.4 nm allows us to observe a new spectral splitting of the coupled dimer mode in the infrared originating in charge-transfer-sensitive gap plasmons. Plasmon tuning can therefore be realised by gating the Graphene sheet.

P13: One-pot hydrothermal synthesis of ZnO/ reduced graphene oxide composite nanosheets
Zhengshan Tian, Chunxiang Xu, Jitao Li, Yi Lin

Graphene oxide sheets were obtained by ultrasonic exfoliation of graphite oxide in deionized water, which were synthesized from natural graphite powder using a modified Hummers method. ZnO quantum dots were synthesized through a sol-gel route.

P14: Near-Infrared active metamaterials and their applications in tunable surface-enhanced Raman scattering
Xinglin Wen, Lai Mun Wong, Shijie Wang, Qihua Xiong

By utilizing the phase transition properties of Vanadium dioxide (VO2), we demonstrated the tuning the

electric and magnetic modes of split ring resonators (SRRs) simultaneously within near IR range. The electric resonance frequency is blue-shift about 73 nm while the magnetic resonance frequency is red-shift about 126 nm during the phase transition from insulating to metallic.We also demonstrated the application of this active metamaterials in tunable surface-enhanced Raman scattering (SERS)

P15: Preparation of APBA-functionalized magnetic microparticle and its adsorption characteristics with nucleic acid
Ning Sun, Congliang Deng, Yi Liu, Qiang Xia, Guanglu Ge

Magnetic microparticles modified with 3-aminophenylboronic acid (APBA-MPs) were prepared by using a four-step post-grafting method, and the adsorption characteristics between as-prepared microparticles and nucleic acid were studied. The results indicated that the particles are spheroid, size-controllable with a narrow hydrodynamic size distribution of about 400 nm, and the boronic acid groups were successfully grafted to silica-coated magnetic microparticles, and have a strong adsorption capacity with RNA.

P16: Quasi-three dimensional post array for terahertz magnetic spoof surface plasmon polaritons
Nozomu Koja, Keisuke Takano, Masanori Hangyo, John Young, Takehito Suzuki

This paper presents the analysis of a quasi-three dimensional post array for the propagation of a terahertz magnetic spoof surface plasmon-polariton (SSPP). Super-fine Ink Jet (SIJ) printing technology has the potential to fabricate quasi-three dimensional structures, such as a post array. Full wave analysys using ANSYS HFSS confirms the propagation in the post array at 0.3, 0.4 and 0.5 THz.

P17: Resolution estimation of optical resonance sensor structures
Dmitry Nesterenko, Sinji Hayashi, Zouheir Sekkat

We report on a unified approach for estimating achievable resolution of optical resonance sensor (ORS) structures based on the analysis of their response independently on noise properties of the light source and detector. The figures of merit (FOMs) are introduced for characterization of bulk media and thin film sensing by spectral modulation (SM) and data post-processing, and by intensity modulation (IM). The comparison of the resolution of different types of ORS is performed by numerical simulation.

P18: Colour printing with aluminium nanostructures
Shawn Tan, Xiao Ming Goh, Di Zhu, Lei Zhang, Joel Yang

In this work, we highlight and demonstrate the first use of aluminium nanostructures for ultra-high-resolution colour printing based on plasmon resonances. We reveal colour generation strategies with aluminium plasmonic pixels that expands the available colour palette from ten to hundreds of colours for photorealistic prints. These strategies may be extended to other materials and adapted to further expand the colour palette.

P19: A study of metamaterial absorber based on circular ring structure with and without copper lines
Osman Ayop, Mohamad Kamal A. Rahim, Noor Asniza Murad

This report presents a study of circular ring metamaterial absorber with the existing of copper lines. Parametric study is done to investigate the effect of copper lines on the resonance frequency. From the simulation, the circular ring metamaterial absorber with vertical copper lines can resonates at lower frequency but this structure is polarization sensitive. This drawback can be improved by adding horizontal copper lines simultaneously with the vertical copper lines.

P20: Optical spin-orbit interaction in plasmonic structures
Feng Lin, Peng Tang, Chaojie Yang, Jie Li, Xing Zhu

In our work, on the Au thin film deposited on glass substrates, we fabricate the subwavelength holes by focused ion beam, which form the ring shape. Using the scanning near-field optical microscope, the modified propagation of surface plasmons has been observed due to the optical spin-orbit interaction.

P21: Radio- and thermoluminescence of gamma-irradiated laser phosphate glasses with Nd2O3

and CeO2 additions
A. N. Salakhitdinov, Maysara Salakhitdinova, A. A. Yusupov

In investigations of alkali-borate and potash alumoboron glasses subjected to thermoradiation processing were received metamaterials with negative coefficient of absorption on differential ranges. In continuation of these researches, in this work the radio- and thermoluminescence of gamma-irradiated laser phosphate glasses with Nd2O3 and CeO2 additions are investigated.

P22: Optical field confinement and WGM lasing enhancement in a graphene-coated ZnO microrod
Chunxiang Xu, Jitao Li, Haiyan Nan, Yi Lin, Gangyi Zhu

Optical field confinement and photoluminescence (PL) enhancement induced by graphene surface plasmon (SP) was investigated theoretically in a graphene-coated ZnO microrod. Distinct optical field confinement and enhancement were observed experimentally in this hybrid microstructure, which acted as a whispering-gallery mode (WGM) microcavity for lasing resonance. Stable and transient spectra were employed to analyze the PL enhancement and the coupling dynamics between graphene SP and the interband emission of ZnO.

P23: Robust-to-loss entanglement generation in a quantum plasmonic nanoparticle array using classical sources of light
Changhyoup Lee, Changsuk Noh, Mark Tame, Dimitris G. Angelakis

We introduce a scheme for generating entanglement between two quantum dots in a quantum plasmonic nanopar- ticle array. We show that the scheme is robust to metallic loss as well as other imperfections such as the detuning of the energy levels of the quantum dots. Here, the entanglement is generated by using dipole-induced interference effects, detection-based postselection, and classical sources of light.

P24: Improvement of human antibodies fluorescent detection using silver nanoparticles
Svetlana Vaschenko, Andrei Ramanenka, Anatoly Lunevich, Yuri Glukhov, Sergey Gaponenko

Plasmonic fluorescence enhancement of FITC-labeled human antibodies was observed using silver nanostructures as substrates. Maximal enhancement achieved was 3.4-times for prostate-specific antigen antibodies and 4.0-times for alpha fetoprotein antibodies depending on a distance between silver surface and antibodies molecules.

P25: Microstructure dye random laser
Lihua Ye, Yexuan Wang, Congsheng Lv, Chong Zhao, Guohua Hu, Yiping Cui

We report random laser in microstructure. The groove processed by wet etching shows more emission laser modes . For the dye-doped polymer films with high surface roughness by surface rubbing, threshold energy is 5uJ/pulse and the laser mode is very stable.

P26: Effect of SiO2-Ag-SiO2 plasmonic structure on anneal induced InGaAs/GaAs quantum well intermixing
Jian Huang, Kar Hoo Patrick Tung, Hongfei Liu, Jinghua Teng, Ning Xiang, Aaron Danner

Dielectric-metal-dielectric structures have been fabricated on top of InGaAs/GaAs quantum well (QW) structures to enhance atomic intermixing across the QW interfaces at elevated temperatures. The QW intermixing enhancement, due to plasmonic enhanced light absorption, is realized during rapid thermal annealing with a halogen lamp. By placing the SiO2-Ag-SiO2 structure on top of a QW sample, a 4 nm longer blue-shift in photoluminescence emission from 920 nm to 882 nm was observed than that of the sample without the plasmonic structure.

P27: Transition from photonic crystals to all-dielectric metamaterials
Mikhail Rybin, Ivan Sinev, Kirill Samusev, Dmitry Filonov, Alexey Slobozhanyuk, Pavel Belov, Yuri Kivshar, Mikhail Limonov

We bridge photonic crystals and all-dielectric metamaterials by analyzing a two-dimensional square lattice

of dielectric rods with varying rod permittivity from low to high values.We analyze an interplay between the Bragg and Mie resonances in such periodic structures and suggest a general phase diagram marking a transition from photonic crystal to metamaterial through the splitting of the lowest TE01 Mieband from the lowest Bragg band.

P28: Dielectric meta-reflectarray for broadband linear polarization conversion and complete phase control
Yuanmu Yang, Wenyi Wang, Parikshit Moitra, Ivan Kravchenko, Dayrl Briggs, Jason Valentine

We present a dielectric metasurface design utilizing high-refractive-index silicon cut-wires in combination with a silver ground plane. We demonstrate through numerical simulation that the meta-reflectarray can be used to realize linear polarization conversion with more than 98 % conversion efficiency over a 200-nm-bandwidth in the short-wavelength infrared band. We also show that complete phase coverage can be achieved with more than 93.6 % average efficiency over a wavelength range from 1500 nm to 1600 nm.

P29: Magnetic response from electrically invisible anisotropic dielectric cylinders
Henrik Kettunen, Henrik Wallen, Ari Sihvola

We consider scattering of a plane wave from an infinitely long circular polarly radially anisotropic (PRA) cylinder. Especially the performance of a PRA shell as an approximate cloak with increasing frequency is studied. Also, a material design based on dielectric PRA cylinders is suggested, showing effective magnetic response but remaining electrically transparent.

10:30 - 12:30 — LT22

Session 2A2

Symposium: Resonant Dielectric Nanostructures and Metamaterials III

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Moti Segev and Andrey Miroshnichenko

10:30 : Keynote talk
Enabling nanophotonics with plasmonics and metamaterials
Vladimir Shalaev, A. Kildishev, A. Boltasseva

New plasmonic materials with superior properties based on transparent conducting oxides and ceramics are to be discussed. We'll also review a new approach for controlling light with meta-surfaces. New plasmonic materials and metasurfaces can make a difference for the fields of plasmonics and nanophotonics.

11:00 : Keynote talk
Variations in parametrization approaches of continuum metamaterials in two and three dimensions
Ari Sihvola

It is the objective of the present contribution to chart the alternative ways of describing and quantifying the fundamental constitutive continuum parameters of metamaterials, and present some special cases as examples how a different description may lead to simpler formalisms and possibly also convey more intuitive understanding of the physical phenomena behind the complex behavior of these interesting media.

11:30 : Invited talk
Coherent effects in the scattered radiation by small particles with high refractive index
Michael Tribelsky, Manuel Nieto-Vesperinas, Fernando Moreno

The purpose of this talk is to present a survey of scattering coherent effects (directionality, Fano resonances,

etc.) shown by small dielectric particles of high refractive index and their possible influence in applications where the advantage of the dielectric nature of materials and low losses is relevant (optimization of harvesting of natural radiation for power generation, supersensitive nanoantennas, surface enhanced applications for matter analysis, building blocks (meta-atoms) for new metamaterials design, etc).

11:50 : Invited talk
Control of the multipolar resonances of nanostructures
Gabriel Molina-Terriza, Xavier Zambrana-Puyalto, Xavier Vidal

In this contribution we present a technique to excite a single mode in a dielectric sphere. The technique is based on controlling the multipolar modes of the excitation beam by modifying its angular momentum content and the degree of focalization. This technique is amenable to be used in more complex nanostructures.

12:10 : Invited talk
Losses undermine the dual-resonant behavior of spheres
Xavier Zambrana-Puyalto, Gabriel Molina-Terriza

We characterize the dual behavior of dielectric particles depending on the losses of the material they are made of. We see that when the losses are very large, e.g. metals, particles scatter the two helicity components of light equally strongly. We relate this phenomenon to the broadening of the Mie coefficients.

10:30 - 12:10 — LT23

Session 2A3

Fundamentals of Quantum Systems in Nano-Meta-Environment I

Organized by: Arkadi Chipouline, Pavel Belov, Ildar Gabitov and Vasili Klimov

Chaired by: Arkadi Chipouline and Vasily Klimov

10:30 : Invited talk
Weak and strong coupling of quantum emitters with optical nanoantennas
Carsten Rockstuhl, J. Straubel, J. Hou, C. Bosel, K. Slowik, R. Filter

Weak and strong coupling of quantum emitters with optical nanoantennas

10:50 : Invited talk
Tunable plasmon tunneling
Shu Fen Tan, Lin Wu, Joel Yang, Ping Bai, Michel Bosman, Christian Nijhuis

By combining atomic-resolution imaging, single-particle spectroscopy, controlled nanofabrication, and quantum-corrected optical simulations, we unambiguously demonstrate the occurrence of quantum-mechanical electron tunneling at optical frequencies between plasmon resonators. Moreover, we experimentally demonstrate a method to tune the frequency of these quantum mechanical plasmon modes. Finally, we show evidence of plasmon-assisted tunneling over distances beyond one nanometer, bringing plasmon tunneling into engineering dimensions, where the fabrication of quantum plasmonic devices becomes a reality.

11:10 : Spontaneous radiation of a two-level atom into multipole modes of a plasmonic nanoparticle whose permittivity equals minus one
Eugeny Andrianov, Alexander Pukhov, Alexey Vinogradov, Alexander Dorofeenko, Alexander Lisyansky

We consider relaxation of an excited two-level system (TLS) positioned near a spherical plasmonic nanoparticle (NP). The transition frequency of the TLS coincides with the frequency of the condensation point of NP plasmonic resonances. Initially, the relaxation has the exponential character. Then, depending upon the distance between the TLS and NP, the probability of the TLS to be in the excited state, exhibits either chaotic

or nearly regular oscillations.

11:25 : Photon-number statistics from resonance fluorescence of a two-level atom near a plasmonic nanoparticle
Yulia Vladimirova, Victor Zadkov

The theory of photon-number statistics in resonance fluorescence is applied to the system two-level atom-plasmonic nanosphere-laser field. Analytical expressions for the mean and the variance are derived. It is shown that the distribution function of the emission probability of n photons in a given time interval T depends on the local field intensity and can be controlled. This distribution function showing sub-Poissonian character. The typical convergence timescale three orders of magnitude longer than for a free atom.

11:40 : Keynote talk
Optical-antenna-enhanced spontaneous emission
E. Yablonovitch, Michael Eggleston, Kevin Messer, Ming C. Wu

This talk will commence with a pedagogic description of the three most important parts of antenna physics: 1. The Radiation Resistance, 2. The Electromagnetic Capture Cross-Section, 3. The Wheeler Limit on antenna Q. These properties are encapsulated in an antenna equivalent circuit that provides us with physical understanding. Since antennas are intended to work at frequencies well below the plasma frequency, plasmonic effects are usually a minor perturbation to antenna physics, only contributing some kinetic inductance to the underlying antenna properties.

10:30 - 12:10 — LT1

Session 2A4

Liquid Crystal-based Photonic Metamaterials I

Organized by: Vassili Fedotov and Ilya Shadrivov

Chaired by: Vassili Fedotov and Ilya Shadrivov

10:30 : Invited talk
Design and control of liquid crystal superlattice forming gold nanoparticles - a route to plasmonic metamaterials
Chih Yu, Bai Tang, Christopher Schubert, M. Tamba, Chris Welch, Olusegun Amos, Xiang Zeng, X. Mang, Feng Liu, Goran Ungar, Jose Dintinger, Toralf Scharf, T. Kienzler, Carsten Rockstuhl, Georg Mehl

The design and investigationof LC organic-gold nanocomposites and the impact of the architectures on the self assembly properties and on the plasmonic properties will be discussed.

10:50 : Invited talk
Tunable and nonlinear metamaterials based on liquid crystals
Dragomir Neshev

This talk will review the advances in liquid crystal tunable metamaterials, including their electrical, thermal and all-optical tunability. In particular we show the demonstration of all-optical tunable fishnet metamaterials, electrical and thermal tuning of the spectral response of split-ring-resonator liquid crystal infiltrated metamaterials operating in the infrared and terahertz spectral ranges. The effect of the liquid crystal anchoring on the tuning range of the metamaterials will also be discussed.

11:10 : Invited talk
Liquid-crystal enabled active plasmonics
Yan Jun Liu, Eunice Sok Ping Leong, Jing Hua Teng

We will review our recent research progress on the liquid crystal based active plasmonics. Various active plasmonic devices will be demonstrated, such as switches, modulators, and filters. These active plasmonic devices are potentially useful for future development of nanophotonic circuits, light sources, imaging and displays.

11:30 : Invited talk
THz spatial light modulator made with liquid crystals metamaterials absorbers
Salvatore Savo, David Shrekenhamer, Willie Padilla

We propose an experimental demonstration of a THz spatial light modulator implemented with metamaterial absorbers functionalized with liquid crystals The device is arranged in a 6x6 pixel matrix where the response of each pixel is modulated by electronically controlling the orientation of the liquid crystals layer covering the entire metamaterial. Experiments show that each pixel can be controlled independently and that pixelated absorption patterns can be created at will. The SLM shows an modulation depth of 75 %.

11:50 : Invited talk
Liquid crystal switching in near-IR metamaterials
Y. U. Lee, E. Y. Choi, J. H. Woo, E. S. Kim, Jeong Weon Wu

Switching of transmission and reflection in near-IR meta- materials is demonstrated in liquid-crystal cell configurations. While a positive-patterned metamaterial is employed for a photo-switching of transmission, a negative-patterned metamaterial is of advantageous to an electric switching of reflection. Spectral positions of plasmonic resonances in near-IR metamaterials are in the range of optical fiber communication, which leads to the possibility of metamaterial application to optical telecommunications.

10:30 - 12:25 — LT2

Session 2A5

Metamaterial-based Radiating and Absorbing Structures I

Organized by: Shah N. Burokur and Andre de Lustrac

Chaired by: Shah N. Burokur and Andre de Lustrac

10:30 : Invited talk
Metamaterials-based antennas: From concepts to technology
Zhi Ning Chen, Xiangming Qing, Jin Shi, Chean Khan Goh, Mei Sun, Pui Yi Lau, Wei Liu

This paper updates the progress in the applications of metamaterials-based antenna engineering at microwave bands. Based on the scientific concepts of metamaterials, the new technologies have been developed to greatly enhance the performance and reduce the volume of antennas. First, the strategy of research and development of metamaterials-based antenna technologies is introduced. Then, the metamaterials-based antennas are shown. Last, some comments on the research and development of metamaterials in antenna engineering are also made.

10:50 : Invited talk
Blind spot mitigation in hased array antenna using bed of nails
Thomas Crepin, Cedric Martel, Benjamin Gabard, Fabrice Boust, Jean-Paul Martinaud, Thierry Dousset, Pablo Rodriguez-Ulibarri, Miguel Beruete, Claudius Loecker, Thomas Bertuch, J. A. Marcotegui, Stefano Maci

In this work, a metamaterial based on a fakir's bed of nails is used to suppress the blind spot of a phased array antenna. The main characteristics of the metamaterial have first been determined with analytical formulas before a numerical optimization. The 100-element antenna and a metaradome have been manufactured and tested. The experimental results show a clear reduction of the blind direction when the metaradome is attached to the antenna.

11:10 : Invited talk
Composite right/left handed metamaterial based leaky wave antennas
Arokiaswami Alphones, Manisha Mujumdar, Jin Cheng

This review paper presents the concepts of Composite Right/Left handed (CRLH) as applicable to Leaky wave antennas. The transmission line aspects of CRLH have been discussed. The equivalent circuit and the dispersion diagram characteristics have been provided for a general CRLH TL. A few CRLH LWA structures have been discussed with their results.

11:30 : Invited talk
Design and model of wideband absorber made of ultrathin metamaterial structures
Alexandre Sellier, Tatiana Teperik, Shah Nawaz Burokur, Guy Sabanowski, Gerard-Pascal Piau, A. de Lustrac

A planar microwave ultrathin broadband absorber is proposed. It is composed of metallic patterns arranged on a dielectric material, which is backed by a metallic plate. The patterns of different dimensions allow to judiciously design absorption peaks at specific frequencies of interest. Numerical and experimental results are presented to validate the proposed method at microwave frequencies. Then a theoretical model is proposed to analyze the physical behavior of this ultrathin absorber.

11:50 : Invited talk
Fractal metamaterials in antennas, absorbers, invisibility cloaks, and radiative transport and transfer
Nathan Cohen

We summarize the practical advantages and enabling applications posed by using fractal shaped resonators in metamaterials. The smaller size and efficiency of suitably chosen fractal resonators produces metamaterials with controllable multiband and wideband performance, thinner metasurfaces, higher gain and more directional behavior (if desired), new families of wideband and pattern-controlled antennas, quasi black-body absorption, a new method of radiative transfer and transport and power dissipation, and practical invisibility cloaks.

12:10 : Dual-band infrared absorption in symmetrical perfect absorber metamaterials
Yongqian Li, Lei Su, Binbin Wang, Zili Zhou

Electromagnetic optical properties of one perfect absorber metamaterials (PAMs) were theoretically and numerically investigated at infrared region. A typical cross-shaped nanostructure exhibiting dual-band absorption was chosen, and effective-medium methods were used to determine the effective permittivity and permeability. The field distributions were probed within the nanostructures to determine the effects of absorption in multiplex plasmonic resonance materials and were simultaneously microscopically analyzed. The work presents an intuitive and original understanding of the effects of dual-band absorption in PAMs.

10:30 - 12:30 — LT3

Session 2A6

Recent Advances in Active and Passive Nano-Particle Systems I

Organized by: Samel Arslanagic and Radu Malureanu

Chaired by: Samel Arslanagic and Radu Malureanu

10:30 : Invited talk
Au-fluorophore nanohybrids: Experimental evidence of the plasmonic Dicke effect
Miguel Comesana-Hermo, Pierre Fauché, Serge Ravaine, Renaud Vallee

In our work we show experimental evidence for the formation of plasmonic superradiant states in a system composed by gold nanoparticles (NPs) decorated with emitters of different nature (organic fluorophores or

inorganic quantum dots (QDs)). The system has been designed by the coating of Au NPs with a homogeneous silica shell that works as spacer while endowing the system with an improved colloidal stability.

10:50 : Invited talk
Circular sector-like nanoantennas for plasmonic applications
Valentyn Volkov, Vladimir Zenin, Anders Pors, Zhanghua Han, Rene Eriksen, Sergey Bozhevolnyi

Gold circular sector-like nanoantennas on glass are investigated in a near-infrared wavelength range. We demonstrate that such configuration features a resonant excitation of standing wave of slow surface plasmons, travelling coherently between a taper and the opposite circular edge of antenna. Higher field enhancement and better predictability of frequency response therefore make circular sector-like nanoantennas more attractive for applications, compared to widely used triangular nanoantennas.

11:10 : Invited talk
From nano-particle to macro-impact: nanopartical-decorated 3D carbon scaffolds
D. Bruce Burckel

Interferometric lithography is used to create 1D/2D/3D photoresist patterns which are converted to amorphous carbon via pyrolysis. These structures can be modified with nanoparticles and make excellent platforms for interaction with a wide variety of nanoparticles. As a research platform, these structures allow the macroscopic observation of behaviors unique to the attached nanoparticles.

11:30 : Invited talk
Giant cascaded four-wave mixing effect in tapered plasmonic nanoantennas embedded in a nonlinear dielectric background
Ivan Maksymov, Andrey Miroshnichenko, Yuri Kivshar

We theoretically study the cascaded four-wave mixing(FWM) in a broadband tapered plasmonic nanoantenna embedded in a nonlinear indium-tin-oxide (ITO)background. In comparison with ITO without the nanoantenna, we demonstrate a 300-fold increase innonlinear frequency conversion. This is achieved by tuning the elements of the nanoantenna to resonance frequencies involved in the cascaded FWM interaction.

11:50 : Invited talk
Novel optical features in asymmetric nanoparticle systems
Rasoul Alaee, Mohammad Albooyeh, Constantin Simovski, Falk Lederer, Carsten Rockstuhl

We discuss the optical properties of complicated nanoparticles made from coupled asymmetric plasmonic nanopatches. This structure possesses a bianisotropic response that renders the meta-atom to act as an omega particle. In contrast with conventional omega particles, its resonance frequency and strength can independently be tuned. This unprecedented tunability makes it possible to achieve extraordinary characteristics such as perfect absorption and zero-backscattering, which are practically impossible to observe with conventional omega particles.

12:10 : Invited talk
Modelling and computation for nanoparticle reconstruction using Electron Energy Loss Spectroscopy
Mirza Karamehmedovic, Lars Kiewidt, Thomas Wriedt

Concerning the Electron Energy Loss Spectroscopy, we describe and discuss important issues that arise in the mathematical modelling and the numerical implementation of forward models based on discrete sources. We pay special attention to a Generalized Multipole Technique (GMT) and to the Null-Field Method with Discrete Sources (NFM-DS) of T-Matrix type.

10:30 - 12:30 — LT4

Session 2A7

A Bottom-up Approach Towards Metamaterials and Plasmonics I

Organized by: Dorota Pawlak and Wounjhang Park

Chaired by: Dorota Pawlak and Wounjhang Park

10:30 : Invited talk
Optical characterization of self-assembled magnetic meta-atoms
Philippe Barois, Virginie Ponsinet, Aurelie LeBeulze, Etienne Duguet, Stephane Mornet, Mona Treguer

We present an optical study of a series of Raspberry-like nanoclusters of plasmonic nanoparticles of various sizes. We show the evolution of the magnetic response with the size of the plasmonic satellites. We quantify the degree of anisotropy of the optical response.

10:50 : Invited talk
3D Optical metamaterials by self-assembly and templated directed solidification of eutectics
Paul V. Braun

Integration of materials in three dimensions is critical for realization of highly functional optical metamaterials. Starting with structures enabled via eutectic solidification, our team is applying unique template-based and post-synthetic materials transformations in conjunction with powerful computational design tools to develop the scientific underpinnings of, and to produce, 3D metamaterials derived from directionally solidified eutectics. Our approach involves close interactions among computational design, photonic theory, eutectic materials development, template fabrication, materials chemistry, and optical characterization.

11:10 : Invited talk
Linear and nonlinear optical properties of semiconductor based metamaterials
Concita Sibilia, Alessandro Belardini, Alessio Benedetti, Grigore Leahu, Dorota A. Pawlak, Marcin Gajc, Pawel Osewski, Katarzyna Sadecka, Andrzej Stefanski, Andrzej Klos

We report the optical characterization of ZnO eutectic composites by means of different techniques: linear transmission and reflection, scattering measurements and second harmonic generation.

11:30 : Invited talk
Direct laser writing: Principles, materials and applications
Elmina Kabouraki, Aggelos Xomalis, George Kenanakis, Maria Kafesaki, Maria Farsari

We summarize the principles of Direct Laser Writing microfabrication, and present our recent work in materials processing and functionalization of 3D structures.

11:50 : Invited talk
A loss compensation condition and SPASER frequency for plasmonic nanoshell assisted by optical gain media
Vitaliy Pustovit, Arkadi Chipouline, Dean Brown, Tigran Shahbazyan, Augustine Urbas

We here presents the first unified theory of the response of plasmonic nanoshells assisted by optical gain media. We derive a fundamental equation for calculation of SPASER frequency which we claim to be valid for any type of SPASER physical geometry. We demonstrate that ONLY radiative losses are responsible for the spasing and loss compensation process in the laser resonator.

12:10 : Invited talk
Active and tunable magnetoplasmonic metasurfaces
A. Dmitriev

We implement a magnetoplasmonic bottom-up metasurfaces that consist of nanoantennas with nanoplasmonic (Au) and ferromagnetic elements, prompting us to modulate the phase and amplitude of light at subwavelength scale with external magnetic field. For the plasmonic modulation of magneto-optics, we devise a concept

of magnetoplasmonic anisotropy, where magneto-optic response of anisotropic nanoferromagnets is entirely defined and tailored at will over the vis and near-IR range by the effective combination of nanoplasmon axis and magnetization direction of the nanoparticle.

10:30 - 12:25 — LT5

Session 2A8

Active and Tunable Metamaterials I

Organized by: Zhengtong Liu, Dongying Li and Yaxin Yu

Chaired by: Zhengtong Liu and Yaxin Yu

10:30 : Invited talk
Real-space mapping of graphene plasmons
Rainer Hillenbrand

We demonstrate the launching and detecting of propagating and localized plasmons in graphene nanostructures by near-field microscopy. Spectroscopic real-space images of the plasmon modes allow for direct measurement of the ultrashort plasmon wavelengths and for visualizing plasmon control by gating the graphene structures. The images also allow for studying the strong plasmon reflection at grain boundaries in CVD graphene and at nanoscale gaps in epitaxially grown graphene on SiC.

10:50 : Invited talk
Reconfigurable graphene metasurfaces: Determining and approaching theoretical upper bounds
Michele Tamagnone, Arya Fallahi, Julien Perruisseau-Carrier

A rigorous general theoretical framework has been developed to determine absolute upper bounds on the performances of graphene passive reconfigurable devices. These limits are related only to graphene conductivity and are independent of the geometrical structure of the device. Second, we design metasurfaces closely approaching these limits. Our analysis not only provides information on the best possible performances as a function of graphene parameters, but demonstrates how to approach them by the simplest design.

11:10 : Invited talk
Active control of THz light propagation through graphene-based electrically reconfigurable metasurfaces
Sara Arezoomandan, Kai Yang, Berardi Sensale-Rodriguez

This work studies the terahertz (THz) light propagation through graphene-based reconfigurable metasurfaces where the unit cell dimensions are much smaller than the THz wavelength. These devices, which poses deep-subwavelength unit-cell/active-region dimensions can operate as amplitude and/or phase modulators in certain specific frequency bands. The ultra-small unit-cell dimension can be advantageous for beam shaping applications.

11:30 : Invited talk
Photonic nanojets: Subwavelength detection, photodiodes, and nanoapertures
Mehdi Hasan, Alireza Samimi, Berardi Sensale-Rodriguez, Jamesina Simpson

A review of photonic nanojets was published in 2005. We summarize three key research findings relating to photonic nanojets that our group has obtained since the publication of that review article. First, photonic nanojets may be used to detect ultra-subwavelength inhomogeneities embedded within dielectric targets. Second, photonic nanojets may be used to improve the performance of photodetectors. Third, the transverse beamwidth of a photonic nanojets may be narrowed from ~1/3rd to 1/6th of a wavelength using a nanoaperture.

11:50 : Invited talk

A semi-dirac point in a photonic crystal
Ying Wu

We demonstrate that an anisotropic photonic crystal is able to produce a semi-Dirac point in the Brillouin zone center. The linear-parabolic behavior is verified by a perturbation theory. The semi-Dirac point is associated with an electromagnetic topological transition in the iso-frequency surface. This transition can be explained by an effective medium theory which also indicates the photonic crystal is a hybrid material at the semi-Dirac point.

12:10 : A nonlinear metamaterial based tunable polarizer
W. Zhang, Weiming Zhu, H. Cai, P. Kropelnicki, A. B. Randles, Y. D. Gu, J. H. Teng, A. Q. Liu

This paper presents an easy fabricated metamaterial of self-aligned bilayer structure. The metamaterial realizes polarization rotation up to 60 in THz regime. It is dynamically controlled and tunes the polarization rotation more than 10.

10:30 - 12:30 — MAS EC1

Session 2A9

Exciton-Polaritons: Basic Physics and Devices I

Organized by: Alexey Kavokin

Chaired by: Alexey Kavokin

10:30 : Invited talk
Exciton-polariton quantum emulators
Na Young Kim

We demonstrate phase-coherent high-orbital exciton-polariton condensates in various two-dimensional lattices. The orbital symmetry of the condensates can be selected by a pump rate. This polariton-lattice system can be a promising candidate towards solid-state quantum emulators.

10:50 : Invited talk
Magneto-exciton-polariton condensates
C. Schneider, J. Fischer, M. Amthor, S. Brodbeck, I. G. Savenko, I. A. Shelykh, A. Chernenko, A. Rahimi-Iman, A. Larionov, V. D. Kulakovskii, S. Reitzenstein, N. Y. Kim, M. Durnev, M. Kamp, A. V. Kavokin, A. Forchel, Y. Yamamoto, Sven Hoefling

The behavior condensates formed of exciton-polaritons, i.e. bosonic quasiparticles originating in the strong coupling regime of quantum well excitons and microcavities, in a magnetic field is studied.

11:10 : Invited talk
Microcavity polaritons: Fundamental and applications
Alberto Bramati

Polaritons are composite bosons which behave as a new type of quantum fluid: its specific properties will be presented in detail. Moreover, the strong potential for the realization of polariton-based optoelectronic and quantum devices will be discussed.

11:30 : Invited talk
Polaritonic lenses for manipulation of exciton-polariton condensates
Elena Ostrovskaya

We present experimental and theoretical results on controlled manipulation of exciton-polariton condensates.

Optically-induced soft potentials and polaritonic lenses with engineered symmetry breaking are used to create directed currents and selected angular momentum states.

11:50 : Invited talk
Polaritonics for optical integrated circuits
Alexey Kavokin

In this talk I will address the most essential characteristics of polariton lasers and comment on their applicability for quantum information processing.

12:10 : Invited talk
Nonlinear plasmon-photon interaction resolved by k-space spectroscopy
Nicolai B. Grosse, Jan Heckmann, Marie-Elena Kleemann, Ulrike Woggon

In this work, the signatures for nonlinear plasmon-photon interactions are revealed by probing the condition for momentum conservation using a k-space spectroscopic method with two independently adjustable femtosecond laser pulses that are applied in the Kretschmann geometry. The temporal and spatial overlap of the two laser pulses is varied and the plasmon-photon wave mixing signal is analyzed in k-space. The impact of mode hybridization in a three-layer glass-metal-air structure is studied in nonlinear optical experiments.

Lunch and Exhibit Inspection

12:30 - 14:00

14:00 - 16:00 — LT22

Session 2A10

Symposium: Resonant Dielectric Nanostructures and Metamaterials IV

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Vladimir Shalaev and Olivier Martin

14:00 : Invited talk
Dielectric subwavelength resonators for enhancing the magnetic field and for controlling the direction of emission
Brice Rolly, Guillaume Boudarham, Sebastien Bidault, Brian Stout, Redha Abdeddaim, Jean- Michel Geffrin, Nicolas Bonod

We report experimentally and theoretically enhancements of the magnetic field intensity higher than 2 orders of magnitude. We also designed and characterized a versatile antenna composed of an electric dipolar emitter coupled with a dielectric resonator of dielectric permittivity 6. This dielectric permittivity allows for mixing dipolar and quadrupolar modes. The high sensitivity of these modes with frequency leads to the possibility to control the forward or backward emission direction, together with a high gain in directivity.

14:20 : Invited talk
Fluorescence enhancement by a dielectric resonant cavity
Yongmin Liu, Sheng Wang, Yong-Shik Park, Xiang Zhang

We demonstrate that based on a two-dimensional dielectric annular Bragg resonator, light can be focused to a diffraction-limited spot and significantly boost the fluorescence emission. Due to the diffraction and constructive interference together with the annular focusing, the periodic ring structure converts the normal incident light into planar guided photonic modes and forms a hot spot at the center of the structure. Experimentally we observe 20-fold fluorescence enhancement, while theoretically the fluorescence emission can be increased over 1000 folds.

14:40 : Invited talk
From sensing to lensing with silicon nanostructures
M. A. Otte, V. Solis-Tinoco, B. Garcia Camara, R. Gomez-Medina, J. J. Saez, P. Prieto, M. U. Gonzalez, B. Sepulveda

We will show two applications of resonant dielectric nanostructures, as refractometric sensors and as metalenses. We will analyze the effect of the external refractive index on the magnetic multipolar resonances and radiation patterns of silicon nanostructures, discussing the configurations that are appealing for biosensing. Conversely, we will demonstrate silicon metalenses composed of arrays of nanostructures with height gradients and how they can be employed to focus the light in arbitrary shapes and to simultaneously induce polarization effects.

15:00 : Invited talk
Surface enhanced circular dichroism spectroscopy mediated by non-chiral high index dielectric nanoantennas
Aitzol Garcia-Etxarri, Jennifer A. Dionne

We explore light-matter interactions for chiral molecules in the presence of nonchiral nanoantennas. Nanostructures supporting optical-frequency isotropic electric or magnetic dipoles are sufficient to enhance locally the excitation of a molecule's chiral polarizability and consequently its circular dichroism spectrum. However, in order to achieve a net, spatially averaged enhancement, simultaneous electric and magnetic dipoles are necessary. High index dielectric nanoantenas are proposed as candidates to facilitate surface enhanced chiral spectroscopy techniques such as Circular Dichroism or vibration circular dichroism spectroscopy.

15:20 : Invited talk
Deep-subwavelength cathodoluminescence imaging spectroscopy of electric and magnetic modes in single silicon resonators
Jorik van de Groep, Toon Coenen, Albert Polman

Resonant dielectric nanoparticles are efficient optical antennas, with large scattering cross sections, and low absorption losses. The goal of this work is to study the resonant properties of individual cylindrical nanoparticles. We fabricate single Si nanocylinders from an SOI wafer. Using cathodoluminescence spectroscopy, we measure the scattering spectrum, field profiles, and angular radiation profiles of individual resonators. Using FDTD simulations, we identify the role of magnetic modes in small nanoparticles and study the influence of the substrate.

15:40 : Invited talk
Probing of magnetic and electric optical responses of silicon nanoparticles
Dmitry Permyakov, Dmitry Markovich, Anton Samusev, Andrey Miroshnichenko, Pavel Belov, Dragomir Neshev, Yuri Kivshar

We experimentally study near- and far-field properties of the magnetic and electric dipole resonances of silicon nanospheres on a glass substrate for different polarisations. By employing scanning near-field optical microscopy we are able to verify the existence of the magnetic dipole resonance of such particles by direct measurements of the near-field distribution.

14:00 - 15:20 — LT23

Session 2A11

Fundamentals of Quantum Systems in Nano-Meta-Environment II

Organized by: Arkadi Chipouline, Pavel Belov, Ildar Gabitov and Vasili Klimov

Chaired by: Arkadi Chipouline and Vasily Klimov

14:00 : Invited talk

Spatially selective broadband emission enhancement of quantum dots
Kenny Lau, Isabelle Staude, Yun Liu, Hua Chen, Zhenrong Li, Dragomir Neshev

We demonstrate broadband enhancement of quantum-dot photoluminescence through spatially selective photochemical deposition of silver nanoparticles on domain patterned ferroelectric crystals. This enhancement is a consequence of coupling of broadband plasmonic modes to the quantumdot emission.

14:20 : Invited talk
Electromagnetic wave propagation and lasing in a toroidal quantum metamaterial
Alexandre Zagoskin, Arkadi Chipouline, Evgeni Il'ichev, Robert Johansson, Franco Nori

We propose a novel type of superconducting qubits with toroidal dipole moments, and investigate wave propagation and lasing effects in a quantum metamaterial formed by such qubits coupled to a transmission line.

14:40 : Invited talk
Modal representation of light-matter interactions in plasmonic nanoresonators
Christophe Sauvan, Jean-Paul Hugonin, Philippe Lalanne

We have developed a self-consistent electromagnetic theory of light-matter interactions in nanoresonators. The theory that relies on the concept of quasinormal modes with complex frequencies is capable of accurately handling any nanoresonator with strong radiation leakage, absorption and dispersion. We use the modal formalism to revisit the concepts of LDOS and Purcell factor. We also derive a modal expansion of the imaginary part of the Green tensor, which characterizes the degree of spatial coherence in the system.

15:00 : Invited talk
Cooperative energy transfer in plasmonic systems
Vitaliy Pustovit, Augustine Urbas, Tigran Shahbazyan

We study cooperative effects in energy transfer (ET) from an ensemble of donors to an acceptor near a plasmonic nanostructure.In the cooperative regime ET takes place from plasmonic superradiant and subradiant states rather than from individual donors leading to a significant increase of ET efficiency. We present numerical results demonstrating the amplification effect for a layer of donors and an acceptor on a spherical plasmonic nanoparticle.

15:20 - 16:00 — LT23

Session 2A12

Superconducting and Quantum Metamaterials

Organized by: Nikos Lazarides

Chaired by: Nikos Lazarides

15:20 : Invited talk
Coherence and collective behavior in SQUID metamaterials
Steven Anlage, Daimeng Zhang, Melissa Trepanier, Oleg Mukhanov

Metamaterials made up of Radio Frequency (RF) Superconducting Quantum Interference Devices (SQUIDs) can display strongly nonlinear behavior over a range of parameters, including dc flux and rf power. The collective response of coupled arrays of rf SQUIDs as a function of dc magnetic field bias is observed to be surprisingly coherent. Here we examine the reasons for this coherence and quantify the limits for the collective behavior.

15:40 : Invited talk
Tunable and nonlinear superconducting terahertz metamaterials

Antoinette Taylor, Nathaniel Grady, Ranjan Singh, Li Yan, Daniel Trugman, Stuart Trugman, Quanxi Jia, Bradford Perkins, Harold Hwang, Nathaniel Brandt, Darius Torchinsky, Keith Nelson, Hou-Tong Chen

In contrast to metals, the conductivity of superconductors can be directly controlled by varying the temperature, applying magnetic fields, optical excitation, or the intrinsic nonlinearity. We exploit this to demonstrate thermal and ultrafast optical tuning of resonances in metamaterials where the conducting elements are composed of high-Tc superconductors. Finally, we observe nonlinear behavior when high currents are induced in the superconducting metamaterials by high intensity terahertz fields.

14:00 - 15:00 — LT1

Session 2A13

Liquid Crystal-based Photonic Metamaterials II

Organized by: Vassili Fedotov and Ilya Shadrivov

Chaired by: Vassili Fedotov and Ilya Shadrivov

14:00 : Invited talk
Tunable metamaterials with resonance and focusing properties
Vladimir Drachev, Satoshi Ishii, Alexander Kildishev

Tunability of metamaterials obtained by heating of liquid crystalls, 5 CB composed with plasmonic nanostructures is demonstrated. Alignment of 5 CB molecules is perpendicular to the gold surface in case of nanosctructure.

14:20 : Invited talk
Active liquid crystal-loaded metasurfaces for photonic applications
Oleksandr Buchnev

We experimentally demonstrate an active near-IR planar metamaterial (metasurface) hybridised with a liquid crystal, where the plasmonic resonance can be electrically tuned both in terms of its magnitude and wavelength.

14:40 : Invited talk
Dynamic liquid crystal metamaterials
Willie Padilla, David Shrekenhamer, Wen-Chen Chen, Salvatore Savo

Multifunctional metamaterials permit construction of novel devices which are used to modulate light. We experimentally demonstrate dynamic liquid crystal spatial light modulators which control the fundamental light interactions of surfaces by all-electronic means.

15:15 - 16:15 — LT1

Session 2A14

Metamaterials and Negative Index Materials III

Chaired by: Tie Jun Cui

15:15 : All dielectric negative refractive index metamaterial
Jong-Ho Choe, Seok Jae Yoo, Q-Han Park, Choon-Gi Choi

We designed a dielectric metamaterial having negative refractive index in the visible range. To avoid metallic

losses, we used silicon nano-cube array structures as a magnetic component of the metamaterial. The negative refraction is achieved at around 500 nm wavelength.

15:30 : Antenna optimization using metamaterial cover
Surabhi Dwivedi, Vivekanand Mishra, Yogesh Kosta

Metamaterials are materials typically engineered with artificial structures to produce electromagnetic properties that are difficult to obtain in nature. They provide engineerable permittivity, permeability, and index of refraction, andhence have drawn broad interest in the field of overall antenna size miniaturization. They have also led to possible utilization in many electromagnetic applications from the microwave to optical regime. Microstrip patch antenna suffers from the limitations like low gain and low directivity. Metamaterial cover which acts as a lens can effectively enhancethe directivity of the microstrip patch antenna.

15:45 : Antireflection coating using single layer of planar metamaterials
Li Huang, Jing-Bo Qi, Sheng-Nian Luo

We examine the antireflection coating by using single layer of planar metamaterials. Different from classical quarter-wavelength antireflection coatings, which rely on the dielectric constant of the antireflection layer, single layer of metamaterial antireflection coating works well even when the dielectric constant of the antireflection layer is close to that of its adjacent medium. Furthermore, the simulational Reflectance/Transmittance of the whole structure with metamaterial antireflection coatings are in excellent accordance with the theoretical results obtained with the interference theory.

16:00 : Tailoring radiation patterns in planar RF metamaterials
Alena Shchelokova, Polina Kapitanova, Dmitry Filonov, Alexander Poddubny, Pavel Ginzburg, Anatoly Zayats, Pavel Belov, Yuri Kivshar

We realize an indefinite media with hyperbolic isofrequency surfaces in wavevector space by employing two-dimensional metamaterial transmission lines in radio-frequency range. We demonstrate an excitation of extraordinary waves propagating in a prescribed direction controlled by the polarization handedness of localized circularly polarized emitter. Our results are supported by a solution of the Kirchhoff equations, an analytical theory, and experimental data.

14:00 - 15:40 — LT2

Session 2A15

Metamaterial-based Radiating and Absorbing Structures II

Organized by: Shah N. Burokur and Andre de Lustrac

Chaired by: Shah N. Burokur and Andre de Lustrac

14:00 : Invited talk
On-metal UHF-RFID tags based on non-bianisotropic complementary split ring resonators
Simone Zuffanelli, Gerard Zamora, Ferran Paredes, Pau Aguila, Ferran Martin, Jordi Bonache

The use of non-bianisotropic complementary split ring resonators (NB-CSRRs) as radiating elements in low-profile on-metal UHF-RFID tags is explored in this work. The radiation properties of the particle, along with the impedance matching strategy, are discussed. Based on the electromagnetic simulation, a final device is proposed.

14:20 : Invited talk
Resistive high-impedance surfaces (RHIS) as absorbers for oblique Incidence electromagnetic waves
Yenny Pinto, Julien Sarrazin, Anne Claire Lepage, Xavier Begaud, Nicolas Capet

This paper presents a thin lightweight microwave absorber suitable for space applications. The absorber is based on Resistive High Impedance Surface (RHIS) optimized to achieve reflection under -15dB in the band [2-2.3GHz] at normal and oblique incidences for Transverse Electric (TE) and Transverse Magnetic (TM) polarizations.

14:40 : Keynote talk
Meta-surface and meta-light
Cheng-Wei Qiu

Metamaterials, derived from transformation optics or negative refraction law, have been receiving intensive attention. Exciting progress has been made to pave the way from fundamental physics to real-world devices, exhibiting unprecedented light phenomena, such as cloaking, super-resolution, focusing, redistribution of photon momentum, etc. In this talk, we will present an alternative look into the realm of non-metamaterials, and see whether they can perform as equally well as, if not better than, the metamaterial counterpart. In particularly, we will introduce meta-surface and its implication of generating metalight, in order to miniaturize the bulky metamaterials. The ultrathin metasurface provides a new dimension to manipulate the light in just few hundreds of nanometer thickness, and metalight, as a consequence, has demonstrated its intrinsic capability in micromanipulation of particles.

15:10 : Constructing perfect metamaterial absorber with assembly of standing arch-shaped resonators
Xiang Xiong, Yuan-Sheng Hu, Shang-Chi Jiang, Yu-Hui Hu, Ru-Wen Peng, Mu Wang

We report in this work that with an assembly of cross-standing metallic arc-shaped resonator (ASR) assembly, polarization independent and dependent absorbance is demonstrated theoretically. We propose a metamaterial absorber design in which the metallic thin film is continuous. There is no dielectric interlayer between different metallic parts which is different from traditional absorber designs. We suggest that this continuous metal design provides a better way for heat dissipation and could be enlightening in exploring metamaterial absorbers.

15:25 : Enhanced bandwidth miniaturized patch antenna using complimentary metamaterials
Mohammad Panahi, Leila Yousefi

Complimentary metamaterials are typically designed to provide negative permittivity. Here, we have shown that these metamaterials can be designed to provide positive permeability. It has been also shown that the resultant permeability has a much slower variation with frequency when compared to other metamaterials. Using this interesting property, a metamaterial-based miniaturized antenna is developed. Since the resultant permeability has a very small frequency variation, a wide impedance bandwidth of 8.6 % is achieved for the resultant miniaturized antenna.

14:00 - 15:50 — LT3

Session 2A16

Recent Advances in Active and Passive Nano-Particle Systems II

Organized by: Samel Arslanagic and Radu Malureanu

Chaired by: Samel Arslanagic and Radu Malureanu

14:00 : Keynote talk
All-dielectric nanophotonics: from magnetic light to Fano metasurfaces
Yuri Kivshar

We review our recent results on the all-dielectric nanophotonics structures such as nanoantennas, nanoantenna arrays, oligomers, and metasurfaces. First, we demonstrate useful functionalities and radiation efficiencies of nanoantennas in the form of isolated nanoparticles with a notch or Yagi-Uda nanoantenna, and discuss the

strategies to achieve the super-radiative performance via the excitation of multipole magnetic resonance modes.

14:30 : Invited talk
Optical properties of symmetric oligomers: polarization-independent Fano resonances and polarization-dependent hot spots
Ben Hopkins, Wei Liu, Andrey Miroshnichenko, Yuri Kivshar, Mohsen Rahmani, Edward Yoxall, Yannick Sonnefraud, Minghui Hong, Chris Phillips, Stefan Maier

The relationship between discrete rotational symmetry in a nanoparticle oligomer and the guarantee of polarization-independent transmission is generally not well-recognized when considering Fano resonances. Here we will provide a rigorous account as to why polarization cannot affect either Fano resonances or transmission generally in symmetric oligomers. We will then, subsequently, offer insight on the use of polarization to control of the near field and associated hot spots of symmetric oligomers, despite the associated invariance of the far field transmission.

14:50 : Invited talk
Photoconductive metamaterials with giant plasmonic photogalvanic effect
Sergei Zhukovsky, Viktoriia Babicheva, Andrey Evlyukhin, Igor Protsenko, Alexander Uskov, Andrei Lavrinenko

Photoelectric properties of metamaterials comprising oriented noncentrosymmetric metallic nanoparticle arrays in a homogeneous semiconductor matrix are theoretically studied. When uniformly illuminated by a plane wave, the asymmetric shape of the nanoparticles results in electro-motive force and photocurrent without any external potential. This is the direct analogue of the photogalvanic effect existing in ferroelectric or piezoelectric crystals, e.g., bismuth ferrite. The reported plasmonic photogalvanic effect is valuable for characterizing photoconductive properties of plasmonic nanostructures, for photodetection, and for photovoltaics.

15:10 : Invited talk
Stacked dipole line source excitation of active nano-particles
Samel Arslanagic

This work investigates electromagnetic properties of cylindrical active coated nano-particles excited by a stacked electric dipole line source. The nano-particles consist of a silica nano-core, layered by silver, gold, or copper nano-shell. Attention is devoted to the influence of the source location and dipole orientation, the gain constant, and the nano-particle material composition on the electromagnetic field distributions and radiated powers. The results are contrasted to those for the magnetic line source illumination of the nano-particles.

15:30 : Invited talk
The physics of Fano resonances in symmetric oligomer geometries
Ben Hopkins, Alexander Poddubny, Andrey Miroshnichenko, Yuri Kivshar

Presented here is a robust approach for interpreting the physics of Fano resonances in oligomer structures. It is shown that the interference of nonorthogonal collective eigenmodes is sufficient to produce Fano resonances. We prove a general theorem to identify the number of collective eigenmodes that can be excited in ring-type oligomers and demonstrate that dark mode excitation is not necessary to produce Fano resonances. We thereby unify the understanding of Fano resonances for both plasmonic and all-dielectric oligomers.

14:00 - 15:40 — LT4

Session 2A17

A Bottom-up Approach Towards Metamaterials and Plasmonics II

Organized by: Dorota Pawlak and Wounjhang Park

Chaired by: Philippe Barois

14:00 : Invited talk
Bottom up approaches for engineering nanoresonators for visible light frequencies
Mona Treguer-Delapierre, Aurelie Le Beulze, Cyril Chomette, Stephane Mornet, Etienne Duguet, Serge Ravaine, Aurelien Crut, Natalia del Fatti, Etienne Pertreux, Fabrice Vallée

Development of new nano-objects for realizing new properties or functions is one of the major challenges in nanosciences and nanotechnology. Herein, we present colloidal chemistry approaches to engineer metal-dielectric nanoresonators with original architecture and their confinement-induced properties.

14:20 : Invited talk
Threading plasmonic nanoparticle strings with light
Ventsislav K. Valev, Lars O. Herrmann, Christos Tserkezis, Jon S. Barnard, Oren A. Sherman, Javier Aizpurua, Jeremy J. Baumberg

Individual plasmonic nanoparticles (NPs) are the constitutive building elements for bottom-up assembled nano- and meta-materials. At the most fundamental level these nanomaterials consists of NP chains, in which single NPs are attached together with molecules. Here we demonstrate the next stage towards achieving continuous bottom-up assembled meta- and nanomaterials. We demonstrate that ultrafast laser pulses can produce a continuous metal thread bridging the chains, thereby allowing charge transfer. A novel plasmon mode, exhibiting both chain- and rod-like features appears.

14:40 : Invited talk
A reconfigurable 3D plasmonic nanomachine
Anton Kuzyk, Robert Schreiber, Hui Zhang, Alexander Govorov, Tim Liedl, Na Liu

Active control of three-dimensional configuration is one of the key steps towards intelligent plasmonic nanomachines with desired functionalities. We lay out a multi-disciplinary strategy to create a reconfigurable 3D plasmonic nanomachine, which executes DNA-regulated conformational changes on the nanoscale

15:00 : Invited talk
Bottom-up design, fabrication and optical characterization of a bi-pyramidal gold nanopillar array embedded in a transparent and flexible substrate
Hanbin Zheng, Renaud Vallee, Rui Almeida, Thomas Rivera, Serge Ravaine

An ordered array of bi-pyramidal gold nanopillars embedded in a flexible and transparent layer of polydimethylsiloxane has been successfully fabricated. The optical response of this material can be easily tuned by varying the size of the polystyrene particles and electrodeposition time used during the fabrication process. The process relies on the self assembly of PS beads and electrodeposition of metals through the porous spaces. This process is relatively fast, highly reproducible and can be easily scaled up if desired.

15:20 : Invited talk
Dynamics of ultrafast nonlinearities of self-assembled gold gyorid metamaterials
Sang Soon Oh, Sebastian Wuestner, Andreas Pusch, Ortwin Hess

Metallic single gyroids are a novel class of self-assembled nanoplasmonic metamaterials exhibiting chiral behaviour in the visible spectrum. To investigate a nonlinear effect by thermo-modulation in a gold gyroid, we numerically simulate pump-probe experiments in the time domain. By combining a two-temperature model with the finite-difference time-domain method, we calculate the time evolution of temperature change of electrons and spectra of differential reflection for a gold single gyroid.

14:00 - 15:35 — LT5

Session 2A18

Active and Tunable Metamaterials II

Organized by: Zhengtong Liu, Dongying Li and Yaxin Yu

Chaired by: Zhengtong Liu and Ching Eng Jason Png

14:00 : Invited talk
Flexible and tunable plasmonics on soft materials
Fumin Huang, Matthew G. Millyard, Jeremy Baumberg

Here we provide an overview of our recent research on flexible plasmonics by combining metal nanostructures with soft materials. Soft materials are deformable and stretchable, which allow to continuously and reversibly tune interparticle spacing and structure of plasmonic nanodevices, therefore tuning their optical properties. We report the development of a variety of tunable plasmonic devices, ranging from elemental structures such as dimers to more complex self-assembled two-dimensional nanoparticle arrays and three-dimensional plasmonic tubes.

14:20 : Invited talk
Active surface plasmon photonics
Pierre Berini

Planar active structures for the amplification of surface plasmon-polaritons (SPPs) are of strong interest. Also of interest are planar structures for SPP photodetection. Both types of active SPP structures are discussed.

14:40 : Invited talk
Polarization-selective coupling to long-range surface plasmon polariton waveguides
J. P. Balthasar Mueller, Virginia Merk, Kristjan Leosson, Federico Capasso

We demonstrate polarization-selective coupling to long-range surface plasmon polariton waveguide modes using polarization-sensitive plasmonic antenna arrays. The polarization-sorting properties of the arrays are fully described using a simple formalism based on Stokes vectors. Polarization-controlled switching with extinction ratios greater than 30 dB was observed with coupling efficiencies comparable to those of a conventional metallic grating.

15:00 : Invited talk
Reconfigurable plasmofluidic lenses
Yongmin Liu, Chenglong Zhao, Yanhui Zhao, Nicholas Fang, Tony Huang

By utilizing laser-induced surface bubbles on a metal film, we demonstrate a plasmonic lens, named the plasmofluidic lens, in a microfluidic environment. Different from most previously reported solid-state plasmonic devices, our plasmofluidic lens is dynamically tunable and reconfigurable. We demonstrate divergence, collimation, and focusing of surface plasmon polaritons using this device. Our results show that the integration of plasmonics and microfluidics offer unprecedented opportunities to design and implement complex plasmonic elements with multiple functionalities embedded within one single device.

15:20 : Tunable terahertz metamaterials by means of piezoelectric MEMS actuators
Antonios Lalas, Nikolaos Kantartzis, Theodoros Tsiboukis

A programmable THz metamaterial, derived from the utilization of a piezoelectric controlled microgripper as a split-ring resonator (SRR), is introduced in this paper. By applying the appropriate actuation voltage on the piezoelectric microelectromechanical systems (MEMS), a reconfigurable complex medium, offering enhanced bandwidth tunability, is attained. Thorough numerical investigations, via a robust finite element method (FEM), support the efficiency and reveal the advantages of the proposed device.

14:00 - 14:40 — MAS EC1

Session 2A19

Exciton-Polaritons: Basic Physics and Devices II

Organized by: Alexey Kavokin

Chaired by: Alexey Kavokin

14:00 : Invited talk
Polaritons: condensate dynamics and their role for all-optical devices
Daniele Sanvitto, Milena De Giorgi, Dario Ballarini, Lorenzo Dominici, Gianni Lerario, Salvatore Gambino, Marco Mazzeo, Armando Genco, Fabrice P. Laussy, Giuseppe Gigli

In this paper we will review a few characterising effects, mostly related to the formation dynamics of a coherent state of microcavity polaritons and we will demonstrate that while on the one hand they provide a perfect test bed for the study of non-equilibrium condensates and coherent propagation of interacting particles, on the other hand they can also show important phenomenology which promotes them to ideal candidates for the realisation of ultrafast optical switches...

14:20 : Invited talk
THz emission from dipolariton systems
Ivan Shelykh

Dipolaritons are mixed light-matter quasiparticles formed in double quantum wells embedded in microcavities. Resonant excitation of the cavity mode can induce oscillations of the indirect exciton density with a characteristic frequency of Rabi flopping. This results in oscillations of classical Hertz dipoles array which generate supperradiant emission on a terahertz (THz) frequency. Both regimes of pulsed and continuous emission can be realized. Resulting THz signal may be sufficiently enhanced using the supplementary THz cavity tuned in resonance with the oscillation frequency.

14:40 - 16:00 — MAS EC1

Session 2A20

Plasmonics and Nanophotonics III

Chaired by: Baile Zhang

14:40 : Study of propagation of plasmon-polaritons in metallic nano-chain
Witold Jacak

Propagation of collective wave type plasmonic excitations, called plasmon-polaritons, along infinite chain of metallic nano-spheres has been analyzed including near-, medium-, and far-field contributions to plasmon interaction with all retardation effects taken into account. Weakly damped self-modes of plasmon-polaritons in the chain were identified for which the propagation range is limited by relatively small Ohmic losses only. Completely undamped collective waves are described for the presence of persistent external excitation of some fragment of the chain.

14:55 : Surface lattice resonances in plasmonic nanorod arrays
Aimi Abass, Said Rodriguez, Jaime Gomez Rivas, Bjorn Maes

Radiative coupling between localized surface plasmon resonances (LSPRs) and Rayleigh anomalies (RAs) gives rise to the mixed states: surface lattice resonances (SLRs). These SLRs can have very narrow linewidth while still providing a large near field enhancement. Here we discuss the tuning of SLR modal properties in

periodic arrays of metallic nanorods through controlling the nanorods' width. Variable angle light extinction measurements were done for five arrays and simulations were done to explain the results.

15:10 : Periodicity induced symmetry-breaking in a Fano metamaterial
Chen Yan, Olivier Martin

We investigate theoretically and experimentally the role of periodicity on the optical response of dolmen plasmonic arrays that exhibit a Fano lineshape. We show that the periodicity, which determines the near-field coupling between neighboring structures, has a dramatic influence on spectral features. High tunability is verified experimentally with dark-field measurements on nanostructure arrays with varying lattice constants. This effect, originated from symmetry-breaking and selective enhancement of the subradiant mode, can be used for the sensitive detection of local perturbations.

15:25 : Invited talk
Proximity interactions of free-electrons with metamaterials and plasmonic nanostructures
Jinkyu So, Kevin MacDonald, Nikolay Zheludev

We introduce an optical fiber platform to interrogate the proximity interaction between free electron evanescent fields and photonic nanostructures at optical frequencies. Conically profiled optical fiber tips are functionalized with nano-gratings, thin silver film on nano-gratings, and metamaterials for the detection, amplification, and controlled coupling of electron evanescent fields.

15:45 : Plasmon-gain interplay: Loss compensation routes in meta-structures
Antonio De Luca, Melissa Infusino, Rakesh Dhama, Alireza R. Rashed, Roberto Bartolino, Giuseppe Strangi

The performance of all metamaterial-based applications is significantly limited by the inherent and strong energy dissipation present in metals, especially in the visible range. We experimentally demonstrate that the incorporation of gain material (fluorophores) in the high-local-field areas of metamaterial nanostructures makes it possible to induce resonant energy transfer processes from gain units to plasmonic nanostructures.

Coffee Break and Exhibit Inspection

Session 2P1

Poster Session IV

16:00 - 16:45

P1: Photoacoustic spectroscopy measurement for plasmonic nanobubbles induced in gold nanorods colloid
Shang-Yung Yu, Jiunn-Woei Liaw, Shiao-Wen Tsai

The photoacoustic (PA) signal of nanobubbles of a larger number of gold nanorods (GNRs), induced by the irradiance of nanosecond pulsed laser, was studied using PA spectroscopy. These nanobubbles are formed due to plasmonic heating of GNRs. Consequently, the cavitation each nanobubble emitts a tiny shock wave, and then the PA signal is generated. Through a focused ultrasonic transducer, the PA signals of two different wavelengths, one at LSPR and the other off-resonance, were measured.

P2: Metal enhanced fluorescence by silver oblate spheroid
Jiunn-Woei Liaw, Chu-Chuan Huang, Mao-Kuen Kuo

Plasmonic effect of a silver island film (SIF) on metal enhanced fluorescence is studied theoretically. The SIF can be modelled as a nanosized oblate spheroid. The excitation rate of the excitation stage and the apparent quantum yield of the emission stage of a molecule above the short-axis vertex of the oblate spheroid irradiated by a plane wave are analyzed numerically. The enhancement factor, the combination of the two factors, is calculated to evaluate the overall performance of MEF.

P3: Discrete diffraction below the diffraction limit in a plasmonic nanocircuit

Arian Kriesch, Ho W. Howard Lee, Daniel Ploss, Stanley Burgos, Hannes Pfeifer, Jakob Naeger, Harry Atwater, Ulf Peschel

We demonstrate discrete plasmon diffraction in an array of highly confined (300nm)surface plasmon polariton (SPP) gap waveguides that constitutes a 2D metasurface.

P4: A molecular electronic plasmon source
Wei Du, Albert Wan, Zhaogang Dong, Nikodem Tomczak, Joel K. W. Yang, Christian Albertus Nijhuis

Tunneling current has been used to excite plasmons. Here, a new molecular electronic plasmon source is developed and opens the door to integration of plasmon sources on a chip. The molecular junction is fabricated with a well-established EGaIn-technique. Mechanisms of plasmon excitation, efficiencies and dynamic aspects of the junctions are investigated.

P5: Gigahertz vibrations in a graded plasmonic-phononic crystal
Paul Otsuka, Ronald Ulbricht, Timothy Kelf, Istvan Veres, Sumeet Mahajan, Jeremy Baumberg, Motonobu Tomoda, Osamu Matsuda, Oliver Wright

We investigate the gigahertz vibrational field in a plasmonic structure consisting of a graded periodic array of gold nanovoids. The effect on the vibrational response of varying both the geometry and probe parameters is investigated. We show that the main vibrational resonance shifts to higher frequencies with increasing nanovoid size. A finite element time domain simulation is shown to be in good agreement with experimental results.

P6: CMOS-compatible switchable plasmonic perfect absorber in the mid-infrared
Andreas Tittl, Behrad Gholipour, Long Cui, Cesare Soci, Harald Giessen

We present a detailed numerical analysis and preliminary experimental results for a CMOS-compatible switchable plasmonic perfect absorber based on the phase-change material GST. Our design incorporates an array of aluminum nanopatches above a GST spacer layer and an aluminum mirror, targeting the atmospheric window, which is of great importance for infrared detection.

P7: Near-field confinement in 3D SRR metamolecules for optical refractive index sensor
Pin Chieh Wu, Hsiang Lin Huang, Kuang-Yu Yang, Ta-Jen Yen, Din Ping Tsai, Hai-Pang Chiang

We experimentally and numerically study the refractive index sensing characteristics of plasmonic arrays composed three-dimensional (3D) split ring resonators (SRRs) at optical region. Due to the strong near-field enhancement in free space, it is demonstrated that the sensitivity of 3D SRR structures (with 60 nm prong length) is at a high value as 796.9 nm and 603.3 nm per refractive index unit in simulation and measurement, respectively. These results pave a promising candidate for label-free sensor chips and biophotonics.

P8: Gigahertz acoustic modulation of light in nanoscale plasmonic waveguides
Yuta Nomura, Motonobu Tomoda, Osamu Matsuda, Leon Webbers, Matthias Wulf, Kobus Kuipers, Oliver Wright

Surface plasmon polaritons (SPP) are promising excitations for the miniaturization of optical circuits, and are hoped to contribute to next-generation nanophotonic devices. For this purpose, many techniques to control surface plasmon polaritons involving active plasmonics have been demonstrated.In this work we report on the modulation of SPP in plasmonic nanoscale waveguides by the use of gigahertz acoustic waves. We demonstrate the interaction between the SPP and such acoustic waves with an ultrafast optical technique.

P9: Plasmonic generation of droplet microreactors for fabrication of Ag nanoparticles
Susan Skelton, Satoshi Kawata

Droplet microreactors are ideal vessels for the synthesis of monodisperse metallic nanoparticles. We present a new, all-optical, method for the generation of droplet microreactors. By exploiting the local optical field enhancement near a plasmonic substrate, we generate femtoliter aqueous droplets suspended in an organic solvent near the boundary between an aqueous solution and a hydrophobic solvent. Furthermore, we use optical forces to controllably fuse droplets containing suitable reagents to initiate a chemical reaction and

hence synthesize Ag nanoparticles.

P10: Periodic dielectric and metallic nanostructures: A novel template for tuning the emission properties of semiconductor quantum dots
Zhang-Kai Zhou, Xuehua Wang, Dang Lei, Huanjun Chen

We demonstrate the emission properties, including the profile and lifetime dynamics, of semiconductor QDs can be significantly tuned using dielectric and plasmonic nanostructures based on anodic aluminum oxide (AAO) templates. Remarkable spectral modification and large total decay rate enhancement in the photoluminescence of QDs are observed when they are deposited on a pristine AAO template. In addition, the photoluminescence intensity of the QDs can also be largely enhanced using AAO templates loaded with metallic nanowires that sustain plasmon resonances.

P11: Aperiodic single-pixel angle-modulated plasmonic color sorter and angle sensor
Matthew Davis, Ting Xu, Christopher Bohn, Henri Lezec, Amit Agrawal

We demonstrate the design, simulation and experimental realization of a single aperiodic slit-groove plasmonic device that exhibits angle-selectable RUK color response at optical frequencies. The structure, designed using an optimization algorithm, demonstrates both high quality-factor and optical contrast while exhibiting a full-color optical response.

P12: Planar plasmonic super-resolution achieved using alternately arranged insulator-metal and insulator-insulator-metal composite structures
Bo Han Cheng, Kai Jiun Chang, Yung-Chiang Lan, Din Ping Tsai

This work develops and analyzes a planar super-resolution device at visible frequencies that is based on alternately arranged insulator-metal (IM) and insulator-insulator-metal (IIM) composite structures. The proposed device overcomes which limitation on optical diffraction limitation. Electromagnetic simulations based on FEM method are performed to verify that the design of the device has subwavelength resolution. The super-resolution of the proposed device at various visible frequencies is achieved by slightly varying the constituent materials and geometric parameters.

P13: Multipolar localized surface plasmons on thin planar textured metallic disk
Xiaopeng Shen, Tie Jun Cui, Haipeng Li

We propose and experimentally verify multipolar spoof localized surface plasmons (LSPs) on a planar textured metallic disk at microwave frequencies. The designed LSP structure demonstrates multiple plasmonic resonances experimentally, which are in good agreements to numerical simulations. Similar to optical properties of LSPs, the spoof LSPs are sensitive to the disk's geometrical parameters and environments. We present an experiment to demonstrate the high sensitivity of the spoof LSPs to the surrounding medium, showing the potential applications to sensing.

P14: General properties of the surface charge pattern of metallic gratings with subwavelength indentations
Haitao Liu, Philippe Lalanne

We report general properties of the surface charge patterns which are common to all metallic gratings over a broad spectral range. We derive analytical expressions quantifying the plasmonic character of the surface charge patterns, i.e. the contribution of surface plasmon polaritons (SPPs) to its formation. The expressions show that the SPP-contribution weight solely depends on the period-to-wavelength ratio, angle of incidence and metal permittivity, irrespective of the existence of a grating resonance or of the indentation shape and permittivity.

P15: The mode properties of the plasmonic structures with magnetoelectric or axion effect
Daria Ignatyeva, Andrey Kalish, Vladimir Belotelov, Anatoly Zvezdin

We study the mode properties of the plasmonic structures containing the materials with magnetoelectric or axion properties. Analysis of various geometries shows that the surface plasmon polariton waves in such

structures can change their polarization, localization and dispersion properties. We reveal the conditions for the enhancement of these effects.

P16: Plasmonic waveguide modes in nanocubes coupled to a metal film
Britt Lassiter, Felicia McGuire, Jack Mock, Cristian Ciraci, Ryan Hill, Antoine Moreau, Benjamin Wiley, Ashutosh Chilkoti, David Smith

In this work, we have experimentally fabricated and measured the optical properties of metal film-coupled nanocubes with varying sizes and varying gap distances separating the nanocube and the metal film. We have performed numerical simulations that show excellent agreement with the experimental results. This system can be modeled as a waveguide cavity resonator, and this model can be used to explain the observed optical properties of the film-coupled nanocube

P17: Surface plasmon polariton enhanced upconversion in rare earth doped nano crystals on plasmonic substrates
Amy Hor, Jon Fisher, Ting-Shan Luk, Mahdi Baroughi, P. Stanley May, Steve Smith

Spectroscopic imaging is used to investigate the intensity enhancement and modification of radiative rates of infra-red to visible energy transfer upconversion from rare-earth doped nanoparticles (NaYF4:Yb:Er [Tm]) on nanopillar and nanocavity array substrates, each designed to support a surface plasmon polariton at frequencies near-resonant with the sensitizer (Yb3+) absorption. Spectroscopic images, spectrally resolved reflectivity, time-resolved luminescence and Finite Difference Time Domain simulations on and off the patterened areas of the substrate confirm the role of the surface plasmon polariton.

P18: The magneto-optical phase effect in plasmonic crystals
Andrey Kalish, Vladimir Belotelov, Anatoly Zvezdin

The magneto-optical phase effects of a hybrid metal-dielectric structure are studied theoretically. An applied magnetic field alters the phase of transmitted and reflected waves. The effect demonstrates resonant behavior at the excitation of plasmonic eigenmodes in the transverse configuration. The conditions for the resonant enhancement of the effect are found.

P19: Femtosecond magneto-optics in magnetoplasmonic nanostructures
Maksim Shcherbakov, Polina Vabishchevich, Alexander Frolov, Tatyana Dolgova, Andrey Fedyanin

We disclose ultrafast manifestations of magnetoplasmonics by observing nontrivial evolution of transverse magnetooptical Kerr effect within 45-fs pulses reflected from an iron-based magnetoplasmonic crystal. The effect takes place for resonant surface plasmons excitation, has opposite signs of time derivative for different slopes of the resonance, and is addressed to magnetization-dependent dispersion relation of surface plasmons.

P20: Numerical analysis of electron-beam induced terahertz radiation from graded metallic grating based on PIC-FDTD method
Akiko Okajima, Tatsunosuke Matsui

We have numerically analyzed the interaction of electron-beam (e-beam) with the graded metallic grating and the terahertz (THz) radiation from it. We have shown that the radiation spectrum is wide band and has several sharp peaks, which cannot be explained by the conventional theory of Smith-Purcell radiation. The frequencies of the radiation peaks can be tuned arbitrarily based on the concept of the spoof surface plasmons. These results may lead to development of novel THz radiation source.

P21: On the link between optical trapping and trapping-induced resonance shift of plasmonic nanoantenna
Weihua Zhang

It was demonstrated that a plasmonic nanoantenna can trap nanoparticles (NP), and exhibit resonance shifts at the same time. In this work, we theoretically studied the connection between the optical trapping, and the associated resonance shift in the context of electric field energy. Using perturbation theory, we predicted a simple linear relationship between trapping potential and resonance shift. It not only unveils the behind

physics of trapping induced resonance frequency shift, but also opens many possible applications.

P22: Observation of quantum interference in the plasmonic Hong-Ou-Mandel effect.
Yannick Sonnefraud, G. Di Martino, M. Tame, S. Kena-Cohen, F. Dieleman, S. K. Ozdemir, M. S. Kim, S. A. Maier

We report direct evidence of the bosonic nature of surface plasmon polaritons (SPPs) in a scattering-based beamsplitter. A parametric down-conversion source is used to produce two indistinguishable photons, each of which is converted into a SPP on a metal-stripe waveguide and then made to interact through a semi-transparent Bragg mirror. In this plasmonic analog of the Hong-Ou-Mandel experiment, we measure a coincidence dip with a visibility of 72 %, signature that quantum interference is clearly involved.

P23: Persistent current in a quantum ring caused by vacuum fluctuations of electromagnetic field
Oleg Kibis, Oleksandr Kyriienko, Ivan Shelykh

We study theoretically interaction between electrons in a quantum ring embedded in a chiral microcavity and vacuum fluctuations of electromagnetic field in the cavity. It is shown that the fluctuations lead to nonzero magnetic moment of the ring. As a consequence, the structure forms a basis for novel metamaterials (optical metamagnets) which are expected to have intriguing properties.

P24: Surface plasmon scattering in polymer and low molecular-weight organic light emitting materials
Syogo Kawasaki, Hiroto Kawase, Takahiro Inui, Kenichi Kasahara, Naoki Ikeda, Yoshimasa Sugimoto

We have compared the enhancement spectra due to surface plasmon scattering between the polymer and low molecular-weight organic light emitting materials to understand the mechanism of the enhancement peak wavelength shifts occurringin the latter. The difference suggested that generated light along with the plasmon scattering in the low molecular-weight organic materials was affected by Forster energy transfers.

P25: Third-harmonic spectroscopy of electric and magnetic resonances in all-dielectric oligomers
Maxim Shcherbakov, Dragomir Neshev, Alexander Shorokhov, Isabelle Staude, Elizaveta Melik-Gaykazyan, Ben Hopkins, Jason Dominguez, Andrey Miroshnichenko, Igal Brener, Andrey Fedyanin, Yuri Kivshar

We perform third harmonic generation (THG) spectroscopy of silicon nanodisk oligomers to reveal the contributions of magnetic and electric dipolar resonances to the third-order nonlinearity. By changing the oligomer geometry we bring both resonances to a partial overlap, which causes a strong THG enhancement for wavelengths of the strongest overlap. This effect is explained in the framework of constructive interference of the third harmonic signal generated by the electric and magnetic dipolar resonances.

P26: Observation of fano resonances in all-dielectric heptamers
Katie Chong, Ben Hopkins, Isabelle Staude, Andrey Miroshnichenko, Jason Dominguez, Manuel Decker, Dragomir Neshev, Igal Brener, Yuri Kivshar

While Fano resonances in nanoparticle clusters have been predominately studied in the plasmonic area, the recent observation of magnetic resonances in low-loss dielectric nanoparticles suggests that Fano resonances are achievable in all-dielectic nanoparticles. Here we study light scattering by all-dielectric heptamers composed of silicon nanoparticles. We observe pronounced Fano resonances driven by magnetic modes as well as their tuning behaviour when the diameters of the heptamers' central particles are varied. The experimental results show good agreement with numerical calculation.

P27: Selective binding of quantum dots for all-dielectric nanophotonics
Isabelle Staude, Varun Sreenivasan, Ivan Shishkin, Kirill Samusev, Manuel Decker, Dragomir Neshev, Andrei Zvyagin, Yuri Kivshar

We demonstrate a new approach for selective binding of semiconductor core-shell quantum dots (QDs) to transparentall-dielectric substrates with nanoscale resolution. Our approach is compatible with standard nanofabricationschemes and it does not rely on the presence of metals,making it suitable for coupling QDs to

all-dielectric nanoresonators.

16:45 - 18:25 — LT22

Session 2A21

Symposium: Resonant Dielectric Nanostructures and Metamaterials V

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Fernando Moreno and Ari Sihvola

16:45 : Invited talk
Controlling light in all-dielectric metamaterials with magnetooptics and nonlinearity leads to dramatic superfocusing energy concentrators
A. Boardman, P. Egan, Y. G. Rapoport

A general theory of magnetooptic waveguides is developed that embraces Cotton-Mouton, Polar and Faraday orientations. Detailed light control is examined together with role of polarization interactions, as the nature of the metamaterial is changed towards an effective zero index.

17:05 : Invited talk
Amplitude, phase, polarization and spectral degrees of freedom in dielectric metamaterials
Boris Desiatov, Avner Yanai, Meir Grajower, Liron Stern, Yeshaiahu Fainman, Uriel Levy

We analyze the various degrees of freedom in dielectric metamaterials including amplitude, phase, polarization and wavelength response. Furthermore,we demonstrate the functionality of dielectric thin layer meta surfaces and compare their performances with metallic metasurfaces.

17:25 : Invited talk
Resonant directional scattering and light extraction with silicon nanodisks
Isabelle Staude, Andrey Miroshnichenko, Manuel Decker, Nche Fofang, Sheng Liu, Edward Gonzales, Jason Dominguez, Ting Luk, Dragomir Neshev, Igal Brener, Yuri Kivshar

Subwavelength silicon nanodisks support electric and magnetic Mie-type resonances which can be tuned independently via the nanodisk geometry. Here we employ arrays of silicon nanodisks with engineered resonances to demonstrate directional far-field scattering as well as shaping of the emission spectra of semiconductor quantum dots. Our results suggest a novel approach for utilizing controlled interference of different Mie-type modes of all-dielectric nanoparticles for functional metasurfaces and highly directional nanoantennas.

17:45 : Invited talk
Creating optical analogous of Casimir and Van der Waals forces with light through photonic magnetism. A new paradigm to control these interactions with partially coherent light
Manuel Nieto-Vesperinas, Juan Miguel Aunon, Cheng Wei Qiu

We create randomly fluctuating electromagnetic radiation at near-infrared and optical wavelengths, and its mechanical action on bodies is equivalent to Casimir and van der Waals forces. This is a novel way of control of these interactions through partial coherence of light. Dielectric nanoparticles with magnetodielectric behavior to this illumination present a rich landscape of optical forces through the excitation of their electric and magnetic dipole resonances.

18:05 : Invited talk
Achieving novel optical effects by independently manipulating angular momenta components with opposite signs in dielectric rods
Junjie Du, Zhifang Lin, S. T. Chui, Aimin Wu, Fuwan Gan, Weiping Zhang

We will demonstrate some interesting optical phenomena such as total omnidirectional reflection and negative transmission by a single layer of high-permittivity(high-) dielectric nanorods. Different from the optical band structure theory of photonic crystals and the effective medium theory of metamaterials, these effects are caused by the independent manipulation of the angular momenta(AM) components with opposite signs in the Mie expansion of the scattering field of two-dimensional infinite rods. In this talk,we also will demonstrate a wide-band mechanism and report our recent experimental work on these effects.

16:45 - 18:05 — LT23

Session 2A22

Superconducting and Quantum Metamaterials

Organized by: Nikos Lazarides

Chaired by: Nikos Lazarides

16:45 : Invited talk
Guiding magnetic fields with superconducting-ferromagnetic metamaterials
Jordi Prat-Camps, Carles Navau, Alvaro Sanchez

We report on how transformation optics applied to static magnetic fields results in a new variety of new possibilities for transmission and guidance of magnetostatic energy. Cases of cloaking, energy concentration and field guidance and transmission are discussed in particular. It is also discussed why static magnetic fields make an ideal case for application of these ideas. Some cases of interests will be also experimentally demonstrated using superconducting and ferromagnetic hybrid systems.

17:05 : Invited talk
SQUID metamaterials: Tuneability and multistability
George Tsironis, Nikos Lazarides

An overview of several dynamic properties of SQUID metamaterials is given in the presence of a magnetic field. The total current as a function of the driving frequency exhibits hysteresis, which is favored by weak disorder. Multistability leads to multiple magnetic responses with different value of magnetic permeability. SQUID metamaterials exhibit periodic, wide-band tuneability, the numerical calculations reproduce fairly well recent the experimental results. Current work reveals the possibility for wave transmission through nonlinear bands.

17:25 : Invited talk
Microwave photonics and Josephson junction parallel arrays
Uta Naether, David Zueco, Juan Mazo

We study the scatering properties of a Josephson-junction parallel array embeded on superconducting transmission lines. Results are shown for varios input/output geometries and as a function of the number of junctions in the array. Special attention is put in the study of the scattering of arrays with different number of fluxons. The ground state problem of the system is analised in the framework of the standard theories.

17:45 : Invited talk
Low-loss and nonlinear superconducting THz metamaterial
Biaobing Jin, C. H. Zhang, J. B. Wu, L. Kang, W. W. Xu, J. Chen, P. H. Wu, I. Kawayama, H. Murakami, M. Tonouchi

We report here our recent works on superconducting (SC) THz metamaterials (MM) made of SC NbN thin films. Due to the low surface resistance of the film, a low ohmic loss of the SC THz MM is obtained below the frequency corresponding to the energy gap of the film. We also investigate the nonlinear effect of SC NbN films under a strong THz pulse and the obvious nonlinear effect is observed. Then, a SC THz MM is investigated.

16:45 - 18:25 — LT1

Session 2A23

Metamaterials and Negative Index Materials IV

Chaired by: Jing Hua Teng

16:45 : Keynote talk
Ultrahigh-efficiency solar cells based on dielectric metamaterial design
Albert Polman

We present novel dielectric metasurface and metamaterial architectures that can lead to solar cells with ultra-high efficiency.

17:15 : Keynote talk
Light produces a nano-forest of trees as metamaterials
Satoshi Kawata

There have been a variety of methods proposed for the fabrication of metamaterials. Among them we have proposed and reported three-dimensional laser drawing of micro/nano structures based on two-photon photo-polymerization and the selective metal coating on the fabricated polymer structures. We also invented direct two-photon photo-reduction of metal structures in three dimensions.

17:45 : Invited talk
Harvesting energy using metamaterials
Omar M. Ramahi, Mohammed AlShareef, Thamer Almoneef

Metamaterials are made of an ensemble of electrically-small resonators. Resonance of each particle of a metamaterial is fundamentally indicative of its ability to store energy. Metamaterials, therefore, can be effective energy harvesters. This does not come as a surprise since metamaterials have been shown to be effective absorbers. However, in the case of absorption, the absorbed energy is mostly dissipated in the dielectric host.

18:05 : Invited talk
Resonating metasurfaces
Xiaobo Yin, Xiang Zhang

The ubiquitous spin-orbit interaction destroys the rotational symmetry of particles spin degree of freedom and introduces a universal transverse spin current regardless the particle nature of being photon or electron. Here we show an optically thin metasurface with a rapid phase gradient over the wavelength scale refracts light anomalously and supports negative spin-orbit interaction when light is negatively refracted.

16:45 - 17:35 — LT2

Session 2A24

Metasurfaces at Terahertz, Infrared and Optical Frequencies III

Organized by: Tahsin Akalin

Chaired by: Tahsin Akalin

16:45 : Invited talk
Full vector terahertz field modulation based on metasurface
Yan Zhang, Tahsin Akalin

Field modulation is quite important for communications, imaging, and other applications of the electromagnetic radiation. Many methods have been proposed to alter the phase, intensity, polarization of the wave front for achieving better results, for example, small focusing point, high resolution imaging, special field distribution, and vortex beams. Metasurface is a kind of subwavlength antenna array which can modulate the amplitude, phase, and polarization of illuminating light simultaneously with a subwavelength resolution.

17:05 : Programmable terahertz metamaterials through V-beam electrothermal devices
Antonios Lalas, Nikolaos Kantartzis, Theodoros Tsiboukis

A reconfigurable THz complex medium, obtained from the embedment of a V-beam electrothermal actuator as a tuning mechanism in a split-ring resonator (SRR), is proposed in this paper. When the appropriate actuation voltage is applied on the electrothermal microelectromechanical systems (MEMS), a controllable metamaterial, presenting enhanced bandwidth tunability at two different resonances, is accomplished. The merits of the proposed device are thoroughly examined via an acute finite element method (FEM).

17:20 : High-order plasmonic modes in nanoclocks
Hailong Liu, Hongjin Fan, Nikolay Zheludev, Cesare Soci

High-order plasmonic modes have attractive applications due to their low radiative losses and high quality factors. Here we present a new platform, the plasmonic nanoclocks, for manipulating and engineering plasmon resonant modes from dipole to triankotadipole modes. In addition, we discuss the influence of symmetry on high-order modes.

17:35 - 18:20 — LT2

Session 2A25

Plasmonics and Nanophotonics IV

Chaired by: Alberto Bramati

17:35 : Ultrafast terahertz nonlinear optics in a graphene-metamaterial device: Difference-frequency generation
Chihun In, Hyeondon Kim, Bumki Min, Hyunyong Choi

We show the first experimental demonstration of nonlinear second-order terahertz frequency generation in a graphene metamaterial device. Characteristic ultrafast nonlinear nature of graphene and strong metamaterials resonances significantly enhance the THz nonlinearity, which is otherwise impossible in graphene alone.

17:50 : Plasmonically enhanced thin film Faraday effect with up to 4 degrees rotation
Dominik Floess, Jessie Chin, Akihito Kawatani, Daniel Dregely, Hanns-Ulrich Habermeier, Harald Giessen

We hybridized thin films of magneto-optical materials with plasmonic structures and achieved 4.2 degrees of Faraday rotation for a 200 nm thick structure. This large Faraday rotation is accompanied with a reasonably high transmittance of 27 %.

18:05 : Review on the process factors limiting the performances of hole-array metallic filters
Romain Girard Desprolet, Sandrine Lhostis, Charlotte Beylier, Vincent Farys, Guy Vitrant, Salim Boutami

In this work, we evaluate through simulations the effect of various process-related inaccuracies on cross-shaped-hole arrays plasmonic filters. Working with CMOS-compatible materials, we demonstrate the potential of these structures for reliable integration at a wafer level. The influence of standard process deviations is analyzed. Optical proximity effects are simulated to estimate the patterns shape after lithography insulation. We evaluate then the impact of the metal oxidation and a sloping profile after etching.

16:45 - 18:05 — LT3

Session 2A26

PT-Symmetry in Photonics, Metamaterials and Plasmonic Systems I

Organized by: Anatole Lupu and Henri Benisty

Chaired by: Anatole Lupu and Henri Benisty

16:45 : Invited talk
Parity-time symmetry in optics
Alexander Zyablovsky, Alexey Vinogradov, Alexander Pukhov, Alexander Dorofeenko, Alexander Lisyansky

We consider pseudo-Hermitian quantum-mechanics and optics. We focus on PT-symmetric optical systems. We show that many of the unusual properties of PT-symmetric systems may also be observed in common optical systems. An exception is the phase transition with PT-symmetry breaking. It is very difficult to observe this phenomenon, however, signatures of the PT-transition in lossy systems have been found experimentally.

17:05 : Invited talk
Near-perfect optical isolation by an all order nonlinear PT-symmetric system
Xuele Liu, Subhasish Dutta Gupta, Girish S. Agarwal

Infinities associated with the spectral singularities in a PT-symmetric system imply the divergence of the fields in the medium, breaking the very assumption of the linearity of the medium, used to obtain such singularities. We identify saturable nonlinearity (with all orders of field) to limit the infinite growth and regularize the spectral singularity. The all order nonlinear PT-symmetric device is shown to exhibit near-perfect isolation or optical diode action, since transmission through such a system is nonreciprocal.

17:25 : Invited talk
Competition and re-entrant PT symmetric phase in lattice models Open systems with balanced loss and gain
Yogesh Joglekar

Please see the attached file for the talk abstract.

17:45 : Invited talk
Time-dynamical model for the optical response of a plasmonic nanoparticle immersed in an active gain medium
Alessandro Veltri, Arkadi Chipouline, Ashod Aradian

The plasmonic response of a metal nanoparticle in presence of gain elements is studied, using a time-dependent model, which integrates a quantum formalism to describe the gain and a classical treatment for the metal. Our model also fully takes into account the influence of the system geometry (nanosphere).

16:45 - 18:25 — LT4

Session 2A27

Near-Field Optics and Nano-Optics

Chaired by: Irina Khromova

16:45 : Invited talk
Structure-based sub-wavelength imaging and super-resolution in time and frequency
Oren Cohen

The last few years have witnessed important breakthroughs on developing concepts borrowed from information sciences for increasing the resolution of measurement systems beyond their fundamental physical limits. On the intuitive level, these concepts can be employed wherever the information (e.g. image, spectrum or temporal shape of a pulse) has structure, that is, the information is not random. I will will describe the basic concepts and provide examples taken from imaging, spectroscopy and diagnostics of ultrashort pulses.

17:05 : Invited talk
Active and passive near-field terahertz microcopy
Yukio Kawano

A near-field imaging technique has been well established in visible, near-infrared and microwave regions. However, the development of the near-field imaging in the terahertz (THz) region remains a formidable task, despite the important energy spectrum in the meV range of materials and biomolecules. In this work we have developed a new device and system for both active and passive near-field THz imaging in which all components: an aperture, a probe, and a detector are integrated on one semiconductor chip.

17:25 : Direct ultra-resolution imaging of plasmonic hotspots
H. L. Hu, Y. Ma, Kassim Johnson, G. H. Yuan, L. Y. Jiang, T. T. Yin, Z. X. Shen

In this talk, we present our results on direct plasmonic field distribution using PL peaks of the plasmonic structures. We show direct evidence that the hotspots between two sharp tips and its dependence on the incident light polarization. Such observation provide critical evidence that on the plasmonic study

17:40 : All-polymer 1D photonic crystals
Paola Lova, Giovanni Manfredi, Luca Boarino, Michele Laus, Giulia Urbinati, Tonia Losco, Franco Marabelli, Valentina Caratto, Maurizio Ferretti, Maila Castellano, Giorgio Adamo, Cesare Soci, Davide Comoretto

Polymer Distributed Bragg Reflectors (DBRs) can be prepared by spin-coating of orthogonal polymer solutions. However, few polymers are suitable for DBR preparation due to low dielectric contrast joined to good processability. We loaded ZnO nanoparticles synthetized by solvothermal route into polystyrene to increase its refractive-index. All-polymer DBR are grown by such nanocomposite and cellulose acetate. They show up to the fifth order photonic band gap and are sensitive to solvent vapors exposure thus opening new perspectives into color-responsive sensors.

17:55 : Perfect Sub-diffraction-limited imaging by a metamaterial-hyperlens
Korbinian Julius Kaltenecker, Alessandro Tuniz, Boris T. Kuhlmey, Alex Argyros, Bernd Michael Fischer, Markus Walther

We demonstrate for the first time in the terahertz regime that an array of metal wires forms a metamaterial-hyperlens capable of transmitting near-field information including evanescent waves with subwavelength resolution, there by enabling perfect imaging.

18:10 : Local field polarization of a plasmonic nanoparticle interacting with a laser beam of arbitrary polarization
Yulia Vladimirova, Evgeny Chubchev, Victor Zadkov

Distributions of the local field polarization near the metal (Ag) prolate spheroidal nanoparticle, interacting with a linearly and elliptically polarized monochromatic wave and Gaussian laser beam of arbitrary polarization, have been studied theoretically in detail, giving a key to qualitative and quantitative analysis of various problems of a quantum emitter-plasmonic nanoparticle interactions, including spontaneous and resonance fluorescence of an atom, molecule, or a quantum dot in the in the close proximity of a plasmonic nanoparticle, and many others.

16:45 - 18:25 — LT5

Session 2A28

Plasmonics and Nanophotonics V

Chaired by: Hongxing Xu

16:45 : Invited talk
Ultrafast nonlinear hybrid plasmonics: Doubling the efficiency of third harmonic generation by positioning ITO and LiNbO3 nanocrystals into the hot-spot of plasmonic gap-antennas
H. Giessen, B. Metzger, M. Hentschel, T. Schumacher, M. Lippitz, B. Knabe, K. Buse, X.C. Ye, C.B. Murray

We incorporate dielectric indium tin oxide and lithium niobate nanocrystals into the hot-spot of gold nanogap-antennas and perform third harmonic spectroscopy on these hybrid nanostructure arrays. The combined system shows a twofold increase of the radiated third harmonic intensity. In order to identify the origin of the enhanced nonlinear response.

17:05 : Invited talk
Structure and surrounding dependent plasmon propagation in silver nanowires and circuits
Hongxing Xu

The propagating surface plasmons in Ag NWs depend strongly on the dielectric surroundings. The chiral plasmons propagation, the period change of the near field pattern of wire plasmons and the substrate effect are investigated here. By introducing local structural symmetry breaking, the conversion of different plasmon modes occurs widely in metallic nanowire waveguides. The different spin of incident photons can also control different plasmon modes in metal nanowires.

17:25 : Surface plasmon resonance in a two-dimensional gold nano-disk array with super-lattice voids
Boyang Zhang, Junpeng Guo

Surface plasmon resonance in a two-dimensional gold nano-disk array with periodic voids are investigated. A narrow line-width transmission peak is found between two transmission dips. The transmission and absorption spectra of the metal nano-disk array have asymmetric Fano resonance line-shapes.

17:40 : The method of excitation blue surface plasmons along thin gold film-gas interface and its use for nanoparticles study, gas sensing and biosensing
Dmitry Basmanov, Valery Konopsky, Elena Alieva, Serguei Sekatskii, Giovanni Dietler, Dmitry Klinov

We demonstrate effective method of using one dimensional photonic crystal for exciting surface plasmons along thin gold film in a blue spectral range. For 405 nm wavelength this PC structure supports ultralong surface plasmon propagation along the gold nanofilm. This structure has been tested as a sensor to detect small concentrations of nitrogen dioxide in air. This technique also were used for nanoparticles properties study, for hydrogen leakage sensing and for biosensing.

17:55 : On-chip mode transformation using mode-selective microring resonators
Lian-Wee Luo, Noam Ophir, Christine Chen, Lucas Gabrielli, Carl Poitras, Keren Bergman, Michal Lipson

Silicon photonics utilize wavelength-division multiplexing (WDM) almost exclusively in the singlemode regime which supports limited scalability inbandwidth density. Often, integrated photonics do not consider mode-division multiplexing (MDM) as handling high-order modes is complex and leads toincreased inter-modal crosstalk. Here we show the first microring-based demonstration of mode transformation with low modal crosstalk and loss. Our approach can potentially increase the overall data rate through MDM for on-chip high bandwidth communications.

18:10 : The influence of plasma dynamics on the properties of the vanadium oxide thin films deposited by KrF laser ablation of VO2 target
Bathusile Masina, Slimane Lafane, Samira Abdelli-Messaci, Lorinda Wu, Tahar Kerdja, Andrew Forbes

The plume expansion dynamics study have been carried out on vanadium-oxygen plasma generated using 248 nm, 25 ns pulses from an excimer KrF laser under oxygen atmosphere at the laser fluence of 2 Jcm-2 using a VO2 pellet. In order to study the plasma plume expansion dynamics, we have plotted the plasma plume front position against time delay at different oxygen pressure.

16:45 - 18:00 — MAS EC1

Session 2A29

Metamaterials and Negative Index Materials V

Chaired by: Xavier Begaud

16:45 : Wavevector selective surfaces
Vassili Fedotov, Jan Wallauer, Markus Walther, Nikitas Papasimakis, Nikolay Zheludev

We demonstrate for the first time that a planar metamaterial (metasurface) can act as a wavefector selective surface and tunnel vision device, effectively discriminating incident waves by their wavevectors. The effect results in arbitrary-shaped wavefronts becoming planar as they traverse the plane of the metasurface in the absence of active/passive spatial phase modulation or adaptive feedback. This new functionality of the metasurfaces can be exploited for enhancing observational instruments, long-distance free-space communications in strongly scattering/turbid environment, and new-principle cloaking.

17:00 : Demonstration of fano resonance in metamaterials composed of asymmetric double bars in optical region
Yuto Moritake, Yoshiaki Kanamori, Kazuhiro Hane

We experimentally demonstrated Fano resonances of metamaterials composed of asymmetric double bars (ADB) in optical region for the first time. The ADB metamaterials were fabricated with a lift-off method and the optical spectra were measured. The measured optical spectra clearly showed the sharp Fano resonances due to weak asymmetry of the ADB structures. Numerical calculations agreed well with the experiments except for the difference of the resonant wavelength positions.

17:15 : Trapped mode resonances in single element Z-shaped meta-atom
Abdallah Dhouibi, Shah Nawaz Burokur, Anatole Lupu, André de Lustrac

We discuss about the excitation of a trapped mode in a Z-shaped meta-atom. The electromagnetic behavior of the meta-atom has been investigated through simulations and measurements in the microwave regime. Depending on the orientation of the polarized electromagnetic field with respect to the Z atom topology and incident plane, the excitation of the dark mode can either lead to a narrowband resonance in reflection or to a very asymmetric Fano-like resonance in transmission, analog of electromagnetically induced transparency.

17:30 : Analysis of periodic strong chiral - metamaterial structures as frequency selective surfaces and polarization rotators using transfer matrix method
M. J. Mughal, S. K. Marwat, N. Amin, M. Omar

In this paper, an electromagnetic wave of millimeter wavelength is incident on multilayered metamaterial structure.Transfer matrix method is used to find the fields on either side of the structure. Field equations are the function of frequency, chirality, incident angle and length. Numerical results for both normal and oblique incident angles are presented in the paper. All the cases satisfy the power conservation law. The structure produce wide rejection bands and narrow pass bands in terahertz regime. These structures can be used in filters, radomes and polarization rotators.

17:45 : Branching behavior of field dynamics of resonators of left handed materials
Satish Inamdar

In this paper, we study dynamics of left handed materials that contain nonlinear cavities. These materials, having a negative refractive index, exhibit a nonlinear electromagnetic behavior. The objective of this work is to investigate how branching behavior can yield useful information about the relative amount of leftand right handed material controlling the diffraction in cavity.

Thursday 22nd May, 2014

08:30 - 10:00 — LT22

Session 3A1

Symposium: Resonant Dielectric Nanostructures and Metamaterials VI

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Manuel Nieto-Vesperinas and Andrey Evlyukhin

08:30 : Invited talk
Optical magnetism from dielectric resonator metamaterials
Igal Brener

In this talk I will review some of our recent work on opticalmagnetic phenomena obtained from dielectric resonatormetamaterials.

08:50 : Invited talk
Resonant tunneling of light through the gradient all-dielectric nanostructures: Theory and the first experiments
Alexander B. Shvartsburg

This research is focused on a newly shaping branch of electromagnetics on the frontier between modern photonics and design of dielectric nanostructures with technologically controlled smooth spatial distributions of refractive indices.

09:10 : Invited talk
Subwavelength circuitry based on high-index dielectric nanoparticles
Pavel Belov, Roman Saveliev, Dmitry Filonov, Alexey Slobozhanyuk, Alexander Krasnok, Andrey Miroshnichenko, Yuri Kivshar

We study the subwavelength guiding properties of arrays of high-index dielectric nanoparticles, originating from the long-range coupling of the effective electric and magnetic Mie resonance modes supported by individual nanoparticles. We analyze theoretically dispersion properties and compare the results with numerical simulations and microwave experiments. We reveal that a chain of silicon nanoparticles can guide light for the distances exceeding several tens of micrometres, and it can transmit the energy through sharp bends and defects.

09:30 : Keynote talk
From plasmonic nanostructure, toroidal metamaterial, reflective metasurface to holographic metadevice
Wei Ting Chen, Yao-Wei Huang, Pin Chieh Wu, Chun Yen Liao, Kuang-Yu Yang, Hao-Tsun Lin, Vassili Fedotov, Greg Sun, Shulin Sun, Lei Zhou, Ai Qun Liu, Nikolay Zheludev, Din Ping Tsai

In recent years, metamaterials/metasurfaces have attracted many attentions due to their ability to manipulate electromagnetic wave in arbitrary frequency regions. In this paper, we report the plasmonic metamaterials with unique optical reponses, a reflective and high-efficienc metasurfaces at optical region, and a polarization-controlled meta-hologram. Our works provide potentials to develop novel devices which are not limited by material composition.

08:30 - 10:00 — LT23

Session 3A2

Plasmonically Enhanced Nanoimaging and Nanospectroscopy I

Organized by: Prabhat Verma

Chaired by: Prabhat Verma

08:30 : Invited talk
Coupled plasmon systems: from plasmonics, to chemical reaction, and to nanospectroscopy
Bin Ren, Xiang Wang, Kaiqiang Lin, Biju Liu

We will demonstrate how to an efffective coupling between nanostructures with metallic film can be used for plasmonic transmission, plasmon-induced reaction and nanospectroscopy. Further, detailed investigation into the photoluminescence will help to understand the SERS mechanism.

08:50 : Invited talk
Nanogap-enhanced Raman scattering(NERS) controlled by DNA
Yung Doug Suh

Based on the idea that controlling nano-gap between two noble metal nanoparticles is the key to realize reliable smSERS, two gold nano particles were linked to each other by double helix DNA (30mer), with a single Raman dye molecule at the center position, to fix the two at a known gap distance (~10 nm). Then this gap was narrowed down to <1 nm by standard silver staining method to form a gold-silver nano dumbbell (GSND).

09:10 : Keynote talk
Direct ultra-resolution imaging of plasmonic hotspots
H. L. Hu, Y. Ma, K. Johnson, G. H. Yuan, L. Y. Jiang, T. T. Yin, Z. X. Shen

In this talk, we present our results on direct plasmonic field distribution using PL peaks of the plasmonic structures. We show direct evidence that the hotspots between two sharp tips and its dependence on the incident light polarization. Such observation provide critical evidence that on the plasmonic study.

09:40 : Invited talk
Multifunctional SNOM and its application in imaging optoelectric materials
Dai Zhang

Optoelectronic material is the basic component in photovoltaic, photodetector, or transistor system. In organic photovoltaic, the photon-electron conversion efficiency is influenced by the local donor/acceptor morphology, such as crystalline, or domain size. Multifunctional scanning near-field microscopy allowing simultaneously collecting correlated topographical, optical (Raman scattering and fluorescence), and photocurrent signals with nanometer scale resolutions are developed. Such a combination provides an important technique to study the local morphology and structural order related photophysical, photochemical and photodegradation of optoelectric materials.

08:30 - 10:00 — LT1

Session 3A3

Nano-Apertures and Applications I

Organized by: Sang-Hyun Oh and Reuven Gordon

Chaired by: Sang-Hyun Oh and Reuven Gordon

08:30 : Invited talk
Complex chiral colloids for visible and ultraviolet plasmonics
David Norris

Because nanoparticles have properties strongly influenced by their shape, various routes to complex geometries have been developed. Despite these advances, chiral shapes, those not superimposable on their mirror image, remain challenging.

08:50 : Characterization of nano-apertures using vertical-cavity surface-emitting lasers
Sajid Hussain, Charanjit Bhatia, Yang Hyunsoo, Aaron Danner

The goal of this paper is to characterize differently shaped nano-apertures using Vertical-Cavity Surface-emitting lasers (VCSELs), which make an excellent test bench for studying designs of nano-apertures for this work. We have fabricated 850 nm VCSELs with large arrays of differently shaped nano-apertures in a gold layer on top of each VCSEL and used statistical methods to obtain reliable indicators of performance of each aperture.

09:05 : Invited talk
Recent progress in hyperbolic and chiral metamaterials
Jun Suk Rho, Xiang Zhang

This talk will discuss recent progress in hyperbolic metamaterials including sub-diffractional hyperlens imaging and nanocavities as well as chirality induced photo-switchable negative index metamolecules. It will also cover the recent progress in scalable nanofabrication method toward 2D hyperbolic metamaterials and 3D chiral metamaterials structures.

09:25 : Manipulation of plasmonic modes in nano-structures for sensitivity enhancement of trace detection of bio-molecules
Mitradeep Sarkar, Maha Chamtouri, Julien Moreau, Mondher Besbes, Anne-Lise Cutrot, Michael Canva

Conventional SPR detectors using uniform metal film have limited performance for the detection of trace concentrations of target bio-molecules. We present a study of 2D nano-structures such as binary metallic gratings and 3D structures such as nano-cylinder arrays. We show that all of these structures exhibit a field enhancement at certain areas. By selective localization of the target molecules in these areas we can enhance the response of the SPR detector, while using fewer amounts of target molecules.

09:40 : Invited talk
Nano-slits for directional generation of plasmonic patterns
Byoungho Lee, Seung-Yeol Lee

In this manuscript, we discuss on various ways to control the plasmonic patterns by using the surface plasmon polariton (SPP) excitation from nano-slits. Starting from methods for directional control of SPP generation on a single nano-slit, it will be expanded to methods of patterning subwavelength nano-slits for polarization-sensitive plasmonic hot spot and vortex generation, switchable focusing and plasmonic meta-surfaces.

08:30 - 10:00 — LT2

Session 3A4

Bionanoplasmonics I

Organized by: Arkadi Chipouline, Alexey Vinogradov, Ilya Kurochkin and Irina Nazarenko

Chaired by: Arkadi Chipouline and Irina Nazarenko

08:30 : AGR2 wt and splice variants as a novel biomarker for the non-invasive exosome-based

diagnosis of prostate cancer
Simon Hefele, Antje Neeb, Stefanie Bormann, Fabian Adams, Philipp Wolf, Arkadiusz Miernik, Martin Schonthaler, Malte Kronig, Wolfgang Schultze-Seemann, Andrew C. B. Cato, Irina Nazarenko

In this study, we assessed the diagnostic potential of new splice variants of anterior gradient 2 (AGR2) gene, using urine exosomes as a biomarker source. Exosomes were isolated from the urine of 27 patients with prostate carcinoma and 14 patients with be benign hypoplasia (BHP). The isolated vesicles were characterized by electron microscopy, dynamic light scattering; Additionally, by using Western blotting their prostate origin and protein levels of exosome markers were verified.

08:45 : New horizons for NTA: scattering labelling of soft particles
Evgeniy Evtushenko

The ability of Nanoparticle Tracking Analysis (NTA) to discriminate between weakly and strongly scattering particles has been tested. Only partial discrimination is possible with standard implementation of NTA. Algorithm based on paertilce spot shape analysis to limit the upper and lower edges of detection volume has been proposed. These improvements open the possibility for the new type of specific labelling in NTA, scattering labelling of soft particles, i.e. weakly scattering biological particles, including exosomes, viruses and protein aggregates.

09:00 : Invited talk
Involvement of extracellular biovesicles in transfer of genetic information
Maksim Kremenskoy

Recently, study on membrane Extracellular Biovesicles (EBs) has greatly engaged the scientific community. This interest is emerged due to RNA presence inside the EBs. In this way the vesicles can contribute in the genetic communication between cells in the living organism. Multiple cell types are secreting the extracellular vesicles, such as exosomes, microvesicles, apoptotic bodies, etc.

09:20 : Invited talk
Photon propagation through arteries: A new diagnostic idea
Andreas Seifert

By simulating the propagation of photons transversely through large arteries subject to pulsatile blood flow, we see that the transmitted light is a linear function of arterial distension. Blood flow related effects and corresponding intrisic optical properties of flowing blood are of subordinate importance in macrocirculation. The theoretical results are corroborated by in vitro and in vivo experiments, in which measured transmission mode photoplethysmograms show that the measured optical signals are predominantly a function of arterial strain. This opens new chances in diagnostics of cardiovascular diseases. The dynamic behavior of the biomechanics of the arterial wall reveals the viscoelastic properties and hence, as for example, a quantitative measure of arteriosclerosis.

09:40 : Invited talk
Multifunctional composite polyelectrolyte based capsules as theranostic system with remote controlling properties
Gleb Sukhorukov

Composite submicron sized capsules are good model to mimicking bio-chemical processes in a confined geometry imitating cell organelles, whilst delivered inside cell (including neurons) and tissues the capsules could serve as intracellular reporter or enzymatic reactor. Biophotonic approaches are envisaged to enhance the possibilities for multifunctional use of capsules. The talk discusses possible solutions and promising applications.

08:30 - 10:00 — LT3

Session 3A5

Hybrid Metastructures and their Applications for Energy, Lighting, Catalysis and Sensing I

Organized by: Hilmi Volkan Demir, Sergey Gaponenko and Alexandre Govorov

Chaired by: Hilmi Volkan Demir, Sergey Gaponenko and Alexandre Govorov

08:30 : Keynote talk
Ultrafast photoinduced energy and charge flow in coupled plasmonic and excitonic nanostructures
Gary Wiederrecht

In this talk, I will discuss our recent work on understanding ultrafast energy and charge flow in hybrid nanomaterials, particularly for coupled plasmonic and excitonic systems. These hybrid nanomaterials present new opportunities for efficient photoinduced energy and charge transfer, as well as nonlinear nanophotonics.

09:00 : Invited talk
Advanced hybrid metal/polymer nanostructures for nanophotonics
X. Zhou, C. Deeb, R. Vincent, T. Lerond, P. M. Adam, J. Plain, G. P. Wiederrecht, Renaud Bachelot

Based on nanoscale photopolymerization triggered by the surface plasmon modes, we developed metal nanoparticle/doped polymer hybrid nanostructures. Due to the anisotropic spatial distribution of the dipolar surface plasmon mode during photopolymerization, this nano- structure is anisotropic in both geometry and optical responses. The trapped dye molecules in the hybrid nanostructure display fluorescence intensity and Raman signature that are dependent upon the polarization of the incident excitation light.

09:20 : Invited talk
Vanadium Dioxide: a reconfigurable disordered metamaterial for tunable absorber and thermal emitter applications
Federico Capasso, Mikhail A. Kats, Romain Blanchard, Shuyan Zhang, Patrice Genevet, Changhyun Ko, Shriram Ramanathan

In VO2 thin films, the Insulator-to-Metal transition occurs gradually with increasing temperature: Nanoscale inclusions of the metallic phase emerge in the surrounding insulating phase VO2, which grow and connect in a percolation process, eventually leading to a fully metallic state at the end of the transition.

09:40 : Invited talk
Developing plasmonic nanostructures for photovoltaics and catalysis
Dongling Ma

The synthesis of certain plasmonic nanostructures and their interesting plasmon resonance will be presented first [1-3]. Their hybridization with other nanomaterials or integration into different devices will also be introduced, which has led to enhanced power conversion efficiency of solar cells or improved catalytic activity in photocatalysis.

08:30 - 09:45 — LT4

Session 3A6

Scattering and Diffraction Phenomena in Plasmonics and Semiconductor Nano-Optical Systems I

Organized by: Fernando Moreno and Manuel Nieto-Vesperinas

Chaired by: Fernando Moreno and Manuel Nieto-Vesperinas

08:30 : Invited talk
Wide band transparent metallo-dielectric nanowires at telecommunications wavelengths: more transparent than glass
R. Paniagua-Dominguez, Diego Abujetas, Luis Froufe-Perez, Juanjo Saenz, J. Sanchez-Gil

In this paper we propose metallo-dielectric nanowires (NW) as structures suitable to construct electrically conducting nanowires which are transparent to infrared radiation at wavelengths used in telecommunication applications. We show that the transparency of metal NWs covered with high permittivity dielectric materials are optimal structures regarding fabrication imperfections, variations in the angle of incidence and polarization of the incoming radiation. The bandwidth of the transparent region entirely covers the near IR telecommunications range.

08:50 : Invited talk
Absorption and scattering efficiency of Core/Shell plasmonic nanowire structures
Hossein Alisafaee, Michael Fiddy

We investigate the efficiency of absorption and scattering in standing nanowire array of semiconductor materials. Enhancement of absorption using plasmonic nanoparticles for higher efficiencies is studied. Core-shell nanoparticles of gold and silicon are used to collect light for an effective coupling to the semiconductor nanowire array. The wide band absorption of the solar spectrum (Air Mass 1.5 Global) is considered utilizing the tunning capability of core/shell plasmonic nanoarticles.

09:10 : Invited talk
Dielectric particles with electric and magnetic dipole resonances: trasmittivity as metamaterial atoms and their behavior as photonic molecules in the near-field of randomly fluctuating sources
Manuel Nieto-Vesperinas, Juan Miguel Aunon, F. J. Valdivia-Valero

Numerical simulations of microwave and NIR transmission in composites of high refractive index dielectric cylinders at frequencies of dipolar electric and magnetic resonances, show strong scattering losses bonding and antibonding of particle optical molecules is determined by the coherence length of random light.

09:30 : Multiple magnetic mode-based fano resonance in split-ring resonator/disk nanocavities
Qing Zhang, Xinglin Wen, Guangyuan Li, Qifeng Ruan, Jianfang Wang, Qihua Xiong

The high-order magnetic modes are observed in SRRs by polarization-resolved transmission spectroscopy. When a disk is centered within the SRRs, multiple high-order magnetic modes are coupled to a broad electric dipole mode of SRR/D, leading to significant Fano resonance spectral features in near-IR regime. The strength and line shape of the Fano resonances are tuned through varying the SRR split-angle and interparticle distance between SRR and disk. Finite-difference-time-domain (FDTD) simulations are conducted to understand the coupling mechanism.

08:30 - 10:00 — LT5

Session 3A7

Acoustic and Elastic Metamaterials I

Organized by: Yoon Young Kim and Jensen Li

Chaired by: Yoon Young Kim and Jensen Li

08:30 : Invited talk
From acoustic metamaterials to functional metasurfaces
Jun Xu, Chu Ma, Tian Gan, Anshuman Kumar, Narges Kaynia, Nicholas Fang

In this invited talk, we will present our research progress toward tailoring the edge rays and creeping rays

with acoustic metasurfaces. In fact our recent study suggest such illusional effects by embedding wedges in a transformed acoustic medium, and we will present theoretical analysis and experimental study of such engineered components with acoustic metasurface. The potential application of such novel device concept in underwater communication and medical ultrasound will be also discussed.

08:50 : Invited talk
Giant concentration by extraordinary acoustic transmission in zero-mass
Sam H. Lee, Jong Jin Park, K. J. B. Lee, Oliver B. Wright, Myoung Ki Jung

We experimentally demonstrate about 80 % transmission of sound through a rigid wall perforated with subwavelength holes of 3 % areal coverage. This remarkable transmission efficiency was obtained by making the mass of the air column in the hole to vanish effectively. The effective mass of the hole was made zero by installing tight thin membranes. Energy flux density of the incident wave was concentrated into the holes by the factor of 30. Potential applications include high sensitivity acoustic sensors.

09:10 : Efficient generation of graphene plasmons through acousto-optics
Mohamed Farhat, Sebastien Guenneau, Hakan Bagci

We propose a novel concept that exploits mechanical and electronic properties of graphene to allow coupling of light to surface plasmon polaritons. The bending biharmonic wave that is induced on the graphene sheet generates a quasi two-dimensional grating permits efficient coupling of energy from the incident light to surface plasmon polaritons. The applicability of this novel concept is demonstrated via analytical calculations and numerical experiments.

09:25 : Membrane-type dark acoustic metamaterials with super absorbing ability for low frequency sound
Jun Mei, Guancong Ma, Min Yang, Zhiyu Yang, Weijia Wen, Ping Sheng

We show that by using thin elastic membranes decorated with asymmetric rigid platelets, the resulting acoustic metamaterials can reach almost 100 % absorption at low frequencies where the relevant sound wavelength in air can be three orders of magnitude larger than the membrane thickness. Finite element simulations are in excellent agreement with the experiments.

09:40 : Invited talk
Super absorbance of acoustic waves with bubble meta-screens
Valentin Leroy, Anatoliy Strybulevych, Maxime Lanoy, Fabrice Lemoult, Arnaud Tourin, John Page

Guided by a simple model, we have performed experiments and simulations to demonstrate the very large absorption of ultrasonic waves that is possible with a thin monolayer of bubbles in a soft elastic medium (a bubble meta-screen). The absorbance is maximized by optimizing the viscosity of the medium for the bubble size and separation. When the meta-screen is placed on a rigid interface, we show that super-absorption is achieved, with less that 1 % of the incident energy being reflected.

08:30 - 10:00 — MAS EC1

Session 3A8

Metamaterials and Negative Index Materials VI

Chaired by: Alex Schuchinsky

08:30 : Negative dispersion of microwave surface waves
Joseph Dockrey, Simon Horsley, J. Sambles, Alastair Hibbins

Two arrays of metallic dumbbell shaped elements separated by a small air gap support symmetric and antisymmetric surface modes analogous to the optical coupled modes of a thin metal film. The upper branch has

a significant region of negative dispersion, providing an effective negative index for a surface wave.

08:45 : Non-rayleigh limit of the radially anisotropic sphere
Yaxian Ni, Lei Gao

We study the Non-Rayleigh scattering behavior of the radially anisotropic spheres. Under certain conditions, we derive the unusual relations between the scattering efficiency and the size parameter in the quasi-static limit which breaks the Rayleigh law. It is found that the scattering efficiency of theanisotropic sphere can be a tunable constant and enlarged byadjusting the anisotropic ratio.

09:00 : Superposing Lorentzian functions towards engineering target responses
Christopher Dirdal, Johannes Skaar

We prove that all functions obeying the Kramers-Kronig relations can be approximated as superpositions of Lorentzian functions, to any precision. Being therefore identical with the general class of causal functions, superpositions of Lorentzians provide a simple manner of visualizing all possible dispersion phenomena. Another important consequence is that Lorentzian resonances may be viewed as possible building blocks for engineering any desired metamaterial response, for example by use of split ring resonators of different parameters.

09:15 : Improved analytical model for short-wire metamaterials
Zahra Mostajabi, Jalil-Agha Rashed-Mohassel, Leila Yousefi

In spite of other metamaterials whose fabrication requires stacking of several printed circuit boards, short-wire metamaterials can be fabricated using standard multi-layer PCB fabrication. These metamaterials have already been introduced and modeled, however, the reported analytical models have a big deviation from simulation and measurement results. Here, we propose an accurate analytical model for prediction of the resonant frequency of these metamaterials, which has a good agreement with previously reported measurement results.

09:30 : Tailoring alphabetical metamaterials in optical frequency: Coupling, dispersion and sensing
Jun Zhang, Cuong Cao, Xinlong Xu, Chihao Liow, Shuzhou Li, Ping-Heng Tan, Qihua Xiong

Here we introduce an alphabetical metamaterials with different size and symmetry to study the electromagnetic coupling effect, dispersion behavior of electronic surface plasmon polaritons (ESPP) and magnetic surface plasmon polaritons (MSPP), as well as specific ultrasensitive SERS sensing of monolayer molecules and femtomolar food contaminants.

09:45 : Theoretical Study of the optical properties of a single-walled nanotube thin film waveguide with nonlinear cladding
Hala El-Khozondar, Rifa J. El-Khozondar, Said Zouhdi

A theoretical approach to study the optical properties of a waveguide consists of a single-walled nanotube (SWNT) film surrounded by nonlinear cladding and linear substrate. In the proposed waveguide the dispersion equation is derived. Numerical calculation is carried out to draw the effective refractive index for transverse electric modes (TE). The effective refractive index as function of frequency is plotted at different values of nonlinearity. Based on the results, proposed structure can be used as tunable MTMs.

Coffee Break and Exhibit Inspection

Session 3P1

Poster Session V

10:00 - 10:45

P1: Enhanced cross-section of gold nanoparticles near a silicon substrate
Kevin Ehrhardt, Zhiqiang Zheng, Julien Vieaud, Olivier Merchiers, Yves Borensztein, Virginie Ponsinet, Ashod Aradian

Monolayers of gold nanoparticles deposited on top of a polymer layer above a silicon wafer were prepared by electrostatically-controlled layer-by-layer assembly. The structure of the system was studied by atomic force microscopy and X-ray reflectivity. Spectroscopic ellipsometry was used to extract the individual absorption cross-section of the nanoparticles in the visible spectrum. We show that this cross-section varies with the substrate proximity, in a way which cannot be fully described by the classically described image dipole effect.

P2: Quasi omnidirectional absorption of light in a anostructured metallic film
Hanbin Zheng, Rui Almeida, Thomas Rivera, Serge Ravaine

Teperik et al, had theoretically and experimentally shown that nanostructured metal surfaces which contain a closed packed monolayer of spherical voids at a certain distance underneath the surface are able to exhibit total absorption of incident light. Such surfaces were also theoretically predicted to demonstrate omnidirectional absorption of light. Here, we have fabricated a nanostructured gold surface that confirms experimentally the quasi omnidirectional absorption properties of such a surface.

P3: Permittivity customised epoxy-BT composites for microwave applications
Qin Lei, Rhiannon Mitchell-Thomas, Joseph Dockrey, Oscar Teruel, Ian Hooper, Patrick Grant, Chris Grovenor

In this work, we have explored the possibility of applying a well-studied epoxy/barium titanate composite system to microwave applications. The ceramic loading versus permittivity profile at high frequency (12-18GHz) up to 40vol

P4: 3D printing of high-dielectric materials for electromagnetic devices
Flynn Castles, Patrick Grant

We report on the development of ceramic-polymer composite materials which are suitable for 3D printing metamaterials with high dielectric permittivities. This versatile technique brings a new range of microwave device designs within the realm of fabrication via 3D printing, which may facilitate rapid prototype production, the preliminary investigation of new optical physics at microwave frequencies, and, indeed, may be the most viable route to device manufacture in certain circumstances.

P5: Spacetime transformation devices: Carpets
Paul Kinsler, Martin McCall

We describe a unified theory encompassing both electromagnetism and simple acoustics, and use it to design spacetime carpet cloak transformation devices (T-devices).

P6: Transformation multiphysics metamaterials
Massimo Moccia, Giuseppe Castaldi, Salvatore Savo, Yuki Sato, Vincenzo Galdi

Transformation optics has been one of the key catalysts of the field of metamaterials. This platform has extended beyond electromagnetism to cover electrostatics, magnetostatics, acoustics, and diffusive heat flow. Traditionally, designs have been limited to single target functionalities. Here we propose a transformation multiphysics paradigm that allows independent and simultaneous manipulation of multiple physical phenomena. As a proof of principle, we design a metamaterial shell that can simultaneously behave as a thermal concentrator and an electrical invisibility cloak.

P7: Three-dimensional broadband all-dielectric magnifying lens
Tiancheng Han, Cheng-Wei Qiu

With inhomogeneous but isotropic parameters, we demonstrate a three-dimensional (3D) magnified lens that can be applied to far-field high-resolution imaging for real 3D objects in actual space. The lens can be realized by non-resonant metamaterials, which are fabricated with multilayered dielectric plates by drilling inhomogeneous air holes. Owing to the isotropic, low-loss and broadband properties, the proposed 3D magnifying lens may have potential applications to create high resolutions in both optical and microwave imaging.

P8: Optomechanical systems as light switches and traps
Sumei Huang, Girish Agarwal

We demonstrate optical switches by using nanomechanical oscillators coupled to optical cavities. We show how electromagnetically induced transparency (EIT) in cavity optomechanical systems can be used to switch the propagation direction of a weak classical probe field. We also show that two weak classical probe fields propagating in opposite directions can be completely absorbed by the optomechanical system.

P9: Far-field plane lens based on a multilayered metal- dielectric structure
Vladimir Belyi, Mohammed A. Binhussain, Nikolai Khilo, Nikolai Kazak, Sergei Kozik

A detailed investigation has been made of the lens effect in plane multilayered metal-dielectric structures (Ag-TiO2). An optical scheme of the lens has been studied with the radiation focusing in the free space. The transfer function is calculated, the phase profile of which determines definitely the possibility of focusing. The focal distance, beam profile and also spatial resolution of lens for the wavelengths of the visible and ultraviolet ranges have been established.

P10: Localized surface plasmon-controlled Forster resonance energy transfer of quantum dots
Ning Zhou, Dongsheng Li, Deren Yang

We have utilized Au@SiO2/QDs system to demonstrate localized surface plasmon-controlled Förster resonance energy transfer. The PL results are consistent with the time-resolved photoluminescence decay curves. The system could be optimized by changing the thickness of spacer layer, the size or shape of metal NPs and the feature of QDs absorbed and so on to pursue stronger PL intensity and FRET rate or efficiency.

P11: Strong coupling at the nanoscale: case of plasmonic rings
N. Rahbany, W. Geng, S. Blaize, R. Salas-Montiel, R. Bachelot, C. Couteau

There is a growing interest nowadays in the study of strong light-matter interaction at the nanoscale. Using plasmonics, nanooptics and metamaterials, there is an important drive towards enhancing such an interaction. In this work, we aim to excite surface plasmon polaritons (SPPs) using circular ring gratings where light-matter interaction can be studied at the nanometer scale.

P12: Coupled plasmonic resonances in metamaterials and hybrid devices
Benjamin Thackray, Vasyl Kravets, Rashid Jalil, Fred Schedin, Alexander Grigorenko

Coupling of plasmon resonances is fundamental to the field of plasmonic metamaterials, however limitations of some approaches restrict their widespread application. We present novel coupling mechanisms which may overcome these limitations. These include plasmonic arrays which couple light to collective modes at normal incidence for simplified biosensing, three-stage cascaded enhancement of electromagnetic fields in composite nanostructures for reliable strong field enhancement, and our progress towards gating control of the resistive coupling of localized plasmon resonances through a graphene layer.

P13: Hiding a non-transparent object with quantum invisible cloaks by scattering cancellation method
Jeng Yi Lee, Ray-Kuang Lee

Based on the scattering cancellation, we provide a method not only making a nano-particle nearly invisible, but also hiding its interior region from the outside probing matter wave, by applying the interplay among the nodal points of partial waves along with the concept of streamline in fluid dynamics for probability flux.

P14: Efficient and reliable SERS substrates for multicomponent analysis of biomarkers
A. C. De Luca, P. Reader-Harris, M. Mazilu, S. Mariggio, D. Corda, A. Di Falco

We present a SERS biosensor based on gold fishnet and its use for glycerophosphoinositol (GroPIns) molecule sensing. High levels of GroPIns have been reported in several tumour cells. Here we demonstrate that with our approach we can quantitatively determine low concentration GroPIns (200 nM) in multicomponent mixtures, with a high accuracy (up to 6 %).

P15: Analysis of wavelength-selective enhancement in plasmonic coupled quantum dots infrared focal plane array
Sang Jun Lee, Sang-Woo Kang, Zahyun Ku, Woo-Yong Jang, Augustine Urbas, Jiang Feng Zhou, Jun Oh Kim, Sanjay Krishna

The effect of a plasmonic structures on the performance of an infrared quantum dots-in-a-well focal plane array is evaluated theoretically and experimentally. The infrared DWELL FPA integrated with 2D-MHA used as the surface plasmon structure results in a wavelength selective enhancement that is significant in infrared multispectral imaging. A comparison of the experimentally measured enhancement of the signal to noise ratio at SP resonant wavelengths with a finite integration technique based simulation results reveals a good agreement.

P16: Surface plasmon of Au enhanced two-photon excited ultraviolet emission of ZnO nanorods
Yi Lin, Chunxiang Xu, Jitao Li, Gangyi Zhu, Jun Dai, Baoping Wang

ZnO nanorods and Au-decorated counterpart are fabricated. Two-photon excited ultraviolet emissions of these two samples are studied. It is found two-photon excitation threshold of Au-decorated ZnO is much lower than the as-grown one under the excitation corresponding to the LSPR of Au. Under the same excitation power, the emission intensity is strongly enhanced after Au NPs are assembled on the surfaces of ZnO nanorods. This improvement is attributed to strong field enhancement generated by the LSPR of Au NPs.5

P17: Plasmonic enhancement of light absorption in CuInS2 layer doped by gold nanoparticles
Taavi Repan, Atanas Katerski, Ilona Oja Acik, Erki Karber, Arvo Mere, Valdek Mikli, Malle Krunks, Leonid Dolgov, Ilmo Sildos

Theoretical and experimental possibilities for plasmonic modification of thin CuInS2 absorber layer doped by various size gold nanoparticles are considered. Placement of gold nanoparticles on the top and inside CuInS2 layer is described. Experimental methods of spray pyrolysis and spin coating are tested for the preparation of the composite CuInS2-gold layer. The most effective plasmonic enhancement of light absorption was obtained in the spectral range 650-700 nm by using of 60 nm size gold nanoparticles.

P18: Thin organic solar cell with Au nanodots
Wakana Kubo, Takuo Tanaka

Well-designed, well-ordered Au nanodots were embedded in a thin organic solar cell to investigate a correlation between surface plasmon and an enhancement mechanism in conversion efficiency of a solar cell.A solar cell with Au nanodots showed higher IPCE spectrum than a solar cell without Au nanodots, in a wavelength range of plasmon resonance. By changing size, shape, and pitches of Au nanodots, we investigated a relation between surface plasmon of Au nanodots and conversion efficiency of a solar cell.

P19: Surface plasmon resonance in a supper-lattice metal nanograting
Junpeng Guo, Haisheng Leong

We investigated surface plasmon resonance in metal super-lattice nanograting structures and observed resonance mode splitting in the super-period metal nanohole grating for TM polarization excitation.

P20: A CMOS-compatible platform based on metal-dielectric-Si hybrid plasmonic waveguide for integrated plasmonic circuits
Shiyang Zhu, Guo-Qiang Lo, Dim-Lee Kwong

The development of electronic and photonic integrated circuits (EPICs) is challenged by the size mismatch between the nanoscale electronic components and the microscale photonic components. A solution to scale the photonic components beyond the diffraction limit of light for future high-density EPICs lies in plasmonics. In this work, we present Cu-dielectric-Si hybrid plasmonic waveguides (HPWs) and various HPW-based photonic devices developed in our lab, which pave a way to the Si integrated plasmonic circuits.

P21: SERS scaling rules
Yoshiaki Nishijima, Yoshiakazu Hashimoto, Lorenzo Rosa, Jacob Khurgin, Saulius Juodkazis

We reveal an intricate relationship between the intensity of surface-enhanced Raman scattering (SERS) and the optical extinction The unusual trends of SERS intensity decrease while the extinction increases observed in experiments is fully explained for the first time The SERS intensity is well known to be strongly correlated with the extinction at excitation and Stokes wavelengths, but the dependence is more involved than the simple product of the two extinction enhancements.

P22: Unidirectional excitation of surface plasmon polaritons and their selective coupling into DLSPPWs
Oubo You, Benfeng Bai

Surface plasmon polaritons (SPPs) have drawn much attention for their highly confined field and subwavelength properties. Here, we demonstrate two structures, a binary blazed area-coded grating (BACG) and a semi-annular groove, which can efficiently launch SPPs in a predetermined direction or focus SPPs to a predetermined point. Furthermore, using the second SPP launcher, we demonstrate the selective coupling of SPPs into different dielectric-loadedsurface plasmon polariton waveguides (DLSPPWs) with good tunability and relatively high coupling efficiency.

P23: Hybrid Periodic dimer array with adjustable period and gap size as an effective plasmonics structure
Bowen Liu, Shou Liu, Bin Ren

In this work, we developed the deep UV HL with 266 nm laser to obtain structure with a periodicity between 100 nm to 1μm. We further developed a strategy to fabricate hybrid periodical dimer arrays by deep UV HL and lift-off process, followed by selectively surface functionalization.

P24: Ethylene glycol assisted solvothermal fabrication of ZnWO4 nanostructure with tunable size, optical properties and photocatalytic activities
Yuxue Zhou, Ling Tong, Xiaobing Chen, Xianghua Zeng

Large scale of uniform ZnWO4 nanocrystals and ZnWO4 nanorods with tunable size have been fabricated in ethylene glycol(EG) assisted solvothermal process, ZnWO4 samples ranging in shape from nanocrystals to nanorods were dependent on the volume ratio of ethylene glycol(EG) and water(H2O).The optical properties of ZnWO4 nanocrystals and nanorods were investigated by photoluminescence (PL) spectroscopy. The photocatalytic performance of ZnWO4 nanostructures was studied also, which indicated that the increased size of ZnWO4 nanorods resulted the degradation of photocatalytic performance.

P25: A sensitive sensor with a double U-shaped rings-based metamaterial
An Yang, Chang-Chun Yan, Ni Zhang, Jie-Bing Tian, Cheng Wang, Ying Han, Dao Hua Zhang

We investigated anisotropy of plasmonic meta-materials with differentstructures which include metal-dielectric multilayer structure, metal in adielectric, and dielectric in a metal. We show that anisotropy of the plasmonic-metamaterials is closely related to the materials used and the structuredesigned, and the structure of dielectric in a metal shows the strongestanisotropy. We also show that the high anisotropy of metamaterials isbeneficial to nanoscale waveguiding, super-resolution imaging and opticalcommunication.

P26: Enhanced nanoparticle scattering: metals vs dielectrics
Yuriy Akimov

In this work, we systematically study the influence of the nanoparticle material on the efficiency of the scattering in a number of applications ranging from nanoparticle-enhanced solar cells and molecule luminescence to light concentration and generation of high electric fields. Finally, we demonstrate that the use of dielectric nanoparticles can lead to similar and even higher enhancements compared to that of metal nanoparticles.

P27: Inductive-to-Capacitive transition of terahertz responses between a metal mesh and a metal cross-shape array through introduction of random cuts
Keisuke Takano, Yuichiro Okui, Hideaki Kitahara, Abdallah Chahadih, Abbas Ghaddar, Xiang-Lei Han, François Vaurette, Tahsin Akalin, Yudai Sekine, Makoto Nakajima, Masanori Hangyo

A transition from conducting (inductive) to insulating (capacitive) effective responses of a metasurface is investigated in the terahertz region. A metal mesh shows Drude-like metallic effective permittivity dispersion. By cutting all wires of the mesh, the metal mesh becomes a metal cross array and shows Lorentz-like effective permittivity dispersion. The intermediate electromagnetic responses are revealed by introducing random cuts to wires by the experiments and simulation.

10:45 - 12:45 — LT22

Session 3A9

Symposium: Resonant Dielectric Nanostructures and Metamaterials VII

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Igal Brener

10:45 : Keynote talk
Coherent control of metamaterials
Nikolay Zheludev, Xu Fang, Jinhui Shi, Kevin MacDonald, Eric Plum, Sayed Sayed Mousavi, Ming Lun Tseng, Din Ping Tsai

We report a new concept of engaging the coherent interactions of opticalwaves on metamaterial nanostructures that allows for the efficient control of optical phenomena from absorption to refraction, from optical activity to anisotropy. We provide a number of demonstrations of coherent control phenomena alongside a discussion of their spectroscopic and optical data processing applications.

11:15 : Keynote talk
Polarization and photonic spin hall effects in plasmonics and metamaterials
Anatoly Zayats

We will discuss nanoplasmonic approaches for manipulation of polarization state of light and the effects associated with the photon spin when circular polarized light interacts with plasmonic nanostructures and metamaterials. Photon spin provides an additional and important tool for extending the available tools of active functions in plasmonic devices.

11:45 : Invited talk
Laser printing of metal and dielectric nanoparticles
Boris Chichkov

I will report on our recent progress in the development of laser printing technologies for fabrication of complex nanoparticle structures. Fabrication, characterization, and applications of the generated nanoparticle arrays will be demonstrated and discussed.

12:05 : Invited talk
Silicon colloids. Optical properties and applications
Francisco J. Meseguer, Roberto Fenollosa, Isabelle Rodriguez, Lei Shi, Ramon Alvarez-Puebla, Brian A. Korgel, Moises Garin

We have recently developed spherical silicon nanoparticles, we call them as Silicon Colloids (SCs), with particle size between 300 nm and 3000 nm. SCs have the following properties: A) They behave as optical microcavities in the VIS and IR region. B) SCs show a magnetic response in the optical region, and they can be of application to metamaterials . C) The huge values of the scattering cross section, and the small size of particles allow them for developing powders and pigments, with extraordinary properties for blocking the IR, VIS and UV radiation. D) The huge evanescent EM fields around the particles make them useful for application as Raman signal enhancers of chemical species attached to them.

12:25 : Invited talk
Universality and scaling in dielectric metamaterials
Didier Felbacq

The homogenization of a two-dimensional dielectric metamaterial made of rods is studied in the vicinity of the internal resonances of the rods. Spatial dispersion and tunability of band gaps are demonstrated.

10:45 - 12:45 — LT23

Session 3A10

Plasmonically Enhanced Nanoimaging and Nanospectroscopy II

Organized by: Prabhat Verma

Chaired by: Bin Ren

10:45 : Invited talk
Tip-enhanced Raman investigation of the localization of electronic properties in carbon nanotubes
Prabhat Verma, Yoshito Okuno, Yuika Saito, Satoshi Kawata

Utilizing tip-enhanced Raman spectroscopy (TERS), we have investigated the localization of electronic properties of single-walled carbon nanotubes (SWNTs) at extremely high spatial resolution. Upon a slight deformation, the SWNTs can change their electronic characteristics.

11:05 : Invited talk
Functions of the near-field probe in tip-enhanced Raman spectroscopy
Yuika Saito, Toshihiro Mino, Prabhat Verma

In tip-enhanced Raman spectroscopy (TERS) a metal coated nano-tip acts as a plasmonic antenna to enhance the originally weak Raman scattering from a nanometric volume of a sample. Therefore, the characterization of the tip is essential for nano-imaging in terms of the sensitivity, and polarization properties. We have successfully analyzed the polarization of near-field light in TERS from the scattering pattern produced by a metallic tip.

11:25 : Invited talk
Maximising information retrieval from naked gold nanoprobes in an intracellular environment
Nicholas Smith

Plasmonic enhancement of Raman scattering is an ideal method for measuring molecular dynamics in a living cell. The potential information content from intracellular nanoparticles is enormous but is limited by the difficulty in treating the resulting data which often appears random. This talk will cover a number of issues relating to plasmonic enhanced measurement of intracellular molecules, experimental approaches to extract information and present an approach to tame the randomness.

11:45 : Invited talk
Dynamic imaging of intracellular molecules by using surface enhanced Raman scattering (SERS)
Katsumasa Fujita, Kazuki Bando, Kai-Chih Huang, Jun Ando, Nicholas Smith, Satoshi Kawata

We observed intracellular transportation by using surface-enhanced Raman scattering (SERS) from gold nanoparticles (GNPs) introduced in the cytosol. Simultaneous detection of the nanoparticle position and the SERS spectrum enables us to visualize the molecular interaction with GNP during the transportation process.

12:05 : Invited talk
From superhydrophobicity for SERS/TERS-like applications to hotelectrons based nanoscopy (to say nothing of the adiabaticity).

Remo Proietti Zaccaria, Andrea Giugni, Bruno Torre, Carlo Liberale, Francesco De Angelis, Gobind Das, Andrea Toma, Enzo Di Fabrizio

We shall describe the concept of adiabaticity applied to an actual 3D plasmonic conical nanostructure for TERS-like applications. Afterwards, we shall move to artifical superhydrophobic nanodevices which can be used to detect, in a very short time, an extremely small number of molecules. Finally, by joining the concept of adiabatic compression and hot electrons, we shall demonstrate how nanoplasmonics can, once again, amaze us by allowing the realization of a new kind of nanoscopy.

12:25 : Invited talk
Metrology challenges in tip-enhanced Raman spectroscopy
Debdulal Roy

Tip-enhanced Raman spectroscopy is powerful chemical analysis tool that is graduating from the status of a very specialised fantasy tool to a more reliable measurement method. This talk will deconstruct the reproducibility issue and address few of the specific ones including reproducibility of TERS tips, tip-characterisation, enhancement factor calculation and interpretation of the measurements. Finally, a development path for TERS will be suggested to take it from a measurement method to a metrology tool.

10:45 - 12:45 — LT1

Session 3A11

Nano-Apertures and Applications II

Organized by: Sang-Hyun Oh and Reuven Gordon

Chaired by: Sang-Hyun Oh and Reuven Gordon

10:45 : Creation of subwavelength needle or multiple spots with ultrathin metalens
Huapeng Ye, Kun Huang, Jinghua Teng, Swee Ping Yeo, Chengwei Qiu

We report an ultra-thin flat lens that is capable of creating a purely longitudinally polarized optical needle with beam size reaching Rayleigh criterion in vaccum in the far field. This highly uniform subwavelength beam is achieved by constructively focusing radially polarized Gaussian beam with flat lens, which is designed and optimized with vectorial Rayleigh-Sommerfeld method and particle swarm optimization algorithm. Moreover, we show that this kind of ultra-thin metalens can also create multiple subwavelength spots.

11:00 : Invited talk
Nanoaperture-enabled surface-plasmon devices: cup resonators, electrochromic color switches, hyperbolic-metamaterial spatial filters and isotropic-metamaterial flat lenses
Henri Lezec

I will discuss recent numerical simulation and experimental work, both within our group and via close collaborations, leading to the implementation of a variety of novel SPP-based devices leveraging metal nanoholes and nanoslits fabricated by focused-ion-beam (FIB) milling.

11:20 : Invited talk
Natural computing with optical fibre networks
Kan Wu, Behrad Gholipour, Wenchao Hu, Perry Ping Shum, Nikolay Zheludev, Cesare Soci

Using simple fiber networks for proof-of-principle demonstrations, we give examples of natural computing in linear optical networks, like solving polynomial (P) and nondeterministic polynomial (NP) problems, and in nonlinear optical networks, like metaheuristic optimization and neuromorphic computing.

11:40 : New optical properties of nanoapertures and their applications

Vasily Klimov

In this talk I will discuss extraordinary light transmission influenced by an optical Tamm state, molecule fluorescence near nanoapertures and atom optics with near fields of nanoholes.

11:55 : Non-resonant-type plasmonic refractive index sensors
Soon-Hong Kwon, Da Eun Lee, Tae-Woo Lee

We propose new types of the plasmonic refractive index sensors, not requiring the wavelength shift. By using cutoff mechanism of the plasmonic waveguide, an ultrasmall index sensor and a channel waveguide sensor are discussed.

12:10 : Invited talk
Optofluidic nanostructures for the spatial and temporal concentration of analytes
Carlos Escobedo

Optofluidic nanostructures with the ability to perform as sensing elements and fluidic conduits offer several benefits over established sensing methodologies, including the enhanced transport of analyte to the active sensing surface of the structures, more efficient analyte utilization and the possibility of full integration into microfluidic systems.

12:30 : Subwavelength slits: The single channel limit and beyond
Reuven Gordon

This talk will outline a theory and supporting numerical simulations showing that single slits in metal films achieve the single channel limit and that multiple slits can be used to achieve super-transmission above the single channel limit.

10:45 - 12:40 — LT2

Session 3A12

Metamaterials and Negative Index Materials VII

Chaired by: Nader Engheta

10:45 : Invited talk
Manipulating propagating properties of EM waves with metamaterials
Qiong He, Shiyi Xiao, Zhengyong Song, Xin Li, Lei Zhou

Manipulating the propagation of electromagnetic (EM) waves at will is always fascinating. Here we present our recent efforts in controlling the transparency of EM wave using metamaterials (MTMs), including continuous transparent metal based on scattering cancellation mechanism and optic-null medium (ONM) based on holey metallic plate with periodic array of subwavelength apertures. Microwave experiments, in excellent agreement with full-wave simulations, are performed to successfully realize our ideas.

11:05 : Optimizing the quality factor of a wideband guided mode resonance biosensorBiosensor
Qi Wang, Dawei Zhang, Zhenyun Wang, Yuanshen Huang

This work studies the effect of the biochemical molecular layer on the quality factor of guided mode resonance (GMR) filter of an ultrasensitive label-free biosensor. In this study, we have managed to present a GMR filter with a narrow bandwidth that requires less precision by controlling the thickness of the biochemical molecule layer, which increases the Q factor by up to three times.

11:20 : Invited talk
Volatile and non-volatile switching in dielectric metamaterials

Kevin MacDonald, Wang Qian, Jon Maddock, Edward Rogers, Tapashree Roy, Chris Craig, Ben Mills, Daniel Hewak, Nikolay Zheludev

The next phase of the photonic technological revolution will be driven by the development of nanoscale/nanostructured switchable and nonlinear materials as functional platforms for integrated nanophotonics. We report here on recent advances in the development of versatile, planar photonic metamaterial solutions to provide a new generation of nanoscale all-optical switching and memory meta-devices.

11:40 : Scattering by a cylindrical dielectric shell with DNG metamaterial
Mousa Hussein

The scattering by a plane wave incident on an infinitely long cylindrical shell loaded with DNG metamaterial is derived using the boundary-value method, and the exact series solution in terms of the Mathieu functions. The validity of the solution is verified by comparison with the circular cylindrical shell. Different types of DNG metamaterial are investigated and the resulting echo width as well as the scattered field pattern and results are presented.

11:55 : Keynote talk
Light harvesting with metasurfaces: applications to sensors and energy generation
David Crouse

Metasurfaces have been receiving increasing interest due to the complex array of radiation controlling properties that are possible with single layer films. This talk will focus on metasurfaces that can provide light filtering according to wavelength, polarization, and other properties of an incident beam, and applied to a variety of sensors.

12:25 : Compact wideband directive antenna above a non-uniform artificial magnetic conductor
Lana Damaj, Anne Claire Lepage, Xavier Begaud

A compact wideband antenna above a non-uniform Artificial Magnetic Conductor (AMC) is presented. The antenna is composed of a bowtie Coplanar Waveguide fed antenna, with wideband harmonic suppression using non-uniform Defected Ground Structure. Besides, a non-uniform wideband Artificial Magnetic Conductor is designed.

10:45 - 12:45 — LT3

Session 3A13

PT-Symmetry in Photonics, Metamaterials and Plasmonic Systems II

Organized by: Anatole Lupu and Henri Benisty

Chaired by: Anatole Lupu and Henri Benisty

10:45 : Invited talk
PT-Symmetry structures modifying resonant cavity behavior
Mykola Kulishov, Bernard C. Kress, Radan Slavik

We review our work regarding a new class of couplers and resonators that employ the concept of Parity-Time (PT) symmetry in optics. PT structures can be implemented as diffractive gratings having complex refractive index profiles.

11:05 : Invited talk
Nonlinear and quantum effects in PT-symmetric optical structures
Andrey Sukhorukov, Sergey Suchkov, Diana Antonosyan, Alexander Solntsev, Igor Barashenkov, Nora Alexeeva, Sergey Dmitriev, Yuri Kivshar

We discuss novel regimes of nonlinear wave interactions in a chain of optical PT -symmetric couplers with balanced gain and loss study the beam propagation in an array of optical waveguides with an embedded defect created by a pair of waveguides with gain and loss, and investigate the quantum process of photon generation through spontaneous nonlinear wave-mixing in coupled waveguides with loss.

11:25 : Invited talk
Nonreciprocal Bragg grating concept using an asymmetric long-range surface plasmon waveguide
Elham Karami Keshmarzi, Niall Tait, Pierre Berini

A nonreciprocal Bragg grating based on an asymmetric stepped-in-width long-range surface plasmon-polariton waveguide operating at near infrared wavelengths is proposed. The transfer matrix method is used to compute the reflection and transmission spectra of the proposed structure. Results show a very strong reflection from one end at about 880 nm as opposed to nearly no reflection from the other end at the same wavelength.

11:45 : Invited talk
Optical exceptional points and their associated phase transition
Liang Feng

Although optical devices have been extensively investigated for decades, absorbing dielectrics for optical applications have not attracted attentions. Here, we will exploit implementation of optical losses to develop innovative optical devices, for example, mimicking exceptional points and their unique transport characteristics in optics. The optical exceptional points have been demonstrated as indicated by the realized unidirectional reflectionless light transport at optical frequencies. The associated phase transitions are observed when crossing over the exceptional points.

12:05 : Invited talk
Parity-time symmetric cloak with one-way invisibility
Xue-Feng Zhu, Liang Feng, Peng Zhang, Xiaobo Yin, Xiang Zhang

A one-way invisible cloak is proposed by transforming the parity-time (PT) symmetric optical materials. At the PT-symmetry breaking threshold, incident light is scattered only along one direction but not the other by satisfying the phase matching condition, making the cloak one-way invisible. In addition, optical scattering from the one-way cloak can be further engineered to create a unidirectional optical illusion of the concealed object.

12:25 : Invited talk
Modulation and switching using PT-symmetry inspired periodically gain/loss modulated waveguides
Anatole Lupu, Henri Benisty, Aloyse Degiron

This work intends to propose new type of PT-symmetry grating assisted devices for switching or modulation applications. Their operation is based on a four-wave interaction marking thus a step in the further development of PT-symmetry devices which currently are essentially based on two-waves interactions.

10:45 - 12:45 — LT4

Session 3A14

Scattering and Diffraction Phenomena in Plasmonics and Semiconductor Nano-Optical Systems II

Organized by: Fernando Moreno and Manuel Nieto-Vesperinas

Chaired by: Fernando Moreno and Manuel Nieto-Vesperinas

10:45 : Invited talk

Dual-resonant spheres
Xavier Zambrana-Puyalto, Gabriel Molina-Terriza

We present a framework to study the duality properties ofscatterers. The formalism can be applied to any geometry and material, but we develop it in the context of spherical scatterers. Thanks to their symmetries, we can formulate the problem analytically using Mie Theory.

11:05 : Invited talk
Invisibility cloaking via Fano resonances
Mikhail Rybin, Dmitry Filonov, Ivan Sinev, Kirill Samusev, Pavel Belov, Yuri Kivshar, Mikhail Limonov

We demonstrate analytically that the characteristic Fano lineshape observed in the Mie scattering by high-index dielectric nanoparticles leads to a dramatic suppression of scattering giving a birth to a novel cloaking mechanism for invisibility at any angle of observation. We verify these concepts numerically and also experimentally, by switching a water cylinder from visible to invisible regimes when its dielectric permittivity is changed by heating.

11:25 : Invited talk
Magneto-dielectric response of polluted silicon nanoparticles
Juan M. Sanz, Rodrigo Alcaraz de la Osa, Fernando Moreno

The influence of the degree of purity of a silicon nanoparti- cle on both its electric and magnetic resonances is assessed by using Mie theory as well as finite-element simulations. In particular, it is shown that the increased absorption due to the pollutants affects mainly magnetic resonances. Re- sistive losses corroborate this effect, showing that the area of influence in the magnetic dipole resonance is much larger than in the electric one.

11:45 : Invited talk
Magneto-optical activity in interacting magnetoplasmonic nanodisks
Gaspar Armelles, Alfonso Cebollada, Fernando Garcia, Maria Gonzalez, David Meneses, Nuno de Sousa, Luis Froufe-Pérez, Antonio Garcia-Martin

In this work we present a study of the interactions between magentoplasmonic nanodisks. We show that the interaction between a plasmonic and a magnetoplasmonic metallic nanodisk leads to the appearance of magnetooptical activity in the purely plasmonic disk induced by the magnetoplasmonic one. Moreover, at specific wavelengths the interaction might cancels the net electromagnetic field at the magnetoplasmonic component,strongly reducing the magneto-optical activity of the whole system.

12:05 : Invited talk
Magnetoelectric effects in local light-matter interactions
Konstantin Bliokh, Yuri Kivshar, Franco Nori

We study the generic interaction of light with bi-isotropic nanoparticles, including interactions associated with the breaking of dual, P- and T-symmetries (chirality and the nonreciprocal magnetoelectric effect). We calculate absorption rates, forces, and torques, and introduce novel field characteristics quantifying the energy, momentum, and angular-momentum transfers in these interactions. We propose the concept of magnetoelectric energy density quantifying the local PT-symmetry of the field. We also propose a complex field for sensitive probing of the magnetoelectric effect in nanoparticles.

12:25 : Invited talk
Making geometrical optics exact
Thomas Philbin

Geometrical optics (GO) is widely used in electromagnetics because of its simplicity compared to full-wave simulations. Exact solutions can differ significantly from GO, and perfect effects for waves cannot usually be derived using GO. We show how to design materials in which GO is exact, allowing the exploration of exact wave propagation with interesting features. Two examples are given: a material in which two point sources do not interfere, and an isotropic cloak for waves from a point source.

10:45 - 11:55 — LT5

Session 3A15

Acoustic and Elastic Metamaterials II

Organized by: Yoon Young Kim and Jensen Li

Chaired by: Yoon Young Kim and Jensen Li

10:45 : Invited talk
Extraordinary absorption and amplification of sound
J. Christensen, J. Christensen, V. Romero-Garcia, N. A. Mortensen, V. J. Sanchez-Morcillo, M. Willatzen

Here we show that strong all-angle sound absorption with almost zero reflectance takes place for a frequency range exceeding two octaves in artificially structured porous materials. Secondly, we also demonstrate strong acoustic gain in electric-field biased piezoelectric semiconductors at frequencies near the plasmon frequency in the terahertz range. It is shown that this effect is particularly effective at epsilon-near-zero response, leading to giant levels of acoustic gain.

11:05 : Invited talk
Elastic metamaterial hyperlens exhibiting hyperbolic equi-frequency contours
Joo Hwan Oh, Hong Min Seung, Yoon Young Kim

While earlier studiesrealized sub-wavelength resolution at a far field for elastic waves by anelastic metamaterial exhibiting an elliptic equi-frequency contour(EFC), we present a recent realization of an elastic metamaterial hyperlens exhibiting truly-hyperbolic equi-frequency contours.

11:25 : Coherent perfect absorption in acoustics
Jin-Zhang Song, Ping Bai, ZhiHong Hang, Yun Lai

We demonstrate that the energy of coherent acoustic waves can be totally absorbed by a fluid absorber with specific values of mass density and bulk modulus. The robustness of such perfect absorption phenomenon under small perturbation of the parameters is also discussed. We also show that by using suitable dispersive acoustic metamaterials, broadband acoustic perfect absorption may be achieved.

11:40 : Focusing of spoof surface-acoustic-waves on graded surface structure
Yangtao Ye, Manzhu Ke, Zhengyou Liu

Focusing of spoof surface acoustic waves (SSAWs) on a rigid surface drilled with array of holes has been investigated in this work. The gradient index of refraction along the transverse directions for the surface is achieved by varying the radii of the holes linearly along the corresponding directions. After being launched along the longitudinal direction, good focusing performance of SSAWs has been demonstrated experimentally.

12:00 - 12:50 — LT5

Session 3A16

Plasmonics and Nanophotonics VI

Chaired by: Cesare Soci

12:00 : Performance bounds of geometry dependent silicon waveguides
Md Khandokar, Masuduzzaman Bakaul, Stan Skafidas, Thas Nirmalathas, Md Asaduzzaman

Nanophotonic technologies have attracted a lot of attention to co-develop optical and electronic devices on

silicon that further modern optical communications in miniaturization. Optical properties of these miniaturized devices are highly dependent on geometry and can be tailored for specific applications. In this paper we have analyzed performance bounds of various optical properties for several silicon waveguides like planar, rib and photonic crystal by tailoring geometry for single mode propagation and 1.5 μm to 1.6 μm telecommunication bands.

12:15 : The longitudinal magneto-photonic intensity effect in plasmonic crystals
Vladimir Belotelov, Andrey Kalish, Lars Kreilkamp, Ilya Akimov, Dmitry Bykov, Sachin Kasture, V. J. Yallapragada, Achanta Venu Gopal, Alex Grishin, Sergey Khartsev, Mohammad Nur-E-Alam, Mikhail Vasiliev, Leonid Doskolovich, Dmitry Yakovlev, Kamal Alameh, Anatoly Zvezdin, Manfred Bayer

The magneto-optical properties of a hybrid metal-dielectric structure are studied experimentally and theoretically. A magnetic field applied in the longitudinal configuration alters the optical transmittance or reflectance. This effect represents a novel class of effects related to the magnetic field induced modification of the structure modes. The effect, called the longitudinal magneto-photonic intensity effect, has two contributions, odd and even in magnetization. The nanostructured material described here may be considered as an ultrafast magneto-photonic light valve.

12:30 : Invited talk
Topological modes in photonic networks
Yidong Chong, Michael Pasek, Guanquan Liang

A lattice of optical resonators can act as a photonic topological insulator. Varying the network coupling parameters induces transitions from conventional to topological phases. Such systems are photonic analogs of Chalker-Coddington network models, which were originally introduced to study disordered quantum Hall systems. Topological edge states can occur even if all bands have zero Chern number, and the winding number of the reflection coefficient from one edge of the network can act as a topological invariant.

10:45 - 12:45 — MAS EC1

Session 3A17

Bionanoplasmonics II

Organized by: Arkadi Chipouline, Alexey Vinogradov, Ilya Kurochkin and Irina Nazarenko

Chaired by: Arkadi Chipouline and Irina Nazarenko

10:45 : Invited talk
Plasmonics biosensors: from bulk to nanoscale architechtures and novel functionalities
Andrey Aristov, Vasyl Kravets, Alexandre Merlen, Ksenia Maximova, Alexander Grigorenko, Andrei Kabashin

This presentation will overview our on-going activities on the improvement of physical sensitivity of plasmonic biosensors.We demonstrate the possibility for the extension of the phase-sensitive plasmonic biosensing concept to novel nanoscale architectures using designed plasmonic metamaterials in order to further improve the sensitivity of plasmonic biosensing technology (potentially, down to singe molecular level) and obtain novel functionalities (concentration of probing field, parallel SERS and fluorescence option etc).

11:05 : Tailoring plasmonic modes of subwavelength metallic structures to enhance fluorescence intensity for biosensing
Ping Bai, Lin Wu, Yi Wang, Xiaodong Zhou

Plasmonic modes excited from subwavelength metallic structures are investigated for the enhancement of fluorescence intensity. Both localized surface plasmon (LSP) and propagating surface plasmon (PSP) modes can be generated with subwavelength metallic structures, but they cannot enhance the fluorescence dyes at the same time due to different resonant wavelengths. Our study reveals that the LSP can be excited simultaneously

with the PSP through a Kretschmann configuration, supported by theoretical and experimental results showing an improved fluorescence enhancement.

11:20 : Sharp resonances in waveguide-coupled surface plasmon sensor structures
Shinji Hayashi, Dmitry Nesterenko, Zouheir Sekkat

We propose a planar structure that allows us to couple a surface plasmon polariton (SPP) mode to a waveguide mode (WGM). Results of reflectivity calculations clearly show very sharp resonances attributed to the Fano resonance and electromagnettically induced transparency (EIT), which may find optential applications in sensing problems.

11:35 : Invited talk
Non-trivial non-radiating excitations and ultra-narrow resonances in toroidal metamaterials
Vassili A. Fedotov, Vassili Savinov, Alexandra V. Rogacheva, Nikolay Zheludev

We demonstrate theoretically and confirm experimentally a new mechanism of resonant electromagnetic transparency, which yields narrow isolated symmetric Lorentzian transmission lines in metamaterials. It exploits the long sought non-trivial non-radiating charge-current excitation based on interfering electric and toroidal dipole moments.

11:55 : Invited talk
Graphene sandwiches as a platform for broadband molecular spectroscopy
Yan Francescato, Vincenzo Giannini, Jingjing Yang, Ming Huang, Stefan Maier

We introduce a promising sensing technique based on the propagation of SPPs. These excitations are intrinsically broadband allowing the amplification of a molecular IR spectrum over an extended range of frequencies. We numerically demonstrate that the effect of a thin analyte on doped graphene can reach unprecedented sensitivity. Together with its broadband behaviour it should reinvigorate interests in basic sensing concepts. Finally, we propose the design of a FTIR accessory for the full characterization of highly diluted mixture.

12:15 : Subgroup decomposition of plasmonic resonances in hybrid oligomers for ultrasensitive biochemical sensing
Dang Yuan Lei

In this talk, we will show how one can easily but significantly tailor the overall spectral profile of plasmonic nanoclusters, nanoparticle quadrumers and pentamers, by selectively altering the nanoparticle shape without a need to change the particle size, inter-particle distance or the number of elementsof the oligomers. We will also show the sensing sensitivities of these nanoclusters to the adsorption of self-assembled alkanethiols monolayers, which are found to depend on the nanocluster arrangement, constitute nanoparticle shape and the plasmon resonance wavelength.

12:30 : Size analysis with particle tracking analysis and dynamic light scattering
Clemens Helmbrecht, Hanno Wachernig

Both methods, PTA particle tracking analysis and DLS dynamic light scattering are based on the evaluation of Brownian motion of colloid particles by laser light scattering. The measured translational diffusion is related to size by applying the Stokes Einstein relation. In PTA- an emerging method- the movement of the individual particles is made visible in a laser scattering video microscope.

Lunch and Exhibit Inspection

12:45 - 14:15

14:15 - 15:15 — LT22

Session 3A18

Symposium: Resonant Dielectric Nanostructures and Metamaterials VIII

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Anatoly Zayats and Boris Chichkov

14:15 : Invited talk
Realization of 2D and 3D optical dielectric metamaterials
Yuanmu Yang, Parikshit Moitra, Wenyi Wang, Zachary Anderson, Ivan Kravchenko, Dayrl Briggs, Jason Valentine

Here, we present our recent efforts to develop purely dielectric metamaterials exhibiting low absorption loss at optical frequencies. We will outline the implementation of both 2D and 3D metamaterial designs. Along these lines, we will discuss how dielectric metasurfaces, can be used to realize near-unity efficiency and 0 to 2 phase variation. We will also discuss how we have used 3D dielectric metamaterials for an realizing impedance matched near-zero refractive index at optical frequencies.

14:35 : Invited talk
Narrowband absorption enhancement and broadband circular polarizers using resonant dielectric based high-contrast gratings
Ekmel Ozbay

Using high contrast gratings (HCG) based on silicon on sapphire wafers, it is possible to achieve enhanced absorption and broadband circular polarizers. Two HCG structures are designed to achieve an enhancement factor of 1310 at 1.06 micron wavelength. The same silicon on sapphire wafer is also used for a broadband circular polarizer. The experimental bandwidth of the polarizer is measured to be 33 %, which is in good agreement with the theoretically calculated bandwidth of 42 %.

14:55 : Invited talk
Spectral performance of dielectric nano-resonator reflectarrays
Christophe Fumeaux, Longfang Zou, Withawat Withayachumnankul, Martin Lopez-Garcia, Charan M. Shah, Arnan Mitchell, Maciej Klemm, Madhu Bhaskaran, Sharath Sriram

Nano-antennas for photonics applications typically consist of resonant metallic structures on a substrate. To circumvent plasmonic losses of metals in the optical regime, we have demonstrated dielectric nano-resonators on a silver film operating as nanoantennas for 633 nm wavelength. The realized nonuniform arrays of TiO2 resonators operate in reflection as reflectarrays, and deflect an incident beam towards a predefined angular offset from specular direction. This paper shows preliminary spectral measurements that demonstrate the intended resonant behavior of the nano-resonators.

15:15 - 16:15 — LT22

Session 3A19

Plasmonics and Nanophotonics VIII

Chaired by: Pierre-Michel Adam

15:15 : Spatio-modal engineering of 2D plasmonic devices built from crystalline colloids
Erik Dujardin, Christian Girard, Arnaud Arbouet, Aurelien Cuche, Michel Bosman, Sviatlana Viarbitskaya, Alexandre Teulle, Jadab Sharma

The tailoring of optical properties has reached the nanometer-scale with the advent of plasmonics. It occurred recently that dissipation and spatial resolution limitations of lithographic devices could be overcome by exploi-

ting the enhanced performances of crystalline metal colloids. In this talk, I will present our recent approaches to chemically tailor the plasmonic properties of isolated crystalline colloids with well-defined shapes, such as nanorods and 2D prisms, or those of self-assembled superstructures, such as extended single-particle chain networks.

15:30 : Au-based alloys for plasmonic applications
Vicki Keast, Rhea L. Barnett, Michael B. Cortie

In this paper we use density functional theory (DFT) and the random phase approximation (RPA) to assess the viability of a broad range of Au-based alloys for plasmonic applications. Doping with a small concentration of some s-p valence metals does slightly improve the predicted plasmonic response, further improvement cannot be achieved with the intermetallic alloys. The notable exception to this is the AuAl2 intermetallic, and the related material, PtAl2 which are both strongly plasmonic.

15:45 : Nanoscale processing of plasmonic films using gas cluster ion beam irradiation
Ee Jin Teo, Noriaki Toyoda, Chengyuan Yang, Bing Wang, Nan Zhang, Andrew Bettiol, Jinghua Teng

We present a smoothing and thinning process for plasmonic films using gas cluster ion beam irradiation (GCIB). We show the ability to increase grain width, reduce surface roughness and thickness with nanometer resolution and reproducibility. Ultrathin Ag films produced by GCIB have lower absorbance compared to as-deposited films. Better adhesion of the metal to the substrate was shown after GCIB treatment.

16:00 : Dark plasmonic modes excitation through symmetry breaking
Xiaofang Su, Dibakar Chowdhury, Yong Zeng, Xiaoshuang Chen, Abul Azad

Plasmonic structures with high symmetry, such as double-identical gap split ring resonators, possess dark modes. These dark modes are dominated by magnetic dipole and/or high-order multipoles such as electric quadrapoles. Experimentally and theoretically, we studied dark modes of symmetrical double-gap split ring resonators. By breaking the symmetry, these dark modes are excited and can be observed in the far-field zone. It is demonstrated that the quality factors of these dark modes are much higher than their bright-mode counterparts.

14:15 - 15:10 — LT23

Session 3A20

Plasmonically Enhanced Nanoimaging and Nanospectroscopy III

Organized by: Prabhat Verma

Chaired by: Dai Zhang

14:15 : Invited talk
AFM-based plasmonically-induced optical force spectroscopy
Taka-Aki Yano, Yasuhiro Morita, Tomohiro Hayashi, Masahiko Hara

We have performed plasmonically-induced optical force spectroscopy using advanced atomic force microscopy (AFM). The optical forces generated between two plasmonic nanostructures were quantitatively and qualitatively characterized as a function of the separation distance between the nanostructures. Moreover, the plasmonically-induced optical forces were applied to control biomolecular reactions (ligand-receptor binding etc.) which were probed with the uses of both AFM force spectroscopy and Raman spectroscopy.

14:35 : Invited talk
Single-particle plasmon-resonance spectroscopy for nanomaterials studies and thin-film nanometrology
Dang Yuan Lei

In this talk, I will introduce a single-particle plasmon-resonance-based nanospectroscopy technique for nanomaterials studies. We have successfully applied this novel technique to reveal the Mott-type phase transition in vanadium dioxide (VO2) thin films and studied the role of defects on the phase-transition energy in VO2 nanoparticles. Following this, I will introduce a new concept for constructing a hybrid nanoparticle-microcavity-based plasmonic nanosensor, which show significantly improved detection resolution and extended remote sensing ability.

14:55 : Optical nanoantenna-based in situ spectroscopy of single sub-10 nm catalytic nanoparticles
Svetlana Syrenova, Christoph Langhammer

We study the size dependence of hydride formation thermodynamics in single Pd nanoparticles in the sub-10 nm size range. The Pd particle is placed in the hot spot of an Au nanodisc dimer structure, which serves as efficient in situ single particle probe by means of dark field scattering spectroscopy. The nanoantenna structures together with the Pd particle of interest are fabricated using our novel Shrinking-Hole Colloidal Lithography (SHCL) technique.

15:10 - 16:05 — LT23

Session 3A21

Technologies and Applications II

Chaired by: David Crouse

15:10 : Invited talk
Random Raman laser
Vladislav Yakovlev

Random medium provides a unique feedback mechanism through light scattering while Raman transitions facilitate the universal method for optical gain in a large variety of materials ranging from diamonds to fertilizers. We have recently demonstrated extremely efficient random Raman lasing in a disordered 3D system and applied for remote chemical sensing at kilometer distances. I will discuss our advances in both the fundamental understanding of nonlinear optical interactions in disordered media and applications of developed methodology for remote chemical sensing and deep-tissue biomedical optical imaging.

15:30 : Invited talk
Design, fabrication and characterization of terahertz metamaterials by laser means
M. H. Hong, D. C. Wang, C. W. Qiu

Terahertz (THz) metamaterials are of great importance in manipulating terahertz waves in novel approaches, which cannot be realized by natural materials. In this work, terahertz metamaterials are designed, fabricated and characterized for broadband resonance tunability and polarization independence. To achieve passive resonance tunability, a three dimensional metamaterial tube is designed by rolling up a single layer two-dimensional metamaterial with split ring resonators (SRRs) array.

15:50 : Cloaking with structured light: Hiding in the darkness
Jingbo Sun, Alexander Cartwright, Natalia Litchinitser

We proposed and experimentally demonstrated a macroscopic invisibility cloak, based on structured light, operating at optical wavelengths. By transforming the incident wave into a vortex wave and then recovering it back to its original form, a macroscopic object can be concealed in the dark core of the optical vortex. The proposed cloak is polarization independent, easy to fabricate, and wide bandwidth. The proposed concept can be extended to realize a multi-directional cloaking using an array of spiral plates pairs.

14:15 - 16:10 — LT1

Session 3A22

Nano-Apertures and Applications III

Organized by: Sang-Hyun Oh and Reuven Gordon

Chaired by: Sang-Hyun Oh and Reuven Gordon

14:15 : Invited talk
Quasi-3D plasmonic nanostructures with controlled Hot Spots for SERS biosensing
Fang Sun, Shaoyi Jiang, Qiuming Yu

Quasi-3D plasmonic nanostructures composed of a gold thin film with subwavelength nanoholes on the top and gold nanodiscs at the bottom of wells separated by a dielectric layer have rich plasmonic and optical properties. The extreme strong local electric fields induced by localized surface plasmon resonance (LSPR) are the hot spots for surface-enhanced Raman scattering (SERS), which can be tuned at either the top or the bottom metal/dielectric interface by simply varying the dimension of nanostructures.

14:35 : Invited talk
Ultrasensitive sensing using metallic nanopores
Michael Cecchini, Aeneas Wiener, Tim Albrecht, Stefan Maier, Joshua Edel

Analytical Sensors plays a crucial role in today's highly demanding exploration and development of new detection strategies. Whether it be medicine, biochemistry, bioengineering, or analytical chemistry the goals are essentially the same: 1) improve sensitivity, 2) maximize throughput, 3) and reduce the instrumental footprint. In order to address these key challenges, the analytical community has borrowed technologies and design philosophies which has been used by the semiconductor industry over the past 20 years.

14:55 : Invited talk
UV lifetime modification by nanoapertures
Xiaojin Jiao, Eric Peterson, Joel Harris, Steve Blair

Using Al nanoapertures of different sizes, we demonstrate lifetime modification of UV chromophores in free solution. Lifetimes generally decrease with aperture size, but are strongly affected by other geometrical and material parameters, such as aperture undercut and Al film composition.

15:15 : Invited talk
Nano-apertures: from trapping to symmetry breaking
Mathieu L. Juan

Nano-apertures have been studied for a large variety of applications in Physical and Biological sciences. In particular, we have been studying the use of nano-apertures for the development of near-field optical traps. This approach relies on both their important sensitivity to changes in the environment, and the high optical confinement they provide. Also, we realized more recently that the important symmetries present in circular nano-apertures have important implications for position-sensing and bio-sensing. Here, we will show the recent progress in these two projects, and their potential applications.

15:35 : Invited talk
Highly efficient 3D nanofocusing plasmonic waveguide
Hyuck Choo

We have demonstrated experimentally a highly efficient on-chip three-dimensional (3D) linearly tapered metalinsulator- metal (MIM) nanoplasmonic photon compressor (3D NPC) with a final aperture size of 14 x 80 nm2. An optimized and linearly tapered MIM gap plasmon waveguide could theoretically reduce the excessive losses that would occur during nanofocusing processes.

15:55 : Wafer scale fabrication of nano-apertures by corner lithography

Narges Burouni, Erwin J. W. Berenschot, Henri V. Jansen, Edin Sarajlic, Han J. G. E. Gardeniers, Niels R. Tas

Wafer scale methods to form nano-apertures can be divided in two main categories: pit approach and tip-approach. We introduce a new pit-based method using a technique called corner lithography. This method potentially gives better size control and is suitable for down-scaling to the sub-10 nm regime. Sub-50 nm aperture sizes have been shown with an acceptable uniformity over large area.

14:15 - 14:45 — LT2

Session 3A23

Bionanoplasmonics III

Organized by: Arkadi Chipouline, Alexey Vinogradov, Ilya Kurochkin and Irina Nazarenko

Chaired by: Arkadi Chipouline and Irina Nazarenko

14:15 : New SERS-active junction based on cerium dioxide facet dielectric films for biosensing
Ilya Kurochkin, Ilya Ryzhikov, Andrey Sarychev, Konstantin Afanasiev, Igor Budashov, Marina Sedova, Irina Boginskaya, Sergey Amitonov, Andrey Lagarkov

In this report we consider the possibility of combining plasmon resonances in metal (gold) nanoparticles with localized electromagnetic resonaces in the facet dielectric films of cerium dioxide for highly sensitive SERS detection of chemical compounds and biological agents.

14:30 : SHG nanoprobes: Advancing harmonic imaging in biology
Periklis Pantazis

We introduce a novel imaging reagent, second harmonic generating (SHG) nanoprobes, to address the need for a bright, robust labeling tool for whole animal imaging. I will discuss the unique advantages and future challenges SHG nanoprobes pose for imaging of living animals, permitting powerful biomedical imaging applications with unmatched sensitivity and temporal resolution in development and disease.

14:45 - 16:00 — LT2

Session 3A24

Hybrid and Quantum Materials

Chaired by: Benabid Fetah

14:45 : Invited talk
Quantum optics with semiconductor quantum dots
David Gershoni

I will discuss recent studies of single semiconductor quantum dots as excellent sources of single and entangled photons. In particular I will discuss and demonstrate methods to fully control the spin state of quantum dot confined carriers and to entangle between their spin states and the polarization states of emitted single photons.

15:05 : Invited talk
Qualitative models in nanophotonics
A. Chipouline

Recent technological advancements allowing creation of nanoobjects/metamaterials in the optical domain has forced the revisiting of basics electrodynamic principles and assumptions. A large amount of new experimental and theoretical data has to be structured within the framework of a new unified approach, in order to distinguish the really fundamental knowledge from various applications and particular cases. A unified approach appears to be extremely important for educational courses in the area of nanophotonics/optical metamaterials. In particular it allows us to present a self-consistent physical picture, which in turn minimizes the amount of educational material to be memorized to the crucial physics.

15:25 : Silicon Carbide tetrapods: novel room temperature quantum systems
Stefania Castelletto, Zoltan Bodrog, Andrew P. Magyar, Angus Gentle, Adam Gali, Igor Aharonovich

Recently, significant research efforts have been made to develop complex nanostructures to provide more sophisticated control over the optical and electronic properties of nanomaterials. Here we present a new quantum system silicon carbide (SiC) tetrapods and report on their structural and optical properties. Remarkably, the SiC tetrapods exhibit narrow line width photoluminescence at wavelengths spanning the visible to near-infrared spectral range as well as single photon emission at room temperature. We discuss the origin of the emission and present modeling results.

15:40 : Invited talk
Flexible microlasers
Van Duong Ta, Rui Chen, Handong Sun

We demonstrate the feasibility of constructing high Q-factor solid state microcavities using a flexible approach. The configurations of the microcavity vary from hemispheres, whole spheres to fibres. We have clearly observed optically pumped lasing from these structures. The lasing characteristics have been systematically investigated in terms of size dependence, temperature dependence and polarization. Especially we have shown that some structures can be operated at single and tunable-frequency. Finally refractive index sensing can be conveniently realized from these structures.

14:15 - 15:55 — LT3

Session 3A25

PT-Symmetry in Photonics, Metamaterials and Plasmonic Systems III

Organized by: Anatole Lupu and Henri Benisty

Chaired by: Anatole Lupu and Henri Benisty

14:15 : Invited talk
Parity-time-symmetric whispering-gallery microcavities
Bo Peng, Sahin Ozdemir, Fuchuan Lei, Faraz Monifi, Mariagiovanna Gianfreda, Gui Lu Long, Shanhui Fan, Franco Nori, Carl M. Bender, Lan Yang

Recently, there has been increasing interest in PT-symmetric optical systems combing balanced loss and gain to generate synthetic devices with unusual properties that are different from those found in systems with only loss or only gain. We report the first experimental demonstration of PT-symmetry and its breaking in optical resonators. Our system is composed of two directly coupled on-chip Whispering-Gallery-Mode (WGM) resonators. We also demonstrate experimentally that PT-symmetry breaking is associated with the onset of nonlinearity-induced nonreciprocal light transmission.

14:35 : Invited talk
Practical limitation on operation of nonlinear parity-time Bragg gratings
Sendy Phang, Ana Vukovic, Hadi Susanto, Trevor Benson, Phillip Sewell

This paper presents analyses of the impact of the physical gain dispersion and saturation on the operation

of nonlinear Parity-Time Bragg grating (PTBG). Performance of the nonlinear PTBG is considered for different input signal intensities and for both low and high values of intensity saturation, whilst the nonlinearity coefficient is considered constant. It is shown that dispersion and gain saturation significantly change the performance of the nonlinear PTBG.

14:55 : Invited talk
PT-symmetry in the effective medium description of metamaterials
James Gear, Fu Liu, Stefan Rotter, Jensen Li

We discuss the properties of the effective medium of a generalized PT (Parity Time)-symmetric potential, which is realized using metamaterials. An example for thin slabs of metamaterials is given so that the PT-symmetric potential can support unidirectional reflection at the exceptional point in the long wavelength limit while the effective medium of such a potential inherits the PT-symmetry through an effective parity operator defined as the polarization exchange operator.

15:15 : Invited talk
PT-symmetric dimers with time-periodic gain/loss function
Nikolaos Lazarides, George Tsironis

Two prototypical PT-symmetric dimers with time-periodic gain/loss function are investigated in a balanced configuration. In the linear regime and particular choice of the gain/loss function, the equations of motion reduce into an area preserving map. Stability analysis identifies stable regions in the parameter space. Nonlinearity induces changes in the stability regions. A comparisonbetween the obtained results ismade both in the linear and the nonlinear regime for similar nonlinearities.

15:35 : Invited talk
Non-Hermitian plasmonic metamaterials
Hadiseh Alaeian, Aitzol Garcia-Etxarri, Brian Baum, Jennifer Dionne

In this presentation, we investigate the emergent optical properties of PT-symmetric metamaterials. We consider a multilayer stack of alternating metal and dielectric layers presenting all-angle negative refraction and Veselago 'perfect lensing.' Its operation is based on the plasmonic modes of its unit cell, a five-layer subwavelength 'metal-insulator-metal' waveguide. While practical utilization of this metamaterial has been limited by propagation and coupling losses, we show that these losses could be overcome by subjecting the plasmonic modes to PT-symmetric potentials

14:15 - 16:15 — LT4

Session 3A26

Scattering and Diffraction Phenomena in Plasmonics and Semiconductor Nano-Optical Systems III

Organized by: Fernando Moreno and Manuel Nieto-Vesperinas

Chaired by: Fernando Moreno and Manuel Nieto-Vesperinas

14:15 : Invited talk
Optical forces in plasmonic and semiconductor resonant nanoparticles
Inigo Liberal, Inigo Ederra, Ramon Gonzalo, Richard Ziolkowski

In this presentation we review our latest achievements on optical manipulation and trapping of plasmonic and semiconductor resonant nanoparticles. We include a survey of optical force phenomena related to electric and magnetic dipole resonances in active and passive, plasmonic and semiconductor nanoparticles, as well as their application in nanofabrication and spectroscopy.

14:35 : Invited talk
Overlapping different scattering channels from a high refractive index core coated by nonlocal plasmonic shell
Yang Huang, Lei Gao

We achieve super-scattering of light from core-shell plasmonic nanospheres with spatial dispersion through overlapping the electric and magnetic dipoles, and electric and magnetic quadrupoles respectively. The mode-expansion method and nonlocal Mie theory are employed for the search of optimal core-shell nanosphere design to realize super-scattering at different wavelengths in the visible spectrum.

14:55 : Invited talk
Selective excitation of magnetic resonances in single dielectric nanoparticles
Pawel Wozniak, Peter Banzer, Gerd Leuchs

We present a versatile scheme for selective study of multipole resonances of individual high refractive index dielectric nanoparticles. For this purpose, we utilize tightly focused cylindrical vector-beams and take advantage of their spatial field distribution.

15:15 : Invited talk
Silicon colloids based metamaterials
Isabelle Rodriguez, Lei Shi, Roberto Fenollosa, Xiaotang Lu, Brian A. Korgel, Francisco J. Meseguer

We have recently developed monodisperse spherical silicon nanocavities, with particle size between 300 nm and 600 nm. SCs have the following properties: A) They behave as optical microcavities in the VIS and IR region. B) SCs show a magnetic response in the optical region, and they can be of application to metamaterials.

15:35 : Invited talk
Spectral analysis of Fano resonances in core-shell and dolmen plasmonic nanostructures
Victor Grigoriev, Brian Stout, Jerome Wenger, Nicolas Bonod

We perform a modal analysis of Fano anomalies in nanoshell and dolmen like structures. We show that their scattering spectra can be fully reconstructed thanks to their modes, calculated in the complex frequency plane. We use the so-called Weierstrass factorization to reconstruct the scattering spectra with respect to their perfectly emitting (poles) and absorbing (zeros) modes.

15:55 : Invited talk
Transmission of angular momentum modes of light through circular nanoapertures in metallic films
Gabriel Molina-Terriza, Nora Tischler, Mathieu L. Juan, Ivan Fernandez-Corbaton, Xavier Zambrana-Puyalto, Xavier Vidal

We present some experimental results on the transmission of cylindrically symmetric modes of light through circular nanoapertures. We have analyzed the transmitted light in terms of their angular momentum and helicity. Our experimental results show that the two helicity components of the transmitted light scale very differently with the aperture's size and that the total transmissivity depends strongly on the angular momentum of the incident field. This last effect gives rise to a giant circular dichroism.

14:15 - 15:35 — LT5

Session 3A27

Hybrid Metastructures and their Applications for Energy, Lighting, Catalysis and Sensing II

Organized by: Hilmi Volkan Demir, Sergey Gaponenko and Alexandre Govorov

Chaired by: Hilmi Volkan Demir, Sergey Gaponenko and Alexandre Govorov

14:15 : Invited talk
Hybrid plasmonic/semiconductor nanoparticle monolayer assemblies as hyperbolic metamaterials
Sergei Zhukovsky, Tuncay Ozel, Evren Mutlugun, Alexander Eychmuller, Nikolai Gaponik, Andrey Lavrinenko, Hilmi Demir, Sergey Gaponenko

We show that hybrid nanostructures made of alternating colloidal semiconductor quantum dot and metal nanoparticle monolayers can function as multilayer hyperbolic metamaterials. By choosing the thickness of the spacer between the quantum dot and nanoparticle layers, one can achieve the indefinite effective permittivity tensor of the structure. This results in increased photonic density of states and strong enhancement of quantum dot luminescence, in line with recent experimental results.

14:35 : Invited talk
Optically-active hybrid nanostructures: Exciton-plasmon interaction, injection of hot plasmonic electrons and chirality
Alexander Govorov

Excitons and plasmons in nanocrystals strongly interact via Coulomb and electromagnetic fields and this interaction leads to the characteristic interference effects observed in optical spectra. An interaction between a discrete state of exciton and a continuum of plasmonic states gives rise to Fano-like resonances and anti-resonances.In chiral nanostructures, near-field interactions createstrong plasmonic circular dichroism. Along with the near-field interactions, we investigate the effect of plasmon-assisted carrier injection from metal nanocrystals to semiconductor contacts or to adsorbed molecules.

14:55 : Invited talk
Transient and non linear optical properties of nano-antennas
Pierre-Michel Adam

Plasmonics is now well established field finding numerous applications in pharmacology, biology, optoelectronics and metamaterials among others. If linear and time-averaged optical properties of metallic nanoparticles are well described in the literature much less is known on non-linear and transient/ultrafast aspects of plasmonic resonances. We propose in this paper to discuss these specific optical properties with the help of recent works performed in collaboration with several groups.

15:15 : Invited talk
Hybrid solar cell with a metallic hole-array as the Intermediate electrode
Xuanru Zhang, Qiuping Huang, Jigang Hu, Yalin Lu

In the study, a metallic hole-array structure was inserted into a tandem solar cell structure as an intermediate electrode, which allows a further fabrication of a novel hybrid solar cell. The hole-array layer reflects the higher-energy photons back to the top cell, and transmits lower-energy photons to the bottom cell via the extraordinary optical transmission (EOT) effect. In this case light absorption in both top and bottom cells can be simultaneously enhanced.

14:15 - 15:45 — MAS EC1

Session 3A28

A Bottom-up Approach Towards Metamaterials and Plasmonics III

Organized by: Dorota Pawlak and Wounjhang Park

Chaired by: Ilya Shadrivov

14:15 : Optically active nanoplasmonic materials fabricated by nanoparticle direct doping
Karolina Korzeb, Marcin Gajc, Anna Kopka, Hancza Surma, Pawel Osewski, Dorota Pawlak

Recently, in the area of nanoplasmonic materials, alternative to metals, plasmonic materials are sought at VIS/IR wavelengths. Additionally combining the nanoplasmonic elements with optically active elements as rare earth ions or quantum dots to enforce enhanced optical processes is broadly investigated. The newest ideas here consider plexcitons, which are plasmon-exciton hybridizations.

14:30 : Invited talk
Self-assembled lamellar metallo-dielectric nanocomposites with strong optical anisotropy
Clemence Tallet, Alexandre Baron, Kevin Ehrhardt, Julien Vieaud, Olivier Merchiers, Philippe Barois, Marc Warenghem, Ashod Aradian, Virginie Ponsinet

In this presentation, we describe the preparation and study of thin films of nanocomposites of polymers and gold nanoparticles. We relate the structure of the composites, and in particular the nature, density and spatial organization of the gold nanoparticles, with the optical properties of the composites, as obtained by spectroscopic ellipsometry measurements.

14:50 : Invited talk
Isotropic metamaterials
Takuo Tanaka, Che-Chin Chen, Atsushi Ishikawa, Yu-Hsiang Tang, Ming-Hua Shiao, Din Ping Tsai

Experimental realization of an isotropic infrared metamaterial using fourfold-symmetric 3D SRRs configuration was demonstrated. Mass-productive formation of the 3D SRRs was achieved by a newly developed metal-stress driven self-folding method.

15:10 : Invited talk
Self-assembly approach to enhance antireflection or light trapping enhancement
Gumin Kang, Kyoungsik Kim

We developed dielectric nanostructures for antireflection (AR) or light trapping enhancement using self-assembly method of colloidal lithography, reactive ion etching (RIE), and soft lithography techniques. Broadband antireflection is improved by integrating dielectric nanoislands with silicon nanoconical-frustum arrays. Light trapping is also enhanced by coupling resonating dielectric nanostructures with a-Si thin-film.

15:30 : Template synthesis and self-assembly of plasmonic nanoparticles using molecular cages
Ryan McCaffrey, Suehyun Cho, Wei Zhang, Wounjhang Park

Precisely controlled synthesis and self-assembly of plasmonic nanoparticles is a long-standing challenge in metamaterials. In this paper, we present a new approach based on molecular cages, which provides great flexibility, stability and robustness.

Coffee Break and Exhibit Inspection

16 :15 - 16:45

Friday 23rd May, 2014

08:30 - 09:40 — LT22

Session 4A1

Symposium: Resonant Dielectric Nanostructures and Metamaterials IX

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Ekmel Ozbay and Francisco Meseguer

08:30 : Keynote talk
Light can push in the wrong way
Kun Ding, Shubo Wang, Jack Ng, C. T. Chan

We present an analytical formula for the optical force acting on a chiral particle. There are chirality dependent terms which couple mechanical linear momentum and optical spin angular momentum. Such chirality induced coupling can serve as a new mechanism to achieve optical pulling force. In addition, it can induce a sideway force that can laterally push particles with opposite chirality to the opposing side of an interface. Our analytical predictions are verified by numerical simulations.

09:00 : Invited talk
Resonant metal-semiconductor nanostructures as building blocks of low-loss negative- and zero-index metamaterials
Ramon Paniagua-Dominguez, Diego Romero-Abujetas, Luis Froufe-Perez, Jose Sanchez-Gil

We propose an isotropic metamaterial with negative electric and magnetic responses in the optical regime, based on hybrid metallo-dielectric core-shell nanowires. The magnetic response stems from the lowest magnetic resonance of the dielectric shell with high refractive index, overlapping with the plasmon resonance of the metal core, responsible for the electric response. Also, the same metamaterial design is shown to yield zero refractive index for a different spectral regime, exhibiting in turn an impedance close to that of vacuum.

09:20 : Invited talk
Metamaterials based on polariton resonances in dielectrics and their combinations with plasmon resonances in metals
Jacob Khurgin

Novel all-dielectric and hybrid metal-dielectric metamaterials based on exciton and phonon polaritons can combine the versatility of metal metamaterials with low losses in dielectrics.

08:30 - 10:00 — LT23

Session 4A2

Analytical and Numerical Modelling I

Chaired by: Mathias Fink and Nicolas Bonod

08:30 : A Bloch mode expansion approach for analyzing quasi-normal modes in open nanophotonic structures
Jakob Rosenkrantz de Lasson, Philip Trost Kristensen, Jesper Mork, Niels Gregersen

We present a new method for determining quasi-normal modes in open nanophotonic structures using a modal expansion technique. The outgoing wave boundary condition of the modes is satisfied automatically without absorbing boundaries, representing a significant advantage compared to conventional techniques. The quasi-normal modes are determined by constructing a cavity roundtrip matrix and iterating the complex mode wavelength towards a unity eigenvalue. We demonstrate the method by determining quasi-normal modes of cavities in two-dimensional photonic crystals side-coupled to W1 waveguides.

08:45 : Second harmonic generation from fano metamolecules: A new route for highly sensitive 3D nonlinear plasmon rulers
Jeremy Butet, Krishnan Thyagarajan, Olivier Martin

Second harmonic generation from plasmonic metamaterials supporting Fano resonances is discussed in detail with the aim of developing highly sensitive plasmon nanorulers. SHG from silver heptamers is first addressed, demonstrating that a proper design of their optical properties increases their nonlinear efficiency. It is then shown that Fano resonances enable the control of the fundamental near-field distribution over metallic nanostructures. This ability is used to design 3D nonlinear plasmon rulers which are more sensitive than their linear counterparts.

09:00 : Development of DGTD solver for nanophotonics application
Stephane Lanteri, Raphael Leger, Claire Scheid, Jonathan Viquerat

We discuss here about the development and application of such a DTGD method for solving the system of time-domain Maxwell equations coupled to material models relevant to nanophotonics. Our efforts aim at improving the accuracy, flexibility and efficiency of the method in view of the numerical treatement of realistic problems.

09:15 : Electromagnetic field and dispersion characteristic analysis of absorbing onion-like carbon tube waveguides
Liudmila Nickelson, Arturas Bubnelis, Romanas Martavicius, Steponas Asmontas

Here we present our calculation results of the electromagnetic (EM) field distributions and the dispersion characteristics of open cylindrical tube waveguides. Analyzed waveguides were made of a modern technological material-onion like carbon (OLC). The solution of this boundary problem was fulfilled by the partial area method. We have discovered the high-frequency cutoff frequencies of the propagating waveguide modes in the considered frequency range. We found that is possible to reach the one-mode regime of OLC tube waveguide.

09:30 : Electromagnetic small-scale modeling of composite panels involving periodic arrays of circular fibers
Changyou Li, Dominique Lesselier, Yu Zhong

Electromagnetic modeling of composite panels as multi-layered planar slabs involving a periodic set of circular fibers in each layer is considered herein. The case of a single layer is studied here. Combining multipole method and plane-wave expansion leads to full-wave field representations in all regions of space, yielding in particular reflection and transmission coefficients for TE/TM oblique plane-wave illumination. The method extends to out-of-plane incidences, and provides the main elements to approach full-wave scattering by the multi-layered structure.

09:45 : FDTD modeling of an infinitesimally thin graphene sheet
Yaxin Yu, Ching Eng Png

A three-dimensional subcell FDTD algorithm is proposed to efficiently simulate an infinitesimally thin graphene sheet to avoid the usage of an extremely fine mesh required by commercially available electromagnetic solvers. The dispersion characteristics of graphene for frequencies of THz and below have been fully incorporated in the algorithm. The simulation results are reported and wll also be discussed during the presentation.

08:30 - 09:40 — LT1

Session 4A3

Graphene Plasmonics, Nano-photonics and Nano-optoelectronics I

Organized by: Pai-Yen Chen and Mohamed Farhat

Chaired by: Pai-Yen Chen and Mohamed Farhat

08:30 : Invited talk
Dynamic light bending with graphene plasmonic structures
Eduardo Carrasco, Tony Low, Julien Perruisseau-Carrier

Graphene plasmonic metamaterials has attracted significant attention in recent years, due to its long-lived plasmonic resonances, strong light-matter interaction and tunability. These attributes allow for unprecedented applications from the terahertz to mid-infrared regimes. The possibility of utilizing graphene-arrays for dynamic light bending of an incident terahertz or mid-infrared beam is discussed. The underlying working principle relies on manipulating the spatial variations of phase-shifts of a reflected or transmitted beam, achieved through gate-tuning of the plasmonic resonance in a graphene-array.

08:50 : Strong exciton-plasmon coupling in graphene-semiconductor structures
Kirill Velizhanin, Tigran Shahbazyan

We study strong coupling between plasmons in monolayer doped graphene and excitons in narrow gap semiconductor quantum well separated by a potential barrier. We show that Coulomb interactions between excitons and plasmons result in mixed states described by Hamiltonian similar to one describing exciton-polaritons and derive the exciton-plasmon coupling parameter. We calculate numerically the Rabi splitting of exciton-plasmariton dispersion branches fo several semiconductor materials and find that it reaches 100 meV for small graphene and quantum well separations.

09:05 : Invited talk
Widely tunable plasmonic antennas with graphene and applications to high responsivity, high speed detectors
Federico Capasso, Yu Yao, Mikhail A. Kats, Raji Shankar, Patrick Rauter, Yi Song, Jing Kong, Marko Loncar

Graphene is emerging as an optical material which can be dynamically tuned by electrostatic doping. However, integration of graphene into optical and optoelectronic devices is limited due to its small thickness and the resultant weak interaction with light.

09:25 : Transition radiation from atomically thin graphene monolayer
Xiao Lin, Hongsheng Chen, Baile Zhang

We theoretically study the forward and backward transition radiations in graphene monolayer in both the non-relativistic and relativistic cases. For the normal and oblique incidence, the angular spectral energy density of the transition radiation is found strongly dependent on the charge's moving velocity and graphene's chemical potential. In particular, the transition radiation of surface wave along graphene is predicted to exist, indicating the fast moving charge particles may be an alternative excitation source to the graphene plasmonics.

08:30 - 09:30 — LT2

Session 4A4

Hybrid Metastructures and their Applications for Energy, Lighting, Catalysis and Sensing III

Organized by: Hilmi Volkan Demir, Sergey Gaponenko and Alexandre Govorov

Chaired by: Hilmi Volkan Demir, Sergey Gaponenko and Alexandre Govorov

08:30 : Invited talk
Chirality in II-VI quantum dot nanostructures
Joseph Govan, Alexander Baranov, Anatoly Fedorov, Yurii K. Gunko

In this paper we report the syntheses of CdS DNA penicillamine stabilised nanostructures and investigation of the new chiral nanomaterials by various instrumental techniques. DNA has also been used as an agent for the controlled assembly of various nanomaterials into arrays. To test the viability of DNA as an agent for the assembly of CdS nanotetrapods it was decided to test the effect of the presence of DNA of preformed CdS nanotetrapods.

08:50 : Invited talk
Plasmonic charge injection and antenna theory for photovoltaic design
Kylie Catchpole

Light trapping is of fundamental importance in many types of solar cells to allow maximum efficiencies, and hence lowest costs, to be reached. We show that that light trapping can lead to substantial efficiency increases using near-field enhancement and evaluate the potential of plasmonic structures to contribute to charge injection in solar cells.

09:10 : Invited talk
Multiscale optical imaging of complex fields based on the use of azobenzene nanomotors
Jerome Plain

We present a review on the use of molecular nanomotors to probe the near field of metal nanoparticles. Both the experimental and theoretical point of view will be presented and discussed.

08:30 - 09:00 — LT3

Session 4A5

Plasmonics and Nanophotonics IX

Chaired by: Carsten Rockstuhl

08:30 : Polarization beam splitter by hybrid plasmonic slot waveguide
Wenfu Zhang, Lingxuan Zhang, Wei Zhao

A compact polarization beam splitter is designed by directional coupling structure in which the two closely packed waveguides are all hybrid plasmonic slot waveguide. The coupling length is about 6 um and can be reduced by careful design.

08:45 : Direct observation of iso-frequency contour of hybrid photonic- plasmonic crystals via incoherent scattering process by defects
Lei Shi, Haiwei Yin, Xiaolong Zhu, Xiaohan Liu, Jian Zi

Different from the traditional band structures which only show the modes along directions of high symmetry in the Brillouin zone, iso-frequency contours, which consist of all the terminals of wavevectors corresponding

to the same frequency, would be more beneficial to analyze how light propagating in photonic crystals and contain all the information of the photonic crystals.

09:00 - 10:00 — LT3

Session 4A6

Educational Aspects of Metamaterials

Organized by: Arkadi Chipouline and Ari Sihvola

Chaired by: Arkadi Chipouline and Ari Sihvola

09:00 : Invited talk
Bows and flows of angel hair and ice cream castles in the air: the wonderful world of metamaterials
Allan Boardman, P. Egan, Y. G. Rapoport, M. McCall

The title of this paper is the leading line of a famous popular song that is singing about clouds and what their fascinating formations bring to mind. This grip on the imagination is similarly enhanced when being confronted by the advent of metamaterials onto the world stage. As will be shown in this paper, it stimulates us, from a teaching point of view, to re-examine our preconceived, almost unquestionable, ideas about waves, especially in the optical and hydrodynamic domains.

09:20 : Invited talk
Computer aided assessment of electromagnetics using STACK
Henrik Wallen

In this presentation, we discuss our experiences in using the web-based automatic assessment system STACK to replace part of the traditional homework on an electromagnetic field theory course during the spring term 2012 at the Aalto University.

09:40 : Invited talk
Modernization of courses of electrodynamics: thanks to metamaterials
A. Chipouline

Education in area of electrodynamics of compound materials, especially electrodynamics of metamaterials (compound materials with magnetic response) requires deep review, modernization, and cooperation in order to follow the actual tendencies in science and technology. In this work I present my experience of giving/teaching my course, Introduction to nanooptics at Friedrich-Schiller University of Jena. I identify the main weak points in the education system in area of modern electrodynamics, and give my opinion about the optimum way of improving educational standards in this area.

08:30 - 10:00 — LT4

Session 4A7

Photonic Dirac Cone and Topological Photonic States I

Organized by: Vassilis Yannopapas and Kazuaki Sakoda

Chaired by: Vassilis Yannopapas and Kazuaki Sakoda

08:30 : Invited talk

A perturbation method for dirac points in classical wave systems
Ying Wu, Jun Mei, Yan Li, C. T. Chan, Zhao-Qing Zhang

We present a first-principle method that can describe the linear dispersion relations in photonic and phononic crystals. The method can accurately predict the linear slopes of the dispersion relations, and reveals that only a particular type of linear dispersions can be described by Dirac Hamiltonian and possess a nonzero Berry phase. A selection rule for the Dirac-like cone in the center of the Brillouin is established from the method.

08:50 : Invited talk
Coupled-cavity lattices as photonic simulators for topological condensed matter
Vassilios Yannopapas

By using a tight-binding Green's tensor formalism, we show that periodic lattices of coupled cavities can serve as photonic simulators for topological condensed matter. We apply the theory to a 3D lattice of interacting cavities respecting time-reversal symmetry and a certain point-group symmetry and demonstrate that it can serve as an analog of a topological crystalline insulator.

09:10 : Invited talk
Design of nonreciprocal metamaterials in the microwave region
Tetsuya Ueda

Recent work on phase-nonreciprocal metamaterials in the microwave region is reviewed. Nonreciprocal refractive indices showing both positive and negative values at the same frequency are discussed for normally magnetized ferrite-based composite right/left handed metamaterials. Dispersion engineering for the phase nonreciprocity is shown.

09:30 : Radiative topological states in one-dimensional resonant photonic crystals
Alexander Poshakinskiy, Alexander Poddubny, Laura Pilozzi, Eugenius Ivchenko

We present a theory of topological edge states in one-dimensional resonant photonic crystals with compound unit cell. We demonstrate how the structure, despite being one-dimensional, can be characterized by topological indices.Contrary to conventional electronic topological states the modes under consideration are radiative, i.e., they decay in time due to the light escape through the structure boundaries. We demonstrate that the edge states survive despite radiative decay and can be detected both in time- and frequency-dependent light reflection.

09:45 : Topological Majorana states in zigzag chains of plasmonic and dielectric nanoparticles
Alexander Poddubny, Andrey Miroshnichenko, Alexey Slobozhanyuk, Yuri Kivshar

We propose a simple realization of topological edge states in zigzag chains of plasmonic or dielectric nanoparticles, mimicking the Kitaev's model of Majorana fermions. We demonstrate the correspondence between the coupled dipole equations in the zigzag chain and the Bogoliubov-de-Gennes equations for the quantum wire on top of superconductor, and support the theory by full-wave electromagnetic simulations. The localized plasmonic/Mie modes can be selectively excited at both edges of the plasmonic/dielectric zigzag chain depending on the incident field polarization.

08:30 - 10:00 — LT5

Session 4A8

Plasmonics and Nanophotonics VII

Chaired by: Philippe Ben-Abdallah

08:30 : Building plasmonic circuits with molecular switches - molecular construction and tuning of nanophotonic biosensors

Alasdair Clark, Jonathan Cooper

We report a novel nanophotonic sensor-circuit which is constructed and activated by DNA hybridisation. Representing a new concept in plasmonic device creation, we combine direct-write lithography with DNA-directed assembly to create a three-part nanophotonic circuit with a laser input, a DNA-controlled switch and a Raman scattered photonic output. In doing so, we demonstrate an engineered nanophotonic device, with an active molecular element, capable of single event detection via surface enhanced Raman spectroscopy (SERS).

08:45 : Large enhancement of Forster resonance energy transfer on graphene platforms
Svend-Age Biehs, Girish Agarwal

We focus on the fundamental aspects of FRET between a donor-acceptor pair in close vicinity to a graphene platform. We show that FRET mediated by the plasmons in graphene is broadband and enhanced by six orders of magnitude. We briefly discuss the impact of phonon-polaritonic substrates.

09:00 : Doped metal-LiNbO3-metal plasmonic waveguides
Montasir Qasymeh

We investigate theoretically doped Metal-LiNbO3-Metal nano-structure. We show that symmetric and anti-symmetric Surface Plasmon Polariton (SPP) modes can be coupled in such a structure by the mean of photorefractive effect. We found that the power transfer in the coupled modes is unidirectional from a strong symmetric mode to a week anti-symmetric mode. Either as an amplification or a mode-conversion process, the presented coupling process promises novel future applications. These include implementing known photorefractive applications in the plasmonic fields.

09:15 : Plasmonic gratings for enhanced THz emission from metal-semiconductor thin films
Gopika Ramanandan, Aurèle Adam, Paul Planken

THz emission from thin film Schottky junctions is enhanced using plasmonic nano-gratings. Enhancement factors of up to 5.6 are observed in the emitted electric field, corresponding to a power enhancement factor of 34. The Fabry-Perot absorption is distinguished from the plasmonic absorption thanks to experimental measurement and corroborated via simulation.

09:30 : A simple approach to form ordered Ag nanoparticles with dual-sized features
Benzhong Wang, Hongwei Gao, Soo Jin Chua

A simple method to fabricate ordered silver nanoparticles with dual-size distribution has been described, where a self-assembled hexagonally nonclose-packed monolayer of nanospheres is employed as a template to form the ordered Ag nanoparticles. Experiments of annealing of the Ag nanostructures and substrate etching after annealing were also carried out. Our experimental results indicate that optical properties of the Ag nanostructures strongly depend on its arrangements and environment.

09:45 : Active control of plasmonic resonances
Giorgos Georgiou, Martijn C. Schaafsma, Hemant H. Tyagi, Jaime Gomez-Rivas

We investigate the photo-excitation of localized surface plasmon polaritons (LSPPs) in semiconducting plasmonic resonators at THz frequencies. This is realized by a patterned optical excitation of free carriers in thin semiconducting films using a spatial light modulator. This enables full spatiotemporal control of plasmonic resonances. By changing the illumination patterns we can excite LSPPs in plasmonic resonators without the need of physically structuring the sample. A single semiconductor layer can be used to generate a variety of plasmonic devices.

08:30 - 09:55 — MAS EC1

Session 4A9

Plasmonics and Nanophotonics X

Chaired by: Giorgio Adamo

08:30 : Invited talk
Ultrafast thermal nonlinearity
Jacob Khurgin

We show that when thermal nonlinearity is combined with nanoplasmonics one can achieve both high value of nonlinear index and reasonably high (100GHz or more)speed.

08:50 : Optical tuning and photochemistry of dimer plasmonics with nanogap CdSe and MoS2
Daniel O. Sigle, Jan Mertens, Lars O. Herrmann, Jeremy J. Baumberg

We use light to directly tune the optical resonances of single nanoparticles that are plasmonically coupled to a gold surface through nano-layers of semiconductor, such as cadmium selenide or molybdenum disulphide. We show the capability to dynamically probe chemical modifications of few-hundred atoms in these gaps via shifts of the plasmon resonances. Further spectral shifting is observed as a result of induced changes in the AuNP morphology during optical irradiation.

09:05 : Engineering gold alloys for plasmonics
Yoshiaki Nishijima, Yoshiakazu Hashimoto, Gediminas Seniutinas, Lorenzo Rosa, Saulius Juodkazis

We demonstrate the experimentally determination of the optical properties of plasmon resonances of metal alloys.The optical constants directly affected to the plasmon resonance wavelength, EM field intensity.Also we demonstrate the surface enhanced raman scattering (SERS) for useful application of alloy metals.Depending on the type of metal which molecules adsorbed on the surface, we could observe different Raman mode were enhanced.It is due to the chemical effect between metal and molecules.

09:20 : Engineering the paired-strips gold nanoantennas for absorption enhancement in ultra-thin P3HT polymer film
Kuo-Ping Chen, Zih-Ying Yang, Chen-Wei Su

The absorption enhancement factor is calculated as an index for engineering the dimension of gold nanoantennas and also optimizing the thin slab thickness. When the resonance mode across the cavity mode, the absorption enhancement could reach ~20 times for gold nanoantennas embedded in 100nm P3HT:PCBM thin film.

09:35 : Invited talk
Polariton nonlinear resonant tunneling diode
Hai Son Nguyen, Dmitry Vishnevsky, Felix Marsault, Chris Sturm, Dimitrii Tanese, Dimitry Solnyshkov, Elisabeth Galopin, Aristide Lemaitre, Isabelle Sagnes, Alberto Amo, Guillaume Malpuech, Jacqueline Bloch

We report the realization of a polariton resonant tunneling diode based on an innovative design of a wire cavity: two constrictions delimits a 0D polariton island coupled to 1D regions through two tunnel barriers. Monochromatic polariton flow sent onto this microstructure undergoes resonant tunneling, which is modulated by a gate laser beam, focused onto the island. Nonlinear properties of the device are demonstrated by the observation of asymmetric transmission peak and bistable behaviors.

Coffee Break and Exhibit Inspection

Session 4P1

Poster Session VI

10:00 - 10:45

P1: Distinction of Opto-Electronic Properties between Random and Ordered Nano-Holed Layers
Mikita Marus, Aliaksandr Hubarevich, Wang Hong, Eugeny Muha, Aliaksandr Smirnov, Sun Xiaowei, Fan Weijun

The distinction of opto-electrical properties in case of aluminum, gold and silver random and ordered nano-holed layers was demonstrated. It is found that transmittance drops due to the shortening of plasmon polaritons propagating length within the Anderson localization effect, while sheet resistance increases in regard of decrement of metal connections volume.

P2: Highly-efficient white quantum dot light-emitting diode based on ZnO quantum dot
Jing Chen, Zhi Li, Jiangyong Pan, Qingguo Du, Wei Lei

White quantum dot light-emitting diodes (QD-LEDs) have been a promising candidate for high-efficiency and color-saturated displays. Here, we report a simply solution-processed white QD-LED using ZnO QDs as emitters. The device is demonstrated with a maximum luminance of 300 cd/m2, exhibiting the Commission Internationale de l'Enclairage (CIE) coordinates of (0.33, 0.33). The unencapsulated white QD-LED has a long lifetime of 120 h.

P3: Broadband asymmetric transmission in ultrathin chiral metamaterials
J. H. Shi, H. F. Ma, C. Y. Guan, Z. P. Wang, T. J. Cui

We theoretically and experimentally demonstrate broadband artificial chirality in ultrathin chiral metamaterials constructed by an array of asymmetrically split ring apertures. The anisotropic bilayered metamaterial with chirality exhibits a broadband diodelike asymmetric transmission of linearly polarized waves with totally suppressed co-polarization transmission.

P4: Photonic crystal based 3D Surface Enhanced Raman Spectroscopy (SERS) substrate for optofluidic application
Xiangwei Zhao, Jiangyang Xue, Zhongde Mu, Meng Lu, Zhongze Gu

In biomedical fields, photonic-based biological and chemical sensing techniques are increasingly used because of their high sensitivity and flexibility. Recently, optofluidics becomes the emerging field which integrates photonics with microfluidics and provides synergistic effect between them. Since the optical traps, resonators, waveguides and CCD detectors are synthesized with microfluids, sample process and optical detection become more compact and efficient.

P5: Femtosecond surface plasmons In one- dimensional plasmonic crystals: Frequency-resolved optical gating
Tatyana Dolgova, Varvara Zubyuk, Alexandr Musorin, Andrey Fedyanin

Femtosecond dynamics of resonantly excited surface plasmons in one-dimensional plasmonic crystals is observed by using frequency-resolved optical gating (FROG). The FROG spectrograms differs significantly for both edges of plasmonic band gap due to strong spectral variation of surface plasmon lifetime within Fano resonances. The asymmetric plasmon-assisted reshaping of the electric field amplitude and phase of the femtosecond pulses is demonstrated.

P6: Anisotropic scattering from plasmonic systems: polarization index allows detecting internal plasmon field
Andrey Sarychev, Vladimir Drachev, Alexandr Rakhmanov, Sergey Boyarintsev, Kliment Kugel, Yuri Sukhorukov

We perform numerical simulations of the local electric field fluctuations and surface enhanced Raman scattering (SERS) in metal-insulator nanocomposites. An efficient method of the computer simulations has been used to find the spatial fluctuations of the local electric field and Raman fields. The degree of the polarization for the scattered light is found.

P7: Sensors based on dielectric metamaterials
Andrey Lagarkov, Ilya Ryzhikov, Alexander Vaskin, Kirill Afanasiev, Irina Boginskaya, Igor Bykov, Ilya Ku-

rochkin, Igor Budashov, Vladimir Gorelik, Andrey Sarychev

New class of the dielectric metamaterials is proposed. We show that random, periodic and quasi periodic dielectric structures can support multiple internal resonances. The interaction of the resonances results in giant electric and magnetic field fluctuations. The dielectric metamaterials can be used to design the new effective bio and chemical sensors and other optical devices.

P8: Bandwidth SRR-inspired antenna augmented by using a negative load
Ilyes Ben Mohamed, Mohamed Latrach, Esthelladi Ramanandraibe, Shah Nawaz Burokur

Non-Foster impedance is used to increase the operating bandwidth of the antenna knowing its reactance, we are able to design the circuit topology of a negative impedance converter (NIC) which will provide the required reactance to cancel the antenna's reactance. The simulation results show that non-Foster elements cancel the antenna's reactance and widen the bandwidth of the antenna structure. The implementation issues and results are discussed.

P9: Simulation of an asymmetric metamaterial waveguide absorber
H. M. Mousa, M. M. Shabat

This paper presents simulation for an asymmetric TE mode absorption in a lossy metamaterial (left-handed) slab (LHM) sandwiched between a lossy substrate and coverd by a losseless dielectric cladding. The asymmetry solutions of the Eigen value equation describe lossy-guided modes with complex-valued propagation constants.

P10: Inntelligent and ultrasensitive analysis of mercury trace contaminants via plasmonic metamaterials-based DNA logic gates
Cuong Cao, Jun Zhang, Shuzhou Li, Qihua Xiong

In this study, we describe AND, INHIBIT and OR logic gate operations based upon the metallophilic properties of a guanine- and thymine-rich oligonucleotide sequence to K+ or Hg2+ ions, which can specifically trigger or interrupt the formation of Hoogsteen hydrogen bonding that could be monitored by means of MetaSERS with high sensitivity and selectivity.

P11: Enhanced light absorption in thin film solar cells using hybrid plasmonic travelling-wave nano-antennas
Fatemeh Taghian, Vahid Ahmadi, Leila Yousefi

A novel hybrid plasmonic travelling wave nano-antenna isproposed to enhance light absorption in thin film solar cells. By using the proposed travelling wave optical antenna the incident light travelling in the vertical direction is redirected by the antenna to travel in the lateral direction The proposed structure is numerically simulated and simulation results show that the short circuit currentof the solar cell is enhanced by a factor of 2.

P12: Plasmon coupling in three-dimensional magnetic SRR metamolecules
Wei-Lun Hsu, Wei-Yi Tsai, Pin Chieh Wu, Wei Ting Chen, Yao-Wei Huang, Chun Yen Liao, Ai Qun Liu, Greg Sun, Din Ping Tsai

This work offers an important method to enhance the interaction between incident fields and metamaterials as well as the plasmon coupling between metamaterials at optical frequencies. Since the smaller occupied area in the case of 3D SRRs, it also paves a way for localized surface plasmon (LSP) based sensing device applications with more pronounced spectral resonant signals.

10:45 - 12:35 — LT22

Session 4A10

Symposium: Resonant Dielectric Nanostructures and Metamaterials X

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Alexander Shvartsburg and Jacob Khurgin

10:45 : Plenary talk
Tunable quantum metaphotonics
Harry Atwater

Understanding the fundamental properties of plasmonic and dielectric materials in resonant subwavelength structures has fueled an explosion of interest in metamaterials and nanophotonic devices. In this seminar, we explore new directions for plasmonics by examining the relationship between plasmons and the electrochemical potential of the electron gas, and we discuss opportunities to observe quantum coherent states in plasmonic structures. Usually plasmons are described in a classical electromagnetic theory context, yet plasmons are fundamentally quantum excitations. Moreover, the carrier density and optical properties of plasmonic materials are typically fixed at the time of fabrication. Field effect tuning of the electrochemical potential in graphene nanoresonators enables the plasmon and phonon dispersion to be measured. Electrochemical and carrier density modulation in metals yields tunable resonances in metal nanostructures and reveals the plasmoelectric effect, a newly-discovered photoelectrochemical potential. By tuning the permittivity and index to near-zero values, expands the length scale over which coherent quantum emitter phenomena (e.g., concurrence, superradiance) can be observed in epsilon-near-zero media. Finally, we demonstrate entanglement or coherent superposition states of single plasmons using two plasmon-quantum interference in chip-based plasmon waveguide directional couplers.

11:25 : Keynote talk
Self-assembling nanoplasmonic arrays: Novel metamaterials for smart mirrors, sensors and antennas
Michael Cecchini, Angela Demetriadou, Joshua Edel, Michael E. Flatté, Alexei A. Kornyshev, Anthony Kucernak, Cheuk Leung, Jack Paget, Vlad Turek, Michael Urbakh, Victoria Walpole

We will overview the physics and basic properties of novel nanoplasmonic systems, based on self-assembling of metal (or composite) nanoparticle (NP) arrays at liquid-liquid, liquid-gas and solid-liquid interfaces. At liquid interfaces, the NPs adsorb due to capillary forces, to block the unfavorable boundary between water and oil, at solid- liquid interfaces due to Van der Waals and image forces.

11:55 : Invited talk
Towards low-loss, Mid-IR nanophotonics and metamaterials: Localized surface phonon polariton modes in polar dielectric crystals
Joshua D. Caldwell, Andrey Kretinin, Yiguo Chen, Vincenzo Giannini, Yan Francescato, Chase Ellis, Orest J. Glembocki, Joseph Tischler, Francisco J. Bezares, Stefan A. Maier, Michael Fogler, Kostya S. Novoselov

The high optical losses inherent in metal-based surface plasmon materials has led to an ever-expanding effort to identify, low-loss alternative materials capable of supporting sub-diffraction confinement. One alternative is the surface phonon polariton (SPhP), which does so in a purely dielectric, and therefore, low-loss material system. Both SiC and hexagonal BN can support such SPhP modes, along with a whole host of alternative SPhP materials. Here we report on the investigations of both SiC and hBN, localized SPhP-based nanostructures.

12:15 : Invited talk
Infrared surface phonon polariton resonant structures
Tao Wang, Peining Li, Benedikt Hauer, Dmitry Chigrin, Thomas Taubner

Plasmon polariton based antennas (nano-antennas) are important elements of nano-optic systems and have been extensively used among others to enhance sensing, spectroscopy, light emission and photodetection. In the infrared spectral range polar crystals provide promising alternative materials for nano-antenna applications. In this presentation we will discuss design constrains, optical properties and possible applications of polar crystals based surface phonon polariton resonant structures.

10:45 - 12:05 — LT23

Session 4A11

Transformation Electromagnetics Concepts and Applications I

Organized by: Shah N. Burokur and Andre de Lustrac

Chaired by: Shah N. Burokur and Andre de Lustrac

10:45 : Invited talk
Antipodal radiation pattern of a patch antenna combined with superstrate using transformation electromagnetics
Mark Clemente Arenas, Anne Lepage, Xavier Begaud

This paper aims to show the design and performances of a flat superstrate placed above an L-band patch antenna. Obtained from the Transformation Electromagnetics technique, this superstrate enables to produce an antipodal radiation with a quasi null radiation in the broadside direction. From analytical transformations used for the calculation of the constitutive parameters, material permittivity and permeability profiles of the superstrate are deduced. Then, the field distribution and radiation patterns of the whole structure confirm the antipodal radiation behavior.

11:05 : Invited talk
Arbitrary control of electromagnetic flux in inhomogeneous anisotropic zero-index media
Jie Luo, Yun Lai, C. T. Chan

We propose a method to control electromagnetic flux in an almost arbitrary way in wavelength and sub-wavelength scales. The capability of sub-wavelength flux control is enabled by the evanescent waves induced by a near zero permittivity component. By designing the spatial profile of the other permittivity component in such inhomogeneous media, the flow and distribution of energy flux can be conveniently manipulated. This method provides another approach to efficiently control electromagnetic flux in nonmagnetic media.

11:25 : Invited talk
Metamaterial-based omnidirectional antenna
Paul-Henri Tichit, Shah Nawaz Burokur, Cheng-Wei Qiu, André de Lustrac

A directional directive emission is converted into an omnidirectional one based on the transformation electromagnetics concept. A dipole antenna used as excitation source is embedded in a bulk metamaterial presenting gradient radial and angular permittivity. Theoretical analysis is presented and numerical simulations are performed to present the concept. Near-field cartography and far-field radiation pattern measurements are done to validate the proposed omnidirectional antenna. A good agreement is observed between simulations and measurements.

11:45 : Invited talk
Transformation electrostatics
Tie Jun Cui, Zhong Lei Mei, Wei Xiang Jiang

Transformation electrostatics is a d.c. reduction of the transformation electromagnetic or transformation optics, which provides a freedom way to control the electric currents and potentials. We have proposed, designed, and fabricated a series of transformation statics devices, such as the d.c. invisibility cloak, exterior cloak, active cloak, partial cloak, carpet cloak, anti-cloak, concentrator, and illusion devices. The proposed theory and methods can also be applied to solve other Laplace problems, such as the control of heat transfers.

10:45 - 12:25 — LT1

Session 4A12

Graphene Plasmonics, Nano-photonics and Nano-optoelectronics II

Organized by: Pai-Yen Chen and Mohamed Farhat

Chaired by: Pai-Yen Chen and Mohamed Farhat

10:45 : Invited talk
Hybrid graphene plasmonic modulator
Daniel Ansell, Ilya Radko, Zhanghua Han, Sergey Bozhevolnyi, Alexander Grigorenko

In the past decade, there has been an explosion of interest in the field of plasmonics, due to the possibilities of utilising surface plasmon-polariton (SPP) modes for subwavelength photonic devices and circuitry. Within the field, the realisation of active-plasmonic devices is particularly challenging. Here, we present a graphene-based plasmonic modulator optimised for operation at telecommunications wavelength.

11:05 : Invited talk
Non-reciprocal graphene magnetoplasmons: Terahertz components and devices
Nima Chamanara, Christophe Caloz

Magnetoplasmons in various graphene strip structures are investigated. The non-reciprocity of the magnetoplasmon modes is leveraged for the realization of non-reciprocal terahertz plasmonic components and devices, such as plasmonic couplers and isolators. Electrically doped strip structures,with potentials in tunable terahertz plasmonic devices,are proposed and investigated.

11:25 : Invited talk
Graphene for near-field thermal energy conversion
Philippe Ben-Abdallah, Riccardo Messina

Thermophotovoltaic devices are energy-conversion systems generating an electric current from the thermal photons radiated by a hot body. We described here the potential of graphene-based photovoltaic cells to convert the near-field energy which is confined at the surface of hot bodies.

11:45 : Invited talk
A broadband graphene-based metasurface absorber
Muhammad Amin, Mohamed Farhat, Hakan Bagci

A broadband graphene-based metasurface absorber operating at tearhertz (THz) frequencies is proposed. The wideband of absorption can be achieved by (i) asymmetrically patterning the graphene metasurfaces to support higher order surface plasmon modes that destructively interfere with the dipolar mode and generate electromagnetically induced absorption, (ii) stacking up these metasurfaces backed-up with dielectric substrates on top of each other, (iii) biasing each metasurface at a different gate voltage, and (iv) finally increasing the Graphene's damping factor.

12:05 : Invited talk
Graphene metadevices and metamaterials for linear and nonlinear THz applications
Woo Young Kim, Hyeon-Don Kim, Hyun Joo Choi, In-Hyung Baek, Bong Ju Kang, Teun-Teun Kim, Kanghee Lee, Young Uk Jeong, Fabian Rotermund, Bumki Min

Graphene metadevices and metamaterials are promising especially for the control of THz waves because the conductivity of graphene can be tuned largely by electrical gating. Among various possible functional devices and materials, THz graphene memory metadevices and THz graphene metamaterial saturable absorbers are introduced as illustrative examples.

10:45 - 12:25 — LT2

Session 4A13

Theoretical and Computational Techniques for Nanophotonics and Nanoplasmonics I

Organized by: Iftikhar Ahmed, Chu Hong Son, Khoo Eng Huat and Ching Eng Jason Png

Chaired by: Chu Hong Son and Ching Eng Jason Png

10:45 : Invited talk
Dynamic and broadband steering of near-field plasmons and far-field photons
Choon How Gan, Geoffrey Nash

Interference phenomena is exploited to achieve broadband, dynamic steering of near-field plasmons and far-field photons emerging from nanoslits. Two configurations are presented. In the first, superposition of the two lowest order modes guided by the nanoslit shifts the angular distribution of the emergent field. In the latter configuration, a second closely spaced nanoslit is included to facilitate broadband operation. Conditions are specified for which the two slits act like a pair of coherent oscillators that interfere constructively or destructively.

11:05 : Quasistatic perturbation theory for the optimal design of Plasmon induced Transparency based sensors
Ravi S. Hegde, Martin Mesch, Harald Giessen

Coupled systems of plasmonic resonators are currently of interest in furthering the capabilities of LSPR based refrac- tive index sensing. A semi-analytical formulation involving quasistatic perturbation theory and numerical integrals of the near field mode fields is presented. The procedure is applied to the surface and volume sensing configurations of a plasmon induced transparency resonantor and the optimal coupling is found. The procedure provides a way to opti- mize the performance of the sensor in a variety of sensing configurations after a single calculation of the modal field and permits fair comparison to other sensing modalities.

11:20 : Beam shaping using nano-structured lens
Zhengtong Liu, Eng Huat Khoo, Chun Yong Ngo, Liying Hong, Rui Fen Wu, Jing Hua Teng

We use geometrical optical method to design nano-structured lens to shape laser beam output from a multimode fiber.

11:35 : Analyzing light transmission through subwavelength holes in metallic films by a vertical mode expansion method
Xun Lu, Hualiang Shi, Ya Yan Lu

An efficient method is developed to rigorously analyze transmission of light through holes in a metallic film. The method relies on expanding the electromagnetic field (subtracted by some one-dimensional (1D) solutions) in 1D (vertical) modes, and it is simpler and more efficient than existing mode-matching or modal methods which expand the field in two-dimensional (horizontal) modes.

11:50 : Invited talk
Electrically-excited point sources of surface plasmons
Zhaogang Dong, Hong-Son Chu, Di Zhu, Wei Du, Yuriy A. Akimov, Wei Peng Goh, Christian Albertus Nijhuis, Joel K. W. Yang

Point sources of plasmons can be achieved through the dipole radiation from molecules or quantum dots. However, it usually requires extreme operator skills in picking up the dipole-source elements with a scanning probe. In this paper, we shall present our recent progress on both the theoretical and experimental investigations of STM-based electrical excitation of point plasmons and its applications, including achieving a miniaturized directional SPP source with a traffic control capability, and plasmon mapping for imaging grain boundaries.

12:10 : Optical metamaterial for tunable low loss sub-wavelength imaging

Yasaman Kiasat, Zsolt Szabo, Chen Xudong, Er Ping Li

In this paper the classical effective medium theory is extended, to design the optical properties of metal-dielectric composites for tunable and low-loss sub-wavelength imaging systems. It is shown that the shape of inclusions possesses sufficiently large degree of freedom to adjust the imaging frequency according to the available laser sources. It is also demonstrated that anisotropic composites made of aligned non-spherical nanoparticles produce images with higher resolution and intensity than isotropic lenses, due to their different mechanism of imaging.

10:45 - 12:45 — LT3

Session 4A14

Atoms with Nanophotonic or/and Nanoplasmonic Structures I

Organized by: Christophe Couteau and David Wilkowski

Chaired by: Christophe Couteau and David Wilkowski

10:45 : Invited talk
Atom photonics on a chip
Jennifer A. Black, Mathieu Girard-Carrier, Aaron R. Hawkins, Holger Schmidt

Atomic vapor cells can be integrated on a semiconductor chip using hollow-core waveguide technology to create a new atom photonic platform. We review the design and fabrication principles of this technology along with applications in atomic spectroscopy, slow light on chip, multi-cell photonic devices, and atom slowers.

11:05 : Invited talk
Atom-induced cavities in photonic crystal structures: a novel paradigm for long-range interactions
Darrick Chang

One of the exciting frontiers in atomic physics involves the use of ultracold atoms as quantum simulators. Here, we describe a novel technique where designable long-range interactions can be added to the toolbox of quantum simulation. Our approach relies on the interfacing of trapped atoms with photonic crystal structures, where the interaction is mediated by localized photons created near a photonic band edge.

11:25 : Invited talk
Atomic vapor photonic microcells for quantum optics applications
Fetah Benabid

We report on our recent work on inner-wall coated-core HC-PCF with polymer such as PDMS for anti-relaxation purposes and with ceramic to minimize the interaction atom-surface and hence increasing the lifetime of the loaded atoms inside the fiber core. This work includes the recent developments on the design and fabrication of hypocycloid core-shaped Kagome HC-PCF, on the achievement of ultra-long lived Rb in HC-PCF core, and the first atomic polarization measurements for Rb filled HC-PCF

11:45 : Invited talk
Infiltrating an artificial opal with an atomic vapour: observation of sub-Doppler signals in linear spectroscopy
Isabelle Maurin, Elias Moufarej, Philippe Ballin, Athanasios Laliotis, Daniel Bloch

When infiltrating an artificial opal with a resonant gas, sub-Doppler structures can be observed in linear spectroscopy. this is because of confinement effect. Our report is on the experimental developments, and on a layered optical model of the opal which helps interpreting some of the observed features.

12:05 : Invited talk
Interfacing cold atoms and surface plasmons
Christian Stehle, David Auwarter, Matthias Mildner, Robin Ropke, Claus Zimmermann, Sebastian Slama

Hybrid systems that combine single atoms with plasmonic nanostructures are interesting candidates both for achieving light-matter interactions on the single photon level and for generating nanoscale potential landscapes in quantum optics. We experimentally realize interfaces between ultracold atoms which are trapped in magnetic traps in vacuum with plasmonic structures that are integrated on solid surfaces. Here, we report on our experiments on trapping and manipulating cold atoms close to plasmonic structures.

12:25 : Invited talk
Microfabricated structures for laser cooling
Chidi Nshii, Matthieu Vangeleyn, Joseph Cotter, Paul Griffin, Ed Hinds, Charles Ironside, Patrick See, Alastair Sinclair, Erling Riis, Aidan S. Arnold

We have developed a microfabricated chip based on planar, diffractive optics, which transforms a single input beam of light to produce all the beams required for a magneto-optic trap (MOT). This simplifies the integration of laser cooling into compact and ultimately portable devices. In such a MOT we have trapped Rb atoms similar to a conventional MOT with the same trapping volume. The larger relative trap volume leads to 104 times more atoms than prior microfabricated MOTs.

10:45 - 12:45 — LT4

Session 4A15

Photonic Dirac Cone and Topological Photonic States II

Organized by: Vassilis Yannopapas and Kazuaki Sakoda

Chaired by: Vassilis Yannopapas and Kazuaki Sakoda

10:45 : Invited talk
Dirac cones, line nodes and Weyl points in photonic crystals
Ling Lu, Liang Fu, Scott Skirlo, John Joannopolous, Marin Soljacic

We discuss robust linear point and line degeneracies in the band structures of photonic crystals: Dirac cones in 2D, line nodes and Weyl points in 3D. We show the symmetry requirements of their topological protections and their associated surface states.

11:05 : Invited talk
Extremely high absorption by Dirac cone mushroom metasurfaces in millimeter-wave regions
Atsushi Sanada, Shotaro Nagai

Angle selective high absorption by mushroom metasurfaces is investigated. A resonator model is introduced and the absorption phenomenon is explained as a critical coupling situation where effective external and unloaded quality factors become identical. Full-wave simulations at V-band reveal that a Dirac cone mushroom metasurface has a larger coupling between incident waves and guided wave compared with the non-Dirac cone one and possibility of realizing the near broadside absorption is shown.

11:25 : Invited talk
Geometric phases and surface impedance in Dirac cone systems
X. Q. Huang, Meng Xiao, C. T. Chan

A subset of two dimensional (2D) photonic crystals (PCs) possessing Dirac-like cone dispersions at k=0 can be described as a zero-refractive-index material at the Dirac-like point frequency. There are always interface states at the boundary between two semi-infinite PCs with the system parameters slightly perturbed from the

Dirac cone condition. The existence of such interface states can be explained by surface impedances derived from a multiple scattering theory as well as the geometric phases of the bulk bands.

11:45 : Invited talk
Geometrical aspects of optical waves in phase space
Kei Sawada

We theoretically study the Berry-phase effects of optical waves. In a system with a gapped dispersion, the optical wavefunctions can have non-trivial geometrical properties related to the Berry curvature in some parameter space. We show that such Berry-phase effects are realized in a deformed medium as an enhanced translation of optical wave packet. We also show experimental results supporting the theory.

12:05 : Invited talk
Method for detecting photonic Dirac cones in optical frequencies
Kazuaki Sakoda, Hiroyuki Takeda

We apply the degenerate perturbation theory for the vector electromagnetic wave to photonic crystal slabs and design a structure that realizes the Dirac cone. We show that the propagation direction of the diffracted wave can be controlled by the polarization of the incident wave. We examine the slightly non-degenerate case and show that the photon effective mass is proportional to the frequency gap. These properties can be used for the efficient detection of the Dirac cone.

12:25 : Invited talk
Numerical analysis on the possibility and stability of a new ype of topological wave-packet
Masaru Onoda

We numerically investigate a novel topological wave-packet with a ring vortex as well as a line vortex associated with orbital angular momentum, inspired by recent developments in optical communication and photonic materials. A simple algorithm for constructing a solution of Maxwell equations with multiple types of vortices is presented. The stability of the wave-packet is also examined with respect to reflection and refraction at conventional interfaces between homogeneous dielectrics, and the transformation law of its topological properties is discussed.

10:45 - 12:45 — LT5

Session 4A16

Active and Tunable Metamaterials IV

Organized by: Zhengtong Liu, Dongying Li and Yaxin Yu

Chaired by: Zhengtong Liu and Yaxin Yu

10:45 : Invited talk
Tunable plasmonic devices
Jinghua Teng

This talk will introduce several tunable plasmonic devices in THz, mid-IR and visible range by using semiconductors, graphene and liquid crystals, respectively.

11:05 : Invited talk
Tuning the efficiency of solar cells by incorporating plasmonic nanoparticles with different morphology
Wai Yan Jim, Wai Kin Yiu, Chap Hang To, Annie Ng, Aleksandra Djurisic, Wai Kin Chan, Charles Surya

Gold nanostructures with different concentrations and/or morphologies were incorporated into dye-sensitized

solar cells and polymer solar cells. The effect of nanostructure morphology and/or concentration on the photovoltaic performance was investigated. Under optimized conditions, efficiency improvements from 7.8 % (without Au) to 8.3 % (with Au) were observed for polymer solar cells, and from 3.14 % to 3.37 % for SnO2-based dye-sensitized solar cells.

11:25 : Invited talk
Electrically driven terahertz metamaterial diffraction modulators
Nicholas Karl, Kimberly Reichel, Rajind Mendis, Daniel Mittleman, Igal Brener, Alex Benz, John Reno, Antoinette Taylor, Hou-Tong Chen

We propose a new scheme of terahertz modulation based on active diffraction gratings formed by planar hybrid metamaterials where the resonances are electrically switchable. Our experimental results reveal promising broadband modulation performance with modulation depth exceeding the current state-of-the-art.

11:45 : Invited talk
Optically tunable metamaterials in the terahertz regime
Ekmel Ozbay

In this talk, we report the design, fabrication and experimental characterization of optically tunable metamaterials in the terahertz (THz) regime. The metamaterial design is based around electric-field-coupled inductor capacitor (ELC) resonators. We observed a tuning range of the fabricated device as high as 26 % (from 0.76 THz to 0.96 THz) by controlling the conductivity of the silicon layer via optical illumination. The simulations showed an all-optical blueshift with the tuning range of 40 %, compared to 26 % in the experiments.

12:05 : Invited talk
CMOS on-chip metamaterial: New opportunities in Mm-wave and THz
Yang Shang, Wei Fei, Hao Yu

This paper shows a latest summary of CMOS on-chip metamterial design from device level to system level. There are two metamaterial types mainly explored: composite right/left handed transmission line (CRLH T-line) and split-ring-resonator/complementary-split-ring- resonator (SRR/CSRR). The applications of metamaterial for mm-wave and THz CMOS integrated circuit design are discussed in big-data communication and THz imaging systems. The CMOS on-chip metamateiral integrated circuits at 60GHz and 140GHz are demonstrated with measured results.

12:25 : Invited talk
Manipulation of quantum-dot emission by multipolar magnetic metamaterials
Manuel Decker, Sergey Kruk, Isabelle Staude, Chennupati Jagadish, Dragomir Neshev, Yuri Kivshar

We overview our recent studies on the control of the spontaneous emission properties of semiconductor quantum dots via their coupling to multipolar resonances in photonic metamaterials. We show how the interaction of quantum dots simultaneously with magnetic and electric resonances of the metamaterial affects their spontaneous emission characteristics with regard to photoluminescence enhancement and lifetime and also results in elliptically-polarized light emission at off-normal directions.

10:45 - 12:25 — MAS EC1

Session 4A17

Photonic Crystals I

Chaired by: Min Gu

10:45 : Invited talk
Diamond photonic crystal slotted cavities for biosensing
Xavier Checoury, Candice Blin, Hugues Girard, Celine Gesset, Samuel Saada, Zheng Han, Philippe Boucaud,

Philippe Bergonzo

Diamond is currently emerging as a novel material for photonic devices thanks to its many attractive properties. We propose a novel approach which consists in combining the sensitivity of slotted photonic crystals to the versatility and biocompatibility of diamond interface for developping innovative diamond-based photonic biosensors. We fabricated slotted photonic crystal cavities in polycrystalline diamond with Q factor as high as 6500. As a proof of concept, we demonstrate label-free molecule detection with them using the biotin-streptavidin recognition system.

11:05 : Optical waves in photonic crystal meta-materials
Kaisar Khan, Khaled Mnaymneh, Hazem Awad, Imad Hasan, Trevor Hall

Dispersion less flat band was observed in photonic Crystal for the frequency region where dielectric constant changes its sign.Theoretical analysis was done to see the dispersion profile of several higher order modes in both polarization (TE and TM). Design effort was made by altering the geometry of the photonic crystal to achieve desired dispersive responses. We use (n-GaAs/gold/silver)to observe surface plasmonic wave. Numerical study was done to investigate the dispersive response of changing magnetic field.

11:20 : L-shaped photonic crystal line defectwaveguide slab
Neslihan Eti, Huseyin Sozuer

We introduce theoretical studies on L-shaped photonic crystal line defect waveguide slabs. The L-shape is given the structure by using 1 dimensionally periodic waveguide (1D-LDWG) slab for straight sections and using a 2 dimensionally periodic square line defect waveguide (2D-LDWG) slab as corner element. We show by using L-shaped photonic crystal slabs bending loss can be reduced for TE-like modes. The calculations are given for two different structures.

11:35 : Two dimension photonic crystal Y-branch beam splitter with variation of splitting ratio based on hybrid defect controlled
Teanchai Chantakit, Keerayoot Srinuanjan, Preecha P. Yupapin

This article represents a hybrid design of 2-D Photonic Crystal with defect controlled. This system is comprised of a modified add/change to a PMMA rod, which can be applied to the beam splitter selection device. By selecting an appropriate temperature, a change of refractive index and radius are formed. The obtained results have showed that the selected amplitude can be separated to 50-50, 60-40 and 67-33. Bolt of Photonic Band Gap and transmission spectra are calculated by OptiFDTD software.

11:50 : Strong attenuation, huge photonic band gaps, and comb-like frequency bands generated by waveguide networks
Xiangbo Yang, Zhenyu Wang, Qiyang Xiao, Huanhuan Song, Timon Chengyi Liu

Periodic networks made of 1D waveguides are a kind of PBG structures and overcome many shortcomings of PBG materials. We construct several kinds of interesting waveguide networks and investigate the optical features of this kind of systems. It is found that strong attenuation, huge PBGs, and comb-like optical transmission spectra can be generated by them. These interesting PBG structures may be useful for the designing of optical switches, optical narrowband filters, high capacity telecommunications, and multichannel filters, etc.

12:05 : Invited talk
Genetically designed L3 photonic crystal nanocavities with ultra-high-Q
Y. Lai, M. Galli, D. Gerace, M. Minkov, V. Savona, A. Badolato

We report on the first experimental realization of ultrahigh quality factor (Q) designs of the L3-type photonic crystal nanocavity. Based on genetic optimization of thE positions of few nearby holes, our design maintains an ultrasmall mode volumes (V) and drastically improves the performance of the conventional L3.

Lunch and Exhibit Inspection

12:45 - 14:15

14:15 - 16:15 — LT22

Session 4A18

Symposium: Resonant Dielectric Nanostructures and Metamaterials XI

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Boris Luk'yanchuk and Nikolay Zheludev

14:15 : Invited talk
Topological electromagnetic resonators
Roberto Merlin

For frequencies within, but near the edges of an allowed band, bulk photonic crystals behave as mirrorless resonant cavities regardless of the shape of their outer boundary. The resonant modes are extended, surface-avoiding states that lie inside the light cone and have exceedingly large quality factors. Similar modes exist in plasmonic media at frequencies just above those at which the refractive index vanishes.

14:35 : Invited talk
Transforming the optical momentum of light
Saman Jahani, Zubin Jacob

We introduce the concept of transforming the optical momentum of light using all-dielectric metamaterials. Ourapproach marks a paradigm shift in light confinement strategy and leads to new lossless metamaterial devices.

14:55 : Invited talk
Plasmonics of topological Insulators at UV-Visible frequencies
Jun-Yu Ou, Jin-Kyu So, Giorgio Adamo, Azat Sulaev, Lan Wang, Nikolay Zheludev

We report the first observation of the plasmonic behavior of a semiconducting material, Bi1.5Sb0.5Te1.8Se1.2, at the UV and visible frequencies, which was revealed by spectroscopic ellipsometry, reflection and cathodoluminescence measurements. Its plasmonic response originates from the negative dielectric permittivity at the material's first absorption edge, which is rarely seen in nature, together with the contribution of the nontrivial surface conducting states of the material.

15:15 : Invited talk
Optical devices based on strong interference effects in nanometer thick absorbing media
Federico Capasso, Mikhail A. Kats

Optical coatings, which consist of one or more films of dielectric or metallic materials, are widely used in applications ranging from mirrors to eyeglasses and photography lenses. Many conventional dielectric coatings rely on Fabry-Perot-type interference, involving multiple optical passes through transparent layers with thickness on the order of the wavelength to achieve effects such as anti- reflection, high-reflection, and dichroism.

15:35 : Invited talk
Plasmonic switches in true optical data processing conditions
Alain Dereux, Nikos Pleros, Laurent Markey, Jean-Claude Weeber, Karim Hassan, Sotiris Papaioannou, Kostas Vyrsokinos, Sergey Bozhevolnyi, Ashwani Kumar, Odysseas Tsilipakos, Alexandros Pitilakis, Emmanouil Kriezis, Tolga Tekin, Michael Waldow, Dimitris Kalavrouziotis, G. Giannoulis, Dimitris Apostolopoulos, Hercules Avramopoulos

Plasmon devices enable to carry optical signals and electric currents through the same thin metal circuitry, Exploring the potential of an hybrid technology merging plasmon and silicon photonics on a single board, this contribution describes the efforts of the European FP7 project PLATON towards the practical implementation and testing in true optical data processing conditions of plasmonic devices for switching operation.

15:55 : Invited talk

Quantum dot based 3D photonic devices
Elmina Kabouraki, David Gray, Maria Vamvakaki, Maria Farsari

We present our most recent results on the fabrication of 3D high-resolution photonic nanostructures containing quantum dots (QDs), exhibiting higher order diffraction patterns and stop-gaps at visible wavelengths. These structures are fabricated using direct laser writing (DLW) and novel, organic-inorganic hybrid materials.

14:15 - 15:25 — LT23

Session 4A19

Transformation Electromagnetics Concepts and Applications II

Organized by: Shah N. Burokur and Andre de Lustrac

Chaired by: Shah N. Burokur and Andre de Lustrac

14:15 : Keynote talk
Can cloaking research generate real technologies?
Baile Zhang

Invisibility cloaking, as the second major stimulus underlying the general field of metamaterials following the pursuit of superlens, has inspired remarkable enthusiasm in the past few years, but also caused sharp criticism at the same time. In this talk I will first review some main confusions in cloaking research on both theoretical and technical levels and then introduce our recent progress towards problem-solving approaches and realistic applications in cloaking research.

14:45 : Invited talk
Trapping light by mimicking gravitational lensing
Hui Liu, Chong Sheng, Yi Wang, Shining Zhu, Dentcho A. Genov

We propose a distorted optical waveguide around a microsphere to mimic curved spacetimes caused by the gravitational fields. Gravitational lensing effects analogues are experimentally demonstrated and this can be used to prospective light harvesting.

15:05 : Invited talk
Ray transformation media
Martin McCall, Paul Kinsler

We construct a transformational theory that is applicable to many disparate areas of wave physics, in the short wavelength limit. A generalized eikonal-ray equation is derived, applicable when the metric of ordinary space (or spacetime) is morphed. The recipe for relating the morphed metric back to physical attributes is shown to reproduce the standard transformation optics algorithm on the one-hand, and to generate novel designs for acoustic transformation devices on the other. A cloak on a sphere is demonstrated.

15:45 - 16:30 — LT23

Session 4A20

Plasmonics and Nanophotonics XI

Chaired by: Dmitry Chigrin

15:45 : Optical torque for gold nanorod's rotation

Jiunn-Woei Liaw, Wei-Jiun Lo, Mao-Kuen Kuo

Optical torque exerted on gold nanorod (GNR) irradiated by a polarized laser beam is studied theoretically. EM field around a GNR is simulated, and then the optical torque in terms of Maxwell stress tensor is analyzed. In addition, the plasmonic heating of the laser on GNR is also studied. The numerical results can help us to evaluate the resultant torque exerted on a GNR of specific size and aspect ratio by a laser of specific wavelength and fluence quantitatively.

16:00 : Shrinking-hole colloidal lithography for complex anoantennas
Svetlana Syrenova, Carl Wadell, Christoph Langhammer

We present three versatile self-assembly-based Shrinking-Hole Colloidal Lithography (SHCL) nano-fabrication strategies for the efficient fabrication of complex plasmonic nanoantenna structures as well as other advanced nanoarchitectures. We are able to control the individual functionality of the antenna elements not only by accurately engineering their size and respective positions in the sub 10 nm range but, most importantly, by being able to craft the individual antenna elements from different materials of choice, all achieved in a single lithography step.

16:15 : Enhanced nonlinear optical effects with extremely coupled plasmonic systems
Christos Argyropoulos, Cristian Ciraci, David Smith

Plasmonic nanowires standing over a spacer layer and a metallic film can form metasurfaces with controlled reflectance. They can localize and enhance the fields inside extremely subwavelength regions. Here, the spacer layer of this plasmonic system is composed of Kerr nonlinear material. We demonstrate enhanced optical bistability and all-optical switching with relative low input pump intensities. The proposed nonlinear metasurfaces may lead to the realization of novel integrated nanophotonic components, such as low-power and ultrafast all-optical memories and nanoswitches.

14:15 - 16:05 — LT1

Session 4A21

Plasmonic Assisted Far-Field Microscopy

Organized by: Yonatan Sivan and Yannick Sonnefraud and Stefan Maier

Chaired by: Yonatan Sivan, Yannick Sonnefraud

14:15 : Invited talk
Far-field superresolution microscopy based on saturable scattering of plasmonic particles
Shi-Wei Chu, Tung-Yu Su, Ryosuke Oketani, Yen-Ta Huang, Hsueh-Yu Wu, Yasuo Yonemaru, Masahito Yamanaka, Hsuan Lee, Guan-Yu Zhuo, Ming-Ying Lee, Satoshi Kawata, Katsumasa Fujita

Conventionally, super-resolution imaging is achieved by manipulating the on/off switching or by saturation of fluorescence. To prevent photobleaching, we demonstrate novel super-resolution imaging based on saturation of scattering from plasmonic particles, for the first time. Spectral studies confirmed that the saturation is directly linked to surface plasmon resonance. With the aid of saturation excitation microscopy, we have achieved optical resolution below 70-nm based on scattering. Our study will open up completely new paradigms for both plasmonics and super-resolution microscopy.

14:35 : Invited talk
Planar metallic lenses for visible light focusing
Satoshi Ishii, Xingjie Ni, Vladimir M. Shalaev, Alexander V. Kildishev

Subwavelength holes as well as subwavelength antennas milled in metallic thin films can shift the phase of incident light. We experimentally demonstrate that the holey lenses and antenna lenses which have sets of

subwavelength holes and subwavelength antennas, respectively, can perform as planar spherical lenses in the visible.

14:55 : Invited talk
Optical super-oscillation: towards the far-field super-resolution focusing and imaging
Guanghui Yuan, Edward T. F. Rogers, Tapashree Roy, Zexiang Shen, Nikolay Zheludev

In this talk, we shall present our recent progress on optical super-oscillation, an intriguing technique capable of breaking the conventional diffraction limit in the optical far-field. Its practical applications in super-resolution focusing and imaging, heat-assisted magnetic recording as well as the interaction of super-oscillation lens with vector optical beams, plasmonic waves and specialized fibers will be demonstrated.

15:15 : Invited talk
Imaging with epsilon-near-zero and hyperbolic metamaterials
Zubin Jacob

We present latest developments in imaging with metamaterials and the behavior of unique modes that lead to sub-diffraction resolution. We analyse the scaling with loss for resonant and non-resonant approaches to meta-material sub-diffraction imaging. We also introduce methods to characterize epsilon-near-zero and hyperbolic metamaterials. Our experimental results show that as expected, loss plays a critical role near resonance but is manageable away from resonance.

15:35 : Nanoparticle-assisted STED, theory and experimental demonstration
Y. Sivan, Y. Sonnefraud, H. Sinclair, P. French, S. Maier

We show that metal nano-particles can be used to improve the performance of super-resolution nanoscopes based on Stimulated-emission depletion (STED). Our scheme allows improvement of existing STED nanoscopes and assist in the development of low cost nanoscopes.

15:50 : Thermally tunable super-resolution image based on alternating multi-layered dielectric-semiconductor system
Bo Han Cheng, Yung-Chiang Lan, Din Ping Tsai

We propose and analyze a multi-layered system which consists of alternating semiconductor and dielectric layers for breaking optical diffraction limitation at THz frequency region. We show that such multi-layered system not only can play a hyperbolic metamaterial but also act as birefringence material by controlling the external temperature. We can tune the temperature parameter to create an effective material with nearly flat isofrequency feature to transfer (project) all the signals excited from the resolution object to the image plane.

14:15 - 15:55 — LT2

Session 4A22

Theoretical and Computational Techniques for Nanophotonics and Nanoplasmonics II

Organized by: Iftikhar Ahmed, Chu Hong Son, Khoo Eng Huat and Ching Eng Jason Png

Chaired by: Iftikhar Ahmed and Khoo Eng Huat

14:15 : Invited talk
Electron energy-loss spectroscopy: An optical point of view
Yuriy Akimov, Hong-Son Chu

In the last years, electron energy-loss spectroscopy (EELS) has demonstrated its capability to serve as a powerful diagnostic technique in the field of nanophotonics and plasmonics. Although the electrodynamic

theory of EELS is well established, it is still unclear how to interpret the results in terms of the optical properties for studied nanostructures. In this work, we give an alternative optical description of EELS based on the classical consideration of the scattering problem.

14:35 : Invited talk
One-side surface plasmon excitation by forward-moving circular-polarized dipole
Xihang Shi, Baile Zhang

The near-field of a dipole or a moving charged particle can be coupled into surface waves at the metal-dielectric interface, which is well known as surface plasmon polaritons (SPPs). The interference of near-field from a circularly polarized dipole has been shown to generate asymmetric SPPs. We show in this paper that the direction of SPPs can be future controlled by a forward moving circularly polarized dipole.

14:55 : Invited talk
Radiation of chiral molecules in chiral metaEnviroment
Vasily Klimov

Within classical and quantum electrodynamics we have considered spontaneous emission of chiral (optically active) molecule placed in different chiral meta- environments. It turns out to be that one can effectively control radiation of right and left molecules separately by tuning parameters of chiral nano-meta particles.

15:15 : Invited talk
Studies of spatial nonlocality effects in plasmonic near-field enhancement
Dang Yuan Lei

In this talk, I will present our theoretical and experimental investigations on the effects of spatial nonlocality in two types of metallic nanostructures, rough metal films and crescent-shaped nanowires. In theory, we have adopted a well-established hydrodynamic description of the collective motion of the electrons inside a metalto calculate the plasmon resonance and near-field enhancement in the two systems. In experiment, we have used the surface-enhanced Raman spectroscopy technique to probe indirectly the near-field enhancement factor in rough metal films.

15:35 : Invited talk
Chiral switching of rotational symmetry on bilayer fourfold symmetry nanostructures
Yew Li Hor, Eng Huat Khoo

This paper, we investigate the subwavelength chiral effect of the four fold rotational symmetry nanostructure under circular polarized light. These structures consist of chiral plasmonic nanostructures made up of bilayered four fold-rotationally-symmetric nanostrips which have switchable chirality effect when the mutual angle rotates with respect to the other layer. This mutual angle rotates from 0 to 90o changing the chirality effect from positive to negative magnitude. Thus, by manipulating the mutual rotation and hence switching the handedness of the nanostructure.

14:15 - 15:35 — LT3

Session 4A23

Atoms with Nanophotonic or/and Nanoplasmonic Structures II

Organized by: Christophe Couteau and David Wilkowski

Chaired by: Christophe Couteau and David Wilkowski

14:15 : Invited talk
On Chip light-atom interactions
Liron Stern, Meir Grajower, Boris Desiatov, Ilya Goykhman, Noa Mazurski, Uriel Levy

We describe our recent results related to the integration of hot vapor cells on top of nanophotonics and nanoplasmonic structures and discuss the future potential directions.

14:35 : Invited talk
Radiative and non-radiative channels of molecule fluorescence near hyperbolic metamaterials
Vasily Klimov

In this talk I will discuss how is it possible to extract the energy captured by hyperbolic metamaterials before it dissipates.

14:55 : Invited talk
Emulating strongly correlated models with photons in driven atom-waveguide interfaces
Changsuk Noh, Priyam Das, Ming-Xia Huo, Dimitris Angelakis

Trapping and manipulating cold atoms around a tapered nanofiber or inside a hollow-core photonic band-gap fiber have recently attracted considerable interest as versatile platforms to realize various quantum protocols. In this work, we begin with a brief introduction to these interfaces, and then discuss two recent theoretical studies on how to use such an interface to emulate interesting models. Specifically, the systems follow the dynamics of 1) driven nonlinear Schrodinger equation and 2) the Thirring model. The transmission spectrum in these engineered waveguide-atom interfaces provide a useful tool for observing characteristics of the emulated models.

15:15 : Invited talk
Excitation of a single photon source with a nanowaveguide
Christophe Couteau

We report the integration of two nanostructures, in which a single nanowire can realize the local excitation of a single photon emitter, by serving as a passive or active sub-wavelength nano-waveguide. In this integration structure, we show one step further towards quantum nanodevices for nanophotonics applications.

15:35 - 16:20 — LT3

Session 4A24

Plasmonics and Nanophotonics XII

Chaired by: Henrik Wallén

15:35 : Generation of Bessel plasmons in a metal-dielectric layered structure
Svetlana Kurilkina, Mohammed A. Binhussain, Vladimir Belyi, Nikolai Kazak

A theory of generation of different types of Bessel plasmons and their superposition in a metal-dielectric layered structure, bounded by two semi-infinite dielectric media and separated from them by a buffer and a cap dielectric layers, is developed. Our study demonstrates that it is feasible to use the superposition of vortex Bessel plasmons in such structures for the formation of an array of diffraction-free nanoscale light needles.

15:50 : Plasmonic perfect absorber for biosensing: a theoretical modal analysis for angular sensitivity
Abdul Aleem Jamali, Bernd Witzigmann

We present simulations of a 3-D plasmonic perfect absorber (PPA) for biosensing applications for a wavelength range of 700-1400 nm. We study the electromagnetic behavior of the PPA system. The electromagnetic response depends on geometric design and surrounding material of the system. The latter dependence makes it a suitable device as a biosensor. We computed the sensitivity of a PPA structure with angular measurement. This novel setup provides improvement in the sensitivity of localized surface plasmon resonance biosensors.

16:05 : Plasmonic terahertz waveguide based on pyramidal troughs etched in silicon
Gagan Kumar, Shanshan Li, Thomas Murphy

We experimentally examine the ability to guide terahertz radiation both in lateral and transverse directions using etched silicon surfaces. Silicon is anisotropically etched to form one dimensional array of concave pyramidal troughs resulting in a plasmonic waveguide. The plasmonic response of the waveguide is measured independently through experiment and simulations.

14:15 - 15:15 — LT4

Session 4A25

Photonic Dirac Cone and Topological Photonic States III

Organized by: Vassilis Yannopapas and Kazuaki Sakoda

Chaired by: Vassilis Yannopapas and Kazuaki Sakoda

14:15 : Invited talk
Spin-optical metasurface route to spin-controlled photonics
Erez Hasman

We report on spinoptical metasurfaces manifested by spin-controlled optical modes - optical Rashba effect, where the inversion symmetry is violated. The design of metasurface symmetries via geometric gradients provides a route for spin-controlled nanophotonic applications.

14:35 : Invited talk
Proposals for realization of topological states of interacting and non-interacting photons
Dimitris Angelakis, Priyam Das, Changsuk Noh

Recently, realizations of topologically nontrivial models in photonic systems have attracted great interest due to its con- ceptual appeal and practical advantages compared to the condensed matter systems. In this work, we discuss from a new angle aspects of the first proposal to realize a photonic fractional quantum Hall state in a two dimensional coupled QED cavity array.

14:55 : Invited talk
Topological edge states in silicon photonics
S. Mittal, J. Fan, A. Migdall, J. Taylor, M. Hafezi

Topological features emerge in variety of physical systems. Deeper understanding of the role of topology in physics has led to a new class of matter: topologically- ordered systems. The best known examples are quantum Hall effects, where insensitivity to local properties manifests itself as conductance through edge states that is insensitive to defects and disorder. Here, we demonstrate how similar physics can be observed for photons, specifically, how various quantum Hall Hamiltonians can be simulated with linear optical elements.

15:15 - 16:00 — LT4

Session 4A26

FSS, HIS and Extraordinary Transmission

Chaired by: Mousa Hussein

15:15 : Tunable meta-liquid-crystal based on mercury microdroplets

Qinghua Song, W. M. Zhu, W. Zhang, E. M. Chia, A. Q. Liu

Here we report a tunable Meta-Liquid-Crystal based on liquid metal droplet, the optical properties of which is tuned by controlled electrowetting effects. The Meta-Liquid-Crystal is flexible in tuning and easy in fabrication, which has potential application on tunable filters, controllable beam steering and flat lens.

15:30 : THz photomixer with milled nanoelectrodes on GaAs
Gediminas Seniutinas, Gediminas Gervinskas, Evan Constable, Arunas Krotkus, Gediminas Molis, Gintaras Valusis, Roger A. Lewis, Saulius Juodkazis

A terahertz (THz) photomixer: (i) a meander type antenna with integrated nanoelectrodes on (ii) a low temperature grown GaAs (LT-GaAs) has been fabricated and characterized. It was designed for spectral range of 0.3-0.4~THz where molecular fingerprinting and sensing is performed. By combination of electron beam lithography (EBL) with post-processing using focused ion beam (FIB) milling the THz emitter with nano-gaps was successfully fabricated.

15:45 : Uncooled narrow bandwidth infrared photodetector
Hung-Hsin Chen, Yan-Chi Su, Wei-Lun Huang, Chun-Yen Guo, Yi-Pu Chen, Po-Shuan Yang, Wei-Cheng Tian, Miin-Jang Chen, Si-Chen Lee

An uncooled infrared photodetector with narrow bandwidth absorption was studied. The device was realized by a resistive temperature detector incorporated with localized surface plasmon (LSP) resonance in an Au/Al2O3/Au tri-layers structure. The incident light with a specific wavelength was absorbed by the LSP resonance and then heating the amorphous silicon film on the top and changing its conductivity. A significant increase of current at constant voltage was observed when the detector is irradiated by a narrow bandwidth infrared light.

14:15 - 15:35 — LT5

Session 4A27

Active and Tunable Metamaterials V

Organized by: Zhengtong Liu, Dongying Li and Yaxin Yu

Chaired by: Yaxin Yu and Ching Eng Jason Png

14:15 : Invited talk
Tunable magnetless non-reciprocal metamaterials and their application to circulators
Toshiro Kodera, Christophe Caloz

Magnet-less non-reciprocal metamaterials (MNMs), which exhibit essentially the same properties as magnetically biased ferrites, but they are lightweight and fully compatible with microwave integrated circuits. We emphasize here the electric tunable property of MNMs, that is much easier than magnetic tuning in ferrites, and apply this property to a circulator featuring a tuning range of 500 MHz at 7.5 GHz with 25 dB isolation.

14:35 : Invited talk
A refracting metasurface that converts linear to circular polarization
Carl Pfeiffer, Anthony Grbic

A metasurface that provides both polarization and wavefront control at 77 GHz was designed and fabricated. When the metasurface is illuminated with a normally incident, linearly polarized beam, the transmitted beam is efficiently refracted to 45 degrees, and its polarization converted to circular. The half-power bandwidth was measured to be 17 %, and the axial ratio of the transmitted field remained below 2.5 dB over the entire bandwidth. The design has a subwavelength thickness of 0.4 mm (lambda/9.7).

14:55 : Invited talk
Nanomechanical metamaterial light modulators
Eric Plum, Jun-Yu Ou, Joao Valente, Pablo Cencillo, Nikolay Zheludev

Reconfigurable photonic metamaterials provide a flexible platform for thermo-optical, electro-optical, magneto-optical and all-optical modulation of metamaterial properties. We provide an overview from fundamental physics to practical metadevices for high-contrast light modulation.

15:15 : Invited talk
An investigation of the plasmonic effect of a single Au nanoparticle inside a dielectric microsphere
Song Sun, Lin Wu, Ping Bai

We perform a fundamental research on the plasmonic effect of a single Au nanoparticle (NP) inside a dielectric microsphere. The diameter of the microsphere d is comparable with or larger than the incident wavelength. The simulations show that the resonance wavelength of absorption cross-section (CS) always varies around 550 nm, depending on the diameter d of the microsphere. More interestingly, the location of the Au NP inside the microsphere greatly affects the absorption CS.

14:15 - 15:30 — MAS EC1

Session 4A28

Plasmonics and Nanophotonics XIII

Chaired by: Polina Kapitanova

14:15 : Probing confined phonon modes in individual CdSe nanoplatelets using surface-enhanced Raman scattering
Daniel O. Sigle, James T. Hugall, Jeremy J. Baumberg

The phonon modes of individual ultrathin cadmium selenide nanoplatelets are investigated using surface-enhanced Raman scattering in a tightly-confined plasmonic geometry. The SERS spectra, taken on single nanoplatelets sandwiched between a gold nanoparticle and a gold surface, reveal a phonon doublet arising from oscillations perpendicular to and within the platelet plane. The resulting strong electric field enhancements and the field vector reorientation within such nanometre-sized plasmonic gaps reveal otherwise hidden information about vibrational properties of ultrathin materials.

14:30 : Near-field enhancement in crescent shaped arrays
Thomas Siegfried, Shourya Dutta-Gupta, Yasin Ekinci, Olivier Martin, Hans Sigg

We present the versatile use of crescent arrays to obtain strong and homogeneous near-field enhancement over large areas. The fabrication is based on angular evaporation adding sharp metal edges and sub-10 nm gap features onto resist arrays. Such arrays support either Fano resonances or gap plasmons and show opposing near-field dependency with the gap size, as will be discussed in detail. Finally, applications will be presented evolving from crescent arrays such as radiance sensing and surface enhanced Raman scattering.

14:45 : Effective model for plasmonic coupling
Meng Qiu, Bin Xi, Shiyi Xiao, Hao Xu, Lei Zhou

We rigorously derived an effective model for plasmoniccouplings between nanoparticles. After justifying itsvalidity by full-wave simulations, we discussed aninteresting application of the effective model.

15:00 : Fano- and Lorentz-like resonances in plasmonic nanorods
Niels Verellen, Fernando Lopez-Tejeira, Ramon Paniagua-Dominguez, Dries Vercruysse, Denitza Denkova, Liesbet Lagae, Pol Van Dorpe, Victor Moshchalkov, Jose Sanchez-Gil

We present the experimental observation of spectral lines of distinctly different shapes in the optical extinction cross-section of metallic nanorod antennas. Surface plasmon resonances of odd mode parity present Fano interference in the scattering cross-section resulting in asymmetric spectral lines. Contrarily, modes with even parity appear as symmetric Lorentzian lines. Finite element simulations are used to verify the experimental results. The emergence of either constructive or destructive mode interference is explained with a semi-analytical 1D line current model.

15:15 : Heating processes in plasmonic resonances: a non-linear temperature dependent permittivity model
Alessandro Alabastri, Francesco De Angelis, Remo Proietti Zaccaria

Here we present a dispersive model of the dielectric function of a metallic medium which depends on temperature. Since temperature depends on the intensity of the electromagnetic source and on the optical response of the medium itself, the model expresses non-linearity features. The model, which does not require any fitting parameter, can be utilized whenever the impact of temperature on the optical response of a system needs to be clarified or when non-linearities might play a major role.

15:30 - 16:15 — MAS EC1

Session 4A29

Photonic Crystals II

Chaired by: Roberto Merlin

15:30 : Optical properties of metamaterial based devices modulated by a liquid crystal
Filiz Karaomerlioglu, Amirullah Mamedov, Ekmel Ozbay

We presented a numerical study of optical properties of metamaterial based devices by a liquid crystal infiltration. The plane wave expansion method and finite-difference time-domain method revealed optical properties in photonic crystal structures in an air background for a square lattice. E7 has been used as a nematic liquid crystal and SrTiO3 as a ferroelectric material. We showed a possibility of the metamaterials for a two dimensional photonic crystal cavity on a ferroelectric base infiltrated with a liquid crystal.

15:45 : An experimental study on the bandwidth and tunability of MSP based one-way transmission
Zhen Li, Rui-Xin Wu, Yin Poo, Qing-Bo Li, Rong-Juan Liu, Zhi-Yuan Li

We studied how constitution parameters and applied magnetic field influence bandwidth and frequency tunability of one-way transmission caused by magnetic surface plasmon of magnetic photonic crystals. We found wide band OWT could be obtained by larger normalized radius and suppressing bulk modes. A simple way to suppress bulk modes is proposed and experimentally demonstrated. Bias field tunes frequencies of OWT but has little effects on bandwidth. The study provides practical ways toward wide band tunable one-way devices in applications.

16:00 : Mechanically tunable light dispersion of 1D and 2D holographic photonic crystals on plastic substrate
Chun-Chou Lin, Vincent K. S. Hsiao

A dispersion angle of 71deg is observed within a continuous spectrum distributed from 470 to 740nm using two-dimensional transmission grating. Rotating the sample tunes the detected spectrum and achieves a spectra resolution of 3.6 nm per degree. The two-dimensional transmission grating shows better optical properties than one-dimensional transmission grating. A phototunable modulation of diffraction intensity in the fabricated two-dimensional gratings is also demonstrated.

Coffee Break and Exhibit Inspection

16 :15 - 16:45

16:45 - 17:45 — LT22

Session 4A30

Symposium: Resonant Dielectric Nanostructures and Metamaterials XII

Organized by: Boris Luk'yanchuk, Yury Kivshar, Mark Brongersma and Lukas Novotny

Chaired by: Boris Luk'yanchuk

16:45 : Invited talk
Electrodynamic description of a spaser: shape, size, multipolar modes, universal figures of merit and threshold minimization
Nikita Arnold, Calin Hrelescu, Thomas Klar

Spasing thresholds in metallic nanostructures with gain material are investigated within the electrodynamic framework. Threshold gain for small particles of arbitrary shape is derived. For any resonant mode there exists an optimal geometry, which minimizes threshold. Threshold gain value depends on the optical properties of the metal and host matrix, it is the same for different particle shapes, and is within reach of commercially available dye-doped polymers. This is illustrated on the examples of Ag spheroids and spherical shells

17:05 : Invited talk
Complexity-driven photonics: from chaotic energy harvesting to femtosecond, subwavelength Rogue waves in random resonators
Andrea Fratalocchi

Chaos and disorder are ubiquitous manifestations of nature that are often unwanted in applications, as they introduce unpredictable degrees of freedom that are difficult to control. If properly understood, conversely, randomness might form the basis of a novel technology that benefits from the millenary evolution of nature. In this invited talk I will summarize my research in the field, discussing my latest theoretical and experimental results in chaotic energy harvesting, light condensation dynamics and subwavelength rogue waves.

17:25 : Invited talk
Functional metallo-dielectric surfaces for integration
Paul Davies, Joachim Hamm, Ortwin Hess

We present tunable low-loss metallo-dielectric metasurfaces in which the photonic wave evanescently couples to nano-gaps, concentrating light in a lattice of hot-spots. We discuss the energy transfer between photonic and plasmonic channels of single trimer triangular nano-gap tilings in dependence on element size. We show that the product of field enhancement, propagation length and element size is close-to-constant in both the radiative and subwavelength regimes, opening pathways for a combination of high field enhancements with large propagation lengths.

16:45 - 17:30 — LT23

Session 4A31

Plasmon-Enhanced Photovoltaics, Photovoltaics, and Solar Fuels

Chaired by: Sergei Zhukovsky and Renaud Bachelot

16:45 : Enhanced broadband light absorption in silicon film by large-size lumpy silver particles
Meng Yuan, Ning Zhou, Dongsheng Li, Deren Yang

We have studied lumpy silver particles as rear located strengthen materials for silicon thin-film solar cell. Though theoretical simulations, the large-size lumpy silver particle has a more advantageous property of scattering incident light back than the spherical particle in a broad wavelength range. This kind of large-size silver particles can be used as rear-position strengthening materials for silicon thin-film solar cells. We demonstrate that when the Ag particles' coverage density is 10 %, the light absorption enhancement is optimal.

17:00 : F-P Lasing Enhancement in graphene-coated ZnO Microbelt
Jitao Li, Chunxiang Xu, Yi Lin, Yueyue Wang, Jun Dai, Junfeng Lu

We report an obvious Fabry-Perrot (F-P) lasing enhancement in a monolayer graphene-coated ZnO microbelt hybrid microstructure, which was fabricated by simply coating a piece of monolayer graphene on a ZnO microbelt. By comparing with the bare ZnO microbelt, the hybrid microcavity exhibited an obvious F-P lasing improvement, including the enhanced emission intensity, the lowered lasing threshold and the improved lasing quality factor.

17:15 : Silver nanoparticles on conducting electrode: A simple two-steps process for realizing plasmonic solar cell design
Mohammad Hossain, Qasem Drmosh, Ayman Mukhaimer, Haitham Bahaidarah

In this report we showed a simple two steps method in fabricating silver nanoparticles on zinc oxide followed by topographic and elemental analysis thereof. Numerical calculation and near-electric field distribution of single silver nanoparticles of different sizes was simulated by finite different time domain analysis. Since the distributed electric flux is crucial for excitons generation in absorbing layer, it aspredicted that nanoparticles excited by radiation of lower energy contribute wider electric flux sacrificing the intensity of localized electric field.

16:45 - 18:15 — LT1

Session 4A32

Technologies and Applications III

Chaired by: Yoshiaki Nishijima and Martin McCall

16:45 : Multilayer graphene for waveguide terahertz modulator
Irina Khromova, Andrei Andryieuski, Andrei Lavrinenko

We study terahertz to infrared electromagnetic properties of multilayer graphene/dielectric artificial medium and present a novel concept of terahertz modulation at midinfrared wavelengths. This approach allows the realization of high-speed electrically controllable terahertz modulators based on hollow waveguide sections filled with multilayer graphene.

17:00 : High permeability and low loss hybrid ferromagnetic composite for very-high-frequency applications
Yunqi Wang, Patrick Grant

Nowadays, many electronic devices operate in the GHz range, and therefore materials with low energy loss and high permeabilities, and operating frequencies are in high demand. Here, we report a novel and simple mould casting method to fabricate epoxy based NiZn ferrite/Fe hybrid composites. The results showed a frequency-independent permeability of ~6 that was comparable with the same filler loading of solely ferrite composites, but with an extended operating bandwidth from 30 MHz to 300 MHz.

17:15 : Fully-coherent terahertz detection via biased onlinear microslits

Matteo Clerici, Sze Phing Ho, Anna Mazhorova, Marco Peccianti, Alessia Pasquazi, Luca Razzari, Jalil Ali, Roberto Morandotti

We report on a novel technique for a fully coherent heterodyne detection at terahertz (THz) frequencies exploiting four-wave mixing in micrometric SiO2 (Silica) layers and an electrically biased gold slit.

17:30 : Asymmetric cloaking theory based on effective electromagnetic field for photon
Masato Taki, Tomo Amemiya

The asymmetric invisibility cloak is a special cloak with unidirectional transparency, that is, a person in the cloak should not be seen from the outside but should be able to see the outside. Existing theories of designing invisibility cloaks cannot be used for asymmetric cloaking because they are based on the transformation optics that uses Riemannian metric tensor independent of direction. To overcome this problem, we propose introducing directionality into invisibility cloaking.

17:45 : Fabrication of sprit-ring resonator arrays towards visible frequency metamaterials by monolayer-assisted nanoimprint lithography
Shoichi Kubo, Tatsuya Tomioka, Takuya Uehara, Masaru Nakagawa, Morihisa Hoga, Takuo Tanaka

Uniform arrays of double-gap Au SRRs with designed line widths of about 50 nm over a 5-mm square were fabricated by nanoimprint lithography assisted by monolayers causing covalent bonds and hydrogen bonding. Monolayers on Au-plated substrates were indispensable in coating very thin resist layers. The fabricated Au double-gap SRR array was demonstrated to exhibit the absorption band at 690 nm derived from the oscillation of free electrons excited by the magnetic field penetrating the SRRs.

18:00 : Measuring the optical absorption of 10 nm gold nanoparticles using multiscattering-enhanced absorption spectroscopy in a dielectric metamaterials
Volodymyr Koman, Christian Santschi, Olivier Martin

Sensitive measurement of the optical absorption of small gold nanoparticles is of great importance. We demonstrate optical absorption measurements of 10 nm gold nanoparticles with enhanced sensitivity. This is achieved through multiscattering due to variations of the refractive index caused by a metamaterial made from a large number of polystyrene beads. Numerical simulations and experimental results reveal the possibility of controling the multiscattering and hence the enhancement of the absorption of the nanoparticles suspended in the medium.

16:45 - 17:45 — LT2

Session 4A33

Analytical and Numerical Modelling II

Chaired by: Lei Zhang

16:45 : Homogenization of nanowires using field optimization
Efthymios Kallos, Georgios Kallos, George Palikaras, Vassilios Yannopapas, Emmanuel Paspalakis

We propose a numerical method for extracting the effective medium parameters of metamaterial structures. The reference field distribution of a metamaterial structure is provided as the target goal of a nonlinear optimization algorithm. The algorithm executes electromagnetic simulations of a homogeneous medium for identical excitations, and varies the relative permittivity and permeability values. A specific example for homogenizing a row of silver nanorods in visible wavelengths is presented.

17:00 : Photonic bands for superlattices of dielectric and spatially-dispersive metal
Alejandro Paredes-Juarez, Denis Iakushev, Benito Flores-Desirena, Nykolay Makarov, Felipe Perez-Rodriguez

We theoretically investigate the photonic band structure of dielectric-metal superlattices. Using the Boltzmann kinetic equation, we calculate the nonlocal relation between the electrical current and field inside the metal layer. The photonic dispersion is determined in terms of the metallic and dielectrical impedances. The structure possesses narrow pass bands associated with Fabry-Perot resonances in each dielectric layer. Because of metal nonlocality, the real part of Bloch wave vector is significantly different from that predicted by the local Drude-Lorentz model.

17:15 : Topology optimization for whispering gallery mode resonator circuits based on level set expression incorporating surface effects
Garuda Fujii, Tsuyoshi Ueta, Mamoru Mizuno, Masayuki Nakamura

This paper presents a level set-based topology optimization method for whispering gallery mode resonator circuits. The amount of light intensity in an optimal resonator becomes larger than 20 times that in an initial one. Dielectric structures are expressed by using level set functions defined as piecewise-constant values and the clear dielectric boundaries of optimal configurations are defined as iso- surfaces of the level set functions.

17:30 : Scattering characteristics of structures of lossy metamaterial-semiconductor cylinders
Juozas Bucinskas, Liudmila Nickelson, Romanas Martavicius

Here we present the rigorous boundary problem solution of Maxwell's equations for the determination of scattering characteristics of a structure. The structure consists of a set of infinite parallel cylinders that can be made of lossless or lossy materials. The transmission and reflection of the incident plane waves from the structure analyzed here. We discovered that the structure can have features of a bandgap photonic crystal dependent on the polarization of incident electromagnetic (EM) wave.

16:45 - 18:15 — LT3

Session 4A34

Plasmonics and Nanophotonics XV

Chaired by: Harry Atwater

16:45 : Unconventional 3D plasmonic nanostructures as building block for multifunctional plasmonics
Andrea Toma, Mario Malerba, Manohar Chirumamilla, Ermanno Miele, Gobind Das, Carlo Liberale, Enzo Di Fabrizio, Remo Proietti Zaccaria, Francesco De Angelis

The fabrication of complex 3D plasmonic nanostructures integrated in innovative device architectures represents a multidisciplinary key activity at the core of most research efforts in nanotechnology. Here we investigate and fully characterize the VIS-IR spectral resonances of 3D plasmonic nanostructures/nanocavities that are tunable in size, shape, and layout. We exploit the unique properties of these nanoplasmonic structures to improve the vibrational signal enhancement in antenna-assisted surface-enhanced Raman and infrared spectroscopy (SERS and SEIRS) induced by near-field hot-spot generation

17:00 : Large-area low-cost substrates for antenna-assisted surface-enhanced infrared spectroscopy by interference lithography
Shahin Bagheri, Frank Neubrech, Harald Giessen

We manufacture large-area plasmonic antenna arrays using laser interference lithography with high quality plasmon resonances. Such resonances are tunable over the whole infrared spectral range and therefore highly suited for surface-enhanced infrared spectroscopy as we demonstrated with octadecanethiol (ODT) as a probe molecule.

17:15 : Internal forces in plasmonic metamaterials
T. V. Raziman, Alok Ji, R. P. Sharma, Olivier Martin

We utilise Surface Integral Equation (SIE) simulations to study internal forces in plasmonic nanostructures using Maxwell's stress tensor. The flexibility of SIE and the direct evaluation of forces from the surface currents allows the simulation of complex structures efficiently and accurately. We show that internal forces in compound systems with plasmonic resonances exhibit significant changes with wavelength. A gold heptamer system which shows Fano resonance is illustrated as an example.

17:30 : Two photon perfect interference in a gap plasmon guide
Subhasish Dutta Gupta, Girish S. Agarwal

We report perfect two photon quantum interference with near-unity visibility in a resonant tunneling plasmonic structure in folded Kretschmann geometry. This is despite absorption-induced loss of unitarity in plasmonic systems. The effect is due to perfect destructive interference between the squares of amplitude reflection and transmission coefficients. We further show that coincidence measurements can be a better spectroscopic probe as compared to stan- dard spectroscopic techniques in both angle and wavelength studies.

17:45 : Ultraviolet surface plasmon polariton propagation for ZnO-based hybrid plasmonic waveguides
Qin Han, Mengzhu Hu, Siyang Zhou, Hua Sun, Liping Zhou, Chunmei Zeng, Xuemei Wu

Nanolasers based on SPP have been realized in the infrared and visible regime. However, the investigation in the ultraviolet surface plasmon polariton propagation (SPPP) is still absent. In our work, ultraviolet SPPP for ZnO-based hybrid plasmonic waveguides are studied by the finite-element method. The field distribution, effective refractivity, propagation distance, and mode area of the hybrid mode supported by the waveguides, which are dependent on the permittivity and geometrical parameters, are analyzed in detail.

18:00 : Electron impact investigations on locally symmetric and anti-symmetric cyclic plasmonic modes
Nahid Talebi, Burcu Ogut, Ralf Vogelgesang, Wilfried Sigle, Peter van Aken

Besides the fact that electron microscopy offers a fast experimental tool for observation of optical density of states with high resolution, it has another important benefit over optical microscopy techniques, due to its monopolar and evanescent radiation when interacting with the near-field of the structure. We show how EELS and EFTEM not only unravels the symmetry and topological properties of the optical modes of oligomer nano-cavities, but also serves as a tool to study symmetry braking of such modes.

16:45 - 18:05 — LT4

Session 4A35

Nanobiophotonics

Chaired by: Rainer Hillenbrand

16:45 : Invited talk
Tip-enhanced infrared annospectroscopy of organic nanostructures and individual protein complexes
Rainer Hillenbrand

We demonstrate nanoscale infrared imaging and spectroscopy of organic nanostructures and individual protein complexes. To that end, we record the elastically scattered light from metallized AFM tips acting as infrared antennas. We discuss applications such as chemical mapping of polymers and structural analysis of the secondary structure (alpha-helices vs. beta-sheets) of individual protein complexes, including viruses, purple membranes and insulin fibrils.

17:05 : Biosynthesis of gold nanostructures using human cells
Shourya Dutta Gupta, Christian Santschi, Davide Stadler, Sandrine Gerber, Lucienne Juillerat-Jeanneret,

Olivier Martin

Synthesis of gold nanoparticles by human cells is studied onthe addition of gold salt (HAuCl4). Using two photon microscopy and transmission electron miscroscopy we show that the nanoparticles are synthesized intracellularly. Furthermore, characterization of the proteins surrounding the nanoparticle, i.e., the protein corona, suggests that the particles show a set of diverse proteins making them highly biocompatible. Finally, we show that the redox state of the cell also strongly affects the particle size.

17:20 : Surface-enhanced raman spectroscopy in silver nanowire-based transparent films VS gold engineered metamaterials
Rossella Capasso, Massimo Rippa, Pasquale Mormile, Marianna Pannico, Pietro La Manna, Pellegrino Musto, Jun Zhou, Weijie Song, Wenfeng Shen, Lucia Petti

In this paper we compare a bottom-up approach and a top-down technique to realize efficient SERS substrates for plasmonic label-free nanobiosensors. We demonstrate that SERS enhancement factors of the order of ~ 107 can be reproducibly obtained using Au photonic quasi crystals arrays of nano-pillars.

17:35 : Hybrid planet-satellites-type nanoclusters based on DNA origami
Robert Schreiber, Jaekwon Do, Eva-Maria Roller, Tao Zhang, Verena Schuller, Philipp Nickels, Jochen Feldmann, Tim Liedl

In this work, DNA origami nanotechnology is used for arrangements of metallic nanoparticles, quantum dots, and organic dyes into planet-satellites-type nanoclusters. This hierarchical assembly method makes it possible to create nanoclusters with a tunable stoichiometry, with defined inter-element distances, and moreover with a control of their overall sizes up to 500 nm. Our planet-satellites nanoclusters allow us to study quantitatively the distance-dependent fluorescence quenching of dye molecules by gold nanoparticles.

17:50 : Volatile organic compounds (VOCs) detection with surface enhanced Raman scattering (SERS) using plasmonic bimetallic nanogap substrate
Chi Lok Wong, U. S. Dinish, Kavitha Devi Buddharaju, Malini Olivo

In this paper, we demonstrate volatile organic compounds (VOCs) detection with surface enhanced Raman scattering (SERS) based on the bimetallic nanogap plasmonic structure fabricated by deep UV photolithography. Measurements on ethanol (5.4 %) and acetone (25.4 %) vapor have been performed with the SERS VOCs sensing platform and highly reproducible results have been shown. Such system can find promising applications in health care, homeland security, chemical sensing and environmental monitoring.

16:45 - 18:15 — LT5

Session 4A36

Plasmonics and Nanophotonics XVI

Chaired by: Federico Capasso

16:45 : Enhanced photodetection in visible region with integrable nanowire plasmonics
Jeong Hyeon Kim, Jong-Souk Yeo

Plasmonic photodetectors have been researched for the future applications in sensing and optoelectronics. Here we demonstrate highly integrative and polarization-sensitive photodetection with nanowire plasmonic device. Far field irradiation of incoherent light in visible regime excites standing plasmons at the nanowire and induces reduction in current. This enables direct transduction of optical sig nal into electrical signal. Metal nanowire geometry also enables free-space coupling and polarization-sensitivity. This approach allows development of photodetector for integrated on-chip photonic applications.

17:00 : Low-loss titanium-nitride-based strip waveguides

Nathaniel Kinsey, Marcello Ferrera, Gururaj Naik, Alexander Kildishev, Vladimir Shalaev, Alexandra Boltasseva

We report about low-loss IMI CMOS compatible plasmonic interconnects. Our waveguides consist of titanium nitride ultra-thin stripes (

17:15 : Plasmonic quasicrystals for designable spectral response
Sachin Kastre, Ajith P. R., Venu Gopal Achanta

Plasmonic quasicrystals of p/5 rotational symmetry are designed by a modified dual grid method. The calculated lattice coordinates are used to pattern gold films by electron beam lithography and dry etching. Optical measurements showed broadband, polarization and launch-angle independent transmission enhancement of up to an order of magnitude compared to unpatterned gold film. Center of the spectral response could be decided by the inherent period. Also, the spectral response could be designed by combining quasicrystal patterns with different rotational symmetries.

17:30 : Disorder-enhanced plasmonic nanolenses
Juan Totero, M. L. Coluccio, Remo Zaccaria, Enzo di Fabrizio, Andrea Fratalocchi

We investigated the field enhancement properties of plasmonic nanolenses made by nanoparticles characterized by a random surface corrugationWe model realistic deformations occurring in standard fabrication procedures. By employing Finite-Difference-Time-Domain (FDTD) simulations, we studied the interplay between Surface Plasmon Polaritons (SPP) and randomness. We show that surface roughness plays a crucial role in enhancing the electromagnetic energy in the near field, thus opening new perspectives in the realization of ultra-focusing nanoplasmonic lenses.

17:45 : Quantum plasmonics
Andrey Sarychev, Ilya Fedorov, Vladimir Parfenyev, Sergei Vergeles, G. T. Tartakovsky

Quantum-mechanical theory of the plasmon nanoresonator laser is presented. The the plasmon field is quantized to develop the quantum plasmonics. We show the local electric field is anomalous large even in the case of few plasmon quanta in the nanoresonator. The heat generation in a metal nanoresonator is found for a given number of plasmons. The stability limits are determined and the number of plasmon quanta needed for the melting of the resonator is found.

18:00 : Investigation of a nanostrip patch antenna in optical frequencies
Rishi Jain, Khushboo Khushboo, Dinesh V.

This is the first investigation of a patch antenna in optical frequency range. Variety of plasmonic nanoantennae reported so far are good at enhancing the local field intensity of light by orders of magnitude. However their far field radiation efficiency is very poor. The proposed patch antenna emits a directional beam with high efficacy in addition to enhancing the intensity of nearfield. The nanostrip patch antenna might be useful in variety of applications such as optical communication, nanophotonics etc.

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