

# Sunday 24th June, 2018

## Registration

Embarkation Counter

12:00 - 15:30

## Opening Address

Teatro Emerald

17:30 - 17:45

# Monday 25th June, 2018

10:00 - 12:25 — Teatro Emerald

## Session 1A1

### Symposium II: Novel Design and Applications of Metamaterials, Metasurfaces and Metadevices using Hybrid and New Materials I

Organized by: Mohamed Swillam

Chaired by: Mohamed Swillam

10:00 : **Keynote talk**

#### Optical Metamaterials with Emerging MXenes

Krishnakali Chaudhuri<sup>1</sup>, Zhuoxian Wang<sup>1</sup>, Mohamed Alhabeab<sup>2</sup>, Xiangeng Meng<sup>1</sup>, Shaimaa Azzam<sup>1</sup>, Alexander Kildishev<sup>1</sup>, Young L. Kim<sup>1</sup>, Vladimir Shalaev<sup>1</sup>, Yury Gogotsi<sup>2</sup>, Alexandra Boltasseva<sup>1</sup>

<sup>1</sup>Purdue University (USA), <sup>2</sup>Drexel University (USA)

We report on an emerging two-dimensional material class MXenes as a potential material platform for plasmonic metamaterials. Application as a broadband plasmonic metamaterial absorber and a random laser device have been discussed.

10:30 : **Invited talk**

#### Anisotropic Gain/Loss Metasurface for Directive Surface Plasmon-Polaritons Propagation

Dmitry Kuzmin<sup>1</sup>, Igor Bychkov<sup>1</sup>, Vladimir Shavrov<sup>2</sup>, Vasily Temnov<sup>3</sup>

<sup>1</sup>Chelyabinsk State University (Russia), <sup>2</sup>Kotelnikov Institute of Radio-Engineering and Electronics of RAS (Russia), <sup>3</sup>Universite du Maine (Russia)

In this work we propose new concept of directive surface plasmon propagation in gain-loss metasurfaces. We show analytically the possibility of propagation of surface plasmon-polaritons, which have a hyperbolic isofrequency contour, along an anisotropic metasurface with gain in one direction and loss in the orthogonal one. We propose the simple realization of such a metasurface based on array of gain and loss stripes.

10:50 : **Invited talk**

#### Optical rotation effects in nanostructured materials

Thierry Verbiest, Tom Swusten, Ward Brulot

University of Leuven (Belgium)

We will discuss optical rotation effects that we have observed in (chiral) nanostructured materials composed of Au and Fe<sub>3</sub>O<sub>4</sub> nanoparticles.

11:10 : **Invited talk**

#### Light-induced driving of a micron-size metallic plate

Min Qiu

Zhejiang University (China)

By employing the synergy of optical force and photophoretic force, we propose and experimentally demonstrate a configuration which can drive a micron-size metallic plate moving back and forth on a tapered fiber with supercontinuum light in ambient air. The results might open exhilarating possibilities in applications of optical driving and energy conversion.

11:30 : **Invited talk**

#### Raman imaging and tip-enhanced Raman scattering for epitaxial graphene grown on SiC

Yasutaka Kitahama<sup>1</sup>, Shohei Uemura<sup>1</sup>, Sanpon Vantasin<sup>1</sup>, Yoshito Tanaka<sup>1</sup>, Toshiaki Suzuki<sup>2</sup>, Daichi Doujima<sup>1</sup>, Tadaaki Kaneko<sup>1</sup>, Yukihiro Ozaki<sup>1</sup>

<sup>1</sup>Kwansei Gakuin University (Japan), <sup>2</sup>UNISOKU Co. Ltd (Japan)

Epitaxial graphene grown on 4H-SiC was measured by Raman imaging and tip-enhanced Raman scattering

(TERS). On a ridge-like nanostructure of the graphene on the C-face, G' band in the TERS spectrum was shifted via different strain and doping between the ridge and the plain. D band was observed on the edge of the graphene on the Si-face, while it disappears on that on the C-face. The reason is a combination between C and SiC on the C-face.

**11:50 : Invited talk**

**What we can Learn from Hybrid Metamaterials Composed of Plasmas**

**Osamu Sakai<sup>1</sup>, Akinori Iwai<sup>1</sup>, Alexandre Bambina<sup>1</sup>, Yuuki Kabe<sup>1</sup>, Teruki Naito<sup>2</sup>, Shigeyuki Miyagi<sup>1</sup>**

<sup>1</sup>The University of Shiga Prefecture (Japan), <sup>2</sup>Kyoto University (Japan)

After several theoretical, numerical and experimental results from metamaterials of plasma-solid hybrid material, we can derive several common principles in metamaterials, such as invariance of parameter identification for refractive index, estimation of minimum size of cloaking devices, and enhanced nonlinear effects. These results are applicable for other materials in metamaterials whose permittivity is in the Drude model, and open possibilities for novel energy and imaging devices.

**12:10 : Silicon Ring Resonator Electro-optical Modulator Utilizing Epsilon-near-zero characteristics of Indium Tin Oxide**

**Mahmoud Elgarf, Mohamed Badr, Mohamed Swillam**

*American University in Cairo (Egypt)*

One crucial component in optical communication systems is the optical modulator. It links between the electric and optical domains as it transforms the electric signal into an optical stream. Electro-optical modulation is a very popular scheme. Recently, indium tin oxide has been intensively used in optical modulators due to its epsilon-near-zero characteristics. A silicon ring resonator modulator based on ITO is proposed. Insertion loss of 0.075 dB and extinction ratio of 14 dB are achieved at 1550 nm.

**10:00 - 12:15 — Salone Teodora**

**Session 1A2**

**Plasmonics: Fundamentals and Applications I**

Organized by: Hong Wei

Chaired by: Hong Wei and Zee Hwan Kim

**10:00 : Invited talk**

**Plasmonics for Highest-Speed**

**Juerg Leuthold<sup>1</sup>, W. Heni<sup>1</sup>, M. Ayata<sup>1</sup>, C. Haffner<sup>1</sup>, A. Messner<sup>1</sup>, U. Koch<sup>1</sup>, C. Hoessbacher<sup>1</sup>, T. Watanabe<sup>1</sup>, Y. Salamin<sup>1</sup>, R. Bonjour<sup>1</sup>, A. Josten<sup>1</sup>, B. Baeuerle<sup>1</sup>, A. Dorodny<sup>1</sup>, P. Ma<sup>1</sup>, Y. Fedoryshyn<sup>1</sup>, M. Burla<sup>1</sup>, D. L. Elder<sup>1</sup>, L. R. Dalton<sup>2</sup>**

<sup>1</sup>ETH Zurich (Switzerland), <sup>2</sup>University of Washington (USA)

Plasmonics is emerging as a technology with a potential for components featuring ultrafast speed, energy efficiency and a most compact footprint. So for instance, novel plasmonic modulators, detectors and microwave components with bandwidths beyond 100 GHz have come into the spotlight of the communications community. More recently, plasmonic losses have been addressed with various measures. Here, we review the recent progress in the field.

**10:20 : Invited talk**

**On-chip plasmon-induced transparency and device applications**

**Xiaoyong Hu**

*Peking University (China)*

We realized on-chip plasmon-induced transparency directly in plasmonic circuits. Several nanoscale integrated devices, including all-optical switching, all-optical diode, and all-optical logic devices were realized based on on-chip plasmon-induced transparency.

**10:40 : Invited talk****Plasmonic Anderson localization in correlated disorder****Ruwen Peng, Wenbo Shi, Renhao Fan, Mu Wang***Nanjing University (China)*

In this work, we experimentally demonstrate Anderson localization of surface plasmon polaritons (SPPs) at visible regime in metallic nanogratings with short-range correlated disorder. Our study provides a unique opportunity for disorder engineering to manipulate light on nanoscale, and may achieve various applications in random nanolasing, solar energy, and strong light-matter interactions.

**11:00 : Invited talk****Lasing at K-point in plasmonic honeycomb lattice****Rui Guo, Marek Necada, Aaro Vakevainen, Tommi Hakala, Paivi Torma***Aalto University (Finland)*

We experimentally demonstrate Bose-Einstein condensation of surface plasmon polaritons in lattice modes of a metal nanoparticle array. In another recent experiment, we observe lasing action at K-points in an active golden nanoparticle array with honeycomb geometry. By thorough analysis of the polarisation properties of the observed emission in both real and reciprocal space and with the help of group theory, we get the microscopical characterisation of the lasing mode. The utilised methods provide prospects for studies of topological systems obtained by breaking symmetries.

**11:20 : Invited talk****Driving Plasmonic Nanocircuits With Antenna-coupled Tunnel Junctions****Surya Prakash Gurunayanan<sup>1</sup>, Jente Vandersmissen<sup>1</sup>, Marc Heyns<sup>2</sup>, Iuliana P. Radu<sup>2</sup>, Pol van Dorpe<sup>2</sup>, Niels Verellen<sup>2</sup>**<sup>1</sup>*KU Leuven (Belgium)*, <sup>2</sup>*IMEC (Belgium)*

Electrically driven optical nanoantennas based on quantum mechanical tunneling of electrons recently gained much interest due to their on-chip electronic-photonic transducing properties. These antenna-coupled tunnel junctions can provide full control over light emission including the directionality. In this talk, we show that by carefully engineering the modes of the metallic nanoantenna, unidirectional light emission can be achieved. Moreover, we also show that these directional antennas can readily couple to plasmonic waveguides thereby injecting propagating modes.

**11:40 : Surface-enhanced Circular Dichroism in the Nanostructure/chiral Medium Hybrid System****SeokJae Yoo<sup>1</sup>, Q-Han Park<sup>2</sup>**<sup>1</sup>*Korea University (Korea)*, <sup>2</sup>*University of California (USA)*

We present a theory of the microscopic origins of the surface-enhanced circular dichroism (CD) in the nanostructure/chiral medium hybrid system. The recent surge of interest in the surface-enhanced CD spectroscopy has been inspired by the enhancement of the inherent molecular CD, but our work shows that the induced CD in nanostructure can dominate the total CD of the hybrid system. We also provide design principles for metamaterial-based CD sensors.

**11:55 : Invited talk****Emerging materials for plasmonics****Jerome Plain***Université de technologie de Troyes (France)*

We report on the fabrication of nanoobjects or nanostructures made from new materials. Moreover, we demonstrate the possibility to tune and control the plasmon resonance of Ni-Au nanoparticles using magnetic field or temperature.

**10:00 - 12:40 — Sala Desirée**

## Session 1A3

## Symposium I: Hybrid and Metastructured Materials for Photonics, Sensors and Energy I

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

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

**10:00 : Invited talk****Plasmonic Nanomaterials as Infrared-Blocking Radiation Filters and Energy-Saving Glasses****Lucas V. Besteiro<sup>1</sup>, Xiang-Tian Kong<sup>1</sup>, Zhiming Wang<sup>1</sup>, Federico Rosei<sup>2</sup>, Alexander Govorov<sup>3</sup>**<sup>1</sup>University of Electronic Science and Technology of China (China), <sup>2</sup>Institut National de la Recherche Scientifique - Énergie, Matériaux Télécommunications (Canada), <sup>3</sup>Ohio University (USA)

Plasmons are collective charge carrier excitations in nanostructured systems. Using different plasmonic materials to fabricate nanocrystals and controlling their size and geometry allows us to obtain sharp resonances from UV to near IR. By embedding ensembles of nanocrystals in dielectric materials, we can design metamaterials with specific transmission profiles that filter out a broad spectrum while remaining transparent to selected frequency bands. We overview this idea, alongside general design principles and illustrative implementations for applications such as energy-saving windows.

**10:20 : Invited talk****Hybrid plasmonic-dielectric nonlinear metasurface with tunable quality factors****Feng Wang, Hayk Harutyunyan***Emory University (USA)*

We develop a hybrid plasmonic/dielectric metasurface that can simultaneously achieve high quality factors and large field enhancement values. The optical response of the designed nano-architecture is dominated by the formation of a tunable hybridized plasmonic-photonic mode. By tuning the Q factors of the system we demonstrate that optimized conditions for nonlinear signal generation can be achieved.

**10:40 : Invited talk****Artificial chirality with fractal aluminum nanostructures****Dmitry Khlopin, Jérôme Martin, Davy Gérard***Université de Technologie de Troyes (France)*

We propose, design and characterize aluminum nanostructures based on the Cayley tree fractal geometry. We demonstrate that adding a twist angle in the fractal geometry generates artificial circular dichroism.

**11:00 : Keynote talk****Advanced hybrid plasmonics based on nanoscale photopolymerization****Renaud Bachelot***University of Technology of Troyes (France)*

We review the synthesis, characterization, and applications of new hybrid plasmonic nanomaterials that are created through plasmon-induced photopolymerization. In particular, involved polymer can contain quantum emitters, resulting in advanced anisotropic hybrid nano-emitters.

**11:30 : Moiré Chiral Metamaterials with Tunable Optical Chirality for Ultrasensitive Sensing****Zilong Wu, Yuebing Zheng***The University of Texas at Austin (USA)*

Moiré chiral metamaterials with strong optical chirality and active tunability were developed to achieve enantiodiscrimination of chiral molecules and sensing of solvent contaminants with ultrahigh sensitivity.

**11:45 : 3D nanostructuring of functional photopolymers for photonics and sensing****Safi Jradi<sup>1</sup>, Mélissa Merheb<sup>1</sup>, Ali Issa<sup>1</sup>, Ying Peng<sup>1</sup>, Aurélien Bruyant<sup>1</sup>, Xuan Quyen Dinh<sup>2</sup>, Xiaowei Sun<sup>2</sup>, Renaud Bachelot<sup>1</sup>**<sup>1</sup>Technological University of Troyes (France), <sup>2</sup>Nanyang Technological University (Singapore)

Two-photon direct writing is a very promising technique for fabrication of arbitrary 3D structures for multiple applications including micro/nanophotonics, microfluidics, and microdevices. Most of the applications require

functional photoresist with high spatial resolution, improved mechanical properties, and chemical compatibility with inorganic nanostructures.

**12:00 : Invited talk**

**Anisotropic chiroptically active nanomaterials**

**Yurii K. Gun'ko<sup>1</sup>, Finn Purcell-Milton<sup>1</sup>, Vera A. Kuznetsova<sup>1</sup>, Natalia Garcia Domenech<sup>1</sup>, Nikita V. Tepliakov<sup>2</sup>, Anvar S. Baimuratov<sup>2</sup>, Ivan D. Rukhlenko<sup>2</sup>, Alexander V. Baranov<sup>2</sup>, Anatoly V. Fedorov<sup>2</sup>**

<sup>1</sup>University of Dublin (Ireland), <sup>2</sup>ITMO University (Russia)

Anisotropic nanostructures have unique physical properties including a high aspect ratio, optical polarization anisotropy, giant birefringence and many others. Here we demonstrate advances in the development of new chiroptically active anisotropic nanostructures such as rods, tetrapods, 2D nanomaterials and others. We present the progress in various colloidal chemistry approaches for the synthesis of these chiral nanostructures. We also discuss structure-property relations as well as the corresponding potential applications of these nanomaterials in sensing, photocatalysis, biology and other areas.

**12:20 : Invited talk**

**Photopolymerization at the nanoscale triggered by plasmon resonance**

**F. Kameche<sup>1</sup>, W. Heni<sup>1</sup>, S. Telitel<sup>1</sup>, X. Zhou<sup>2</sup>, C. Deeb<sup>2</sup>, R. Bachelot<sup>2</sup>, O. Soppera<sup>1</sup>**

<sup>1</sup>Université de Haute-Alsace (France), <sup>2</sup>Université de Technologie de Troyes (France)

We report on the physicochemical and optical parameters controlling the photopolymerization process in near-field at the vicinity of metal nanoparticles. Kinetic parameters were shown to be of paramount importance to control the polymerization in highly confined space. Different photopolymers were used in this context to investigate the process at the molecular scale and finely tune the final properties of the nanoparticles.

**11:00 - 12:40 — Piano Bar Principe Nero**

**Session 1A4**

**Harnessing Acoustic and Elastic Waves via New Materials and Advanced Technologies I**

Organized by: Jie Zhu and Xue-Feng Zhu

Chaired by: Jie Zhu and Xue-Feng Zhu

**11:00 : Invited talk**

**Accidental acoustic double Dirac degeneracy emerged by rotating scatterers and the corresponding topological transitions**

**Xiang Xie<sup>1</sup>, Honglang Li<sup>2</sup>, Qiuyun Fu<sup>1</sup>, Xuefeng Zhu<sup>1</sup>, Degang Zhao<sup>1</sup>, Wei Luo<sup>1</sup>**

<sup>1</sup>Huazhong University of Science and Technology (China), <sup>2</sup>Chinese Academy of Sciences (China)

The specific two-dimensional phononic crystal (PC) consists of hexagonal steel plates with fan-like holes positioned in a triangular-lattice. Mutual evolution between deterministic Dirac degeneracy and accidental Dirac degeneracy was realized at the corner of the first Brillouin zone (FBZ). This provides multiple choice to achieve topological transition in acoustics. The associated valley-protected backscattering suppression around the curved interface channel was further demonstrated.

**11:20 : Invited talk**

**Handed walk of sound in periodically driven systems**

**Xue-Feng Zhu<sup>1</sup>, Jie Zhu<sup>2</sup>, Yu-Gui Peng<sup>1</sup>, Ya-Xi Shen<sup>1</sup>**

<sup>1</sup>Huazhong University of Science and Technology (China), <sup>2</sup>the Hong Kong Polytechnic University (China)

Topological insulator provides intriguing properties such as spin-momentum locking that allows symmetry protected surface states with robustness against local defects. Here, we report the pseudo-spin free topological transport of sound in a periodically driven waveguides system with periodical modulations along three spatial dimensions, where acoustic waves propagating along the tightly coupled waveguides experience four different hopping patterns in one periodically driven cycle and follow a handed walk with chirality and topological

protection.

**11:40 : Invited talk**

**A Design of Transparent Anisotropic metamaterial for airborne sound**

**Weiwei Kan, Mengping Guo**

*Nanjing University of Science and Technology (China)*

We present design of transparent anisotropic media based on transformation acoustics. The acoustic parameters of the structures, constructed by periodically arranging subwavelength objects in acoustic chambers, are studied in the quasi-static limit. By properly tuning the corresponding parameters, the acoustic parameters can be modulated independently, thereby the realizable ranges of these effective parameters can be broadened. The transparent feature of the designed structure is verified in broadband. The scheme will provide feasibility in versatile acoustic manipulation with metamaterials.

**12:00 : Invited talk**

**Observation of the Weyl points and Fermi arcs in a chiral phononic crystal**

**Feng Li<sup>1</sup>, Xueqin Huang<sup>1</sup>, Jiuyang Lu<sup>1</sup>, Jiahong Ma<sup>2</sup>, Zhengyou Liu<sup>1</sup>**

<sup>1</sup>South China University of Technology (China), <sup>2</sup>Wuhan University (China)

The discovery of Weyl semimetals extends not only semimetals beyond the Dirac type but also topological matters beyond topological insulators. Weyl points have also been found for classical waves in artificial periodic structures, for example, for electromagnetic waves in photonic crystals and for acoustic waves in phononic crystals. Here, we experimentally realize Weyl points in a chiral phononic crystal system, and we demonstrate the topological one-way propagation of the surface states associated with the Weyl points.

**12:20 : Invited talk**

**Valley States and Valley Edge States in Phononic Crystals**

**Jiuyang Lu<sup>1</sup>, Chunyin Qiu<sup>2</sup>, Zhengyou Liu<sup>1</sup>**

<sup>1</sup>South China University of Technology (China), <sup>2</sup>Wuhan University (China)

The valley pseudospin is now serving as a new approach to manipulate sonic and elastic waves in artificially designed phononic crystals (PCs). Here we review the valley states with intrinsic vortex features in PC. Topological index nominated as valley Chern number can be introduced to describe the valley material and distinguish the PCs into different valley Hall phases (VHPs). The valley edge states are expected on the domain walls between PCs with distinct VHPs.

**10:00 - 12:40 — Country Rock Club**

**Session 1A5**

**Nonlinear Metasurfaces and Plasmonics I**

Organized by: Guixin Li and Dangyuan Lei

Chaired by: Guixin Li and Tun Cao

**10:00 : Invited talk**

**Giant Optical Chirality in a Quasi-3D Meta-structure**

**Jiafang Li, Ximin Tian, Zhiguang Liu**

*Chinese Academy of Sciences (China)*

Here we report the studies on two kinds of quasi-3D meta-structures with reduced fabrication complexity and enhanced interaction with the magnetic component of incident light, which result in giant optical chirality.

**10:20 : Invited talk**

**Phase control of second harmonic generation from metasurfaces composed of complementary split ring resonators**

**Xin Yang, Zhuo Chen, Zhenlin Wang**

*Nanjing University (China)*



We demonstrate that complementary split-ring resonators (CSRRs) are able to generate second harmonic (SH) currents that are asymmetric with respect to their bases, and thus allowing for imposing a 180-degree-phase shift on the SH radiation by reversing orientation of the CSRRs. By simultaneously adjusting geometrical parameters and reversing orientation of the CSRRs, we further demonstrate the realization of continuous control over the phase change from 0 to 360 degrees for SH radiation.

**10:40 : Invited talk**

### **Hide and Seek in the Polarization Profile of a Laser Beam**

**Xianzhong Chen<sup>1</sup>, Fuyong Yue<sup>1</sup>, Shuang Zhang<sup>2</sup>**

<sup>1</sup>Heriot-Watt University (United Kingdom), <sup>2</sup>University of Birmingham (United Kingdom)

Hide-and-seek is a popular children's game in which some players conceal themselves in the environment, to be found by seekers. We propose and experimentally demonstrate a metasurface approach to hide a high-resolution grayscale image in the polarization profile of a laser beam. An image with a pixel size of 300 nm by 300 nm is encoded into the spatially variant polarization states of the laser beam and revealed by using a linear polarizer.

**11:00 : Invited talk**

### **Fano resonance enhancement using fishnet metamaterials**

**Jiaxin Bao, Libang Mao, Tun Cao**

*Dalian University of Technology (China)*

Fano resonance (FR) is observed in 3D symmetric metamaterials (MMs) consisting of elliptical nanoholes array (ENA) embedding through metal/dielectric/metal (MDM) multilayers. It is shown theoretically that a square periodic ENA perforating through MDM layers produces a FR response in the near infrared regime. This FR is attributed to the interplay between bright modes and dark modes, where bright modes originate from electric resonance caused by the ENA and the dark modes are due to the magnetic resonance induced by the MDM multilayers.

**11:20 : Invited talk**

### **Magnetic Hyperbolic Metasurface**

**Yihao Yang, Peifei Qin, Bin Zheng, Huaping Wang, Lian Shen, Hongsheng Chen**

*Zhejiang University (China)*

We hereby proposed, designed, and fabricated magnetic hyperbolic metasurfaces on which magnetic surface plasmons travel in a convergent manner. We experimentally observed diffraction-free propagation, anomalous diffraction, negative refraction, and frequency-dependent strong spatial distributions of the MSPs on the metasurface in the hyperbolic regime at microwave frequencies.

**11:40 : Invited talk**

### **Plasmonic enhancement and manipulation of optical nonlinearity in monolayer WS<sub>2</sub>**

**Jinwei Shi<sup>1</sup>, Wei-Yun Liang<sup>1</sup>, Hyeyoung Ahn<sup>1</sup>, Soniya S. Raja<sup>1</sup>, Yungang Sang<sup>2</sup>, Xin-Quan Zhang<sup>3</sup>, Chun-An Chen<sup>3</sup>, Yanrong Wang<sup>2</sup>, Xinyue Yang<sup>2</sup>, Yi-Hsien Lee<sup>3</sup>, Shangjr Gwo<sup>3</sup>**

<sup>1</sup>National Chiao-Tung University (Taiwan), <sup>2</sup>Beijing Normal University (China), <sup>3</sup>National Tsing-Hua University (Taiwan)

Two-dimensional transition metal dichalcogenides have giant second order nonlinearity. However, the sub-nanometer thickness of monolayer limits the conversion efficiency. Here, we experimentally show that the second-harmonic generation of WS<sub>2</sub> can be enhanced by integrating it on a plasmonic metasurface. The direct enhancement factor of 400 can be realized due to the strong field confinement of the plasmonic dark mode. Meanwhile, the polarization dependence of SHG can also be controlled by the plasmonic mode.

**12:00 : Invited talk**

### **Enhancement of nonlinearity at interfaces with discontinuous second-order susceptibility**

**Yuanlin Zheng, Xiaohui Zhao, Xianfeng Chen**

*Shanghai Jiao Tong University (China)*

We discuss the nonlinear response at the interface of two media with sharply discontinuous second-order susceptibilities. The enhancement of nonlinear Cerenkov radiation was theoretically predicted and experimentally observed. In our experiment, there was one order of magnitude enhancement in the conversion efficiency at the nonlinear interfaces as compared to the crystal boundary. The result suggests potential applications for efficient frequency conversion, and the scheme can also be useful in the UV or even EUV generation.



**12:20 : Invited talk**

**Active Plasmonics Based on Liquid Crystals**

**Yanjun Liu<sup>1</sup>, Shengtao Yin<sup>1</sup>, Dong Xiao<sup>1</sup>, Guixin Li<sup>1</sup>, Dan Luo<sup>1</sup>, Wei Ji<sup>2</sup>, Shouzhen Jiang<sup>3</sup>, Xiaowei Sun<sup>1</sup>**

<sup>1</sup>*Southern University of Science and Technology (China)*, <sup>2</sup>*Shandong University (China)*, <sup>3</sup>*Shandong Normal University (China)*

We summarize our recent research on the liquid crystal based active plasmonics. Various active plasmonic devices are 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.

**10:00 - 12:45 — Discoteca Pietra di Luna**

**Session 1A6**

**Nanophotonics and Plasmonics Based on Graphene and Related 2D Materials**

Organized by: Mohamed Farhat and Pai-Yen Chen

Chaired by: Mohamed Farhat and Pai-Yen Chen

**10:00 : Invited talk**

**Sensitivity of all dielectric layered metastructures on a scale below the periodicity**

**Agnes Maurel<sup>1</sup>, Jean-Jacques Marigo<sup>2</sup>**

<sup>1</sup>*ESPCI (France)*, <sup>2</sup>*Ecole Polytechnique (France)*

The unusual scattering properties of multilayered dielectric metamaterial near the critical angle for total reflection are revisited. Our findings are twofolds: (i) we shows that in TE polarization, a fully local model accurately reproduces them, (ii) the sensitivity of these structures is much higher than that reported in previous studies.

**10:20 : Invited talk**

**Actively tuning the topological valley edge states in photonic**

**Zhiwei Guo, Haitao Jiang, Yunhui Li, Hong Chen**

*Tongji University (China)*

Actively tuning the topological valley edge states in photonic boron nitride structure via carrier photo-injection; We reveal that topological valley edge states can be actively tuned in photonic boron nitride structure by changing the carrier density of InP via photo injecting. Our work provides a direct avenue towards the realization of actively tunable topological valley transport and the related nano-photonic devices.

**10:40 : Invited talk**

**Plasmonically Enhanced Schottky Solar Cell**

**Mohamed Farhat<sup>1</sup>, Fahhad Alharbi<sup>1</sup>, Pai-Yen Chen<sup>2</sup>**

<sup>1</sup>*Hamad Bin Khalifa University (Qatar)*, <sup>2</sup>*Wayne State University (USA)*

In this proposal, we aim to use plasmonic light confinement to build Schottky solar cells. The photovoltaic effect in these cells is induced by the metal semiconductor interface. And the presence of the plasmonic metal will increase the generated current in the active silicon layer and thus increase the overall efficiency of the cell. We will discuss limitations and potentials of this kind of solar cells, in particular ease of fabrication.

**11:00 : Invited talk**

**2D semiconductors for nanophotonics**

**Alberto G. Curto**

*Eindhoven University of Technology (Netherlands)*

Layered 2D semiconductors are ideal sources and detectors for nanophotonics and optoelectronics. They exhibit a strong optical response, can be incorporated into the very near field of devices, are easy to position and pattern, and give access to exciting electronic degrees of freedom like the spin, valley and layer numbers. Here we present two experimental examples of the advantages and flexibility of 2D semiconductors as light sources for nanophotonics.

**11:20 : Invited talk****Polaritonic light-matter interaction in van der Waals heterostructures****Itai Epstein***ICFO (Spain)*

In this talk I will present our recent research relating to plasmonic and excitonic light-matter interaction in Van der Waals heterostructures: We show that heterostructures of graphene, h-BN, and metals support highly confined and slow plasmons, at 300 times the fraction of the speed of light, where nonlocal effects can be probed. We also investigate the limits of (out-of-plane) confinement of plasmons down to the ultimate physical boundary of one atom-thick layer.

**11:40 : New graphene-based circulators and switches for THz region****Victor Dmitriev, Wagner Castro, Samara Matos, Sergio Rabelo***Federal University of Para (Brazil)*

In this work we suggest and analyze five new graphene based components operating in THz region. They are Y, W and edge guided mode circulators and two switches with different geometries. The graphene elements are magnetized normally to their plane by a modest DC magnetic field. Numerical simulations demonstrate a high level of isolation, low insertion losses and a large bandwidth of circulators. The switches are characterized by high ON-OFF ratio and low insertion losses.

**11:55 : Micron-sized phase-matching-free parametric oscillators based on two-dimensional semiconductors****Andrea Marini<sup>1</sup>, Alessandro Ciattoni<sup>2</sup>, Carlo Rizza<sup>2</sup>, Claudio Conti<sup>3</sup>***<sup>1</sup>University of L'Aquila (Italy), <sup>2</sup>Consiglio Nazionale delle Ricerche (Italy), <sup>3</sup>Institute for Complex Systems (ISC-CNR) (Italy)*

By the exact solution of nonlinear Maxwell equations and first-principle calculations of the semiconductor nonlinear response, we devise a novel kind of parametric micro-resonators adopting monolayer transition-metal dichalcogenides as quadratic nonlinear materials, showing that they are free of phase-matching requirements owing to their surface-like nonlinear interaction.

**12:10 : Strong light-graphene interaction in graphene/hBN heterostructures based electro-optic modulator on silicon photonics****Binbin Wang<sup>1</sup>, Sylvain Blaize<sup>1</sup>, Jinbong Seok<sup>2</sup>, Sera Kim<sup>2</sup>, Heejun Yang<sup>2</sup>, Rafael Salas-Montiel<sup>1</sup>***<sup>1</sup>Université de technologie de Troyes (France), <sup>2</sup>Sungkyunkwan University (Korea)*

We propose the integration of a plasmonic crystal into graphene/hBN based modulator on silicon photonics. Strong in-plane electric field confinement of the plasmonic Bloch mode enhances the overlap with graphene and hence their light absorption, which reduces device footprint and energy consumption. Here, we also report our current experimental results towards the fabrication and characterization of the nanomodulator with the use of near-field scanning optical microscopy. Optical confinement and absorption of graphene is found for encapsulated graphene on hBN compare to hBNgraphene-SiO<sub>2</sub> heterostructure on silicon photonic waveguides.

**12:25 : Invited talk****Controlling the directivity, bandwidth and rate of thermal emission with epsilon-near-zero media****Inigo Liberal<sup>1</sup>, Nader Engheta<sup>2</sup>***<sup>1</sup>Public University of Navarre (Spain), <sup>2</sup>University of Pennsylvania (USA)*

Epsilon-near-zero (ENZ) media provides the essential ingredients for the design of directive and narrowband thermal emitters. In particular, directivity and emission rate scale along with the size of an ENZ body, while the bandwidth is inversely proportional to it. In addition, ENZ thermal emitters exhibit exotic properties, such as geometry invariance and dopant-position independence. Here, we investigate these theoretical aspects as well as the trade-offs involved in the practical implementation of these concepts in silicon carbide (SiC).

**Lunch****12:30 - 14:00**

18:30 - 20:00 — Sala Desirée

## Session 1A7

## Plasmonics and Nanophotonics I

Chaired by: Evgeniya Sheremet

**18:30 : Nanonewton Plasmonic Forces from a 3D Coaxial Nanopillar****Brandon Terranova, Adam Fontecchio***Drexel University (USA)*

Nanoplasmonic systems are capable of imparting relatively large forces to micro and mesoscopic objects due to their strong field confinement and enhancement, beyond the diffraction limit of traditional optical tweezers or otherwise diffraction-limited optomechanical actuation systems. Here we report on a 3D nanostructure which is numerically shown to impart large forces and possess nanoscopic plasmonic trapping regions. Results of this work can contribute to the field of near-field plasmonics of 3D nanostructures as well as optomechanical nanomanipulation.

**18:45 : Optical metasurface based holographic stereogram****Yun-Seok Choi<sup>1</sup>, Joo-Yun Jung<sup>2</sup>, Min-Kyo Seo<sup>1</sup>***<sup>1</sup>Korea Advanced Institute of Science and Technology (Korea), <sup>2</sup>Korea Institute of Machinery and Materials (Korea)*

Holographic stereogram displays fully three-dimensional images by generating different two-dimensional holograms depending on the direction of viewpoint. Conventional holographic stereograms by micrometer-scale pixels suffer from multiple diffraction orders and narrow viewing angle. We demonstrate optical metasurface based holographic stereogram with a wide viewing angle of 60 degrees. The metasurface consists of several phase-only hologram sub-metasurfaces producing different directional holograms at specific angles. We combine a spatial Fourier filter with the Gerchberg-Saxton algorithm to calculate phase distributions for directional holograms.

**19:00 : Optical properties and mid infrared applications of plasmon perfect absorber metasurfaces****Yoshiaki Nishijima<sup>1</sup>, Armandas Balcytis<sup>2</sup>, Gediminas Seniutinas<sup>2</sup>, Saulius Juodkazis<sup>2</sup>***<sup>1</sup>Yokohama National University (Japan), <sup>2</sup>Swinburne University of Technology (Australia)*

We demonstrate the optical properties of a plasmonic perfect absorber (PPA) in mid-infrared (IR) wavelength region with a layered structure: the bottom metal layer, insulator, and top nano-structures. Thickness was optimised for the perfect absorption at mid-IR wavelengths. We have fabricated PPA structures with various combinations of metal and insulator layers. The experimentally measured optical properties were compared with simulations by finite-difference time-domain calculations. Also, we demonstrate applications of these structures for the plasmonic IR-light sources and detectors.

**19:15 : Frequency discrete diffraction control by photonic gauge potentials****Chengzhi Qin, Bing Wang, Peixiang Lu***Huazhong University of Science and Technology (China)*

We demonstrate theoretically and experimentally photonic gauge potential in synthetic frequency dimension. The gauge potential is realized by controlling the modulation phase in optical phase modulators. We experimentally achieve a 50 GHz frequency shift and three-fold expansion of an impinging comb and frequency analogues of refraction phenomena, including negative refraction and perfect focusing in the frequency domain, both for discrete and continuous incident spectra. Our study paves a way towards versatile frequency management for optical communications and signal processing.

**19:30 : Active controlled scattering from dielectric nanoantennas in the visible range****Jiahao Yan, Churong Ma, Yingcong Huang, Guowei Yang***Sun Yat-sen University (China)*

Dielectric nanoantennas and metasurfaces with low-loss feature and strong magnetic dipole responses offer a brand new mechanism to tailor and modulate the electromagnetic waves. The ability to dynamically modulate plasmon resonances or Mie resonances shows a practical approach to build nanophotonic devices. However, how to actively modulate the resonant peaks in dielectric structures especially at visible wavelengths

still needs to be answered. Here, we realize the spectral tailoring of an individual silicon nanoparticle and vanadium dioxide (VO<sub>2</sub>) nanostripe.

### 19:45 : Inelastic Relaxation and Thermal Properties in Strongly Coupled Plasmon-Exciton Hybrid Nano Structures

**Martin Claes Wersall, Gulis Zengin, Jorge Cuadra, Tomasz Antosiewicz, Mikael Kall, Timur Shegai**  
*Chalmers University of Technology (Sweden)*

Nanoscale light-matter interactions are an interesting topic for numerous reasons, including realization of future quantum optics/plasmonics. Recent studies have demonstrated single-particle strong coupling at ambient conditions by investigating formation of hybrid states in optical scattering spectra. However, these works lack signatures of spectral hybridization in photoluminescence (PL), yet another important signature of strong coupling dynamics. Here we demonstrate mode hybridization in PL from a nanoscale system comprised of single plasmonic silver nanoprisms embedded in layers of J-aggregated TDBC molecules.

## 18:30 - 19:10 — Piano Bar Principe Nero

### Session 1A8

#### Harnessing Acoustic and Elastic Waves via New Materials and Advanced Technologies II

Organized by: Jie Zhu and Xue-Feng Zhu

Chaired by: Jie Zhu and Xue-Feng Zhu

### 18:30 : Invited talk

#### Soft Metasurface with Gradient Acoustic Index

**Yabin Jin, Raj Kumar, Olivier Poncelet, Olivier Mondain-Monval, Thomas Brunet**  
*Université de Bordeaux (France)*

We report a new class of soft metasurface with a wide range of refractive index for water-borne waves focusing with subwavelength thickness. The porous metasurface is fabricated via an emulsion templating method, locally controlling porosity along 2mm-thickness metasurface, so that it realizes gradient index profile as design. We experimentally and numerically study a rectangular and a circular metasurfaces for 2D and 3D focusing, respectively, with excellent quantitative agreements.

### 18:50 : Invited talk

#### Ultra-high sensitive distributed acoustic sensor (DAS) based on distributed micro-structured optical fiber (DMOF)

**Qizhen Sun, Fan Ai, Zhijun Yan, Wei Zhang, Hao Li, Deming Liu**  
*Huazhong University of Science and Technology (China)*

A novel Fiber distributed acoustic sensor (DAS) with ultra-high sensitivity is presented. Through designing and fabricating the DMOF with successive longitudinal microstructures to enhance the signal-to-noise ratio of the backscattered light, and employing the coherent optical time domain reflectometer technique (C-OTDR), the minimum detectable strain down to  $20n\epsilon$  at 0.01Hz, and the ultimate detection limit of  $0.02n\epsilon$  over 10Hz are experimentally demonstrated, which is higher than the reported results to the best of our knowledge.

## 19:10 - 19:55 — Piano Bar Principe Nero

### Session 1A9

#### Metamaterials and Negative Index Materials

Chaired by: Osamu Sakai

**19:10 : Investigation on the optimization of the coding matrix based on the tailor scattering properties of the coding metamaterials****Shuai Yang<sup>1</sup>, Qun Wu<sup>1</sup>, Yuming Wu<sup>2</sup>, Xumin Ding<sup>1</sup>, Kuang Zhang<sup>1</sup>**<sup>1</sup>Harbin Institute of Technology (China), <sup>2</sup>Beijing Insititute of Technology (China)

Diverse electromagnetic(EM) responses of coding metamaterials have been investigated, and the general research method is to use full-wave simulation. But if we only care its scattering properties, it is not necessary to perform full-wave simulation. Based on metamaterial particle that has multiple response and genetic algorithm which is coupled with the scattering pattern analysis, we can optimize the coding matrix quickly to tailor the scattering properties without using full-wave simulation every time.

**19:25 : Shear Horizontal Wave Propagation in Magnetoelastic Multilayered Plates with Negative-Indexed Piezomagnetic Materials****Yongqiang Guo, Liangteng Guo***Lanzhou University (China)*

The method of reverberation-ray matrix (MRRM) is introduced to analyze the dispersion curves of SH waves in magnetoelastic multilayered plates consisting of piezomagnetic and elastic laminates. Any piezomagnetic layer can be negative-indexed magnetic material with part or all of its permeabilities being negative. Novel dispersions of SH waves in magnetoelastic multilayered plates with this left-handed piezomagnetic materials are studied. The effects of the magnitude of negative permeabilities and of the overlaid elastic layers on these new properties are discussed.

**19:40 : Double-Epsilon-Near-Zero and Resonant Gain Metal/Dielectric Multilayers****Vincenzo Caligiuri, Milan Palei, Muhammad Imran, Liberato Manna, Roman Krahn***Istituto Italiano di Tecnologia (Italy)*

Here we investigate the possibility to weakly-couple a CsPbBr<sub>3</sub> perovskite dye with a double-epsilon-near-zero planar plasmonic nanoresonator in order to obtain a noticeable enhancement of its spontaneous emission, quantum efficiency and decay rate. Furthermore, we illustrate the possibility to reach the so-called Resonant Gain dielectric singularity propagation regime, in which remarkable amplification and canalization of the emitted light are possible, constituting a very promising starting point for nanoscale lasing effects and amplified perfect lensing.

**18:30 - 19:45 — Country Rock Club****Session 1A10****Modeling and Computational Techniques**

Chaired by: Shuming Wang

**18:30 : Modal Analysis of Cylindrical Waveguide with 2D Metamaterial Wall****Lucille Kuhler<sup>1</sup>, Gwenn Le Fur<sup>2</sup>, Luc Duchesne<sup>3</sup>, Nathalie Raveu<sup>1</sup>**<sup>1</sup>University of Toulouse (France), <sup>2</sup>CNES (France), <sup>3</sup>MVG Industries (France)

In this article the Modal Expansion Theory (MET) is developed for 2D metamaterial cylindrical waveguides. A new code based on 2D Finite Element Method (FEM) is implemented to compute conformal surface impedances. The MET using this FEM code is successfully applied to a corrugated waveguide. For such a case computation time is around 30 times faster than the commercial software HFSS.

**18:45 : 2D-3D coupled spectral element method for modelling of guided waves propagation in a composite plate****Piotr Fiborek, Pawel Kudela, Wieslaw Ostachowicz***Polish Academy of Sciences (Poland)*

Elastic waves are extensively used in Structural HealthMonitoring for damage detection in the structures. In this paper, spectral element method with a various dimension of elements is used for modelling of the wave propagation in a composite plate. All components used in the simulation are decomposed from each other and connected by Lagrange multipliers. In this type of scheme elements with different dimension can be used

for modelling of each component significant decreasing the time of the simulation.

### 19:00 : A Theoretical, Numerical and Experimental Analysis of Adhesive Bond Effect on Lamb Wave Propagation in Sandwich Structure

**Shirsendu Sikdar<sup>1</sup>, Wieslaw Ostachowicz<sup>2</sup>**

<sup>1</sup>Polish Academy of Sciences (Poland), <sup>2</sup>Warsaw University of Technology (Poland)

A combined semi-analytical analysis, finite element simulation, and experimental investigation have been carried out in order to study the bond effect on the Lamb wave propagation in a jointed honeycomb sandwich structure. It is observed that the presence of adhesive bond significantly influences the propagating wave modes in terms of decrease in amplitude and propagation velocity. A good agreement is noticed among the theoretical, numerical, and experimental results, in all the cases studied.

### 19:15 : An asynchronous FDTD solver for efficient simulations in nanophotonics

**Sergei Belousov<sup>1</sup>, Sergey Khilkov<sup>2</sup>, Vadim Levchenko<sup>3</sup>, Anastasia Perepelkina<sup>3</sup>, Ilya Valuev<sup>2</sup>**

<sup>1</sup>Kintech Lab Ltd. (Russia), <sup>2</sup>HIPERCONe Ltd. (Russia), <sup>3</sup>Keldysh Institute of Applied Mathematics (Russia)

We present a full-wave electromagnetic solver based on FDTD method, extremely efficient in terms of CPU and GPU performance and scalability (HIPERCONe FDTD). The use of asynchronous mesh updates, localization of data in the fast memory, and parallelism at all levels including vectorization allows the solver to achieve the performance up to 1-2 orders of magnitude higher than the traditional approaches. The asynchronous mesh update algorithm provides a natural framework for non-iterative simulations of oblique incidence on periodic metamaterials.

### 19:30 : Near Optimal Freeform Inverse Design Approach For Future Metastructures

**Mohammad Haghtalab<sup>1</sup>, Federico Capasso<sup>1</sup>, Safieddin Safavi-Naeini<sup>2</sup>**

<sup>1</sup>Harvard University (USA), <sup>2</sup>University of Waterloo (Canada)

Demands for highly efficient meta-structures require the employment of designs with high degrees of freedom in design parameters. Due to large number of variables, using the conventional global optimization methods is not efficient in such structures. To overcome this challenge, new approaches should be devised, allowing us to efficiently explore electrically large and geometrically complex structures. In this paper, we introduce a stochastic-based algorithm for this purpose.

## 18:30 - 19:15 — Birreria Dresden Green

### Session 1A11

### Photonic Crystals, Laser and Cavities

Chaired by: Rair Macedo

### 18:30 : Standing waves with infinite group velocity in temporal photonic crystals

**Juan Sabino Martinez Romero, Peter Halevi**

*Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico)*

We extend our studies of a medium whose permittivity and/or permeability are modulated periodically in time, namely temporal photonic crystals (TPCs). When the frequency of the wave  $\omega$  is equal to  $1/2, 3/2, \dots$  of the modulation frequency, we find that the fields in a TPC slab (as well as in a boundless TPC) are standing waves. Interestingly, at these values of  $\omega$  the group velocity is infinite. Such behavior strongly differs from that of an ordinary photonic crystal.

### 18:45 : Ultralow-threshold continuous-wave lasing assisted by a metallic optofluidic resonator

**Bei Jiang, Hailang Dai, Xianfeng Chen**

*Shanghai Jiao Tong University (China)*

We report an ultralow-threshold continuous-wave lasing via a metallic optofluidic resonant cavity. The high quality factor and spontaneous emission coupling factor of the waveguide strengthen the interaction between the gain medium and the ultrahigh order modes. Methylene blue with concentration of  $2.57 \times 10^{13}$  mol/ml is chosen to verify the applicability of the proposed concept, and the narrow-band lasing can be effectively



pumped from the chip surface by a continuous laser with the launched pump threshold as low as 2.1  $\mu\text{W}/\text{cm}^2$ .

**19:00 : An angular study of the diffraction of light from one row of cylinders**

**Jesus Daniel Valenzuela-Sau, Raul Garcia-Llamas**

*Universidad de Sonora (Mexico)*

The scattering of a Gaussian beam from a finite number of cylinders aligned in a row, is studied. The row is treated as an inhomogeneous periodic bounded medium. The magnetic field is expanded in terms of the eigenvector obtained by using the Plane Wave Method. We observed that the total integrated scattering in transmission (reflection) presents minima (maxima) and one of them can be explained as if the row of cylinders behaved as a photonic crystal.

**19:15 - 19:45 — Birreria Dresden Green**

**Session 1A12**

**Acoustic Metamaterials**

Chaired by: Bahram Djafari Rouhani

**19:15 : Acoustic Metasurface for Giant Transmission through Water-Air Interface**

**Eun Bok<sup>1</sup>, Jong Jin Park<sup>2</sup>, Haejin Choi<sup>1</sup>, Chung Kyu Han<sup>1</sup>, Oliver B. Wright<sup>3</sup>, Sam H. Lee<sup>1</sup>**

<sup>1</sup>Yonsei University (Korea), <sup>2</sup>Reserch Department, Center for Advanced Meta-Materials (Korea), <sup>3</sup>Hokkaido University (Japan)

Giant acoustic transmission through water-air interface lead to dramatic enhancement of the sensitivity of underwater sound detection. However, such transmission was never realized until recently, because of three orders of magnitude difference in acoustic impedance between water and air. Here, we present the new method that we first realized. We designed an acoustic metasurface for the giant transmission, and experimentally demonstrated that the metasurface increases the power transmission by 160 times of magnitude.

**19:30 : Double negative and super-focusing properties of star-structured sonic metamaterial**

**Yuren Wang, Meng Chen, Heng Jiang**

*Chinese Academy of Sciences (China)*

The band gap formation mechanisms and effective parameters of a four-pointed star structure were investigated using FEMs. This auxetic metamaterial can generate two broad band gaps in the low frequency. The calculated parameter values verify that the single-phase star-shaped structure can achieve double-negative properties owing to the hybrid state formed under bending. Moreover, Simulations verify the effective focusing of sound by a single-phase solid lens with a spatial resolution of about  $0.39 \lambda$ .



# Tuesday 26th June, 2018

08:00 - 09:45 — Teatro Emerald

## Session 2A1

### Plenary Session I

Chaired by: Federico Capasso

08:00 : **Plenary talk**

#### **Evolutionary metamaterials : the imitation game of Nature for renewable energy harvesting, artificial intelligent photonics and advanced material engineering**

**Andrea Fratolocchi**

*King Abdullah University of Science and Technology (Saudi Arabia)*

In this presentation, I summarize recent research in the field, discussing both fundamental and applied aspects. These encompass the exploitation of irreversible chaotic dynamics for energy harvesting, the control of rare catastrophic events at nanoscale, coherent light generation from black-bodies, biomimetic nanomaterials with unique properties, record performing photocatalysis membranes generated by warped spaces, early stage cancer detection, and new types of optical neural networks.

08:35 : **Plenary talk**

#### **Catching Light with Metamaterials**

**Vladimir Shalaev**

*Purdue University (USA)*

In this presentation, emerging plasmonic, metamaterial and metasurfaces concepts as well as material platforms will be discussed with the focus on practical photonic technologies for communication, quantum optics, bio-medical and energy applications.

09:10 : **Plenary talk**

#### **X-Y-Z-T Metamaterials**

**Nader Engheta**

*University of Pennsylvania (USA)*

In this talk, I will present an overview of our ongoing efforts in exploring four-dimensional "X-Y-Z-T Metamaterials", i.e., the metastructures in which the material parameters can vary with time as well as with space. We will show how some of the exciting features such as "freezing and growing waves in combination with the non-Foster circuits, temporal effective parameters, temporal anti-reflection matching, etc. can be obtained by proper combinations of temporal and spatial variations of parameters in metamaterials. We will also show how we can expand this 4D metamaterials concept to higher-dimensional metamaterials using temporal anisotropy, which leads to other exciting features such as rainbow radiation". I will discuss some of our most recent results from my group and forecast future directions and potentials.

## Session 2P1

### Poster Session I

09:45 - 10:20

#### **P1: Low Cost Silicon-Based Hot-Electron Photodetector in the Near-Infrared Regime**

**Yupei Li, Yusheng Zhai, Guangdian Chen, Zhiyang Qi, Qilong Wang**

*Southeast University (China)*

In this study, we propose a low-cost broadband near infrared light (NIR) photodetector fabricated by coating a thin layer of Au film onto a pyramidally textured silicon (Si) wafer. This structure utilizes the internal photoemis-

sion effect (IPE) through an Au/Si Schottky junction. The responsibility of the silicon pyramid photodetector exhibited up to 10-times increase compared with a control Schottky photodetector with a flat Au/Si surface. Large-area and lithography-free fabrication makes these devices suitable for low-cost NIR detection applications.

### **P2: Analysis of solitonic pulse propagation in metamaterials implemented in photonic crystals**

**Michelle Savescu<sup>1</sup>, Kaisar Khan<sup>2</sup>**

*<sup>1</sup>Kutztown University of Pennsylvania (USA), <sup>2</sup>McNeese State University (USA)*

In this paper, we present the theoretical study of soliton pulse propagation in photonic crystal metamaterials. The traveling wave model for short pulse propagation through waveguides implemented in photonic crystals reveals constraint conditions related to wavelength dependent dispersion in negative refraction cases. Earlier simulations show that at certain wavelengths the optical wave guided in photonic crystals can get negative refraction if the holes are filled with metals. Current analysis also considers the unavoidable larger losses of the waveguides.

### **P3: Realizing Scattering Dark State in a Hybrid System of Germanium Nanogroove and Molecular Excitons**

**Yingcong Huang, Churong Ma, Jiahao Yan, Guowei Yang**

*Sun Yat-sen University (China)*

Coupling between light and matter gives rise to many infusive physical effects and potential applications. However, the Joule heating losses at the optical frequencies makes plasmonic nanostructures not suitable to interact with molecular excitons. Here, we demonstrated germanium nanogroove as a new all-dielectric metasurface building block for the Kerker effect with molecular excitons. A significant dip was observed in the backward scattering spectra because of the cavity magnetic resonance mode, which is benefit from the refractive index of germanium.

### **P4: Second harmonic generation enhancement by Mie resonances in individual barium titanate nanoparticles**

**Churong Ma, Jiahao Yan, Yingcong Huang, Guowei Yang**

*Sun Yat-sen University (China)*

All-dielectric materials (ADMs) offer new ways to generate nonlinear optical (NLO) behavior at subwavelength scales. Herein, we report enhancement in the tunable second harmonic generation (SHG) reflected from individual mid-refractive ADM nanoparticles, BaTiO<sub>3</sub> nanoparticles (BTO NPs). Multipole decomposition, as observed in the linear spectra, demonstrated that the SHG enhancement originated from an overlap between the magnetic dipole or quadrupole resonance and the SH wavelength of the pump source.

### **P5: Multiple toroidal Resonances in Folded Metamaterials**

**Shengyan Yang, Zhe Liu, Ling Jin, Wuxia Li, Junjie Li, Shuang Zhang, Changzhi Gu**

*Chinese Academy of Sciences (China)*

We demonstrate the excitation of multiple high-Q-factor toroidal resonances in folded metamaterials, which were fabricated by focused- ion-beam induced deformation technique. The field distributions clearly show the generation of toroidal mode with tightly restrained magnetic vortex in the subwavelength structures. It is shown that the toroidal resonances can be controlled by the geometry of the metamaterial and the angle of incident light. The folded metamaterial exhibiting toroidal resonances holds potential for applications in lasing spaser, nonlinear processing, and sensing.

### **P6: The silicon dimer array based sensor**

**Ziwei Liu, Tanchao Pu, Jiebin Niu, Lina Shi, Changqing Xie**

*Chinese Academy of Sciences (China)*

We propose a sensor structure of silicon dimer array based on magnetic resonances. The refractive index sensing capability is investigated numerically. We obtained the sensitivity of 559nm/RIU and FOM of 52.8 for Y-polarization incident and the structure with  $P_x=600$  nm and  $P_y=340$  nm. We also investigate the effects of periods and polarizations on the sensitivity and find the larger period  $P_x$  and Y-polarization incident light will benefit the sensitivity. Our results offer opportunities for designing sensors with low loss.

### **P7: High Quality Factor Fano Resonances in All-Dielectric Metasurfaces**

**Tanchao Pu, Ziwei Liu, Jiebin Niu, Lina Shi, Changqing Xie**

*Chinese Academy of Sciences (China)*

We numerically demonstrated an all-dielectric metasurface with high quality factor Fano resonance. The metasurface comprises a two-dimensional array of amorphous Si hexamers. Numerical results show that both square and triangular lattices support the asymmetric Fano resonances. Especially, the quality factor of the triangle array can attain 836.1 for the closely packed case in the near infrared range. Such metasurfaces with Fano resonance are promising for practical applications, such as biosensor and optical filter.

#### **P8: Engineering Photon Upconversion with an Optical Cavity**

**Ye Yu<sup>1</sup>, Yejing Liu<sup>2</sup>, Joel K. W. Yang<sup>2</sup>, Tobias A. F. Konig<sup>1</sup>, Andreas Fery<sup>1</sup>**

<sup>1</sup>Leibniz-Institut für Polymerforschung Dresden e. V. (Germany), <sup>2</sup>Singapore University of Technology and Design (Singapore)

In this poster we will show a strategy to manipulate the upconversion of photons using an optical cavity as the work horse. Instead of chemically re-designing the upconvertive nanomaterial to tune the upconversion process, an optical cavity can manipulate the effective excitation feature and hence engineer the photon upconversion pathways. As a result, the upconverted light intensity, lifetime, as well as emission ratio can be readily tuned.

#### **P9: A phase-shifted Solc-type filter based on periodically poled lithium niobate in a reflective geometry**

**Tingting Ding, Yuanlin Zheng, Xianfeng Chen**

*Shanghai Jiao Tong University (China)*

We observe the transmission of electromagnetic induction transparent (EIT)-like effect in periodically poled lithium niobate (PPLN) based on transverse electro-optic (EO) effect. The configuration can be dynamically tuned or switched on/off by the applied electric field. The mechanism features a tunable center wavelength in a wide range with respect to temperature and controllable optical delay by the external electrical field, which may offer new way for optical tunable filters or delay lines.

#### **P10: External control of multipolar third harmonic generation from arrays of dielectric-metal core-shell resonators**

**Xin Yang, Chi Zhang, Lina Qian, Zhi-Qin Li, Ping Gu, Zhuo Chen, Zhenlin Wang**

*Nanjing University (China)*

We demonstrate that the dielectric-metal core-shell resonators (DMCSRs) in the array are acting as a set of phase-coherent sources of THG emission and their interference in the far-field region leads to the spatially tailored nonlinear radiation. By selectively matching fundamental wave to different cavity plasmons, the THG emission from the single DMCSR element can be redirected in different radiation patterns, and thus the ratio between the THG intensities into the first and zeroth order diffraction can be modified accordingly.

#### **P11: Optimal double resonant condition in metallic core-shell nanocavity for third harmonic generation**

**Wenbo Zang, Lingling Fan, Guangxu Su, Xin Yang, Mingyu Ma, Peng Zhan, Zhuo Chen, Zhenlin Wang**

*Nanjing University (China)*

Numerical simulations show that the third harmonic generation (THG) intensity in the far field can be enhanced when the pump light and the THG signal are both coupled to spherical cavity modes. And it is optimum on double resonant conditions coupling two modes with the same order, up to 3 magnitudes. Subsequent theoretical analysis indicates that changing third-order nonlinear susceptibility of the metal shell while keeping that of the core fixed has almost no effect on THG efficiency.

#### **P12: Crystal Growth and optical properties of BaMgF<sub>4</sub> single crystal**

**Zhuo Wang, Junjie Chen, Yanzhi Ma, Yuanlin Zheng, Xianfeng Chen**

*Shanghai Jiao Tong University (China)*

BaMgF<sub>4</sub> crystal is a very promising candidate for many applications in vacuum ultraviolet region. In our experiments, the BaMgF<sub>4</sub> single crystal is grown by temperature gradient technique and the short cut-off wavelength is determined to be 130 nm. The second- and third-order nonlinear optical coefficients are measured by Maker fringe and Z-scan technique, respectively. A considerable electro-optic coefficient is measured as well. At last, frequency conversion experiment is discussed.

#### **P13: Bands structure and electro-optical properties in ternary InAs/GaInSb type II superlattice for**

**LWIR photodetection**

**Nassima Benchtaber, Abdelhakim Nafidi, Abderrazak Boutramane, Driss Barkissy, Rachid Ben Koujan, Es-Saïd Es-Salhi**

*University Ibn Zohr (Morocco)*

We have used the envelope function formalism to investigate the bands structure of LWIR type II SL InAs ( $d_1=2.18d_2$ )/In<sub>0.25</sub>Ga<sub>0.75</sub>Sb ( $d_2=21.5\text{\AA}$ ). Thus, we are able to extract optical and intrinsic properties as the effective mass, Fermi level and the density of state. Our results shows that the higher optical cut-off wavelength can be achieved with smaller layer thicknesses. The SC-SM transition was studied as a function of temperature. The agreement with experimental results is good and limited by the inevitable experimental uncertainty.

**P14: Metamaterial with magnetism and structural chirality in the deep UV region**

**Hiroyuki Kurosawa, Shin-Ichiro Inoue**

*National Institute of Information and Communications Technology (NICT) (Japan)*

This study investigates the magneto-chiral (MCh) effects in a metamaterial with magnetism and chirality. The MCh effect is modeled by a coupled oscillator subject to an external magnetic field. Solution of the coupled equation indicates that the MCh effect is realized even in the absence of an internal coupling between magnetism and chirality. The validity of the model is confirmed by numerical calculations.

**P15: Surface electromagnetic waves in a semiconductor with strong magnetic field**

**Igor Bychkov<sup>1</sup>, Dmitry Kuzmin<sup>1</sup>, Valentin Tolkachev<sup>1</sup>, Vladimir Shavrov<sup>2</sup>, Vasily Temnov<sup>3</sup>**

*<sup>1</sup>Chelyabinsk State University (Russia), <sup>2</sup>Kotelnikov Institute of Radio-Engineering and Electronics of RAS (Russia), <sup>3</sup>Universite du Maine (Russia)*

The propagation of surface electromagnetic waves along the surface of semiconductor in strong magnetic fields (so-called surface helicons) is studied. Conditions for the existence of surface helicons at the vacuum - semiconductor boundary are obtained. Dependence of the refractive index and the damping coefficients of surface helicon on the angle between the direction of propagation of the wave and the magnetic field is calculated.

**10:30 - 12:30 — Salone Teodora****Session 2A2****Nonlinear Metasurfaces and Plasmonics II**

Organized by: Guixin Li and Dangyuan Lei

Chaired by: Guixin Li and Tun Cao

**10:30 : Keynote talk****Ultrafast pump-probe studies on graphene and graphene-based structures**

**Mu Wang, Yingying Zhu, Lianzi Liu, Dongxiang Qi, Renhao Fan, Ruwen Peng**

*Nanjing University (China)*

The request for novel high-speed and ultrathin optoelectronic devices has triggered numerous researches in the ultrafast behavior of two-dimensional materials and their heterostructures, especially graphene-based materials. In this work, we demonstrate an unexpected saturation behavior happens in the ultrafast systems based on graphene. Ultrafast pump-probe spectroscopy has been used to monitor the carrier dynamics down to femtosecond in our system. The investigations provide a microscopic view on ultrafast multi-channel scattering dynamics in nonlinear physics.

**11:00 : Invited talk****Guide Mode Enhanced Third Harmonic Generation in Silicon Metasurfaces**

**Shumei Chen<sup>1</sup>, Mohsen Rahmani<sup>2</sup>, King Fai Li<sup>3</sup>, Andrey Miroshnichenko<sup>4</sup>, Thomas Zentgraf<sup>5</sup>, Guixin Li<sup>3</sup>, Dragomir Neshev<sup>2</sup>, Shuang Zhang<sup>1</sup>**

*<sup>1</sup>University of Birmingham (United Kingdom), <sup>2</sup>The Australian National University (Australia), <sup>3</sup>Southern Uni-*

versity of Science and Technology (China), <sup>4</sup>University of New South Wales (Australia), <sup>5</sup>University of Paderborn (Germany)

We propose to enhance the efficiency of the third harmonic generation (THG) in a complementary silicon nonlinear metasurface, consisting of cross nanoapertures in the silicon film. By exploiting its guided mode resonance, the measured THG efficiency from the silicon metasurface is 100 times higher than that from a planar silicon film of the same thickness.

#### 11:20 : **Invited talk**

##### **Interfacial Solar Steam Generations: Materials, Structures and Applications**

**Jia Zhu**

*Nanjing University (China)*

Water scarcity is one of the most pressing global challenges. We report a plasmon-enhanced solar desalination device. This most efficient and broad-band plasmonic absorber is fabricated through self-assembly of metallic nanoparticles onto a nanoporous template by one step deposition process. Because of its efficient light absorption and strong field enhancement, it can enable very efficient and effective solar desalination by using low cost aluminum nanoparticles.

#### 11:40 : **Engineering optical responses of plasmonic objects with a hyperbolic coating**

**Pan Wang<sup>1</sup>, Alexey Krasavin<sup>1</sup>, Francesco Viscomi<sup>2</sup>, Ali Adawi<sup>2</sup>, Jean-Sebastien Bouillard<sup>2</sup>, Diane Roth<sup>1</sup>, Giovanni Sartorello<sup>1</sup>, Anatoly Zayats<sup>1</sup>**

<sup>1</sup>King's College London (United Kingdom), <sup>2</sup>University of Hull (United Kingdom)

We report the engineering of optical responses of plasmonic objects by coating them with a layer of anisotropic metamaterial, which displays a hyperbolic dispersion and allows the design of refractive index on demand. This is experimentally demonstrated by coating Au nanospheres with alternating SiO<sub>2</sub> and Au multishells, which creates rich plasmonic modal structures with high tuneability and produces highly enhanced local fields.

#### 11:55 : **Invited talk**

##### **Broadband Achromatic Optical Metasurface Devices**

**Shuming Wang<sup>1</sup>, Pin Chieh Wu<sup>2</sup>, Vin-Cent Su<sup>3</sup>, Yi-Chieh Lai<sup>4</sup>, Cheng Hung Chu<sup>2</sup>, Jia-Wern Chen<sup>3</sup>, Shen-Hung Lu<sup>3</sup>, Ji Chen<sup>1</sup>, Beibei Xu<sup>1</sup>, Chieh-Hsiung Kuan<sup>3</sup>, Tao Li<sup>1</sup>, Shining Zhu<sup>1</sup>, Din Ping Tsai<sup>2</sup>**

<sup>1</sup>Nanjing University of Science and Technology (China), <sup>2</sup>Academia Sinica (Taiwan), <sup>3</sup>National Taiwan University (Taiwan), <sup>4</sup>National Cheng Kung University (Taiwan)

The broadband achromatic metalenses corresponding to the near-infrared and visible region have been obtained by using the integrated resonance unit elements. The achromatic focusing and colorful imaging have also been demonstrated.

#### 12:15 : **Direct visualization of momentum conversation through second harmonic Fourier image in 1D waveguide**

**Junjun Shi, Yang Li, Meng Kang, Shunping Zhang, Hongxing Xu**

*Wuhan University (China)*

Coherently adding up signal wave from different locations are a prerequisite for realizing efficient nonlinear optical processes in traditional optical configurations. Here we present the experiment observation of momentum conversed coherent SHG in a 1D plasmonic nanowire (NW) waveguide and identify distinctive features that are inherent to the 1D system. Periodic second harmonic signal is measured in a semiconductor nanowire through second harmonic Fourier image.

**10:30 - 12:40 — Sala Desirée**

## Session 2A3

## Symposium II: Novel Design and Applications of Metamaterials, Metasurfaces and Metadevices using Hybrid and New Materials II

Organized by: Mohamed Swillam

Chaired by: Alexandra Boltasseva

**10:30 : Invited talk****Frenkel Exciton-Polaritons in Organic Photonics****Boris Fainberg***Tel-Aviv University (Israel)*

We develop a mean-field electron-vibrational theory of Frenkel exciton-polaritons in organic dye structures. The theory contains experimentally measured quantities that make it closely related to experiment. Between other things, we explain the additional red shift of the H-aggregate absorption spectra (that are blue-shifted as a whole). We apply the theory to experiment on fraction of a millimeter propagation of Frenkel exciton-polaritons in photoexcited organic nanofibers made of thiocyanine dye. A good agreement between theory and experiment is obtained.

**10:50 : Invited talk****Metamaterial superconductors****Vera N. Smolyaninova<sup>1</sup>, Igor I. Smolyaninov<sup>2</sup>**<sup>1</sup>*Towson University (USA)*, <sup>2</sup>*University of Maryland (USA)*

Searching for natural materials exhibiting larger electron-electron interactions constitutes a traditional approach to superconductivity research. Very recently we have noted that the newly developed field of electromagnetic metamaterials deals with a somewhat related task of dielectric response engineering on the sub-100 nm scale. Considerable enhancement of electron-electron interaction may be expected in such metamaterial scenarios as ENZ and hyperbolic metamaterials. This approach has been verified in experiments with aluminum based metamaterial superconductors.

**11:10 : Invited talk****Golden dodecapods: a promising nanoresonator for the development of metamaterials active at the optical frequencies****V. Many<sup>1</sup>, J. Majimel<sup>1</sup>, G. Drisko<sup>1</sup>, S. Mornet<sup>1</sup>, P. Barois<sup>2</sup>, A. Baron<sup>2</sup>, P. Richetti<sup>2</sup>, S. De Cicco<sup>3</sup>, J. Leng<sup>3</sup>, J.-B. Salmon<sup>3</sup>, S. Ravaine<sup>2</sup>, E. Duguet<sup>1</sup>, M. Treguer-Delapierre<sup>1</sup>**<sup>1</sup>*ICMCB-CNRS (France)*, <sup>2</sup>*CRPP-CNRS (France)*, <sup>3</sup>*LOF-CNRS (France)*

We show in this communication that the use of patchy particles enables to produce isotropic plasmonic clusters consisting of a controlled number of gold satellites around a silica core. This versatile chemical approach offers the possibility to produce dodecapods nanoclusters on a large scale i.e. in gram quantities. These clusters exhibit magnetic and electric responses of high magnitude in visible or near-IR light and offer the possibility to tune and overlap the electric and magnetic responses (Huyghens' sources).

**11:30 : Keynote talk****Quantum nanophotonics with semiconductor quantum dots****Leonardo Midolo, Peter Lodhal***University of Copenhagen (Denmark)*

I will report about the recent progress on developing quantum photonic technologies based on semiconductor quantum dots in Gallium Arsenide membranes. The excellent properties of quantum dots as sources of efficient, pure, and indistinguishable single photons, allows us to build a platform for solid-state quantum optics by combining these emitters with active and passive planar nanophotonic devices.

**12:00 : Invited talk****Fiber drawn metamaterials: from guidance to sub-resolution imaging, spanning from IR to THz****Alessio Stefani, Simon C. Fleming, Boris T. Kuhlmeiy***The University of Sydney (Australia)*

Fiber drawing is used to realize extended and scalable metamaterials. Such metamaterials are used for light



guidance and sub-resolution imaging. The scalability of the process allows to obtain structures sized for frequencies between the THz and the IR.

**12:20 : Invited talk**

**Negative permeability in magnetostatics: experimental realization and applications**

**Rosa Mach-Batlle, Albert Parra, Sergi Laut, Nuria Del-Valle, Carles Navau, Alvaro Sanchez**

*Universitat Autònoma de Barcelona (Spain)*

Negative permeability is presented as a useful novel tool to control magnetostatic fields. Analogous to negative refraction in optics, we show how negative permeability can yield new phenomena in magnetostatics. To overcome the fact that passive materials with static negative permeability do not exist we demonstrate how their effective behavior can be emulated by tailored sets of currents. The experimental realization of magnetic illusion is presented as an example of the possibilities opened by negative permeability in magnetostatics.

**10:30 - 12:45 — Piano Bar Principe Nero**

**Session 2A4**

**Symposium I: Hybrid and Metastructured Materials for Photonics, Sensors and Energy II**

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

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

**10:30 : Resonant-state expansion generalized to magnetic, chiral, and bi-anisotropic open optical systems and metamaterials**

**Egor Muljarov<sup>1</sup>, Thomas Weiss<sup>2</sup>**

<sup>1</sup>*Cardiff University (United Kingdom)*, <sup>2</sup>*University of Stuttgart (Germany)*

We have generalized the resonant-state expansion for open optical systems containing arbitrary reciprocal bi-anisotropic materials or metamaterials, including those having magnetic and chiral optical activity, as well as circular dichroism. The resonant-state expansion is the most efficient and intuitive computational approach for treating open optical systems, as demonstrated in numerous publications. The present theory has the widest spectrum of applications, ranging from modeling and optimization of chirality sensors to accurate description of the optics of magnetic and metamaterial systems.

**10:45 : Invited talk**

**Optical detection of proteins in complex media**

**Ramon A. Alvarez-Puebla**

*ICREA-Universitat Rovira i Virgili (Spain)*

Changes in protein expression levels and protein structure may indicate genomic mutations and may be related to some diseases. Compared with several other alternative methods SERS spectroscopy is regarded as an excellent choice for the quantification and structural characterization of proteins. Herein, we review the main advance of using plasmonic nanostructures as SERS sensing platform for this purpose.

**11:05 : Invited talk**

**Ultra-Fine Electrochemical Tuning of the Plasmonic Dimer Structures to Generate Highly Confined Light field**

**Hiro Minamimoto, Shunpei Oikawa, Kei Murakoshi**

*Hokkaido University (Japan)*

The plasmon-active metal nano dimer structure with the gap distance less-than a single nm can confine the energy of light very effectively beyond the diffraction limit. In this study, we have tried to establish a new method by combining electrochemical method with in-situ dark-field microscopy for tuning the optical properties of Au nanodimers. As the result, the plasmonic property switching from the charge transfer plasmon to the bonding dipolar plasmon mode has been successfully observed.



**11:25 : Invited talk****Plasmonic Nanostructures for Point-of-Care Sensors****Nianqiang Wu***West Virginia University (USA)*

This talk presents our effort to develop zero-dimensional (0D), one-dimensional (1D) and two-dimensional (2D) plasmonic nanostructures. The plasmonic band and the electromagnetic field of the plasmonic nanostructures have studied and tuned systematically. The plasmonic nanostructures developed are used to construct surface-enhanced Raman scattering (SERS) sensor. This talk will give several examples of the applications of SERS sensor in the point-of-care setting.

**11:45 : Invited talk****3D plasmonic supercrystals: SERS enhancing properties****Nicolas Pazos-Perez, Ramon Alvarez Puebla***Universitat Rovira i Virgili (Spain)*

In this work, we report novel methods to produce arrays of nanoparticles, either as continuous or as isolated super-crystals made with plasmonic nanoparticles. These macroscale organizations are created via confinement controlled drying and spin coating. SERS studies on the super-crystals shape and size were conducted. Moreover, the produced structures were effectively use for SERS sensing showing very good reproducibility among big areas.

**12:05 : Invited talk****Surface enhanced spectroscopies with new plasmonic platforms****Pierre-Michel Adam***Université de Technologie de Troyes (France)*

Plasmonics deals with surface plasmons at subwavelength scale. It has highly potential applications for nanoscale and ultrafast photonics. Understanding the coupling properties between quantum emitters and plasmons resonances and/or nanonantennas is a key step towards realistic applications in the near future. We will present in this paper our latest experimental and theoretical results on surface enhanced spectroscopies, consisting in emitters coupled to different types of surface plasmons excitations, localized plasmons on bimetallic nanoparticles and surface plasmons polaritons on waveguides.

**12:25 : Invited talk****Self-assembled metamaterials active at optical frequencies****V. Many<sup>1</sup>, G. Drisko<sup>1</sup>, P. Barois<sup>2</sup>, A. Baron<sup>2</sup>, V. Ponsinet<sup>2</sup>, S. De Cicco<sup>3</sup>, J. Leng<sup>3</sup>, J.-B. Salmon<sup>3</sup>, S. Ravaine<sup>2</sup>, A. Crut<sup>4</sup>, N. Del Fatti<sup>4</sup>, E. Duguet<sup>1</sup>, M. Treguer-Delapierre<sup>1</sup>**<sup>1</sup>ICMBC-CNRS (France), <sup>2</sup>CRPP-CNRS (France), <sup>3</sup>LOF-CNRS (France), <sup>4</sup>ILM-CNRS (France)

In this talk, we will review some of the self-assembled optical metamaterials active in the visible range that we recently developed.

**10:30 - 12:30 — Country Rock Club****Session 2A5****Plasmonics: Fundamentals and Applications II**

Organized by: Hong Wei

Chaired by: Ruwen Peng and Xiaoyong Hu

**10:30 : Invited talk****Atomic-Scale Plasmonic Hot-Spots: A Frequency-Domain Existential Proof and Unusual Photo-Chemical Activities****Hyun-Hang Shin, Gyu Jin Yeon, Han-Kyu Choi, Sang-Min Park, Kang Sup Lee, Zee Hwan Kim***Seoul National University (Korea)*

I will present evidences that angstrom-sized hot-spots exist on the plasmon-excited nanostructures, and that

they accelerate chemical reaction. The SERS spectra of biphenyl dithiols placed in metallic junctions reveal simultaneously blinking Stokes and anti-Stokes components, some of which exhibit only one prominent vibrational peak, which could be explained by a model hotspot no larger than 3.5 angstrom. We also observe SERS spectra of nitrobenzenethiols on plasmonic junctions suggesting that such hotspots accelerate the electron-transfer between metallic surfaces and molecules.

**10:50 : Invited talk**

**One Particle, Three Superlattices: Configuring Particle Superlattice for Enhanced Raman Spectroscopy**

**Xing Yi Ling**

*Nanyang Technological University (Singapore)*

The structural design on nanoparticle superlattice can significantly impact the macroscopic optical behaviors owing to the nanoscale unique and structure specific light-matter interactions. I will discuss how nanoscale surface chemistry is used to direct the self-assembly of shape-controlled silver nanoparticles into three distinct two-dimensional plasmonic superlattices. The structure-to-function characterization reveals that the nanoparticle assembly with the least packing density generates plasmonic hotspots, with 10-fold more efficient surface-enhanced Raman scattering compared with the other more densely packed configurations.

**11:10 : Invited talk**

**Modulation of chiral optical responses in hybrid nanostructures**

**Wei Zhang**

*Institute of Applied Physics and Computational Mathematics (China)*

We discuss the modulation of chiral optical responses in hybrid nanostructures by geometric conformation and by external magnetic field. Our studies show the existence of both structural chirality and induced chirality in nanostructure AuNR@AuNPs (Au nanoparticles (AuNPs) in helical arrangement around a center Au nanorod (AuNR)). Distinct magnetic circular dichroism (MCD) responses of AuNR can be modulated by external magnetic field and geometric configuration (aspect ratio of AuNR, end-to-end and side-by-side assembly configurations).

**11:30 : Invited talk**

**Plasmonics for Optical Information Processing**

**Lukas Wesemann<sup>1</sup>, Kalpana Singh<sup>1</sup>, Evgeniy Panchenko<sup>1</sup>, Daniel E. Gomez<sup>2</sup>, Timothy J. Davis<sup>1</sup>, Ann Roberts<sup>1</sup>**

<sup>1</sup>*The University of Melbourne (Australia)*, <sup>2</sup>*RMIT University (Australia)*

Optical antennas and metasurfaces can be tailored to modify the intensity, polarization and phase of a scattered electromagnetic wave. These planar devices have considerable potential for integration into photodetectors with enhanced functionality. Resonances of nanoscale particles and thin metallic films can also modify the spatial Fourier spectrum of an optical field suggesting their potential as devices for real-time image processing. Here the use of plasmonics in compact optical information processing systems is discussed and recent progress plasmonics-integrated photodetectors presented.

**11:50 : Invited talk**

**Cavity QED based on plasmon nanostructures**

**Ying Gu, Juanjuan Ren, Fan Zhang, He Hao, Qihuang Gong**

*Peking University (China)*

Requirements for handling on-chip quantum information and building scalable quantum networks are prompting the development of nanostructure-based cavity quantum electrodynamics (CQED) characterized as strong light confinement. Combining the advantages of ultrahigh photon emission rates achievable in the gap surface plasmon polaritons with high extraction decay rates into low-loss nanofibers, we demonstrate theoretically the efficient photon emission of a single dipole emitter and one-dimensional nanoscale guiding in metallic nanorod-coupled nanofilm structures coupled to dielectric nanofibers.

**12:10 : Invited talk**

**Mapping photoemission and hot-electron emission from plasmonic nanoantennas**

**Richard Hobbs<sup>1</sup>, William Putnam<sup>2</sup>, Arya Fallahi<sup>3</sup>, Yujia Yang<sup>4</sup>, Franz Kartner<sup>3</sup>, Karl Berggren<sup>4</sup>**

<sup>1</sup>*Trinity College Dublin (Ireland)*, <sup>2</sup>*Northrop Grumman Corporation (USA)*, <sup>3</sup>*Deutsches Elektronen-Synchrotron (Germany)*, <sup>4</sup>*Massachusetts Institute of Technology (USA)*

Understanding plasmon-driven electron emission and energy transfer on the nanometer length scale is critical to controlling light-matter interactions at nanoscale dimensions. In photoresist and electron-beam resist materials, electron emission and energy transfer lead to chemical transformations. In this work, we employ such chemical transformations in two different high-resolution electron-beam lithography resists, poly(methyl methacrylate) (PMMA) and hydrogen silsesquioxane (HSQ), to map local electron emission and energy transfer with nanometer resolution from plasmonic nanoantennas excited by femtosecond laser pulses.

## 10:30 - 12:20 — Discoteca Pietra di Luna

### Session 2A6

#### A bottom-up Approach Towards Metamaterials and Plasmonics I

Organized by: Dorota Pawlak and Virginie Ponsinet

Chaired by: Maria Farsari and Alessandro Belardini

#### 10:30 : Invited talk

##### Self-Assembled Metasurfaces and Nanostructured Materials for Linear, Non-Linear and Circular Optical Polarization Manipulation

**Alessandro Belardini<sup>1</sup>, Grigore Leahu<sup>1</sup>, Emilija Petronijevic<sup>1</sup>, Marco Centini<sup>1</sup>, Roberto Li Voti<sup>1</sup>, Joseph W. Haus<sup>2</sup>, Ventsislav K. Valev<sup>3</sup>, Teemu Hakkarainen<sup>4</sup>, Mircea Guina<sup>4</sup>, Dorota A. Pawlak<sup>5</sup>, Concita Sibilia<sup>1</sup>**

<sup>1</sup>Sapienza University of Rome (Italy), <sup>2</sup>University of Dayton (USA), <sup>3</sup>University of Bath (United Kingdom), <sup>4</sup>Tampere University of Technology (Finland), <sup>5</sup>Institute of Electronic Materials Technology (Poland)

A self-assembly approach in the fabrication of nanostructured metasurfaces can lead to high reproducible, low cost, large area samples that can exploit different optical functionalities, like polarization manipulation or optical filtering. Usually these effects are gotten with more complex processes. Here we investigate different self-assembled structures by using linear and nonlinear optical techniques such as photothermal and photoacoustic spectroscopy, second harmonic generation circular dichroism among others. The results show the wide range of possibilities offered by a bottom-up approach.

#### 10:50 : Invited talk

##### Combining Laser 3D Printing with Self-Assembly

**Maria Farsari, Argyro Klini, Argyro N. Giakoumaki, George Kenanakis**

*IESL-FORTH (Greece)*

We report on a new method for preparing fully three-dimensional ZnO nanorod structures based on a combination of two laser techniques and low temperature hydrothermal growth. 3D structures are firstly fabricated employing Multiphoton Lithography. They are subsequently covered by a Zinc layer using Pulsed Laser Deposition, this layer acts as a seed for the growth of ZnO nanorods by Aqueous Chemical Growth. The resulting structures are covered uniformly by nanorods and are electrically conductive.

#### 11:10 : Invited talk

##### Can optically-active silicon meta-atoms be produced through bottom-up chemistry?

**Glenna L. Drisko, Sanaa Semlali, Benoit Cormary, Maria Letizia De Marco, Cyril Aymonier, Philippe Barois**

*Bordeaux University (France)*

Semiconductors boast the highest refractive index across the visible spectrum. Silicon is generally favored for optical applications due to its natural abundance and relatively easy synthesis compared to other semiconductors. However, even silicon is extremely difficult to fabricate using bottom-up chemistry. It is easy to produce 10 nm silicon particles, however these are too small for optically-active meta-atoms and such small particles oxidize completely to low-refractive index SiO<sub>2</sub>. This begs asking, what silicon forms can we expect to produce?

#### 11:30 : Synthesis of silicon nanoparticles for optically active metamaterials

**Sanaa Semlali, Benoit Cormary, Maria De Marco, Philippe Barois, Patrick Rosa, Mathieu Gonidec, Glenna Drisko**

*Bordeaux University (France)*

Due to its high refractive index, silicon is considered promising for the next generation of optically active metamaterial. Large Si particles could conceivably be produced via wet chemistry. However, wet chemistry methods typically generate fluorescent quantum dots. We successfully synthesize Si nanoparticles with sizes above 50 nm, by changing the solvent at room temperature and by changing the experimental conditions in microwave. We have begun preliminary optical measurements on these large dielectric resonators.

**11:45 : Light scattering from randomly rough metasurfaces with embedded nanoparticles: realizations, low grazing incidence and effective medium theory**

**Gerard Berginc**

*Thales (France)*

First of all, we present designs and realizations of randomly rough metasurfaces or thin films with metallic nanoparticle inclusions demonstrating antireflective or absorption properties in the visible or near-infrared band. Then we discuss the formulations of the scattering field at grazing angle for these randomly rough films containing nanoparticles, the multiple scattering of the surface waves upon the rough interface and the expression of the effective permittivity of inhomogeneous nano-films.

**12:00 : Invited talk**

**Novel Photonic Architectures by Nanoimprinting Unconventional Materials**

**Camilla Dore, Andre Espinha, Pau Molet, Cristiano Matricardi, Juan Luis Garcia-Pomar, Agustin Mihi**

*Institut de Ciencia de Materials de Barcelona (ICMAB-CSIC) (Spain)*

In this presentation, I will demonstrate how to use soft nanoimprinting lithography to mold unconventional materials such as cellulose derivatives to fabricate a variety of photonic architectures exhibiting exciting optical properties with tremendous applications as inexpensive disposable photonic components and sensors.

## Lunch

12:30 - 14:00

**18:30 - 19:00 — Sala Desirée**

## Session 2A7

### Emerging Applications

Chaired by: Osamu Sakai

**18:30 : Cloaking a magnetic sensor**

**Rosa Mach-Batlle, Carles Navau, Alvar Sanchez**

*Universitat Autònoma de Barcelona (Spain)*

Magnetic sensors are employed in a wide range of technologies. Most sensors contain ferromagnetic materials because of the field attraction they provide. This limits the sensor applicability, because ferromagnets distort the probing field, which may be an issue in some applications. Here we present a novel strategy on how to make a three-dimensional sensor magnetically undetectable while maintaining its ability to sense.

**18:45 : Artificial Intelligence Based Complex ENZ Network Nanomaterials for Large Scale Microprinting, Broadband Holograms and Bio-imaging**

**Gael Favraud, Marcella Bonifazi, Valerio Mazzone, Yi Tian, Andrea Fratilocchi**

*King Abdullah University of Science and Technology (Saudi Arabia)*

We present a complex Epsilon Near Zero Network material able to guide broadband light in 10 nm thick oxide layer. This material is designed thanks to swarm artificial intelligence methods. We discuss applications to micro-printing, bio-imaging, and broadband holograms.

**18:30 - 19:10 — Piano Bar Principe Nero****Session 2A8****A bottom-up Approach Towards Metamaterials and Plasmonics II**

Organized by: Dorota Pawlak and Virginie Ponsinet

Chaired by: Glenna Drisko and Alessandro Belardini

**18:30 : Invited talk****Large area self-assembled split-nanorod metamaterials****Mazhar E. Nasir<sup>1</sup>, R. Margoth Cordova-Castro<sup>1</sup>, Jean-Sebastien Bouillard<sup>2</sup>, Pan Wang<sup>1</sup>, Alexey V. Krasavin<sup>1</sup>, Anatoly V. Zayats<sup>1</sup>**<sup>1</sup>King's College London, (United Kingdom), <sup>2</sup>University of Hull (United Kingdom)

Plasmonic metamaterials have gained great attention due to their unique optical properties and have already achieved a significant impact in a variety of photonic, data processing, and sensing applications. Here we report the design and fabrication of periodic arrays of split nanorods AuZnOAu using highly ordered porous alumina templates. Nanoscale confinement of light between two Au segments opens up possibilities for a variety of applications in the field of nanophotonics. These metamaterials can be used in optically controlled memristive devices.

**18:50 : Invited talk****Three-Dimensional Photonic Devices Functionalized With CdS Quantum Dots****Ioanna Sakellari, Elmina Kabouraki, Dimitris Karanikolopoulos, Sotiris Droulias, David Gray, Panagiotis Loukakos, Maria Vamvakaki, Maria Farsari***Institute of Electronic Structure and Laser-Foundation for Research and Technology (Greece)*

The fabrication of three-dimensional high-resolution woodpile photonic crystals containing an organic-inorganic silicon-zirconium composite and cadmium sulfide (CdS) quantum dots is presented. The structures are fabricated by combining Direct Laser Writing by two-photon absorption and in-situ synthesis of CdS nanoparticles inside the photonic matrix. The novel composite material exhibits a high nonlinear refractive index measured by means of Z-scan method. Woodpile structures with inlayer periodicity down to 500nm show clear photonic stop-bands in the Vis-NIR wavelength region.

**18:30 - 19:10 — Country Rock Club****Session 2A9****Current Advances in Frequency Selective Surfaces and Metasurfaces I**

Organized by: Tzong-Lin Wu, Chun-Wen Lin and Zakaria Zouhdi

Chaired by: Willie Padilla

**18:30 : Invited talk****Plasmonic components towards photonic-nose****Yoshiaki Nishijima<sup>1</sup>, Armandas Balcytis<sup>2</sup>, Gediminas Seniutinas<sup>2</sup>, Saulius Juodkazis<sup>2</sup>**<sup>1</sup>Yokohama National University (Japan), <sup>2</sup>Swinburne University of Technology (Australia)

We demonstrate the frequency selective plasmonic metamaterials in mid infrared (MIR) wavelengths range. Such components can be applied for a plasmonic smell sensor (photonic nose) application, which detects a small amount of specific molecules in air. Plasmonic materials can be used not only for signal enhancement by surface enhanced infrared absorption, but also for thermal radiation light sources and photo detectors. We also discuss the possibility of on-chip integration.

**18:50 : Invited talk**

**Optical Metasurfaces for Simultaneous Control of Holograms and Twisted Light Beams****Xianzhong Chen, Chunmei Zhang, Wei Wang***Heriot-Watt University (United Kingdom)*

An optical device with multiple functionalities is desirable for device miniaturization and system integration. We experimentally demonstrate an optical device that can simultaneously realize polarization-controllable hologram and superposition of orbital angular momentum (OAM) in multiple channels. By continuously controlling the polarization state of the incident light, the polarization-dependent holographic images in two channels along the horizontal direction and the continuous control of OAM superposition in two channels along the vertical direction are realized.

**18:30 - 19:15 — Discoteca Pietra di Luna****Session 2A10****Materials for Photonics**

Chaired by: Mikhail Limonov

**18:30 : Highly confined biaxial hyperbolic phonon polaritons in van der Waals crystal of semiconducting transition metal oxides****Zebo Zheng, Huanjun Chen***Sun Yat-Sen University (China)*

Here we report the biaxial hyperbolic phonon polaritons (HPhPs) in layered van der Waals  $\alpha$ -MoO<sub>3</sub>. The ultra-confined infrared HPhPs waves resulted from the coupling of IR light and optical phonons of  $\alpha$ -MoO<sub>3</sub> were launched, detected, and imaged in real space. Due to the low symmetric lattice structure, the HPhPs of  $\alpha$ -MoO<sub>3</sub> exhibits a naturally biaxial hyperbolic dispersion. Our results suggest  $\alpha$ -MoO<sub>3</sub> as a new platform for studying on novel regimes of light-matter interactions and the future nanophotonic devices.

**18:45 : Dynamically Tunable Electromagnetically Induced Transparency in Graphene and Split-Ring Hybrid Metamaterial****Guangxu Su, Zhong Huang, Wenbo Zang, Peng Zhan, Zhenlin Wang***Nanjing University (China)*

We proposed a novel hybrid metamaterial consisting of periodic array of graphene nano-patch and gold split-ring resonator to realize an active control of the EIT analog by tuning the Fermi energy of the graphene nano-patch through electric gating in the mid-infrared regime. A narrow transparency window occurs over a wide absorption band due to the coupling of the high-quality factor mode provided by graphene dipolar resonance and the low-quality factor mode of split-ring resonator magnetic resonance.

**19:00 : Laser-patterning of graphene oxide beyond the diffraction limit****Raul D. Rodriguez<sup>1</sup>, Ma Bing<sup>1</sup>, Gennadiy Murastov<sup>1</sup>, Munis Khan<sup>2</sup>, Ashutosh Mukherjee<sup>2</sup>, Zoheb Khan<sup>2</sup>, Suhail Shah<sup>2</sup>, Alexey Ruban<sup>1</sup>, Sergey Pavlov<sup>1</sup>, Anna Lipovka<sup>1</sup>, Ammar Al-Hamry<sup>2</sup>, Olfa Kanoun<sup>2</sup>, Varnika Prakash<sup>3</sup>, Surinder K. Mehta<sup>3</sup>, Evgeniya Sheremet<sup>1</sup>**<sup>1</sup>*Tomsk Polytechnic University (Russia)*, <sup>2</sup>*Chemnitz University of Technology (Germany)*, <sup>3</sup>*Panjab University (India)*

Graphene oxide (GO) offers excellent possibilities demonstrated in applications ranging from biological sensors to optoelectronic devices. Thermal annealing modifies GO by removing the oxygen-containing groups making GO more graphene-like. This thermal reduction can also be achieved by intense light. Here, we demonstrate a scalable and straightforward method based on laser-reduction to pattern graphene oxide films beyond the diffraction limit of light. The potential of this method is illustrated by the fabrication of different devices on flexible and transparent substrates.

**18:30 - 19:15 — Birreria Dresden Green**



## Session 2A11

## Plasmonics and Nanophotonics II

Chaired by: Nicolo Maccaferri

**18:30 : Holographic tracking for real-time spectroscopy of moving nanoparticles****Minh-Chau Nguyen<sup>1</sup>, Pascal Berto<sup>1</sup>, Fabrice Valentino<sup>1</sup>, Catherine Combellas<sup>2</sup>, Frederic Kanoufi<sup>2</sup>, Gilles Tessier<sup>1</sup>**<sup>1</sup>Paris Descartes University (France), <sup>2</sup>Paris Diderot University (France)

The scattering spectrum of nanoparticles can reveal their behavior as well as their chemical and physical properties. However, the spectral study of an individual nanoparticle in solution is extremely difficult due to its Brownian motion. Here, we present a system based on digital holographic microscopy which localizes a moving nanoparticle with sub-diffraction accuracy in real-time and uses its localisation to drive an adaptive optical system and redirect the light scattered by the moving nano-object towards the spectrometer.

**18:45 : Full control of near-field dipolar coupling beyond spin-momentum locking****Michela F. Picardi, Lei Wei, Jack J. Kingsley-Smith, Anatoly V. Zayats, Francisco J. Rodriguez-Fortuno**  
*King's College London (United Kingdom)*

Unidirectional coupling of circularly polarized dipoles into photonic structures has opened the way to the design of novel devices such as polarization-based nano-routers, integrated Stokes nano-polarimeters, and non-reciprocal optical devices. Here we propose an extension to the directionality of dipolar near-fields, uncovering novel directional sources that exhibit distinct symmetries and behaviors. We provide a complete analytical theory of dipolar near-field directionality in planar slabs.

**19:00 : Substrate engineering for super-resolution tip-enhanced Raman spectroscopic imaging****Evgeniya Sheremet<sup>1</sup>, Ashutosh Mukherjee<sup>2</sup>, Vladimir Kolchuzhin<sup>2</sup>, Alexander Milekhin<sup>3</sup>, Ekaterina Rodyakina<sup>3</sup>, Dietrich R.T. Zahn<sup>2</sup>, Raul D. Rodriguez<sup>1</sup>**<sup>1</sup>Tomsk Polytechnic University (Russia), <sup>2</sup>Chemnitz University of Technology (Germany), <sup>3</sup>A.V. Rzhanov Institute of Semiconductor Physics (Russia)

We present an overview of published and unpublished work on the effects of the substrate optical properties on micro-Raman and tip-enhanced Raman spectroscopy (TERS) signal intensity. The investigation of a range of substrates and the two approaches provides a systematic understanding of the substrate effects in hyperspectral imaging methods. The key novel result concerns the substrates with interference effects, and their combination with near-field amplification in resonantly-excited plasmonic nanoantenna in surface-enhanced (SERS) and TERS regimes.

## Session 2P2

## Poster Session II

19:00 - 19:45

**P1: CMA-ES based topology optimization for external cloaks****Garuda Fujii***Shinshu University (Japan)*

This paper presents topology optimization for external cloaks which can render a scattering object at a distance invisible. To design external cloaks, the intensity of the scattered electric field is minimized as the objective function and external cloaks are transformed in a fixed design domain which is set at a distance from a PEC scattering object.

**P2: Partially-Embedded Plasmonic Nanoparticles within Semiconductors for Enhanced Hot Electrons Extraction****Charlene Ng<sup>1</sup>, Peng Zeng<sup>2</sup>, Julian Lloyd<sup>3</sup>, Ann Roberts<sup>2</sup>, Trevor A. Smith<sup>2</sup>, Udo Bach<sup>3</sup>, Timothy J. Davis<sup>4</sup>, Andreas Fery<sup>1</sup>, Daniel E. Gomez<sup>3</sup>**<sup>1</sup>Leibniz-Institut für Polymerforschung (Germany), <sup>2</sup>The University of Melbourne (Australia), <sup>3</sup>Australian Na-



*tional Fabrication Facility (Australia), <sup>4</sup>CSIRO (Australia)*

When plasmonic nanoparticles are coupled with semiconductors, highly energetic hot carriers are extracted from the interface for various light-related applications. Here we demonstrate using visible pump, near-infrared probe transient-absorption spectroscopy, that increases in the contact area between metal and semiconductor leads to an increase in the quantum yield for hot electron injection. Further analysis of the experimental data suggests that the hot electrons are emitted across the interface via a surface photoemission mechanism, instead of a homogeneous energy-momentum distribution.

### **P3: Broadband enhancement of light absorption in energy harvesting systems by complex epsilon-near-zero materials**

**Marcella Bonifazi, Yi Tian, Andrea Fratallocchi**

*King Abdullah University of Science and Technology (KAUST) (Saudi Arabia)*

We create a new class of dispersionless composite metamaterials, engineered from suitably disordered metallic nanostructures. By means of Atomic-Force-Microscopy (AFM) and Photoluminescence (PLE) measurements we demonstrate that our ENZ dramatically increases the absorption in ultra-thin films, from UV to near-infrared wavelengths. Furthermore, a broad-band enhancement of 170% in the external quantum efficiency (EQE) is observed when these materials are inserted in a working device. In addition, we developed a cost-effective fabrication process that makes these materials suitable for large-scale production.

### **P4: Near-field coupling and mode competition in anapole system**

**Valerio Mazzone, Juan Sebastian Toterogongora, Andrea Fratallocchi**

*King Abdullah University of Science and Technology (Saudi Arabia)*

Inspired by recent progress in the development of an integrated near-field based laser source, we designed a new scheme for optical guiding at the nanoscale. In principle, should not be possible to transfer an anapole state among different subwavelength nanoparticles. However, our results show how, exploiting the interference nature of anapoles, it is possible to couple light in an effective and robust fashion

### **P5: Effective-Medium Permittivity of Planar One-Dimensional Gratings of Vertically Invariant and Laterally Arbitrary Permittivity Distribution**

**Lifeng Li**

*Tsinghua University (China)*

Subwavelength gratings can be considered as one of the most basic forms of meta-surfaces. When the period-to-wavelength ratio is very small, the meta-surface is characterized by the grating's effective-medium permittivity. An explicit formula of effective-medium permittivity accurate to the second order in the above ratio for gratings of vertically invariant and laterally arbitrary permittivity distribution in TM polarization and oblique incidence is rigorously derived. The derived formula will be compared with previously published results.

### **P6: Air-coupled ultrasound manipulation and laser vibrometry for damage detection in plate-like structures**

**Maciej Radzienski, Pawel Kudela, Michal Jurek, Wieslaw Ostachowicz**

*Polish Academy of Sciences (Poland)*

In this studies, we presented an approach for ultrasonic, air-coupled excitation of guided waves in a thin composite plate for damage detection purposes. An array of ultrasound transmitters was prepared. Scanning laser vibrometer measurements and full wavefield analysis were used to create a damage map of the specimen.

### **P7: Theoretical Study of Resonance Effects in Graphene-Based Double Ring Resonator**

**Cristiano Braga<sup>1</sup>, Geraldo Melo<sup>2</sup>, Gianni Portela<sup>1</sup>, Victor Dmitriev<sup>1</sup>**

*<sup>1</sup>Federal University of Para (Brazil), <sup>2</sup>Federal Rural University of Amazonia (Brazil)*

The unit cell of the graphene-based electromagnetic filter is formed by two coaxial graphene rings placed on the opposite sides of a thin dielectric substrate. The two rings electromagnetically coupled resonate with the dipole plasmon modes. We analyze the transmission and reflection coefficients of the structure by employing a Temporal Coupled Mode Theory. There is a good agreement between the analytical and finite element numerical results.

### **P8: Thin metalens based on subwavelength grating**

**Sergey Stafeev<sup>1</sup>, Anton Nalimov<sup>1</sup>, Changyu Hu<sup>2</sup>, Liam O'Faolain<sup>3</sup>, Maria Kotlyar<sup>4</sup>, Desmond Gibson<sup>2</sup>, Shigeng Song<sup>2</sup>, Victor Kotlyar<sup>1</sup>**

<sup>1</sup>Russian Academy of Sciences (Russia), <sup>2</sup>University of the West of Scotland (United Kingdom), <sup>3</sup>Cork Institute of Technology (Ireland), <sup>4</sup>Samara National Research University (Russia)

We designed, fabricated, and characterized a thin metalens with diameter of 30  $\mu\text{m}$  and focal length of 633 nm in anamorphous silicon film. The lens is capable of simultaneously manipulating the state of polarization and phase of incident light and converts a linearly polarized beam into radially polarized light, producing a subwavelength focus. Illuminated by a linearly polarized Gaussian beam, the lens produces a focal spot with diameters at full-width half maximum of 0.49 of wavelength and 0.55 of wavelength.

#### **P9: Fabrication of plasmonic nanostructure for optical brain imaging**

**Ji Suk Kang, Jun Hyun Kim, Zeshan Shoaib, Myung Yung Jeong**

*Pusan National University (Korea)*

Recently, many researchers investigated human's brain and the optical brain imaging system was widely used. However, it had limitation of spatial resolution. To solve this problem and enhance contrast-to-noise ratio, in this study, noble plasmonic nanostructure was designed and fabricated by nanoimprint lithography.

#### **P10: Spectroscopic Analysis of Structural Colour Reflectors of Helical nanostructures**

**Taewoo Ha<sup>1</sup>, Wongi Park<sup>2</sup>, Teun-Teun Kim<sup>1</sup>, Anna Zep<sup>3</sup>, Hyungju Ahn<sup>4</sup>, Tae Joo Shin<sup>5</sup>, Damian Pocięcha<sup>3</sup>, Kyung Ik Sim<sup>6</sup>, Taek Sun Jung<sup>6</sup>, Jae Hoon Kim<sup>6</sup>, Ewa Gorecka<sup>3</sup>, Dong Ki Yoon<sup>2</sup>**

<sup>1</sup>Sungkyunkwan University (Korea), <sup>2</sup>Korea Advanced Institute of Science and Technology (Korea), <sup>3</sup>University of Warsaw (Poland), <sup>4</sup>POSECH (Korea), <sup>5</sup>UNIST (Korea), <sup>6</sup>Yonsei University (Korea)

We have measured a polarized reflection of colour reflectors that are fabricated using hierarchical structure of liquid crystal (LC) material. A controlled pitch of nano-helix structure present angle-dependent reflection colour probed by polarized reflection measurement. Transverse electric (TE) and transverse magnetic (TM) modes can be clearly separated by numerical simulation. We demonstrated reflection characteristics of specific colour reflector produced by the self-assembled nano-helix structure with unique resonance frequency as a short wavelength region in visible from green to blue.

#### **P11: Negative refraction and negative dispersion due to quadrupole response of finite size particles**

**Eugene Fourkal<sup>1</sup>, Andrei Smolyakov<sup>2</sup>**

<sup>1</sup>UPMC Pinnacle (USA), <sup>2</sup>University of Saskatchewan (Canada)

The relation between magnetic response of the dispersive media, negative refraction and negative dispersion is discussed. Negative dispersion and refraction is demonstrated for longitudinal and transverse electromagnetic modes in the system of finite size charged clouds. It is also shown that a random set of non-magnetic metal spheres embedded in a dielectric host possesses additional longitudinal and transverse eigen-modes with negative dispersion due to the electric quadrupole coupling. In the region of negative refraction the calculated effective negative permittivity and permeability are also negative.

#### **P12: Plasmon resonances, extraordinary transmission and reflection-less absorption in overdense plasma-diffraction grating structures**

**Andrei Smolyakov<sup>1</sup>, N. Sternberg<sup>2</sup>**

<sup>1</sup>University of Saskatchewan (Canada), <sup>2</sup>Clark University (USA)

Structure of resonances and coupling are studied in the overdense plasma slab configuration with a diffraction grating. Analytical criteria and exact expressions are obtained for resonance conditions for absolute transparency of the ideal over-dense plasma and reflectionless absorption in plasma slab with dissipation.

#### **P13: A phase space plot of resonances in transformation cavities**

**Inbo Kim<sup>1</sup>, Jinhang Cho<sup>1</sup>, Yushin Kim<sup>2</sup>, Bumki Min<sup>2</sup>, Sang-Jun Park<sup>1</sup>, Muhan Choi<sup>1</sup>**

<sup>1</sup>Kyungpook National University (Korea), <sup>2</sup>Korea Advanced Institute of Science and Technology (Korea)

Gradient index cavities designed by conformal transformation optics enable directional whispering gallery modes (WGMs). For the inhomogeneous cavities, Husimi function, one of the widely used phase space representations for resonant modes can be obtained using the conventional Husimi functions for uniform index cavities through a fictitious space. As an illustration, we calculated Husimi function of a bidirectional WGM, which agrees well with the directionality of far-field of the WGM.

# Wednesday 27th June, 2018

08:00 - 10:05 — Sala Desirée

## Session 3A1

### Symposium II: Novel Design and Applications of Metamaterials, Metasurfaces and Metadevices using Hybrid and New Materials III

Organized by: Mohamed Swillam

Chaired by: Ekmel Ozbay

08:00 : **Keynote talk**

#### Quantum and Classical Phenomena in Bio-Plasmonic Nanostructures and Assemblies

Alexander O. Govorov, Lucas V. Besteiro, Xiang-Tian Kong

Ohio University (USA)

Metal nanocrystals and semiconductor quantum dots have the ability to absorb and scatter light very efficiently. This study concerns special designs of hybrid nanostructures with electromagnetic hot spots, where the electromagnetic field becomes strongly enhanced and concentrated. Overall plasmonic nanostructures with hot spots demonstrate strongly amplified optical and energy-related effects. For example, using nanoparticle arrays made of different metals, one can transfer plasmonic signals coherently and with small losses [1]. [1] E.-M. Roller, et al., Nature Physics, 13, 761 (2017).

08:30 : **Invited talk**

#### Longitudinally Multi-slotted Taper for Smooth Transition between Conventional Planar Waveguide and Multi-slotted MMI

Hamdam Nikkhah, Trevor J. Hall

University of Ottawa (Canada)

Longitudinal multi-slotted metamaterial structure has shown an improvement in the accuracy of the paraxial approximation required by the Talbot effect and consequently a reduction in the deviation from perfect imaging of an MMI quantified by the modal phase error. An adiabatic longitudinal multi-slotted waveguide taper is introduced to provide a smooth transition between a conventional waveguide and the longitudinal subwavelength structure that provides an Ex transmission of 92 % and Ey transmission of 99 %.

08:50 : **Invited talk**

#### Magnetic spin-orbit interaction of light steers Bloch surface waves

Mengjia Wang<sup>1</sup>, Hongyi Zhang<sup>1</sup>, Tatiana Kovalevich<sup>1</sup>, Roland Salut<sup>1</sup>, Myun-Sik Kim<sup>2</sup>, Miguel-Angel Suarez<sup>1</sup>, Maria-Pilar Bernal<sup>1</sup>, Hans-Peter Herzig<sup>2</sup>, Huihui Lu<sup>3</sup>, Thierry Grosjean<sup>1</sup>

<sup>1</sup> Université Bourgogne Franche-Comté (France), <sup>2</sup> Ecole Polytechnique Fédérale de Lausanne (EPFL) (Switzerland), <sup>3</sup> Jinan University (China)

We show the directional excitation of Bloch surface waves controlled by the magnetic field of light. The phenomenon in play is the first magnetic spin-orbit interaction of light. It opens new degrees of freedom in the manipulation of light and offers appealing novel opportunities in the detection of the spin density of the magnetic optical field.

09:10 : **Invited talk**

#### Dispersion-tailored metalenses and their applications

Wei Ting Chen, Alexander Y. Zhu, Jared Sisler, Federico Capasso

Harvard University (USA)

Metalenses are planar lenses comprised of sub-wavelength spaced nanostructures that have been demonstrated with many promising applications. However, the control of their dispersion over a large bandwidth has been a challenge. Here, we show that it is possible to realize metalenses with tailored dispersion, including achromatic metalenses over almost the entire visible bandwidth from wavelength 470 to 670 nm. In addition,

applications related to these dispersion-engineered metalenses will be introduced.

**09:30 : Invited talk**

**Party-Time Symmetry in Chiral Metamaterials**

**Maria Kafesaki, Ioannis Katsantonis, Sotiris Droulias, Eleftherios Economou, Costas M. Soukoulis**  
*Foundation for Research and Technology Hellas (FORTH) (Greece)*

We explore and present the possibility, the conditions and the novel physical phenomena that become possible by combining the quite new concept of Party-Time symmetry with the advanced polarization control capabilities offered by chiral metamaterials. Phenomena like unidirectional invisibility and anisotropic transmission resonances, in general, are demonstrated and analyzed.

**09:50 : Compact Silicon Nanowire Ring Resonator Sensor**

**Sherif Mohamed<sup>1</sup>, Lamees Shahada<sup>1</sup>, Mohamed Swillam<sup>2</sup>**

<sup>1</sup>Qatar University (Qatar), <sup>2</sup>The American University in Cairo (Egypt)

We propose a highly sensitive ring resonator sensor. The structure of the sensor utilizes the silicon nanowires platform. The gas to be sensed dominates the spacings between the silicon nanowires. The proposed device is characterized by its small footprint, low insertion losses, and high sensitivity. Full 3D Finite Difference Time Domain simulations were employed for designing and simulating the operation of the sensor at the telecommunication wavelength, while characterizing the device performance.

**08:00 - 10:00 — Country Rock Club**

**Session 3A2**

**Symposium I: Hybrid and Metastructured Materials for Photonics, Sensors and Energy III**

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

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

**08:00 : Invited talk**

**Dynamic hot-spots in plasmonic photocatalysis**

**Miguel A. Correa-Duarte**

*Universidade de Vigo (Spain)*

Here in, we introduce a novel approach for achieving a real-time control over the hot-electron injection process in metal-semiconductor photocatalysts. Such functionality is attained through the design of a hybrid nanocomposite in which plasmonic Au nanorods and TiO<sub>2</sub> nanoparticles are synergistically integrated with a thermoresponsive polymer.

**08:20 : Invited talk**

**Plasmo-Mechanical Control of Photo-Induced Heat Generation from Au Nanoparticles Immobilized on a Flexible Substrate**

**Roberto Caputo<sup>1</sup>, Giovanna Palermo<sup>1</sup>, Antonio Condello<sup>1</sup>, Ugo Cataldi<sup>2</sup>, Thomas Buergi<sup>2</sup>, Cesare Paolo Umeton<sup>1</sup>, Antonio De Luca<sup>1</sup>**

<sup>1</sup>University of Calabria (Italy), <sup>2</sup>University of Geneva (Switzerland)

A method is presented to control the photo-induced heat generated by an amorphous arrangement of gold nanoparticles immobilized on a flexible substrate. The application of a strain to the polydimethylsiloxane tape supporting the particles leads to a nanoscale change of their gap. The strong variation of the particles near-field coupling results in a sensitive change of the photo-generated heat. A fine control of the amount of generated heat is possible by stretching the initially isotropic sample of few percents.

**08:40 : Invited talk**

**Hematite in the hot spot: trapping surface plasmons in ultrathin semiconductor films for water splitting**

**Alberto Naldoni<sup>1</sup>, Aveek Dutta<sup>1</sup>, Stepan Kment<sup>2</sup>, Radek Zboril<sup>2</sup>, Alexandra Boltasseva<sup>1</sup>, Vladimir M. Shalaev<sup>1</sup>**

<sup>1</sup>Purdue University (USA), <sup>2</sup>Palacky University (Czech Republic)

The use of plasmonic nanoantennas in solar energy conversion has recently focused much attention on processes that generate hot carriers through the metal-semiconductor interface. Here, we will present our recent results on ultrathin hematite films for water splitting used as dielectric layer in gap plasmon structures. Several designs including metallic and high index nanoresonators will be analyzed and results will be discussed in terms of physics of electric field enhancement, hot electron generation, and chemical reactivity of plasmonic metamaterials.

**09:00 : Invited talk**

**Image multiplexing with laser-controlled plasmonic colors**

**Nathalie Destouches, Nipun Sharma, Oleksii Vodorov, Nicolas Dalloz, Christophe Hubert, Francis Vocanson, Mathieu Hebert**

*Lyon University (France)*

Anisotropic plasmonic nanostructures have recently had a renewed interest for producing colors with sub-wavelength resolution and have been used for color image multiplexing owing to the identification of two orthogonal parameters enabling changes in the nanostructures color in specific polarized modes of observation. Here, we extend the concept to multidimensional color image multiplexing and we demonstrate that it can be implemented with a scanning laser technique enabling the control of plasmonic colors.

**09:20 : Invited talk**

**All Dielectric Metamaterial for MIR Applications**

**Mohamed Swillam**

*American University in Cairo (Egypt)*

Metamaterials have the ability to focus and absorb light at different wavelengths. These characteristics are highly useful for harvesting thermal radiation in the Mid infrared range. They are also important for sensing and absorption spectroscopy application. In the work we discuss different designs for metamaterials in the Mid infrared using all dielectrics to reduce the losses and the fabrication complexity.

**09:40 : Invited talk**

**Tailoring the Resonance Couplings between 2D-Excitons and Nanophotonics Structures**

**Jinxu Wen, Hao Wang, Huanjun Chen**

*Sun Yat-sen University (China)*

Resonance coupling between excitons and nanophotonics structures occurs when the excitons are placed in a nanomicrocavity with spectrally overlapped optical modes. In this talk I will review our recent results on resonance couplings between 2D excitons in monolayer semiconductors and nanophotonic structures, including the plasmonic nanorods and dielectric Si nanospheres. The tailoring strategy for these couplings will be discussed in detail.

**08:00 - 10:00 — Discoteca Pietra di Luna**

### Session 3A3

#### Fano Resonances in Optics and Microwaves: Physics and Application I

Organized by: Eugene Kamenetskii and Almas Sadreev

Chaired by: Eugene Kamenetskii and Almas Sadreev

**08:00 : Invited talk**

**Quantum state control in single quantum dots and the coupling with photonic crystal cavities**

**Chenjiang Qian, Kai Peng, Xiulai Xu**

*Chinese Academy of Sciences (China)*

We report on high-resolution photocurrent (PC) spectroscopies of a single self-assembled InAs/GaAs quan-

tum dot with an applied magnetic field. When the magnetic field is applied in Voigt geometry, the mixture of bright and dark states results in an observation of dark exciton states. Strong coupling for cavity QED between different excitonic states in a single quantum dot and the cavity will be presented, two-photon Rabi splitting in a strongly coupled cavity-dot system is demonstrated.

**08:20 : Invited talk**

**Light scattering treated by the resonant-state expansion**

**Sergey Lobanov, Wolfgang Langbein, Egor Muljarov**

*Cardiff University (United Kingdom)*

We present a new rigorous approach to the general problem of light scattering from an arbitrary finite optical system. This approach is based on explicit use of the resonant states of the optical system. These are in turn calculated using the resonant-state expansion, which is a novel powerful method in electrodynamics. We verify and illustrate the developed approach on an example of a dielectric sphere in vacuum which allows an exact analytic solution known as Mie theory.

**08:40 : Invited talk**

**Bound States in the Continuum Surrounded by Ultra-strong Resonances**

**Lijun Yuan<sup>1</sup>, Ya Yan Lu<sup>2</sup>**

<sup>1</sup>Chongqing Technology and Business University (China), <sup>2</sup>City University of Hong Kong (China)

On periodic structures sandwiched between two homogeneous media, a bound state in the continuum (BIC) is a guided mode above the light line, and it is always surrounded by a family of resonant modes with quality factors tending to infinity. The quality factors typically blow up quadratically. We present a condition on the BIC, such that the quality factors of the resonant modes have a fourth power blowup.

**09:00 : Invited talk**

**Giant subradiance, strong interactions and positional disorder in metamaterials**

**Stewart D. Jenkins<sup>1</sup>, Nikitas Papasimakis<sup>2</sup>, Salvatore Savo<sup>2</sup>, Nikolay I. Zheludev<sup>2</sup>, Janne Ruostekoski<sup>1</sup>**

<sup>1</sup>University of Southampton (United Kingdom), <sup>2</sup>University of Southampton Southampton (United Kingdom)

We consider strongly interacting metamaterials for regular and disordered arrays and show how to engineer massive subradiance in metamaterials as a spatially extended eigenmode comprising over 1000 metamolecules. Disorder can be employed to control the electromagnetic response of metamaterial arrays. Our systematic analysis reveals how the response of disordered arrays with strong field-mediated interactions is inherently linked to their cooperative response to electromagnetic waves where the multiple scattering induces strong correlations between the excitations of individual resonators.

**09:20 : Invited talk**

**Fano resonance generation and application of three dimensional metamaterials**

**Shengyan Yang, Zhe Liu, Junjie Li, Changzhi Gu**

*Chinese Academy of Sciences (China)*

We report the generation of high-quality-factor Fano resonances in substrate-free 3D metamaterials. The unique 3D configurations lead to the excitation of otherwise inaccessible out-of-plane dark modes, which strongly couple with the surface-plasmon-polaritons mode in the square apertures, and results in the emergence of the sharp Fano resonance with pronounced electromagnetic field enhancement.

**09:40 : Invited talk**

**Electromagnetically induced transparency in a superconducting qubit**

**Tiefu Li**

*Tsinghua University (China)*

Fulfilling the EIT conditions for artificial atoms made from superconducting circuits is a more difficult task. Here we report an experimental observation of the EIT in a tunable three-dimensional transmon by probing the cavity transmission. From the experimental observations, we clearly identify the EIT and Autler-Townes splitting (ATS) regimes as well as the transition regime in between.

**Break**

**10:00 - 10:30**



10:30 - 12:15 — Sala Desirée

## Session 3A4

## Symposium I: Hybrid and Metastructured Materials for Photonics, Sensors and Energy IV

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

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

10:30 : **Invited talk****Oscillatory Plasmon-Exciton Coupling and Non-Traditional Plasmonics****Matthew S. Kirschner, Wendu Ding, Xiao-Min Lin, Lin X. Chen, George C. Schatz, Richard D. Schaller**  
*Northwestern University (USA)*

We report oscillatory plasmon exciton coupling in colloidal nanoparticles. Coherent acoustic phonons derived from plasmonic nanoparticles are examined for modulation of electronic interactions with proximal excitonic molecular species. Gold bipyramids with varied localized surface plasmon resonances, functionalized with J-aggregate thiocarbocyanine dye molecules, produce distinct hybridized states that exhibit coupling. Photo-generated oscillations alter the metal nanoparticle energetic contribution to the hybridized system and, as a result, transiently change the coupling between the plasmon and exciton in oscillatory manner.

10:50 : **Invited talk****Molecular Junction-Controlled High-Order Charge Transfer Plasmon and Fano Resonance****Ximin Cui, Yunhe Lai, Lei Shao, Jianfang Wang***The Chinese University of Hong Kong (China)*

We report the fabrication of molecular-tunnel-junctions-bridged plasmonic nanocavities with high quality from single-crystalline metal nanostructures and use them as a platform for quantum plasmonics study. Specifically, we observed the excitation of high-order charge transfer plasmon modes. We also found the effect of quantum tunneling on the peak shift of other plasmon resonances and the Fano interference between different plasmon modes. Furthermore, the experimental results can be well reproduced by a theoretical model.

11:10 : **Keynote talk****Enhancing Photon Harvesting with Plasmonic Nanostructures****Dongling Ma***Institut National de la Recherche Scientifique (INRS) (Canada)*

With unique surface plasmon resonance properties, plasmonic nanostructures are able to enhance photon harvesting of semiconductor materials via near-field effects and/or enhanced light scattering, which has significant implications for the realization of cost-effective high-performance solar technologies. In this talk, I will overview some of our recent progress on the development of plasmonic nanostructures and their beneficial role in solar water splitting, photocatalytic degradation of pollutants and solar cells.

11:40 : **Invited talk****Plasmon-Enhanced Quantum Dot Solar Cells****Jiang Wu<sup>1</sup>, Peng Yu<sup>2</sup>, Alexander Govorov<sup>2</sup>, Zhiming Wang<sup>2</sup>***<sup>1</sup>University College London (United Kingdom), <sup>2</sup>University of Electronic Science and Technology of China (China)*

In this paper, plasmon-enhanced InAs/GaAs quantum dot solar cells have been investigated. Detailed optical characterization has been carried out to study the effects of different kinds of plasmonic metal nanoparticles on the performance of quantum dot solar cells. We demonstrate that star-shaped gold nanoparticles can be particularly helpful in enhancing the absorption in the quantum dot solar cells. FDTD method is used to analyze the efficiency enhancement, indicating the broad plasmon resonances of nanostars with different sizes and shapes.

12:00 : **Towards energy transfer of nanoemitters assisted by surface plasmons****Aurélie Broussier<sup>1</sup>, Ali Issa<sup>1</sup>, Loic O. Le Cunff<sup>1</sup>, Tien Hoa Nguyen<sup>2</sup>, Dinh Xuan Quyen<sup>2</sup>, Safi Jradi<sup>1</sup>, Christophe Couteau<sup>1</sup>, Renaud Bachelot<sup>1</sup>**



<sup>1</sup>Université de Technologie de Troyes (France), <sup>2</sup>Nanyang Technological University (China)

Quantum plasmonic systems require efficient coupling between emitters and plasmonic structures. We present results on energy transfer between a plasmonic system (silver nanowires) and nanocrystals. The nanocrystals have been placed on the nanowires using photopolymerization. We used a confocal microscope to investigate the interactions between nanocrystals and surface plasmons on nanowires. When nanocrystals are in the close vicinity of nanowires, coupling between guided modes and nanocrystals emission can occur.

## 11:15 - 12:20 — Piano Bar Principe Nero

### Session 3A5

#### Parity-Time and Related Symmetries in Photonics, Plasmonics, Acoustics I

Organized by: Anatole Lupu and Henri Benisty

Chaired by: Pierre Berini

#### 11:15 : **Invited talk**

#### **PT-symmetry of magnetostatic resonances in subwavelength ferrite particles**

**Eugene Kamenetskii**

*Ben Gurion University (Israel)*

Magnetostatic resonances in magnetized subwavelength ferrite-disk particles are macroscopically quantized states. In this structure, long-range dipole-dipole correlation in positions of electron spins can be treated in terms of collective excitations of a system as a whole. The spectra of the magnetostatic oscillations, well described by scalar MS-potential wave functions, have property of PT symmetry. The near fields in the proximity of the particle are with space and time symmetry breakings.

#### 11:35 : **Asymmetric Optical Effects in Hyperbolic Media**

**Rair Macedo<sup>1</sup>, Thomas Dumelow<sup>2</sup>, Robert L Stamps<sup>1</sup>**

<sup>1</sup>University of Glasgow (United Kingdom), <sup>2</sup>Universidade do Estado do Rio Grande do Norte (Brazil)

Metamaterials have attracted significant attention in recent years due to their many unusual optical properties. These are often artificial structures with negative permeability and negative permittivity. However, a class of strongly anisotropic media has gained in attention as subclass of metamaterials, the so-called hyperbolic media. Here, we show how by rotating the optical axis of crystals, the hyperbolic dispersion and its properties are also rotated. Therefore, the properties of waves propagating in hyperbolic media are also modified and become extremely asymmetric.

#### 11:50 : **Exceptional points in non-Hermitian optical system**

**Qingjie Liu, Bing Wang, Peixiang Lu**

*Huazhong University of Science and Technology (China)*

We investigate the optical exceptional points (EPs) in the graphene incorporated multilayer metamaterial manifesting Fano resonance. The system is non-Hermitian and possesses EPs where both the eigenvalues and eigenvectors of the Hamiltonian coalesce. In the aid of Fano resonance, the reflection may reach zero, resulting in the EPs. The most important property of EPs lies in the topological structure. In our later work, we will design a silicon structure easier to realize in experiment to explore the topological structure.

#### 12:05 : **Dynamically encircling an exceptional point in voltage-controlled LRC resonator circuits**

**Youngsun Choi, Jong Kyun Hong, Yeonghwa Ryu, Jae Woong Yoon, Seok Ho Song**

*Hanyang University (Korea)*

We discuss time-resolved measurements on encircling an exceptional point parametric evolution in electrically tunable LRC resonator circuits.

**10:30 - 12:20 — Country Rock Club****Session 3A6****Advanced Passive and Active Metasurfaces I**

Organized by: Howard Lee and Din Ping Tsai

Chaired by: Howard Lee

**10:30 : Keynote talk****Optical Metasurfaces from classical to quantum regime****Xiang Zhang, Yuan Wang***University of California (USA)*

This talk will review our research efforts in optical metasurfaces in the past few years, which ranges from classical to quantum regime.

**11:00 : Invited talk****Enhanced spin-orbit interaction and all-optical modulation by subwavelength near-zero index media****Andrea Marini<sup>1</sup>, Alessandro Ciattoni<sup>2</sup>, Carlo Rizza<sup>2</sup>**<sup>1</sup>*University of L'Aquila (Italy)*, <sup>2</sup>*Consiglio Nazionale delle Ricerche (Italy)*

We demonstrate that a homogeneous and isotropic subwavelength near-zero index film enables efficient polarization control, phase manipulation and amplitude modulation at the nanoscale. When illuminated by a circularly polarized paraxial beam with axial symmetry, the near-zero index film acts as a vortex generator thanks to the enhanced spin-orbit interaction triggered by the medium. In addition, the near-zero index medium enhances nonlinearity thus enabling efficient all-optical modulation of a probe beam.

**11:20 : Invited talk****Optical chiral effects in ENZ ultrathin slabs****Carlo Rizza<sup>1</sup>, Xin Li<sup>2</sup>, Andrea Di Falco<sup>2</sup>, Elia Palange<sup>3</sup>, Andrea Marini<sup>3</sup>, Alessandro Ciattoni<sup>1</sup>**<sup>1</sup>*National Research Council (CNR-SPIN) (Italy)*, <sup>2</sup>*University of St. Andrews (United Kingdom)*, <sup>3</sup>*University of L'Aquila (Italy)*

We show the boosting of asymmetric transmission for forward and backward propagation of tilted circular polarized optical waves in ENZ regime. The effect is solely triggered by anisotropy without resorting to any breaking of reciprocity and chiral symmetries or spatial nonlocal effects. The ENZ enhancement is due to the fact that the hyperbolic dispersion activates etalon resonances where extraordinary waves accumulate propagation phase even though the slab is ultrathin.

**11:40 : Invited talk****Tailorable nanophotonic devices with ultra-thin transition metal nitrides****Deesha Shah<sup>1</sup>, Alessandra Catellani<sup>2</sup>, Harsha Reddy<sup>1</sup>, Nathaniel Kinsey<sup>3</sup>, Vladimir Shalaev<sup>1</sup>, Arrigo Calzolari<sup>2</sup>, Alexandra Boltasseva<sup>1</sup>**<sup>1</sup>*Purdue University (USA)*, <sup>2</sup>*CNR-NANO Istituto Nanoscienze (Italy)*, <sup>3</sup>*Virginia Commonwealth University (USA)*

Here, we present a joint theoretical and experimental study on the dielectric permittivity of ultra-thin TiN films of varying thicknesses. Our results indicate a remarkably persistent metallic character as the thickness is reduced. The effects of oxidation and strain on the plasmonic properties of the thin films emerge as fundamental parameters to optimize their response. Due to their increased sensitivity to structural parameters, atomically thin plasmonic materials display great potential for the realization of tailorable and dynamically switchable metasurfaces.

**12:00 : Invited talk****Tunable zero-index and metasurface optics in extreme optical platforms****Jingyi Yang, Aleksei Anopchenko, Long Tao, Sudip Gurung, Subhajit Bej, Catherine Arndt, Khant Minn, Ho Wai Howard Lee***Baylor University (USA)*

We present our recent development on the use of tunable transparent conducting oxides to demonstrate

electrically tunable epsilon-near-zero (ENZ) optical devices and to develop ENZ/metasurface nanostructured optical fibers.

## 10:30 - 11:50 — Discoteca Pietra di Luna

### Session 3A7

#### Symposium II: Novel Design and Applications of Metamaterials, Metasurfaces and Metadevices using Hybrid and New Materials IV

Organized by: Mohamed Swillam

Chaired by: Philippe Lalanne

#### 10:30 : Invited talk

##### Optoelectronic metasurfaces

**Pierre Berini**

*University of Ottawa (Canada)*

Metasurfaces constructed from metal nanostructures can operate as efficient coupling structures for incident optical beams to surface plasmons. On a semiconductor, metallic metasurfaces can act simultaneously as a device electrode while ensuring strong plasmon field overlap with the active region. Additionally, plasmon fields can be confined to sub-wavelength dimensions and significantly enhanced relative to the exciting field. These features are very attractive for nanoscale optoelectronic device applications, such as photodetectors and modulators.

#### 10:50 : Invited talk

##### Attojoule Modulators for Photonic Neuromorphic Computing

**Rubab Amin<sup>1</sup>, Jonathan George<sup>1</sup>, Jacob Khurgin<sup>2</sup>, Tarek El-Ghazawi<sup>1</sup>, Paul Prucnal<sup>3</sup>, Volker J. Sorger<sup>1</sup>**

<sup>1</sup>George Washington University (USA), <sup>2</sup>Johns Hopkins University (USA), <sup>3</sup>Princeton University (USA)

We show how the nonlinear transfer function of electrooptic modulators enables vector matrix multiplications of photonic neural networks. Here the modulators energy-per-bit function and signal-to-noise ratio are critical factors impacting system performance.

#### 11:10 : Invited talk

##### Power generation from thermal radiation: Photon-assisted tunneling in a metasurface-coupled rectifier

**Paul Davids, Josh Shank, Andrew Starbuck, Robert Jarecki, David Peters**

*Sandia National Laboratories (USA)*

Electrical power generation from a thermal source is demonstrated using a large-area metasurface-coupled tunnel diode rectifier. Transverse electric field confinement in the tunnel gap due to epsilon-near-zero (ENZ) material dispersion from the oxide longitudinal optical phonon mode is shown to enhance the gap field and leads to photon-assisted tunneling. A general model for photo-assisted tunneling is developed and shown to accurately model the short-circuit current in the device.

#### 11:30 : Invited talk

##### Metasurface Pulse Shaping

**Shawn Divitt, Wenqi Zhu, Cheng Zhang, Henri J. Lezec, Amit Agrawal**

*National Institute of Standards and Technology (USA)*

Optical pulse shaping is an integral part of ultrafast optical technology. In general, changing the shape of an optical pulse requires a change in the amplitude and/or phase of its spectral components. Metasurfaces provide extremely fine spatial control over the amplitude and phase of incident light and are natural candidates for use in optical pulse shaping. Here, we demonstrate shaping of less than 15 femtosecond ultrafast laser pulses using a silicon-metasurface acting as both spectral amplitude and phase mask.

**11:30 - 12:15 — Birreria Dresden Green****Session 3A8****Plasmonics-based Devices**

Chaired by: Nianqiang Wu

**11:30 : Photocurrent transient variation in IGZO phototransistors decorated with Au nanoparticles**  
**Yusheng Zhai, Guangdian Chen, Yupei Li, Qilong Wang***Southeast University (China)*

Here, we decorated the channel of IGZO-TFT with the Au nanoparticles (AuNPs) by post-annealing the Au film and delicately investigate the photocurrent transient variation under different wavelength illumination (405nm, 532nm and 658nm). The AuNPs decorated devices show dramatic overshoot photocurrent transient variation at wavelength of 658nm, which demonstrate the existence of the hot electron ejection into the IGZO channel. The FDTD method was employed to obtain the electromagnetic field distribution and explain the background mechanism.

**11:45 : Plasmonic-coupled sensors: from multiphoton-assisted quantum coupling to graphene-coupled subwavelength resonant strain sensors****Morteza Aramesh, Raphael Tiefenauer, Janos Voros***ETH Zurich (Germany)*

Plasmonic sensors enable ultrahigh speed information processing and are emerging as promising platform for future optoelectronic devices. For some practical applications, plasmonic materials need to be coupled to other materials - such as quantum emitters or 2D materials - to provide multi-functionalities. Despite their great importance, approaches towards scalable fabrication of hybrid plasmonic-coupled devices remain limited due to considerable technical challenges. Here, we present various techniques towards multiscale fabrication of plasmonic-coupled devices and investigate their potentials as sensors.

**12:00 : Polarization-controlled tunable-focusing of surface plasmon polaritons with nanostructure array****Mingqian Zhang***China Academy of Space Technology (China)*

Tunable focusing devices are highly demanded in various applications of nanophotonics. Here, a tunable-focusing device with an array of V-shape slots is suggested which allows polarization-controlled tunable plasmonic directing and focusing. The plasmonic field regulation performance was theoretically simulated with FDTD method and experimentally measured with a self-constructed phase-resolved near-field microscopy. These results indicate the focal position of the excited plasmon field can be flexibly tuned between two distinct positions just by manipulating the incident polarization state.

**Lunch****12:00 - 14:00****17:00 - 19:05 — Sala Desirée****Session 3A9****Advanced Passive and Active Metasurfaces II**

Organized by: Howard Lee and Din Ping Tsai

Chaired by: Howard Lee

**17:00 : Keynote talk**

**Optical components and systems based on dielectric metasurfaces****Adrei Faraon, Ehsan Arbabi, Seyedeh Mahsa Kamali, MohammadSadeqh FarajiDana, Yu Horie, Amir Arbabi***California Institute of Technology (USA)*

In this talk I give an overview of our recent work on various optical components and systems based on dielectric metasurfaces.

**17:30 : Invited talk****Active Mid-Infrared Plasmonics in Graphene****Min Seok Jang***Korea Advanced Institute of Science and Technology (KAIST) (Korea)*

We showed that these plasmonic modes can play a dominant role in controlling the optical properties of periodically patterned graphene at mid-infrared frequencies. By utilizing the idea of overlapping various scales of resonances in a narrow spectral and spatial window, we recently demonstrated that it is possible to achieve perfect mid-infrared absorption modulation based on graphene plasmonic metasurfaces. These tunable plasmonic modes offered by graphene provide new opportunities to create electro-optically active devices with novel functionalities.

**17:50 : Invited talk****Waveguided modes, nonlinearity and magneto-optics in self-assembled metamaterials****Mazhar E. Nasir<sup>1</sup>, Pan Wang<sup>1</sup>, Anton Bykov<sup>1</sup>, Alexey V. Krasavin<sup>1</sup>, Bo Fan<sup>1</sup>, Viktor A. Podolskiy<sup>2</sup>, Anatoly V. Zayats<sup>1</sup>**<sup>1</sup>*King's College London (United Kingdom)*, <sup>2</sup>*University of Massachusetts Lowell (USA)*

Hyperbolic metamaterials play a key role in the design of integrated biochemical sensors, nonlinear and magneto optical applications. Here we discuss a waveguided mode structure of nanorod hyperbolic metamaterials and its effects on various optical properties, such as magneto optical and nonlinear responses. The mode structure variation with nanorod length will be discussed. Nonlinear response of these metamaterials will be presented, focusing on the second harmonic generation. We describe the design and magneto optical response of core shell metamaterials.

**18:10 : Invited talk****Highly Nonlinear III-V Semiconductor Metasurfaces****Polina Vabishchevich<sup>1</sup>, Sheng Liu<sup>1</sup>, Aleksandr Vaskin<sup>2</sup>, John L. Reno<sup>1</sup>, Gordon A. Keeler<sup>1</sup>, Gregory M. Peake<sup>1</sup>, Michael B. Sinclair<sup>1</sup>, Isabelle Staude<sup>2</sup>, Igal Brener<sup>1</sup>**<sup>1</sup>*Sandia National Laboratories (USA)*, <sup>2</sup>*Friedrich Schiller University Jena (Germany)*

Optical metasurfaces are quasi-planar nanostructured materials that have the ability to tailor local fields, providing new opportunities for light control and manipulation. In this talk I will show our recent results in the nonlinear optical response of III-V semiconductor metasurfaces, starting from the second harmonic generation and strategies for increasing its efficiency by applying broken symmetry designs. Then I will present results of nonlinear frequency mixing in the GaAs metasurface, pumped with two femtosecond near-IR laser pulses.

**18:30 : Multipole Contribution into Resonant Scattering of Dielectric Nonspherical Nanoparticles****Yongqian Li<sup>1</sup>, Yueyue Chen<sup>1</sup>, Yujie Yang<sup>1</sup>, Zili Zhou<sup>2</sup>, Xiaoying Li<sup>1</sup>, Ji Wang<sup>3</sup>**<sup>1</sup>*Northwestern Polytechnical University (China)*, <sup>2</sup>*Chinese Aeronautical Establishment (China)*, <sup>3</sup>*Science and Technology on Metrology and Calibration Laboratory (China)*

Dielectric cylindrical nanoparticles with resonant responses are elemental blocks for building metasurfaces. Here, the scattering effects of high-dielectric silicon cylindrical particles are investigated by discrete-dipole approximation (DDA), which calculates the multipole contribution into the resonant responses of nanoparticles. Resonant electric and magnetic multipole responses up to the electric octupole moment have been analyzed in theory and calculated by our self-written DDA toolbox. The results help to understand the resonant scattering process of metasurface devices made of dielectric cylindrical particles.

**18:45 : Invited talk****Numerical Optimisation and Near-field Phase Transformation in Metasurface Design for Resonant Cavity Antennas****Karu P. Esselle, Muhammad U. Afzal, Maria Kovaleva, Ali Lalbakhsh**

*Macquarie University (Australia)*

This paper reviews two of the latest techniques used to improve radiation performance of resonant cavity antennas (RCAs) by means of metasurfaces. The first technique employs numerical optimisation to find the optimal set of design parameters of a metasurface that produces the desired performance. The second technique is based on near-field phase transformation. Application of these techniques has led to a significant improvement in the performance of resonant cavity antennas compared to the classical design approaches.

## 17:00 - 17:30 — Piano Bar Principe Nero

### Session 3A10

#### Parity-Time and Related Symmetries in Photonics, Plasmonics, Acoustics II

Organized by: Anatole Lupu and Henri Benisty

Chaired by: Pierre Berini

#### 17:00 : Broadband time-asymmetric silicon-photonic architecture grounded on non-Hermitian wave dynamics near exceptional points

**Jae Woong Yoon<sup>1</sup>, Youngsun Choi<sup>1</sup>, Choloong Hahn<sup>2</sup>, Ki-Yeon Yang<sup>2</sup>, Jeong Yub Lee<sup>2</sup>, Gunpyo Kim<sup>1</sup>, Jong Kyun Hong<sup>1</sup>, Yeonghwa Ryu<sup>1</sup>, Seok Ho Song<sup>1</sup>, Pierre Berini<sup>3</sup>**

<sup>1</sup>*Hanyang University (Korea)*, <sup>2</sup>*University of Ottawa (Canada)*, <sup>3</sup>*Electronics and Telecommunications Research Institute (ETRI) (Korea)*

We discuss a promising silicon-photonic architecture that creates dynamically encircling an exceptional point and consequent time-asymmetric transmission of broadband optical signals in the technologically important optical telecommunications window.

#### 17:15 : Active plasmonic and PT symmetric structures for broadband amplified non-reciprocity

**Maude Amyot-Bourgeois<sup>1</sup>, Elham Karami Keshmarzi<sup>1</sup>, Choloong Hahn<sup>1</sup>, Youngsun Choi<sup>2</sup>, Jae Woong Yoon<sup>2</sup>, Niall Tait<sup>3</sup>, Seok Ho Song<sup>2</sup>, Pierre Berini<sup>1</sup>**

<sup>1</sup>*University of Ottawa (Canada)*, <sup>2</sup>*Hanyang University (Korea)*, <sup>3</sup>*Carleton University (Canada)*

We discuss amplified and lasing plasmonic systems and amplified waveguide isolators based on exceptional-point optical structures.

## 17:30 - 19:20 — Piano Bar Principe Nero

### Session 3A11

#### Structural Color for Displays and Imaging

Organized by: Debashis Chanda

Chaired by: Debashis Chanda

#### 17:30 : Invited talk

#### Structural colors for practical applications

**Chengang Ji, L. Jay Guo**

*The University of Michigan (USA)*

Structural colors hold promise as alternative to the existing colorant-based filters, which may find applications in many fields. The structural colors can be produced by exploiting optical resonances in various resonators, which can be either 3D, 2D or 1D structures, and can be measured in transmission, reflection or scattering from the designed structures. We have investigated several types of 3D periodic array structural colors in the past. This presentation will focus on thin-film based structural colors and various applications.



**17:50 : Invited talk**

**Hybrid organic and plasmonic systems for smart surfaces and energy-efficient displays**

**Magnus Jonsson**

*Linköping University (Sweden)*

In this presentation, I will focus on our recent development of switchable plasmonic surfaces for reflective-based electronic paper in colour.

**18:10 : Plasmonic Pixel: Progress in nanoimprint lithography**

**Faris Shahidan, Jingchao Song, Evgeniy Panchenko, Paul Mulvaney, Timothy D. James, Ann Roberts**

*The University of Melbourne (Australia)*

The use of plasmonics to generate structural color has attracted considerable recent attention. Here we demonstrate the use of nanoimprint lithography to produce 'plasmonic pixels' producing non-diffractive color. Both polarization-sensitive and polarization-insensitive designs are presented. The extension of the plasmonic pixel concept to semiconductor devices will also be discussed.

**18:25 : Metal free, X-ray fabricated metamaterials reproduce full CYMK chromaticity system with 80 nm spatial resolution**

**Marcella Bonifazi, Valerio Mazzone, Andrea Fratallocchi**

*King Abdullah University of Science and Technology (Saudi Arabia)*

We present new types of complex metamaterials obtained by suitably processing a transparent dielectric with high-fluency hard X-rays. We investigated their properties both experimentally and by means of FDTD analysis. We discuss experimental applications for creating structural colors, reproducing the full spectrum of Cyan, Yellow, Magenta, Black (CYMK) with a resolution down to 80nm. This approach opens an innovative way to engineer nanomaterials with advanced functionalities that can be exploited for several applications.

**18:40 : Invited talk**

**Dual-color plasmonic filters**

**Esmail Heydari, Justin Sperling, Steven Neale, Alasdair W. Clark**

*University of Glasgow (United Kingdom)*

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

**19:00 : Invited talk**

**Skin-like Full-Color Angle Independent Plasmonic Reflective Displays**

**Daniel Franklin, Debashis Chanda**

*University of Central Florida (USA)*

Tuning plasmonic light absorption with liquid crystal (LC), the color reflected from a nanostructured surface can be changed as a function of voltage. The engineered plasmonic surface allows complete LC reorientation and maximum overlap between plasmonic fields and LC, enabling large tunability across the entire visible spectrum.

**17:00 - 19:40 — Country Rock Club**

**Session 3A12**

**Transformation Optics and Other waves: Novel Physics and Practical Applications**

Organized by: Hongsheng Chen and Hui Liu

Chaired by: Hongsheng Chen and Hui Liu

**17:00 : Invited talk**

**Optical Spacetime in Self-Assembled Hyperbolic Metamaterials**

**Igor I. Smolyaninov<sup>1</sup>, Vera N. Smolyaninova<sup>2</sup>**

<sup>1</sup>University of Maryland (USA), <sup>2</sup>Towson University (USA)

Ferrofluid in the presence of magnetic field forms a hyperbolic metamaterial, which may be described via an effective spacetime. If the magnetic field is reduced, this effective Minkowski spacetime gradually melts under the influence of thermal fluctuations. On the other hand, it may restore itself if the magnetic field is increased back to its original value. Microscopic visualization of such a spacetime melting/crystallization is presented, which is similar to hypothesized formation of the Minkowski spacetime in loop quantum cosmology.

**17:20 : Invited talk**

**Optical orbital angular momentum generated in a metamaterial ring by transformation optics**

**Mu Wang, Hongwei Wu, Renhao Fan, Ruwen Peng**

*Nanjing University (China)*

In this work, we propose a scheme for the generation of transverse orbital angular momentum of light in metamaterial ring based on transformation optics. The metamaterial ring is designed to transform the straight trajectory of light into the circulating one by enlarging the azimuthal angle, effectively generating transverse orbital angular momentum of light. This technique provides a unique platform for applications related to optical micromanipulation.

**17:40 : Invited talk**

**Light in Transformed Spaces: Optical Black Holes and Nanofocusing Lenses**

**Alexander V. Kildishev<sup>1</sup>, Lian Shen<sup>1</sup>, Hongsheng Chen<sup>2</sup>, Ludmila J. Prokopeva<sup>1</sup>**

<sup>1</sup>Southeast University (USA), <sup>2</sup>Zhejiang University (China)

We use the formalism of transformed optical spaces to design omnidirectional concentrators and nanofocusing lenses employing manufacturable layered approximations in their designs. We show that accurate theoretical analyses and an improved effective medium theory allow to estimate and drastically improve the performance metrics of the proposed metadevices by reducing the number of approximating layers. We successfully verify the proposed theoretical design rules vs. full-wave numerical simulations.

**18:00 : Invited talk**

**Magnetic invisible cloak without superconductor**

**Wei Jiang, Jianfei Zhu, Yungui Ma**

*Zhejiang University (China)*

In this work, we show that good magnetic cloaking effect could be achieved without superconductors by using metallic shell or active current surface for kilo hertz or ultralow frequencies, respectively.

**18:20 : Invited talk**

**Chirality and Cartan's torsion in transformation optics**

**Yongliang Zhang<sup>1</sup>, Che Ting Chan<sup>2</sup>, Kin Hung Fung<sup>1</sup>**

<sup>1</sup>The Hong Kong Polytechnic University (China), <sup>2</sup>The Hong Kong University of Science and Technology (China)

We generalize the geometry of transformation optics to effective Riemann-Cartan space carrying both metric and torsion. By relaxing the integrable condition of the coordinate transformation, chiral magneto-electric coupling term emerges as torsion in the transformed Maxwell's equations. As a result, it is shown that a chiral medium is equivalent to a Riemann-Cartan space. Our theory provides a differential geometry description of the chiral medium and a generalization of the covariant pre-metric electrodynamics to realistic, complex media.

**18:40 : Invited talk**

**Controlling Surface Plasmons by Covariant Curved Spaces in One-dimensional Transformation Optical Nanostructures**

**Fan Zhong, Jensen Li, Hui Liu, Shining Zhu**

*Nanjing University (China)*

In this work, we use one-dimensional transformation optical nanostructures to mimic accelerating particles in curved space-time. Using the covariant principle of general relativity, we can obtain different nanostructures designed from covariant space-times. Based on Lorentz covariance and conformal covariance, all these covariant structures can produce the same surface plasmon field when excited by polarized photons. Furthermore, using gauge (conformal) transformations between metrics, we can obtain more general covariant

curved space-times and novel equivalent plasmonic structures.

**19:00 : Invited talk**

**Lightcone fluctuations in a metamaterial that mimics a cosmic string**

**Jiawei Hu, Hongwei Yu**

*Hunan Normal University (China)*

We study the flight time fluctuations in an anisotropic medium that mimics a cosmic string with an effective fluctuating refractive, which are analogous to the lightcone fluctuations in quantum gravity. For a probe light close to the analogue string, the flight time fluctuations can be amplified compared with those in a normal homogeneous and isotropic medium. We argue that it seems possible to fabricate a metamaterial so that a currently observable flight time variance might be achieved in laboratory.

**19:20 : Invited talk**

**Definite Light Deflection of Cosmic Topological Defects Mimicked By Rotational Metasurfaces**

**Chong Sheng, Ying Chen, Zhiwei Yan, Lin Xu, Xiangyang Wang, Qing Huo Liu, Shining Zhu, Huanyang Chen, Hui Liu**

*Nanjing University (China)*

The existence of cosmic string, one-dimensional topological defect formed during a symmetry breaking phase transition in the early universe, was predicted in the 1970s. However, thus far there is no direct astronomical observation. Here, by using rotational metasurfaces in an artificial waveguide, gravitational lensing caused by nontrivial spacetime of cosmic string is experimentally emulated. Our technique is a brand-new way to manipulate photons on chip using metasurfaces, and may be widely used in transformation optical devices in geometrical optics.

**17:00 - 19:15 — Discoteca Pietra di Luna**

**Session 3A13**

**Quantum Nanophotonics for Applications in Quantum Information Science**

Organized by: Tobias Heindel and Stephan Reitzenstein

Chaired by: Tobias Heindel

**17:00 : Invited talk**

**Quantum Dots in Nanowires Tuned to Atomic Transitions**

**Nika Akopian**

*Technical University of Denmark (Denmark)*

Hybrid semiconductor-atomic systems are promising building blocks for quantum photonic communication technologies. Here we show such a system, where we combine semiconductor nanowire quantum dots with an atomic vapor. We demonstrate: (1) a controlled growth of GaAs quantum dots in AlGaAs nanowires, (2) their excellent optical properties, and (3) tuning of their emission frequency to the optical transitions of Rb atoms.

**17:20 : Invited talk**

**Towards practical single-photon sources at telecom wavelengths with GaAs-based deterministic QD-mesas**

**Anna Musial<sup>1</sup>, Lukasz Dusanowski<sup>1</sup>, Pawel Holewa<sup>1</sup>, Pawel Mrowinski<sup>1</sup>, Aleksander Marynski<sup>1</sup>, Krzysztof Gawarecki<sup>1</sup>, Tobias Heuser<sup>2</sup>, Nicole Srocka<sup>2</sup>, David Quandt<sup>2</sup>, André Strittmatter<sup>2</sup>, Sven Rodt<sup>2</sup>, Stephan Reitzenstein<sup>2</sup>, Grzegorz Sek<sup>1</sup>**

<sup>1</sup>Wroclaw University of Science and Technology (Poland), <sup>2</sup>Technical University of Berlin (Germany)

Hereby, we present a comprehensive combined experimental and theoretical study of band structure and optical properties of strain-engineered InGaAs quantum dots (QDs) emitting at telecom O-band (1.3  $\mu\text{m}$ ). The main focus is on generation and purity of single-photons from QDs integrated into photonic nanostructures - mesas defined by means of electron-beam lithography. The proposed approach enabled us to realize quasi-

resonantly-driven efficient QD-based single-photon sources with high photon purity (as measured  $g(2)(0) = 0.03$ ) emitting at the second telecom window.

**17:40 : Invited talk**

**In(Ga)As quantum dots at the telecom wavelength: single and entangled photons emission**

**Simone L. Portalupi, Fabian Olbrich, Marc Sartison, Stephan Hepp, Cornelius Nawrath, Sascha Koblatschek, Michael Jetter, Peter Michler**

*University of Stuttgart (Germany)*

In the present work we describe different techniques for the growth of single In(Ga)As quantum dots (QDs) emitting in the telecom regime. Single and entangled photon emission is demonstrated.

**18:00 : Invited talk**

**A Bright Triggered Twin-Photon Source in the Solid State**

**Tobias Heindel<sup>1</sup>, Alexander Thoma<sup>1</sup>, Martin von Helversen<sup>1</sup>, Marco Schmidt<sup>1</sup>, Alexander Schlehahn<sup>1</sup>, Manuel Gschrey<sup>1</sup>, Peter Schnauber<sup>1</sup>, Jan-Hindrik Schulze<sup>1</sup>, Andre Strittmatter<sup>1</sup>, Jorn Beyer<sup>2</sup>, Sven Rodt<sup>1</sup>, Alexander Carmele<sup>1</sup>, Andreas Knorr<sup>1</sup>, Stephan Reitzenstein<sup>1</sup>**

<sup>1</sup>Technische Universität Berlin (Germany), <sup>2</sup>Physikalisch-Technische Bundesanstalt (Germany)

We propose and experimentally demonstrate the efficient, triggered generation of photon twins using the energy-degenerate biexciton-exciton radiative cascade of semiconductor quantum dots. Deterministically integrated within a microlens, these nanostructures emit highly correlated photon pairs, degenerate in energy and polarization. We analyze the generated light states via polarization-resolved photon-correlation experiments and directly observe the twin-photon states by employing photon-number-resolving detectors, enabling the reconstruction of the emitted photon number distribution.

**18:20 : Invited talk**

**Correlations of cascaded photons: Two-photon processes in the Mollow regime**

**Alexander Carmele<sup>1</sup>, Samir Bounuoar<sup>2</sup>, Max Strauss<sup>2</sup>, Stephan Reitzenstein<sup>2</sup>**

<sup>1</sup>Nichtlineare Optik und Quantenelektronik, Institut für Theoretische Physik (Germany), <sup>2</sup>Optoelektronik und Quantenbauelemente, Institut für Festkörperphysik (Germany)

Mollow physics in the two-photon regime gives access to time-reordering of photon pairs, erasing the which-path information of the decay process. Here, we calculate the two-photon correlations, essential to discuss and study such phenomena in the resonant-driven dressed-state regime. We stress the unlikelihood to observe antibunching for the delay time in the exciton-biexciton correlation functions in such experiments, since antibunching stems from a coherent and in-phase superposition of different photon emission events.

**18:40 : Nonlinear AlGaAs nanodisks as sources of sum-frequency light and entangled photons**

**Giuseppe Marino<sup>1</sup>, Alexander S. Solntsev<sup>1</sup>, Lei Xu<sup>1</sup>, Valerio F. Gili<sup>2</sup>, Luca Carletti<sup>3</sup>, Alexander N. Poddubny<sup>1</sup>, Mohsen Rahmani<sup>1</sup>, Daria Smirnova<sup>1</sup>, Haitao Chen<sup>1</sup>, Guoquan Zhang<sup>4</sup>, Anatoly V. Zayats<sup>5</sup>, Costantino De Angelis<sup>3</sup>, Giuseppe Leo<sup>2</sup>, Yuri S. Kivshar<sup>1</sup>, Andrey A. Sukhorukov<sup>1</sup>, Dragomir N. Neshev<sup>1</sup>**

<sup>1</sup>Australian National University (Australia), <sup>2</sup>Paris Diderot University (France), <sup>3</sup>University of Brescia (Italy), <sup>4</sup>Nankai University (China), <sup>5</sup>King's College London (United Kingdom)

We demonstrate experimentally the generation of heralded photons with non-classical correlations via spontaneous parametric down-conversion in AlGaAs nanodisks. A quantum-classical correspondence establishes the AlGaAs nanoresonators as nanoscale nonlinear sources of efficient sum-frequency and difference frequency conversion.

**18:55 : Invited talk**

**Near-optimal entangled-photon sources in the solid state?**

**Fei Ding**

*Leibniz Universität Hannover (Germany)*

How far are we away from an optimal entangled photon source? This is a difficult question, and the answer depends, of course, on the specific applications. For optical quantum communications, the high repetition rate, photon indistinguishability, entanglement fidelity and brightness are required for a useful polarization entangled photon source. The aim of our works is to gather the above-mentioned features in a solid state source based on single semiconductor quantum dots.

**17:00 - 18:00 — Birreria Dresden Green****Session 3A14****Wave Propagation in Acoustic and Elastic Metamaterials: Novel Design and Practical Applications I**

Organized by: Marco Miniaci and Guancong Ma

Chaired by: Marco Miniaci and Guancong Ma

**17:00 : Invited talk****Controlling Reverberating Sound with an Acoustic Metasurface****Guancong Ma***Hong Kong Baptist University (Hong Kong)*

We show with experiments in a very complex reverberating room, we are able to achieve versatile control of sound fields by only modifying the room reverberating properties using a spatial sound modulator (SSM), which is an actively tunable metasurface for acoustic sound. We show the on-demand creation quiet zones or hot spots, which shows the potential to improve quality of life in everyday situations.

**17:20 : Invited talk****Lamb wave focusing by a plano-concave aspherical lens: numerical studies****Pawel Kudela, Wieslaw Ostachowicz***Polish Academy of Sciences (Poland)*

Lamb waves are often used for damage detection in structures. Hot-spot monitoring by wave focusing is considered here. It can be achieved by using a plano-concave aspherical lens. Once attached to the plate, the lens modifies the effective plate thickness, and therefore change the Lamb wave characteristics such as the wavenumber and phase velocity, providing convenient way of controlling Lamb waves. We conducted numerical simulations and demonstrated that planar A0 mode can be focused on the desired focal point.

**17:40 : Invited talk****Losses in gradient acoustic rainbow trapping metamaterials****Tuo Liu, Shanjun Liang, Fei Chen, Jie Zhu***The Hong Kong Polytechnic University (China)*

Acoustic rainbow trapping metamaterials allows spatial spectral modulation and broadband trapping of sound. We introduce a model of gradient acoustic rainbow trapping metamaterial. We consider the inherent thermal and viscous losses. The gradually diminished group velocity becomes anomalous at the trapping position, induced by the inherent losses. Such absorptive trapped rainbow is the result of the balanced interplay among the local resonance, the mutual coupling of adjacent unit cells, and the losses due to thermal conductivity and viscosity.

**18:00 - 18:30 — Birreria Dresden Green****Session 3A15****Metamaterial-based Devices**

Chaired by: Mengxin Ren

**18:00 : Quantum Searching with Metamaterials****Weixuan Zhang<sup>1</sup>, Kaiyang Cheng<sup>2</sup>, Chao Wu<sup>2</sup>, Yi Wang<sup>2</sup>, Hongqiang Li<sup>2</sup>, Xiangdong Zhang<sup>1</sup>**<sup>1</sup>*Beijing Institute of Technology (China)*, <sup>2</sup>*Tongji University (China)*

We designed and printed metamaterials to perform quantum search algorithm. The structures, comprising of an array of two-dimensional sub-wavelength air holes with different radii perforated on the dielectric layer, have been fabricated by using 3D printing technique. When an incident wave enters in the designed meta-

materials, the profile of beam wavefront is processed iteratively as it propagates through the metamaterial periodically. After  $\sqrt{N}$  roundtrips searched items will be found with the incident wave all focusing on the marked positions.

**18:15 : Electrically Small Resonators-Based Infrared Imaging Pixel Configuration**

**Mohammed R. AlShareef<sup>1</sup>, Mohamed Ramy Abdel-Rahman<sup>2</sup>**

<sup>1</sup>*King Abdulaziz City for Science and Technology (Saudi Arabia)*, <sup>2</sup>*King Saud University (Saudi Arabia)*

In this work, an electrically small resonator-based infrared imaging pixel configuration is presented, designed and simulated. Split ring resonators (SRRs) are configured in an array arrangement where the absorbed power is coupled to a resistive sheet, resembling a microbolometer, via a microstrip (MS) line. The proposed structure shows an ability to absorb incident infrared radiation in the 8-14  $\mu\text{m}$  band.



# Thursday 28th June, 2018

08:00 - 09:10 — Teatro Emerald

## Session 4A1

### Plenary Session II

Chaired by: Nader Engheta

08:00 : **Plenary talk**

#### Microstructured Materials for Thermal Heating and Memory

**Michelle L. Povinelli**

*University of Southern California (USA)*

We explore the effect of microstructure on regulating the interaction light and heat. In particular, we examine the use of absorptive resonances in photonic crystal slabs. In the first part of the work, we use resonances to create selective on-chip heating for lab-on-chip applications. In the second part, we use an absorptive resonance to encode information in the internal device temperature, forming a hybrid optothermal memory. Such a device may prove useful for operation in highly fluctuating environments.

08:35 : **Plenary talk**

#### The Present and Future of Flat Optics: from Metalenses to Polarization Metaoptics and Arbitrarily Structured Light

**Federico Capasso**

*Harvard University (USA)*

Metasurfaces enable the redesign of optical components into thin, planar and multifunctional elements, promising a major reduction in footprint and system complexity as well as the introduction of new optical functions including arbitrary wavefront control. The planarity of flat optics will lead to the unification of semiconductor manufacturing and lens-making, where the planar technology to manufacture computer chips will be used to make CMOS compatible metasurface-based optical components, ranging from metalenses to novel polarization optics, areas where I foresee the greatest technological and scientific impact. New polarization optics results on an ultracompact metasurface polarimeter and polarization state generator, will be presented and applications to polarization sensitive imaging for a wide range of applications will be discussed. Finally structured light generation with metasurfaces based on J-Plates for arbitrary spin to orbital angular momentum converter will be discussed, along with the general problem of arbitrary vector beam generation.

## Session 4P1

### Poster Session III

09:10 - 09:50

**P1: Active metasurface for terahertz beam steering**

**Sang-Hyeok Mun, Yong-Hoon Lee, Sang-Jun Park, Jinhang Cho, Inbo Kim, Muhan Choi**

*Kyungpook National University (Korea)*

We have designed tunable meta-lens operating in Terahertz frequency regime. The meta-lens is composed of the metasurface blocks coupled with graphene layers in which gate voltage can be controlled individually. In order to achieve maximum phase shift, meta-atoms with strong capacitive coupling are employed

**P2: Design of plasmonic grating nano structure for enhancing optical imaging system signal**

**Junhyun Kim, Jisuk Kang, Zeshan Shoaib, Myung Yung Jeong**

*Pusan National University (Korea)*

The metasurfaces have many unexpected properties including anti-refractivity, anti-doppler effect, and sur-

face plasmon. Among these properties, surface plasmon effect was considered importantly because of the enhancement of optical signals. It is important to detect small optical signal in neuroscience and bio technology due to detect smaller image or signal. In this paper, we proposed the nano-micro patterned structure to detect small optical signal by using surface plasmon effect which can enhance electromagnetic field.

### **P3: Non-local effect on surface modes of non-reciprocal effective media**

**Kai Fung Lee, Raymond Pak Hong Wu, Yong-Liang Zhang, Wang Tat Yau, Kin Hung Fung**

*The Hong Kong Polytechnic University (China)*

Recently, it has been shown theoretically that macroscopic Maxwell's equations support interesting surface magnetic mode having zero electric field and polarization field at an interface between two homogenous magnetic domains. We introduce inhomogeneous lattice to the magnetic domains and study its effect on the surface magnetic mode. We found the edge mode not only becoming repeating in Brillouin Zone but also has significant change in dispersive property. This change can be caused by non-local lattice effect.

### **P4: Lock-in study of acoustic waves through a lead phononic plate**

**Cesar Alejandro Torres-Torres, Carlos Roberto Santillan-Rodriguez, Renee Joselin Saenz- Hernandez, Maria Eugenia Botello-Zubiarte, Maria Cristina Grijalva-Castillo, José Andres Matutes Aquino**

*Centro de Investigación en Materiales Avanzados (Mexico)*

A plate-shaped phononic crystal for preventing the propagation of acoustic waves in a frequency range from 45 to 73 kHz was simulated, constructed and tested. The structural elements of the phonon crystal were made up of a periodic arrangement of air holes in a lead metal plate. The band gap was experimentally determined with a lock-in amplifier. The experimentally determined band gap coincides with the simulated one by the finite elements method.

### **P5: Multiple-DWDM-channel heralded single-photon source based on a periodically poled lithium niobate waveguide**

**Tong Xiang, Yuanhua Li, Yuanlin Zheng, Xianfeng Chen**

*Shanghai Jiao Tong University (China)*

We report on the experimental realization of a multiple-DWDM-channel heralded single-photon source in a periodically poled lithium niobate waveguide. Our single photon at the telecom wavelength covers more than 40 channels of the ITU grid. All channels have virtually identical efficiencies, and the multi-photon emission probability is reduced by a factor up to more than 150 compared to a Poissonian light source. The pump with a 50MHz pulsed laser has potential applications in practical quantum communication.

### **P6: High-efficiency sound collimation with an ultra-thin metastructure**

**Jie Hu<sup>1</sup>, Bin Liang<sup>1</sup>, Jun Xiao Qiu<sup>2</sup>**

*<sup>1</sup>Nanjing University (China), <sup>2</sup>University of Technology Sydney (Australia)*

We herein design an acoustic metastructure perforated with an aperture much thinner than the working wavelength for realizing collimated sound beam. The aperture has a zigzag-shaped cross section for substantially increasing the propagation distance of incident acoustic waves. The surface of the structure is decorated with subwavelength resonators for the reduction of diffraction effects, which enables directional emission of acoustic energy at the transmitted side. We use numerical simulations to verify the device having strong directivity at low frequency.

### **P7: Flexibly Tunable Valley Polarized Exciton-Plasmon Polaritons in 2-dimensional Semiconductors**

**Boyang Ding<sup>1</sup>, Zhepeng Zhang<sup>2</sup>, Yu-Hui Chen<sup>1</sup>, Yanfeng Zhang<sup>2</sup>, Richard John Blaikie<sup>1</sup>, Min Qiu<sup>3</sup>**

*<sup>1</sup>University of Otago (New Zealand), <sup>2</sup>Peking University (China), <sup>3</sup>Zhejiang University (China)*

We report the room temperature valley-polarized photoluminescence from a WS<sub>2</sub> monolayer that is deposited on a self-assembled plasmonic crystal. More importantly we find that the degree of valley-polarization is highly dependent on excitation angles of the pump beam. This flexibly tunable valley polarization is possibly due to the angle-dependent dispersive properties of polaritons as the result of strong coupling between excitons in WS<sub>2</sub> monolayers and lattice plasmon modes in plasmonic crystals.

### **P8: Multichannel Optical Encryption based on Dielectric Metasurface**

**Hang Feng<sup>1</sup>, Fengliang Dong<sup>2</sup>, Lihua Xu<sup>2</sup>, Bo Wang<sup>1</sup>, Zhiwei Song<sup>2</sup>, Xianfeng Zhang<sup>2</sup>, Lanqin Yan<sup>2</sup>, Xiaojun Li<sup>2</sup>, Weiguo Chu<sup>2</sup>, Yan Li<sup>1</sup>**

*<sup>1</sup>Peking University (China), <sup>2</sup>National Center for Nanoscience and Technology (China)*

Here we demonstrate an optical encryption based on dielectric metasurface that information can be encoded into different channels according to different wavelengths and polarizations. The encoded image can be extracted only when the light with designed wavelength and polarization irradiates on the metasurface, or it remains hidden. Furthermore, we realize 63 information encoding combinations through 6 independent channels, including two circular polarization states (RCP, LCP) and the RGB wavelengths (633nm, 532nm and 473nm).

#### **P9: Generating of optical vortices by spiral metalenses**

**Victor Victorovich Kotlyar<sup>1</sup>, Anton Gennadyevich Nalimov<sup>2</sup>**

<sup>1</sup>*IPSI RAS (Russia)*, <sup>2</sup>*Samara National Research University (Russia)*

It is demonstrated numerically and theoretically that in the intensity pattern of the resulting focal spot formed using a metalens there are local (symmetric and asymmetric) regions, which can be located both at its center or on the periphery, where the light energy flux has the opposite direction. The effect discovered can be utilized for moving a microparticle in the opposite direction to the beam propagation.

#### **P10: Probing dynamics and controlling ultrafast plasmon via photoemission electron microscopy**

**Boyu Ji, Yingping Dou, Haiyan Tao, Xiaowei Song, Xun Gao, Zuoqiang Hao, Jingquan Lin**

*Changchun University of Science and Technology (China)*

We demonstrate subwavelength imaging plasmon dynamics evolution and control of the localized near-field distribution in gold bow-tie and nanoring nanostructure through photoemission electron microscopy. Different localized near-field dynamics are disclosed within a bow-tie nanostructure. Subwavelength imaging of near field distribution between the structure with sharp corners (bow-tie) and the one without (nanoring) is compared and the underlying physics responsible for the difference is discussed.

#### **P11: Local polarization of nano rectangle ring and the spontaneous emission enhancement of a circularly polarized emitter**

**Fan Zhang, Juanjuan Ren, Zhao Chen, Xueke Duan, Ying Gu, Qihuang Gong**

*Peking University (China)*

We have illustrated the electric field and local polarization of various symmetry nanostructures excited by right- and left-handed circularly polarized light. For nano rectangle ring, we find that the polarization character performs opposite corresponding to adjacent modes because of the mode coupling in it. The spontaneous emission rate of a circularly polarized emitter has a 6069-fold enhancement by the nano-ring than that in the vacuum.

### **10:00 - 12:20 — Salone Teodora**

#### **Session 4A2**

#### **Symposium I: Hybrid and Metastructured Materials for Photonics, Sensors and Energy V**

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

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

#### **10:00 : Invited talk**

#### **Enhanced Terahertz Light - Matter Coupling in Plasmonic Nanocavities**

**Xin Jin<sup>1</sup>, Andrea Cerea<sup>2</sup>, Gabriele C. Messina<sup>2</sup>, Andrea Rovere<sup>1</sup>, Riccardo Piccoli<sup>1</sup>, Francesco De Donato<sup>2</sup>, Francisco Palazon<sup>2</sup>, Andrea Perucchi<sup>3</sup>, Paola Di Pietro<sup>3</sup>, Roberto Morandotti<sup>1</sup>, Stefano Lupi<sup>4</sup>, Francesco De Angelis<sup>2</sup>, Mirko Prato<sup>2</sup>, Luca Razzari<sup>1</sup>**

<sup>1</sup>*INRS Energie, Matériaux et Télécommunications (Canada)*, <sup>2</sup>*Istituto Italiano di Tecnologia (Italy)*, <sup>3</sup>*Elettra - Sincrotrone Trieste S.C.p.A (Italy)*, <sup>4</sup>*Università di Roma - La Sapienza (Italy)*

We report on our recent findings regarding the coupling of the resonance of terahertz nanoantennas with phonons in nanomaterials.

**10:20 : Invited talk****Modal Design to Control Transient Ultrafast Events in Nanoscale Materials****Gregory Wurtz***King's College London (United Kingdom)*

In this work we focus our attention on 2D plasmonic metamaterials and metasurfaces, which development provides both passive and active optical functionalities. In particular we studied the ultrafast transient response of multi-resonant plasmonic systems, including nonlinear coherent emitters, and demonstrate the ability to modulate both their linear and nonlinear properties at the sub-ps timescales.

**10:40 : Invited talk****Comparative plasmonic waveguide design for nanoscale lasing and four-wave mixing****Stefano Palomba, Guangyuan Li, Martijn da Sterke***The University of Sydney (Australia)*

Nanolasers and nano-sized nonlinear optical devices are the two fundamental building blocks of any modern optical integrated circuit. In order to operate beyond the diffraction limit, these devices implement plasmonic waveguide-based platforms. However, both classes of devices are currently at an impasse. In this presentation we show how a unified theoretical framework can lead to novel and superior performing plasmonic waveguide configurations, in spite of the fact that the underlying physics is totally different.

**11:00 : Active control of the photoluminescence emitted by quantum dots using metallic nanoparticles and photochromic molecules****Gwenaëlle Lamri<sup>1</sup>, Jana B. Nieder<sup>2</sup>, Edite Figueiras<sup>2</sup>, Jean Aubard<sup>3</sup>, Pierre-Michel Adam<sup>1</sup>, Christophe Couteau<sup>1</sup>, Nordin Felidj<sup>3</sup>, Anne-Laure Baudrion<sup>1</sup>**<sup>1</sup>*Université de Technologie de Troyes (France)*, <sup>2</sup>*INL- Braga (Portugal)*, <sup>3</sup>*ITODYS - Paris (France)*

In this work, we demonstrate an optical activation of the resonant coupling between quantum dots and metallic nanoparticles due to the photochromic transition. Indeed, the quantum dots photoluminescence is highly enhanced when the plasmon resonance coincides with the quantum dots emission and both are in presence of the colored form of the photochromic molecules. We also show a Forster Resonant Energy Transfer between the quantum dots (donors) and the colored form of the photochromic molecules (acceptors).

**11:15 : Simulation the Effect of Transparent Conducting Oxides Layer on the Waveguide Reflection****Hala J. El-Khozondar, Ahmed A. AlShembari, Mohammed M. Shabat***Islamic University of Gaza (Palestine)*

A four layer waveguide structure is proposed. It consists of transparent conducting oxide (TCO) substrate made of ITO, topped by two layers of Silicon monoxide (SiO) and Fe-InGaAsP that are covered by air. The Transfer Matrix Method is used to investigate the properties of the structure. The reflectance in the visible light are derived and plotted versus the operating wavelength for different physical parameters for TM mode. The results indicates that the waveguide is suitable for solar cell fabrication.

**11:30 : Invited talk****Plasmon-Assisted Selective and Super-Resolving Excitation of Individual Quantum Emitters on a Metal Nanowire****Hong Wei<sup>1</sup>, Qiang Li<sup>2</sup>, Deng Pan<sup>3</sup>, Hongxing Xu<sup>3</sup>**<sup>1</sup>*Chinese Academy of Sciences (China)*, <sup>2</sup>*South China Normal University (China)*, <sup>3</sup>*Wuhan University (China)*

We show that multiple quantum dots coupled with a silver nanowire can be controllably excited by tuning the interference field of surface plasmons on the nanowire. We demonstrate the selective excitation of two quantum dots separated by a distance as short as 100 nm. We also numerically demonstrate a new kind of super-resolution imaging method that combines the tunable surface plasmon interference pattern on the nanowire with the structured illumination microscopy technique.

**11:50 : Strong Light-Matter Interaction in Single Plasmonic Nanocavity and the Photoluminescence Evolution****Di Zheng<sup>1</sup>, Shunping Zhang<sup>1</sup>, Qian Deng<sup>1</sup>, Meng Kang<sup>1</sup>, Peter Nordlander<sup>2</sup>, Hongxing Xu<sup>1</sup>**<sup>1</sup>*Wuhan University (China)*, <sup>2</sup>*Rice University (USA)*

Strong light-matter interaction between plasmons and excitons in nanocavities can result in the formation of hybrid plexcitonic states. Understanding the dispersion relation in the plexcitonic states is important both for fundamental quantum science and for applications including optoelectronics and nonlinear optics devices.

Here we realize strong light-matter interaction in single nanocavity with excitons in monolayer WSe<sub>2</sub>. The plexciton dispersion along with photoluminescence spectrum evolution is measured by in-situ red shifting the plasmon energy via successive deposition of dielectric layers.

**12:05 : ZnO-Au heterojunction enhanced the photoluminescence of ZnO nanocrystals**

**I. Shahine<sup>1</sup>, J-J. Gaumet<sup>1</sup>, A. En-Naciri<sup>1</sup>, P. Miska<sup>1</sup>, B. El-Eulmi<sup>1</sup>, H. Rinnert<sup>1</sup>, Safi Jradi<sup>2</sup>, Suzanna Akil<sup>1</sup>**  
<sup>1</sup>Université de Lorraine (France), <sup>2</sup>Université de Technologie of Troyes (UTT) (France)

The photoluminescence of ZnO-Au nanoparticles of different characteristics was investigated. More precisely, the role of both the size of ZnO and Au NPs, and the ZnO-Au mass ratio in the ZnO-Au coupling was studied to determine the quenching and enhancement conditions of ZnO photoluminescence.

**10:00 - 12:10 — Sala Desirée**

**Session 4A3**

**Fano Resonances in Optics and Microwaves: Physics and Application II**

Organized by: Eugene Kamenetskii and Almas Sadreev

Chaired by: Eugene Kamenetskii and Almas Sadreev

**10:00 : Keynote talk**

**Rigorous modal analysis of plasmonic nanoresonators**

**Wei Yan, Philippe Lalanne, Jean Paul Hugonin, Christophe Sauvan**  
*Bordeaux University (France)*

Because they enhance and localize fields, nanoresonators are key elements for controlling light at the nanoscale. This control is ultimately limited by our capability to engineer electromagnetic near-fields with several nanoresonances, enable energy transfers between them, and model how every individual mode precisely interfere to create new resonant states that overlap in space and energy. We review recent advance in the development of theories for analyzing the response of nanoresonators.

**10:30 : Invited talk**

**Magnetostatic resonances in subwavelength particles: Eigenvalue problem and bound states in microwave continuum**

**Eugene Kamenetskii**

*Ben Gurion University (Israel)*

We make a comparative analysis of quasistatic eigenvalue problems for plasmon and magnon oscillations in subwavelength particles. We show that in a case of magnetostatic resonances one observes non-Maxwellian propagation-wave behaviors. We show that a case of a quasi-2D ferrite-disk particle, the problem for magnetostatic-potential wave function is Hermitian. We analyze bound states in a microwave-field continuum with an embedded magnetostatic-resonance ferrite particle.

**10:50 : Invited talk**

**Localized field control by plasmonic mode interference**

**Keiji Sasaki, Hideki Fujiwara**

*Hokkaido University (Japan)*

We investigate the wavelength dependence of localized plasmonic field distributions in a gold nanodimer structure under total internal reflection illumination condition. Although the gold dimer structure is well known to induce strong localized field at a nanogap, we find that the higher-order plasmonic modes are excited by the oblique light incidence and their interference effect enables the localized spot control at the nano-scale.

**11:10 : Invited talk**

**Fano resonances in photonics**

**Mikhail Limonov**

*ITMO University (Russia)*

Fano resonance has a long and interesting history in photonics. However, it continues to surprise with new insights and applications [1]. Here we review the fundamental aspects of Fano resonance and a broad range of resonant electromagnetic effects using a clear two coupled oscillators model and demonstrate a phase diagram of different photonic regimes [2]. That includes Fano resonance as such together with electromagnetically induced transparency, Kerker and Borrmann effects, as well as parity-time symmetry breaking and Rabi splitting.

**11:30 : Invited talk**

**Fano resonances and supercavity modes**

**Mikhail Rybin, Kirill Koshelev, Zarina Sadrieva, Kirill Samusev, Andrey Bogdanov, Yuri Kivshar, Mikhail Limonov**

*ITMO University (Russia)*

We reveal strong mode coupling and Fano resonances in the simplest object - a single homogeneous cylindrical subwavelength dielectric resonator resulting in high-Q factors at the nanoscale. We found that the features of Fano parameter repeat with pinpoint accuracy the behavior of the quality factor Q. Thus, the Fano resonance can be considered as a precursor of bound states in the continuum and high-index dielectric resonators represent the simplest example of nanophotonic supercavities.

**11:50 : Invited talk**

**On bound states in the continuum in dielectric gratings**

**Evgeny N. Bulgakov, Dmitrii N. Maksimov**

*MF Reshetnev Siberian State University of Science and Technology (Russia)*

Bound states in the continuum (BICs) in dielectric gratings are considered. We found the geometries of the gratings supporting propagating BICs. It is demonstrated that if a two-sided grating possesses either mirror or glide symmetry the propagating BICs are stable to variation of parameters. The formation of the BICs is explained via the Friedrich-Wintgen mechanism in the spectral vicinity of avoided crossings. The concurrent phenomenon of collapsing Fano resonances is discussed.

**11:00 - 12:15 — Piano Bar Principe Nero**

**Session 4A4**

**Extraordinary Topological Effects and Singular Plasmonics I**

Organized by: Yuri Gorodetski and Denis Garoli

Chaired by: Yuri Gorodetski and Denis Garoli

**11:00 : Invited talk**

**Nanostructured magnetoplasmonic metamaterials: from extreme bio-sensing to active control of light polarization states at the nanoscale**

**Nicolo Maccaferri**

*Italian Institute of Technology (Italy)*

A major challenge facing plasmon-based nanophotonics is the poor dynamic tunability. The rapidly developing field of magnetoplasmonics merges the concepts from plasmonics and magnetism to realize novel and unexpected phenomena for the active manipulation of light properties at the nanoscale. Multifunctional magnetoplasmonic systems may open new views towards applications to variety of emerging nanotechnologies such as magnetoplasmonic rulers and ultrasensitive molecular sensors.

**11:20 : Invited talk**

**Meta-atoms for arbitrary tuning of plasmonic vortex by using geometric and detour phase multiplexing**

**Seung-Yeol Lee<sup>1</sup>, Seong-Won Moon<sup>2</sup>, Gun-Yeal Lee<sup>2</sup>, ByoungHo Lee<sup>1</sup>**

<sup>1</sup>*Kyungpook National University (Korea)*, <sup>2</sup>*Seoul National University (Korea)*

Various methods for utilizing a meta-atom to the generation of plasmonic vortex and far-field vortex beam are



discussed. The concept of multiplexing geometric and detour phase of meta-atoms is introduced in order to provide a polarization-multiplexed plasmonic vortex with arbitrary topological charge. Moreover, the proposed concept also verified that the polarization insensitive plasmonic hot spot or vortex can be manipulated using the geometric phase, by compensating the role of conventional spin-orbital interaction occurred by circular slit distribution.

#### 11:40 : Far-field Polarization Singularities of a Dipolar Emitter

**Sergey Nechayev, Martin Neugebauer, Martin Vorndran, Gerd Leuchs, Peter Banzer**

*Max Planck Institute for the Science of Light (Germany)*

We investigate the far-field emission of an elliptically polarized dipole, exhibiting in general four C points. We reveal that the C points' properties bare information on the spin and ellipticity of the dipole. For an almost linear dipole, the C points are barely separated and obscured by the low intensity in the corresponding angular region. However, they can be resolved via weak measurement. Our results link the polarization state of the dipolar emitters and their far-field polarization singularities.

#### 11:55 : Invited talk

#### Interaction of an Individual Chiral Nanostructure with Light Carrying Orbital Angular Momentum

**Peter Banzer**

*Max Planck Institute for the Science of Light (Germany)*

We discuss the interaction of individual chiral nanostructures with light beams carrying orbital angular momentum (OAM). We show that the twisting sense (sign of OAM) of a Laguerre-Gaussian beam can be imprinted on the relative phase between longitudinal electric and magnetic fields created by tight focusing, matching and efficiently exciting, for one sign only, the chiral mode of a helical nanostructure. The chiral scatterer is hence capable of indirectly distinguishing the sign of the original OAM.

### 10:00 - 12:20 — Country Rock Club

#### Session 4A5

#### Nonlinear Metasurfaces and Plasmonics III

Organized by: Guixin Li and Dangyuan Lei

Chaired by: Guixin Li and Tun Cao

#### 10:00 : Invited talk

#### Nonlinear Spin-Orbital Angular Momentum Interaction in Plasmonic Nanostructures

**Xiaoyan Y. Z. Xiong<sup>1</sup>, Li-Jun Jiang<sup>1</sup>, Wei E. I. Sha<sup>2</sup>, Ahmed Al-Jarro<sup>3</sup>, Nicolae C. Panoiu<sup>3</sup>, Weng Cho Chew<sup>1</sup>**

<sup>1</sup>The University of Hong Kong (Hong Kong), <sup>2</sup>Zhejiang University (China), <sup>3</sup>University College London (United Kingdom)

Second-harmonic generation in plasmonic nanostructures has attracted significant attentions in nonlinear optics field due to unique properties of surface-sensitive and plasmonenhancement effects. In this work, a rigorous selfconsistent surface integral equation method has been developed for studying nonlinear spin-orbital angular momentum coupling induced by second-harmonic generation in plasmonic nanostructures. A general angular momenta conservation law is formulated for describing the nonlinear spin-orbital interaction process.

#### 10:20 : Invited talk

#### Linear frequency conversion via sudden merging of resonances in time-variant metasurfaces

**Kanghee Lee, Jaehyeon Son, Jagang Park, Byungsoo Kang, Wonju Jeon, Fabian Rotermund, Bumki Min**

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

Here, we propose rapidly time-variant metasurfaces as a frequency-conversion platform and experimentally demonstrate their efficacy at THz frequencies. The proposed metasurface is designed for the sudden mer-

ging of two distinct resonances into a single resonance upon ultrafast optical excitation. From this spectrally-engineered temporal boundary onward, the merged-resonance frequency component is radiated.

**10:40 : Invited talk**

**Four-wave mixing in Epsilon-Near-Zero Aluminum Zinc Oxide**

**Enrico Giuseppe Carnemolla<sup>1</sup>, Vincenzo Bruno<sup>1</sup>, Matteo Clerici<sup>2</sup>, Stefano Vezzoli<sup>1</sup>, Clayton DeVault<sup>3</sup>, Lucia Caspani<sup>4</sup>, Alexandra Boltasseva<sup>3</sup>, Vladimir Shalaev<sup>3</sup>, Daniele Faccio<sup>2</sup>, Marcello Ferrera<sup>1</sup>**

<sup>1</sup>Heriot-Watt University (United Kingdom), <sup>2</sup>University of Glasgow (United Kingdom), <sup>3</sup>University of Purdue (USA), <sup>4</sup>University of Strathclyde (United Kingdom)

Transparent Conductive Oxides are at the center of a tremendous scientific and technological interest. At relevant telecom wavelengths, TCOs allow to operate in the epsilon-near-zero regime where the material transparency is still high, and the optical nonlinear response is enormously enhanced. After a general introduction about nonlinear optics in TCOs, experiments of semi-degenerate four-wave mixing in aluminum zinc oxide thin films will be reported where photons were generated in the visible window with a measured efficiency reaching 2%.

**11:00 : Invited talk**

**Unidirectional Second-Harmonic Generation with Plasmonic Nanoresonator Dimers**

**Shao-Ding Liu<sup>1</sup>, Danyuan Lei<sup>2</sup>**

<sup>1</sup>Taiwan University of Technology (China), <sup>2</sup>The Hong Kong Polytechnic University (China)

We propose and show that the second-harmonic generation of a single gold split-ring resonator dimer is strongly enhanced with the mode-matching condition. At the same time, the coupling between the two split-ring resonators results in constructive and destructive interferences on the two opposite emission directions, thereby leading to unidirectional second-harmonic generation. The simultaneously realization of enhanced and unidirectional second-harmonic generation makes the split-ring resonator dimer an excellent platform for realizing compact and on-chip ultrafast nonlinear optoelectronic devices.

**11:20 : Invited talk**

**All-optical dynamic metasurface for terahertz wave-front modulation**

**Yan Zhang, Jingying Guo, Teng Wang, Xinke Wang**

*Capital Normal University (China)*

A novel configuration for active modulation of terahertz (THz) wave-front which is based on the all-optical dynamic metasurface is proposed. The dielectric metasurface is generated by pumping a thin silicon wafer with structured femtosecond light. Arbitrary pure phase modulation for THz radiation can be achieved. Several devices based on this technology, such as focal length tunable lens and dynamic holograms, have been experimentally demonstrated.

**11:40 : Invited talk**

**Wavefront engineering based on complex amplitude modulation with metasurfaces**

**Lingling Huang<sup>1</sup>, Xu Song<sup>1</sup>, Ruizhe Zhao<sup>1</sup>, Yongtian Wang<sup>1</sup>, Thomas Zentgraf<sup>2</sup>**

<sup>1</sup>Beijing Institute of Technology (China), <sup>2</sup>University of Paderborn (Germany)

Metasurfaces have attracted extensive interests due to their ability to locally manipulate optical parameters of light and easy integration to complex optical systems. Here, we propose and experimentally demonstrate novel methods for either generating independently selective diffraction orders or near-field plasmonic beam shaping based on complex amplitude modulation with metasurfaces, respectively. Our developed method with metasurfaces can provide an attractive platform for applications both in near- and far-field wavefront engineering.

**12:00 : Invited talk**

**Highly uniform and controllable metasurface structures fabricated by shaped femtosecond laser: Fundamentals and Applications**

**Xiaowei Li**

*Beijing Institute of Technology (China)*

In this study, the formation principle of surface structures by laser direct writing is intensively investigated, which reveals the fabrication rule and modulation mechanism. Several flexible and efficient approaches have been proposed to fabricate highly uniform and controllable metasurface structures by shaping femtosecond laser pulse in temporal or spatial domains. The flexible and high efficiency of this structuring strategy should

facilitate applications in numerous fields, including metamaterials, nanoplasmonics, nanoelectronics, and mechatronics.

## 10:00 - 11:20 — Discoteca Pietra di Luna

### Session 4A6

#### Plasmon-Induced Hot Carrier: Fundamentals and Applications I

Organized by: Qin Chen and Xiaofeng Li

Chaired by: Qin Chen and Xiaofeng Li

##### 10:00 : **Invited talk**

##### **Plasmon-enhanced electron emission in nano-metallic/semiconductor composites**

**Qilong Wang, Zhiyang Qi, Yupei Li, Yusheng Zhai**

*Southeast University (China)*

Due to the excellent optical properties, plasmonics nanostructures have been applied to many fields. Here, we present two aspects of works about the localized surface plasmon (LSPR) induced light trapping and hot electron in the application of photocathodes and photodetectors, respectively. Both experimental results indicate that the Au film or nanoparticles can improve the quantum yield and responsivity of the photocathodes and photodetectors, respectively.

##### 10:20 : **Invited talk**

##### **Anisotropic Pt-Au Nanostructure with Plasmonic Hot Electron Transfer for Hydrogen Generation Studied at Single-Particle Level**

**Zaizhu Lou**

*Jinan University (China)*

In recent years, SPR-induced hot electrons were used for hydrogen generation from water splitting. For traditional plasmonic photocatalysts metal/semiconductor composites, rapid recombination of plasmon-induced carriers results in low efficiency in photocatalysis. Based on fast transfer of electrons between metals, we developed metal/metal composites plasmonic photocatalysts Pt-Au with various nanostructures including Pt-edged, Pt-covered, Pt-tipped Au triangular nanoprisms and Pt-edged Au nanodisks for hydrogen generation. Plasmon-induced hot electron transfer between Au and Pt was studied and demonstrated by single-particle photoluminescence spectroscopy.

##### 10:40 : **Invited talk**

##### **Plasmon-based nanohybrid structures for SERS and temperature sensing**

**Hongxiang Lei**

*Sun YatSen University (China)*

Developing plasmon-based nanohybrid structures with peculiar photoresponsive behaviors is critical and highly desired for the practical applications in surface-enhanced Raman scattering (SERS) and temperature sensing. Here, a SERS-active substrate was fabricated by decorating a MoS<sub>2</sub> monolayer with Ag Nanowire (NW)-Nanoparticle (NP) structures, which exhibited an ultrasensitive ability, reliable reproducibility and good stability. Another nanohybrid structure was achieved by covering upconversion nanoparticles (UCNPs) on the surface of an Au-nanofilm-coated microfiber, which can be applied in temperature sensing.

##### 11:00 : **Invited talk**

##### **Broadband hot-electron photodetection based on hotspots-enriched disordered nanosystem**

**Qin Chen, Long Wen**

*Jinan University (China)*

The ability of plasmonic nanostructures to harvest photons beyond the band-to-band photovoltaic conversion has stimulated intensive research activities in hot electron. An approach for near-infrared photodetection by combining randomly and densely packed photonic nanostructures with plasmonic nanocoatings was demonstrated with a photoresponsivity around 1.5-13 mA/W at wavelengths ranging from 1100 to 1500 nm. Different

loss mechanisms were described quantitatively and a large improvement potential of internal quantum efficiency above 20 % was identified in the proposed hot electron harvesting platform.

### Lunch

12:00 - 14:00

## 17:00 - 17:40 — Salone Teodora

### Session 4A7

#### Extraordinary Topological Effects and Singular Plasmonics II

Organized by: Yuri Gorodetski and Denis Garoli

Chaired by: Yuri Gorodetski and Denis Garoli

#### 17:00 : **Invited talk**

#### **Optical momentum, angular momentum, and helicity in plasmonic and dielectric structures**

Konstantin Y. Bliokh<sup>1</sup>, Aleksandr Y. Bekshaev<sup>2</sup>, M. F. Picardi<sup>3</sup>, F. Alpegiani<sup>4</sup>, F. J. Rodriguez-Fortuno<sup>3</sup>, L. Kuipers<sup>4</sup>, Franco Nori<sup>1</sup>

<sup>1</sup>*CEMS-RIKEN (Japan)*, <sup>2</sup>*I. I. Mechnikov National University (Ukraine)*, <sup>3</sup>*King's College London (United Kingdom)*, <sup>4</sup>*University of Michigan (USA)*

We introduce a novel approach efficiently describing the canonical properties - momentum, spin and orbital angular momenta, and helicity - of structured optical fields in structured media. The general theory is applied to examples of surface plasmon-polaritons at metal-dielectric interfaces, guided modes of dielectric and plasmonics cylindrical waveguides, and other systems.

#### 17:20 : **Invited talk**

#### **High index dielectric nanostructures: From directional scattering to electric/magnetic local density of optical states control**

Peter R. Wiecha<sup>1</sup>, Bruno Masenelli<sup>2</sup>, Gérard Colas des Francs<sup>3</sup>, Franck Fournel<sup>4</sup>, Vincent Larrey<sup>4</sup>, Thierry Baron<sup>4</sup>, Aurélie Lecestre<sup>1</sup>, Guilhem Larrieu<sup>1</sup>, Arnaud Arbouet<sup>1</sup>, Christian Girard<sup>1</sup>, Vincent Paillard<sup>1</sup>, Aurelien Cuche<sup>1</sup>

<sup>1</sup>*Toulouse University (France)*, <sup>2</sup>*Lyon University (France)*, <sup>3</sup>*Bourgogne-Franche Comté University (France)*, <sup>4</sup>*Grenoble Alpes University (France)*

We show both experimentally and theoretically that dielectric nanowires (Si) are able to scatter very efficiently visible light. Furthermore, due to a Fano-like process, we demonstrate that the direction of light scattering can be controlled (forward or backward scattering). Then, we show the effect of a high index dielectric nanoantenna (dimers) on the spontaneous emission of electric and magnetic emitters placed in its vicinity. Our approach allowed us to simultaneously map the electric and magnetic LDOS of individual Si nanostructures.

## 17:40 - 19:20 — Salone Teodora

### Session 4A8

#### Symposium II: Novel Design and Applications of Metamaterials, Metasurfaces and Metadevices using Hybrid and New Materials V

Organized by: Mohamed Swillam

Chaired by: Mohamed Swillam

**17:40 : Invited talk****Observation of topologically protected helical edge modes in an elastic waveguide****Marco Miniaci<sup>1</sup>, R. K. Pal<sup>1</sup>, B. Morvan<sup>2</sup>, M. Ruzzene<sup>1</sup>**<sup>1</sup>Georgia Institute of Technology (USA), <sup>2</sup>University of Le Havre (France)

In this work we propose the first experimental observation of topologically protected helical edge modes in a Kagome elastic plate. We achieved this by means of a novel and simple approach based on a rational metamaterial design that produces an isolated accidental degeneracy of two overlapped Dirac cones and subsequently lifts it through careful manipulation of geometrical symmetries.

**18:00 : Invited talk****Magneto-plasmonic metamaterials****Evangelos Papaioannou***Department of Physics and Research Center OPTIMAS (Germany)*

Strong localization of light, enabled by surface plasmons, increases the magneto-optical response of ferromagnetic materials. In this work, we define the strategy to design the magneto-optic response of a magneto-plasmonic crystal by correlating near- and far-fields effects. The engineering of the magneto-optic response based on the plasmon-induced modification of the optical properties introduces the concept of a magneto-plasmonic meta-structure. Furthermore, we present how magneto-plasmonic metamaterials can connect the field of plasmonics with magnonics and spintronics.

**18:20 : Invited talk****Metamaterial based nanobiosensors, nanophotodetectors and perfect absorbers****Ekmel Ozbay***Bilkent University (Turkey)*

In this talk, we will present metamaterial based nanobiosensors, nanophotodetectors and perfect absorbers. We present a label-free, optical nano-biosensor based on the LSPR effect that is observed by using nanocylinder arrays located periodically on a sapphire substrate by EBL. We will report on UV plasmonic antenna integrated MSM photodetectors based on GaN. We also report a lithography free, and large scale compatible fabrication route to fabricate ultra-broadband wide angle perfect absorber based on non-uniform texturing and disordered nano hole plasmonic patterns.

**18:40 : Invited talk****Hybrid Graphene Metasurface for High-Speed Mid-Infrared Light Modulation and Single-Pixel Imaging****Beibei Zeng<sup>1</sup>, Zhiqin Huang<sup>2</sup>, Akhilesh Singh<sup>1</sup>, Yu Yao<sup>3</sup>, Abul Azad<sup>1</sup>, Aditya Mohite<sup>1</sup>, Antoinette Taylor<sup>1</sup>, David Smith<sup>2</sup>, Hou-Tong Chen<sup>1</sup>**<sup>1</sup>Los Alamos National Laboratory (USA), <sup>2</sup>Duke University (USA), <sup>3</sup>Arizona State University (USA)

By leveraging graphene and metasurfaces we demonstrate a high-performance free space mid-infrared modulator operating at gigahertz speeds, low gate voltage and room temperature. We further pixelize the hybrid graphene metasurface to form a prototype spatial light modulator for high frame-rate single-pixel imaging, suggesting orders of magnitude improvement over conventional liquid crystal or micro-mirrors based spatial light modulators. This work opens up the possibility of exploring wavefront engineering for infrared technologies where fast temporal and spatial modulations are indispensable.

**19:00 : Invited talk****Quantum nonlinear effects in metal-insulator-metal plasmonic nanostructures****Imad Agha, Mallik R. Hussain, Andrew Sarangan, Joseph Haus***University of Dayton (USA)*

In our recent experiments, nonlinear optical harmonics of scattered light from metal-insulator-metal systems were measured to expose an underlying quantum signatures of the electron quantum process. Using atomic layer deposition and self-assembled nanoparticles, we show enhancement, saturation, and quenching of the third harmonic efficiencies, in agreement with the quantum theory. While fundamental in nature, these experiments could potentially lead to new techniques for probing nonlinearities and surface properties of novel materials.

**17:00 - 19:10 — Sala Desirée**

## Session 4A9

## Current Advances in Frequency Selective Surfaces and Metasurfaces II

Organized by: Tzong-Lin Wu, Chun-Wen Lin and Zakaria Zouhdi

Chaired by: Andrei Faraon

**17:00 : Keynote talk****Exploration of Novel Electromagnetic Scattering with All-Dielectric Metamaterials****Willie Padilla, Andrew Cardin, Xinyu Liu, Kebin Fan***Duke University (USA)*

All-dielectric metasurfaces (DMSs) are a versatile system to investigate a number of unconventional physical scattering responses ranging from Huygens' surface to high absorption and bound-states-in-the-continuum (BIC). We present experimental results from several types of DMSs. DMSs are fabricated with semiconducting materials, and we further demonstrate the ability to control the scattering properties of DMSs in real-time with optical band-gap light.

**17:30 : Invited talk****Learning from Nature: Bio-inspired Metasurface Microwave Absorber****Shubo Wang<sup>1</sup>, C. T. Chan<sup>2</sup>***<sup>1</sup>City University of Hong Kong (China), <sup>2</sup>The Hong Kong University of Science and Technology (China)*

Recent advances in metasurfaces have given rise to the designs of electromagnetic wave absorber with unprecedented performance. We show that a bio-inspired design of metasurface composed of logarithmic spiral resonators can achieve greater than 95% absorption of incident microwave within the frequency range of 7.7 GHz - 37 GHz. The near-perfect absorption, subwavelength and broadband properties are attributed to the impedance matching of the magnetic resonance modes, space coiling, and the self-similarity of the logarithmic structure.

**17:50 : Invited talk****Surface Acoustic Wave Manipulation by a Phononic Crystal Made of Multilayered Ridges or Pillars****M. Oudich<sup>1</sup>, Y. Jin<sup>1</sup>, E. H. El Boudouti<sup>2</sup>, B. Bonello<sup>3</sup>, Y. Pennec<sup>4</sup>, F. Sarry<sup>1</sup>, B. Djafari Rouhani<sup>4</sup>***<sup>1</sup>Université de Lorraine (France), <sup>2</sup>LPMR (Morocco), <sup>3</sup>UPMC (France), <sup>4</sup>University of Lille (France)*

After reviewing our recent works on band structure and possibility of very confined modes in pillared phononic crystals, we focus on pillars made of periodic multilayered materials. Each pillar behaves itself like of a 1D phononic crystal exhibiting band gaps where very localized modes can be found either at the upper or lower edge, or inside a cavity. We study the scattering of Rayleigh waves by such modes and evidence very narrow Fano and Acoustic Induced Transparency resonances.

**18:10 : Invited talk****Advances in Textile (Knitted) Frequency Selective Surfaces (FSS) and Meta-Surfaces****Alan Tennant<sup>1</sup>, Xiaobin Jia<sup>1</sup>, William Hurley<sup>2</sup>, Tilak Dias<sup>2</sup>***<sup>1</sup>University of Sheffield (United Kingdom), <sup>2</sup>Nottingham Trent University (United Kingdom)*

We report a commercially attractive approach to manufacturing conducting textile meta-surfaces which is based on computerised flat-bed knitting technology using conducting yarns. We examine how flat-bed knitting can be used to manufacture large area samples of functional electromagnetic structures such as frequency selective surfaces (FSS). In addition we show how the knitting process can be adapted to allow the integration of conducting vias into a 3-D knitted spacer structure to form an electromagnetic high impedance surface (HIS).

**18:30 : Invited talk****Wideband Metamaterial Absorber Made of Composite Materials****Olivier Rance<sup>1</sup>, Anne-Claire Lepage<sup>1</sup>, Xavier Begaud<sup>1</sup>, Michel Soiron<sup>2</sup>, André Barka<sup>3</sup>, Patrick Parneix<sup>4</sup>***<sup>1</sup>Telecom ParisTech (France), <sup>2</sup>SART (France), <sup>3</sup>ONERA (France), <sup>4</sup>Naval Group (France)*

The dielectric layers of a metamaterial absorber initially designed for RF materials are replaced with fiber-reinforced composite materials. The thickness of the dielectric layers is optimized again. The absorber achieves



ves a reflection coefficient below -14 dB within the band 4.6 GHz-17.2 GHz, for a total thickness of 8.9 mm.

**18:50 : Invited talk**

**Metasurfaces: from fundamental ideas of polarization conversion, broadband Huygens' surfaces and topological photonics to applications in magnetic resonance imaging**

**Stanislav B. Glybovski, Alena V. Shchelokova, Irina V. Melchakova, Alexey P. Slobozhanyuk, Pavel A. Belov**

*ITMO University (Russia)*

Metasurfaces have become a new paradigm in the studies of artificial subwavelength structures due to their potential to overcome many challenges typically associated with metamaterials. In this contribution, recent advances in the field of microwave metasurfaces are described with the focus on novel fundamental ideas of polarization conversion, broadband Huygens' surfaces and two-dimensional topologically protected structures as well as on applications in the field of medical imaging.

**17:00 - 18:20 — Piano Bar Principe Nero**

**Session 4A10**

**Fano Resonances in Optics and Microwaves: Physics and Application III**

Organized by: Eugene Kamenetskii and Almas Sadreev

Chaired by: Eugene Kamenetskii and Almas Sadreev

**17:00 : Invited talk**

**Bound States in the Continuum in tri-layer Photonic Crystal slab**

**Li Liangsheng**

*Science and Technology on Electromagnetic Scattering Laboratory (China)*

We have investigated the Fano resonances in the tri-layer photonic crystal (PhC) structures by tuning the hole size and displacement of the middle PhC slab along the y axis. It is found that a new kind of bound states in the continuum (BIC) in this systems without C2 rotational symmetry for the z axis. These new BIC phenomena can be understood by the two band coupled model, which has different resonance frequencies and different radiation rates.

**17:20 : Invited talk**

**Applications of plasmonic near-perfect absorbers in Chemistry**

**Timothy Connell<sup>1</sup>, Kevin Q. Xiao<sup>2</sup>, Jasper J. Cadusch<sup>3</sup>, Anthony Chesman<sup>2</sup>, Ann Roberts<sup>3</sup>, Timothy J. Davis<sup>3</sup>, Daniel E. Gomez<sup>1</sup>**

<sup>1</sup>*RMIT University (Australia)*, <sup>2</sup>*CSIRO (Australia)*, <sup>3</sup>*The University of Melbourne (Australia)*

Hot charge carrier extraction from metallic nanostructures is a very promising approach for applications in photocatalysis, photovoltaics, and photo-detection. Here we demonstrate that a monolayer of Au nanoparticles can be assembled on a multi-stack layered configuration to achieve broadband, near-unity light absorption. We show that this enhanced light absorption leads to a 40-fold increase in the photon-to-electron conversion efficiency in photoelectrochemical cells. The measured data is interpreted with a model that enables us to establish that efficient hot carrier extraction is limited to spectral regions where (i) the photons have energies higher than the Schottky barrier at the gold-semiconductor junction and (ii) the absorption of light is localized on the metal nanoparticles..

**17:40 : Invited talk**

**Guiding electromagnetic waves through the bound states in the radiation continuum in novel types of fibers**

**Evgeny N. Bulgakov<sup>1</sup>, Almas Sadreev<sup>2</sup>**

<sup>1</sup>*MF Reshetnev Siberian State University of Science and Technology (Russia)*, <sup>2</sup>*Federal Research Center KSC SB RAS (Russia)*

We consider propagated electromagnetic waves through the Bloch bound states in the radiation continuum

(BICs) in two novel fibers. The first is a single dielectric rod with refractive index periodically modulated along the rod. The second fiber consists of dielectric rods arranged in circular way. The guiding modes can be excited by plane wave excited by oblique plane wave with tuned frequency, polarization and angle of incidence. Because of axial symmetry of the fibers the BICs can carry also angular orbital momentum.

**18:00 : Invited talk**

**Experimental observation of bound state in the continuum in 1D chain of dielectric disks at GHz frequencies**

**Mikhail Balyzin<sup>1</sup>, Zarina Sadrieva<sup>1</sup>, Mikhail Belyakov<sup>1</sup>, Polina Kapitanova<sup>1</sup>, Almas Sadreev<sup>2</sup>, Andrey Bogdanov<sup>1</sup>**

<sup>1</sup>ITMO University (Russia), <sup>2</sup>Kirensky Institute of Physics (Russia)

In this work we experimentally observe a symmetry protected optical bound state in the continuum (BIC) with zero angular momentum in 1D array of ceramic disks at GHz frequencies. We analyze the dependence of Q factor of BIC on the number of the disks and the level of the material losses. We confirmed theoretical prediction about quadratic growth of the Q factor with the number of the disks and its following saturation due to material losses.

**18:20 - 19:05 — Piano Bar Principe Nero**

**Session 4A11**

**Optical Antennas**

Chaired by: Richard Hobbs

**18:20 : Strong coupling at SWIR in Photocurrent of Quantum Cascade Infrared Photodetectors Coupled to Metamaterial Nano-antennas**

**Matias Katz<sup>1</sup>, Ofir Sorias<sup>1</sup>, Ben Dror<sup>1</sup>, Nicolas Grandjean<sup>2</sup>, Meir Orenstein<sup>1</sup>, Gad Bahir<sup>1</sup>**

<sup>1</sup>Technion-Israel Institute of Technology (Israel), <sup>2</sup>Ecole Polytechnique Fédérale de Lausanne (Switzerland)

We present the design, realization, and characterization of room temperature optical and electrical strong light-matter coupling between intersubband transitions, at wavelength of 1.8 micron, in quantum cascade detector and planar metamaterials nano-cavity antenna.

**18:35 : Broadband Infrared Refractive Index Measurement Using Plasmonic Antenna Resonance**

**Hibiki Kagami, Tomohiro Amemiya, Satoshi Yamasaki, Keisuke Masuda, Zhichen Gu, Nobuhiko Nishiyama, Shigehisa Arai**

*Tokyo Institute of Technology (Japan)*

We propose a novel method to measure broadband complex refractive indices of liquid materials using plasmonic antenna resonance. By applying this method to PMMA, we succeeded in obtaining high-precision infrared refractive index from 50 to 250 THz.

**18:50 : 3D Multi-scale Nanostructured Plasmonic Materials for Record Efficient Hot-Carriers Based Photocatalysis**

**Yi Tian<sup>1</sup>, Francisco Pelayo Garcia de Arquer<sup>2</sup>, Cao-Thang Dinh<sup>2</sup>, Gael Favraud<sup>1</sup>, Marcella Bonifazi<sup>1</sup>, Min Liu<sup>2</sup>, Sjoerd Hoogland<sup>2</sup>, Edward H. Sargent<sup>2</sup>, Andrea Fratalocchi<sup>1</sup>**

<sup>1</sup>King Abdullah University of Science and Technology (Saudi Arabia), <sup>2</sup>University of Toronto (Canada)

By engineering metal epsilon-near-zero metamaterials, we demonstrate a new photocatalyst for hydrogen evolution. Electron energy loss spectroscopy is employed to illustrate hot carriers are excited in a broadband fashion within a 10-nm region. Finally, the resulting photocatalyst achieve a hydrogen production rate of 9.5- $\mu$ mol h<sup>-1</sup>cm<sup>-2</sup> that exceeds, by a factor of 3.2 that of the best previously reported plasmonic-based photocatalysts for the dissociation of H<sub>2</sub> with 50 h stable operation.

**17:00 - 18:50 — Country Rock Club**

## Session 4A12

## Wave Propagation in Acoustic and Elastic Metamaterials: Novel Design and Practical Applications II

Organized by: Marco Miniaci and Guancong Ma

Chaired by: Marco Miniaci and Guancong Ma

17:00 : **Invited talk****Tunable Perfect Absorbers for Low-Frequency Sound****Sibo Huang<sup>1</sup>, Xinsheng Fang<sup>1</sup>, Xu Wang<sup>1</sup>, Badreddine M. Assouar<sup>2</sup>, Qian Cheng<sup>1</sup>, Yong Li<sup>1</sup>**<sup>1</sup> *Tongji University (China)*, <sup>2</sup> *CNRS - Institut Jean Lamour (France)*

Metasurface-based acoustic absorbers possessing the ability of perfect absorption with ultra-thin thickness have attracted comprehensive attention. Here, we present theoretical analysis and experimental verification of perfect absorbers via acoustic spiral metasurfaces consisting of coiled channels and further an innovative configuration with embedded-apertures. Due to their superior acoustic impedance manipulation, great tunability and capability in acoustic absorption performance is demonstrated. Our research would benefit to reveal the absorption mechanism and pave a way to design optimal acoustic absorbers.

17:20 : **Invited talk****Lossy Acoustic Materials with Independent Control of Phase and Amplitude for High-quality Manipulation of Airborne Sound****Bin Liang, Yi-Fan Zhu, Xue-Feng Zhu, Jian-Chun Cheng***Nanjing University (China)*

The existing wave-steering metamaterials can only modulate the propagation phase, posing a fundamental limitation on the quality of the resulting acoustic fields. Here we show, both theoretically and experimentally, that by judiciously tailoring energy loss, the phase and amplitude can be tuned independently, ensuring fine manipulation of acoustic field. We experimentally demonstrate the effectiveness of our mechanism via projection of high-quality acoustic holograms. Our design may open a new degree of freedom for realizing the complete control of sound.

17:40 : **Invited talk****Soft Acoustic Metamaterials: from 3D locally resonant metafluids to soft porous gradient index metasurfaces****Thomas Brunet, Olivier Poncelet, Christophe Aristegui, Jacques Leng, Olivier Mondain-Monval***Bordeaux University (France)*

Soft acoustic metamaterials are classes of functional materials for acoustics achieved by means of soft matter techniques such as microfluidics, chemical formulation or self-assembly. In this talk, I will review our recent advances in that field that allowed us to achieve the first soft 3D acoustic metamaterials with a negative index. I will also show how to manipulate acoustic beams, e.g. through ultrasound focusing, with soft porous gradient index metasurfaces.

18:00 : **Invited talk****Negative refraction and double negativity for acoustic waves in three-dimensional bubble metamaterials****John Hilton Page<sup>1</sup>, Maxime Lanoy<sup>1</sup>, Geoffroy Lerosey<sup>2</sup>, Fabrice Lemoult<sup>2</sup>, Arnaud Tourin<sup>2</sup>, Valentin Leroy<sup>3</sup>**<sup>1</sup> *University of Manitoba (Canada)*, <sup>2</sup> *ESPCI Paris (France)*, <sup>3</sup> *Paris Diderot University (France)*

Bubble metamaterials are created by exploiting the low-frequency Minnaert resonance of bubbles, and can radically modify acoustic wave behaviour. Here we show how three-dimensional structures with pair-wise spatial correlations between the bubbles can exhibit doubly negative behaviour. This can occur when the bubble pairs are arranged in either random or periodic configurations. Predictions for both types of structure will be presented and the influence of dissipation on doubly negative behaviour discussed.

18:20 : **Conversion of surface waves in a forest of trees**

**Kim Pham<sup>1</sup>, Sebastien Guenneau<sup>2</sup>, Agnes Maurel<sup>3</sup>, Jean-Jacques Marigo<sup>4</sup>**

<sup>1</sup>ENSTA (France), <sup>2</sup>Aix-Marseille University (France), <sup>3</sup>ESPCI (France), <sup>4</sup>Ecole Polytechnique (France)

We inspect the propagation of surface waves through a forest of trees atop a guiding layer on a soil substrate. We show that these waves behave like spoof plasmons in the limit of a vanishing guiding layer, and like Love waves in the limit of trees with a vanishing height. When we consider a forest with trees of increasing or decreasing height, this hybrid wave is either reflected backwards or converted into a downward bulk wave.

**18:35 : Band structures of a 1D tunable piezoelectric phononic crystal coupled to a 2D-periodic dispersive electric circuit**

**Olivier Poncelet<sup>1</sup>, Alexander Shuvalov<sup>1</sup>, Anton Kutsenko<sup>2</sup>**

<sup>1</sup>Bordeaux University (France), <sup>2</sup>Jacobs University (Germany)

The need to confer tunable features to phononic crystals (PC) has prompted the community to invent different types of approaches to modify (online) their band structure (for instance variable frequency ranges of forbidden bands, modification of apparent velocity/elasticity under the quasistatic regime or long-wave conditions etc).

**18:50 - 20:05 — Country Rock Club**

**Session 4A13**

**Plasmonics and Nanophotonics III**

Chaired by: Ann Roberts

**18:50 : Three-wave mixing of guided contra-propagating electromagnetic waves in hyperbolic metamaterials: shaping light**

**Victor A. Tkachenko<sup>1</sup>, Vitaly V. Slabko<sup>1</sup>, Sergey A. Myslivets<sup>1</sup>, Alexander K. Popov<sup>2</sup>**

<sup>1</sup>Siberian Federal University (Russia), <sup>2</sup>Purdue University (USA)

Three-wave mixing of the phase matched contrapropagating electromagnetic waves enables extraordinary greatly enhanced amplification, frequency and propagation direction conversion as well as control of shape of the light pulses. We present numerical simulation of the plasmonic metamaterials, which provide phase matching of guided ordinary and backward electromagnetic waves, and demonstrate extraordinary transient processes that emerge in such metamaterials.

**19:05 : Tuning propagation of surface plasmon polariton by geometric phases**

**Feng Lin**

*Peking University (China)*

We used a scanning near-field optical microscope (SNOM) to observe the near-field distribution of surface plasmon polaritons (SPPs) from a ring-shaped metasurface under illumination of circularly polarized light. It was found that with an additional degree of freedom of the geometric phase provided by the regularly arranged metamolecules, control over the near-field interference of the SPPs can be achieved, which is governed by the metasurface geometric symmetry that can be tuned by its topological charge.

**19:20 : Probing and Controlling Negative Photoconductivity of Plasmonic Nanowire**

**Jihye Lee, Jiyoung Yoon, Sang-Heon Park, Jong-Souk Yeo**

*Yonsei University (Korea)*

Here, we investigate the photoresponsivity by changing the wavelength of incident light on plasmonic nanowires with their resonant scattering colors in visible wavelength. By varying the wavelength of light and its coherency, we probe and control the negative photoconductivity of gold nanowire based on localized surface plasmon resonance (LSPR), surface plasmon polariton (SPP), and perturbation related damping mechanisms.

**19:35 : Probing Spin-Orbit Interaction via Fano Interference**

**Rajesh Desapogu, Dima Cheskis, Shmuel Sternklar, Yuri Gorodetski**

*Ariel University (Israel)*

We experimentally present a novel plasmonic phenomenon of Fano interference in plasmonic wavefront excitation by a nanoscale structure which is strongly affected by the spin-orbit interaction. This effect allows to directly probe the helical phase arising in the plasmon coupling process.

**19:50 : Controlling Transmission, Reflection and Absorption of Graphene-MoS<sub>2</sub> Micro-gratings with Help of a Liquid Crystal**

**Victor Reshetnyak<sup>1</sup>, Victor I. Zadorozhnyi<sup>1</sup>, Igor P. Pinkevych<sup>1</sup>, Timothy J. Bunning<sup>2</sup>, Dean R. Evans<sup>2</sup>**

<sup>1</sup>Taras Shevchenko National University of Kyiv (Ukraine), <sup>2</sup>Air Force Research Laboratory (USA)

The transmission, reflection and absorption of a far-infrared wave are calculated for electromagnetic wave normally incident onto MoS<sub>2</sub> and graphene-MoS<sub>2</sub> micro-ribbon gratings placed between a nematic liquid crystal (LC) slab and an isotropic dielectric medium. The spectral characteristics depend on the grating spacing, micro-ribbon width, and conductivity of the ribbons. The influence of the LC orientational state on the grating optics enables control of the transmission, reflection and absorption.

**17:00 - 18:20 — Discoteca Pietra di Luna**

**Session 4A14**

**Bio-Engineered Metamaterials and Plasmonics**

Organized by: Alasdair W. Clark

Chaired by: Alasdair W. Clark

**17:00 : Invited talk**

**Fluorous directed facial selectivity of DNA origami structures on surfaces for the assembly of plasmonic nanoparticles**

**Sarah Louise Henry<sup>1</sup>, Gabriella Flynn<sup>1</sup>, Andrea Taladriz Sender<sup>2</sup>, Jamie Withers<sup>2</sup>, Nadia Chaher<sup>1</sup>, Glenn Burley<sup>2</sup>, Alasdair Clark<sup>1</sup>**

<sup>1</sup>University of Glasgow (United Kingdom), <sup>2</sup>University of Strathclyde (United Kingdom)

Facial selectivity of DNA structures is key for the creation of effective self-assembling building platforms. Typically, DNA nanostructures are made in liquid and deposition onto surfaces occurs in random orientation. In this work we functionalised one face of a DNA origami structure with fluorous labelled DNA strands to control the orientation of the structure on a surface.

**17:20 : Invited talk**

**Utilising Nature's Biological Toolkit to Control the Enhancement of Raman Scattering through DNA Hybridisation**

**Jennifer Gracie, Karen Faulds, Duncan Graham**

*University of Strathclyde (United Kingdom)*

Plasmonic nanoparticle assemblies can be meticulously engineered to give greater control of the surface enhanced Raman scattering (SERS) effect. Nanoparticle hot-spots can be purposely formed by exploiting the specificity of biological molecules such as DNA, this increases the SERS intensity observed. Bacterial and viral infections, and even genetic mutations, can be accurately diagnosed through the symbiotic interplay between noble metal nanoparticles and specific sequences of DNA. Herein, key examples of biological nanoparticle assemblies from our research group will be discussed.

**17:40 : Invited talk**

**Surface Enhanced Raman Scattering-Active Nanoparticle Assemblies for the Probing of Protein-Carbohydrate Interactions and their Applications**

**Craig Ward<sup>1</sup>, Karen Faulds<sup>1</sup>, Daniel Bracewell<sup>2</sup>, Duncan Graham<sup>1</sup>**

<sup>1</sup>University of Strathclyde (United Kingdom), <sup>2</sup>University College London (United Kingdom)

Protein-Carbohydrate interactions are prevalent in biological systems, and are known to be vitally important for various processes, including cellular recognition, and host-pathogen interactions. Here, we have taken advantage of these processes to, first of all, probe the interactions between carbohydrates and lectins, using

assemblies of surface enhanced Raman scattering (SERS)-active nanoparticles. We have then moved on to disease detection and biopharmaceutical glycosylation analysis using similar assembly processes, monitored by localized surface plasmon resonance shifts in extinction spectroscopy, and SERS.

**18:00 : Invited talk**

**Optogenetic, tissue clearing, and viral vector approaches to understand and influence whole-animal physiology and behavior**

**Viviana Gradinaru**

*Caltech (USA)*

Our research group at Caltech develops and employs optogenetics (control of neuronal circuits with light), tissue clearing for optical access into deep tissue, and viral vectors to gain new insights on circuits underlying locomotion, reward, and sleep. In addition to control of neuronal activity we need feedback on how exactly the tissue is responding to modulation. We have worked on two related topics: optical voltage sensors and imaging of single molecule RNA in cleared tissue.

**18:20 - 18:50 — Discoteca Pietra di Luna**

**Session 4A15**

**Chiral and Bianisotropic Materials**

Chaired by: Thierry Verbiest

**18:20 : Broadband and high-efficiency wavefront manipulation based on chiral metamaterials**

**Chaoqun Fang, Chao Wu, Zhijie Gong, Song Zhao, Anqi Sun, Zeyong Wei, Hongqiang Li**

*Tongji University (China)*

Wave front shaping devices based on PancharatnamBerry (PB) phase possess broadband manipulating range owing to its frequency-independent feature. Chiral metamaterials can achieve high-efficiency circular polarization regulation in a broadband frequency range. Combining with the frequency independent PB phase, broadband and high-efficiency wave front shaping devices can be realized with chiral metamaterials.

**18:35 : Large Area Fabrication of 2D Chiral Plasmonic Nanoparticles**

**Vladimir E. Bochenkov**

*Lomonosov Moscow State University (Russia)*

Large-area arrays of substrate-supported chiral plasmonic gold particles with comma-like shape have been manufactured using a new colloidal lithography technique with in-situ formed silica resist layer and glancing angle evaporation. The structures support three localized plasmon resonance modes spanning from visible to near infrared spectral region and exhibit a pronounced circular dichroism.

**17:00 - 17:40 — Birreria Dresden Green**

**Session 4A16**

**Plasmon-Induced Hot Carrier: Fundamentals and Applications II**

Organized by: Qin Chen and Xiaofeng Li

Chaired by: Qin Chen and Xiaofeng Li

**17:00 : Invited talk**

**Hot-electron generation in plasmonic nanostructures with hot spots: Quantum mechanisms**

**Alexander O. Govorov, Lucas V. Besteiro, Xiang-Tian Kong**

*Ohio University (USA)*



Generation of energetic (hot) electrons is an intrinsic property of any plasmonic nanostructure under illumination. Simultaneously, a striking advantage of metal nanocrystals over semiconductors lies in their very large absorption cross sections. Therefore, metal nanostructures with strong and tailored plasmonic resonances are very attractive for photocatalytic applications in which excited electrons play an important role. Here we develop a theory describing the hot electron production.

**17:20 : Invited talk**

**Electrical generation of hot electrons in plasmonic nanorod metamaterials**

**Pan Wang, Alexey Krasavin, Mazhar Nasir, Wayne Dickson, Anatoly Zayats**

*King's College London (United Kingdom)*

We report electrical generation of hot electrons and plasmons in plasmonic nanorod metamaterials by electron tunnelling. The large flux of hot electrons makes the tunnel junctions highly reactive, facilitating strongly confined chemical reactions in the junctions which results in dramatic changes in tunnelling current and light emission (radiative decay of tunnelling-induced plasmons).

**17:40 - 19:10 — Birreria Dresden Green**

**Session 4A17**

**Photo/Thermal Conversions and Their Applications**

Organized by: Qiang Li

Chaired by: Min Qiu

**17:40 : Invited talk**

**Opto-Thermal Nano-Tools for Advanced Materials and Life Sciences**

**Linhan Lin, Yuebing Zheng**

*The University of Texas at Austin (USA)*

Through turning disadvantages to advantages, we develop various low-power opto-thermal nano-tools based on the plasmon-enhanced opto-thermal effect, including bubble printer, opto-thermal tweezers, and opto-thermal scissors. With their simple optics, low operation power, and wide applicability, these opto-thermal nano-tools will find applications in materials science and life sciences such as fabrication of colloidal meta-molecules, bio-sensing, and early disease diagnosis.

**18:00 : Invited talk**

**Resonant laser printing of optical metasurfaces**

**Xiaolong Zhu<sup>1</sup>, N. Asger Mortensen<sup>2</sup>, Uriel Levy<sup>3</sup>, Anders Kristensen<sup>1</sup>**

<sup>1</sup>*Technical University of Denmark (Denmark)*, <sup>2</sup>*University of Southern Denmark (Denmark)*, <sup>3</sup>*The Hebrew University of Jerusalem (Israel)*

Optical metasurfaces realized by the state-of-the-art nanofabrication technologies have offered the control of light with nanoscale metallic or dielectric elements. Most of them rely on the ability to precisely control its individual meta-elements within the subwavelength scale. The absorption in metallic or dielectric elements provides a new route for photo-to-thermal conversions and processing. Here, we introduce a resonant laser printing (RLP) technique as a flexible photo-thermal post-writing technology for mass-customization of optical metasurfaces.

**18:20 : Invited talk**

**Narrow-band thermal emitter by coupling of cavity and Tamm plasmon resonances**

**Zhiyu Wang<sup>1</sup>, J. Kenji Clark<sup>1</sup>, Ya-Lun Ho<sup>1</sup>, Bertrand Vilquin<sup>2</sup>, Hirofumi Daiguji<sup>1</sup>, Jean-Jacques Delaunay<sup>1</sup>**

<sup>1</sup>*The University of Tokyo (Japan)*, <sup>2</sup>*Université de Lyon (France)*

By coupling an optical cavity mode to a Tamm plasmon mode, an efficient and spectrally selective thermal emitter is realized. The proposed structure, which can be fabricated without the need for patterning steps, produces narrow-band thermal emission with both low angular dependence and low background emission. A thermally induced emittance peak is produced with a maximum peak emittance of  $\sim 0.90$  and a full width at

half maximum of 54 nm.

**18:40 : Plasmonic Membranes: Control of Fluid Flow through Light**

**Ana Sousa-Castillo<sup>1</sup>, Leonardo N. Furini<sup>1</sup>, Brylee David B. Tiu<sup>2</sup>, Peng-Fei Cao<sup>3</sup>, Begum Topcu<sup>1</sup>, Miguel Comesana-Hermo<sup>1</sup>, Benito Rodriguez-Gonzalez<sup>1</sup>, Walid Baaziz<sup>4</sup>, Ovidiu Ersen<sup>4</sup>, Rigoberto C. Advincula<sup>3</sup>, Moises Perez-Lorenzo<sup>1</sup>, Miguel A. Correa-Duarte<sup>1</sup>**

*<sup>1</sup>Universidad de Vigo (Spain), <sup>2</sup>University of California Berkeley (USA), <sup>3</sup>Case Western Reserve University (USA), <sup>4</sup>CNRS-Strasbourg University (France)*

A novel generation of porous substrates endowed with synergistic sensing and actuating capabilities opens the door to a paradigm shift in membrane technology. Through this synthetic approach, commercial membranes can be easily retrofitted allowing for an unprecedented control over fluid flow in response to an external light stimulus.

**18:55 : Thermoplasmonic metasurfaces for energy applications - Solar-heated windows and energy harvesting from random light fluctuations**

**Magnus Jonsson**

*Linköping University (Sweden)*

I will present our recent research on utilizing plasmonic heat generation for passive thermal management and active energy harvesting.

# Saturday 30th June, 2018

08:00 - 09:40 — Salone Teodora

## Session 5A1

### Shaping Light Using Photonic Integrated Devices

Organized by: Jian Wang

Chaired by: Jian Wang

08:00 : **Invited talk**

#### Shaping Light with an Inclusion: Contribution of Multipoles in Scattering Effect on Waveguide

Alina Karabchevsky<sup>1</sup>, Yuriy A. Artemyev<sup>1</sup>, Nikita Volsky<sup>1</sup>, Alexey A. Basharin<sup>2</sup>, Alexander S. Shalin<sup>3</sup>

<sup>1</sup>Ben-Gurion University (Israel), <sup>2</sup>National University of Science and Technology (MISiS) (Russia), <sup>3</sup>ITMO University (Russia)

Spectral multipole resonances of cylindrical inclusion embedded in a waveguide core and excited by guided optical mode are numerically explored. Here, we show that the scattered light can be shaped by means of the cylindrical inclusion filled with air in optical waveguide. A numerical FDTD method is applied for the calculations of the scattering cross sections. The contribution of multipole moments to the scattering effect is analyzed using our reformulation of the semi-analytical multipole decomposition approach.

08:20 : **Invited talk**

#### Light wavefront manipulation using dielectric metasurfaces

Yan Li, Bo Wang, Qitong Li, Dong Yang, Hang Feng, Qihuang Gong

Peking University (China)

Light wavefront manipulation using dielectric metasurfaces was demonstrated. By spin manipulation and wavelength multiplexing, we can change the color of, not only the entire holographic image reconstructed from a silicon-on-insulator metasurface hologram, but also of defined parts of it. We design and fabricate the Rochon-prism-like planar circularly polarized beam splitters based on silicon metasurfaces by simultaneously controlling the geometric phase and the propagation phase via manipulation of the orientations and the sizes of the constituent silicon nanoblocks.

08:40 : **Invited talk**

#### Integrated OAM Laser at Telecom Wavelengths

Changzheng Sun<sup>1</sup>, Juan Zhang<sup>1</sup>, Bing Xiong<sup>1</sup>, Jian Wang<sup>1</sup>, Zhibiao Hao<sup>1</sup>, Lai Wang<sup>1</sup>, Yanjun Han<sup>1</sup>, Hongtao Li<sup>1</sup>, Yi Luo<sup>1</sup>, Takuo Tanemura<sup>2</sup>, Yoshiaki Nakano<sup>2</sup>, Xinlun Cai<sup>3</sup>, Siyuan Yu<sup>3</sup>

<sup>1</sup>Tsinghua University (China), <sup>2</sup>Department of Electrical Engineering and Information Systems (Japan), <sup>3</sup>Sun Yat-Sen University (China)

An integrated OAM laser operating at telecom wavelengths will be presented. Vortex beam is generated by monolithically integrating an optical vortex emitter with a distributed feedback (DFB) laser on the same InGaAsP/InP epitaxial wafer. The device is believed to have promising potential for applications in fiber communications and quantum optics.

09:00 : **Invited talk**

#### Optical Vortices Generation with Metallic Nano-Slit

Xue Feng, Xuesi Zhao, Yidong Huang

Tsinghua University (China)

We have proposed a novel method of utilizing the propagation induced radial phase gradient of incident Laguerre-Gaussian (LG) beam to sculpture PVs from integer to fractional OAM dynamically. Furthermore, a series of plasmonic devices are proposed to generate multi-patterned and two-dimensional optical lattice with helicity or not.

**09:20 : Invited talk**

**Nonlinear Metasurface for Simultaneous Control of Spin and Orbital Angular Momentum**

**Guixin Li**

*Southern University of Science and Technology (China)*

Here, we report the generation of spin controlled OAM of light in harmonic generations by using ultrathin photonic metasurfaces. The spin manipulation of OAM mode of harmonic waves is experimentally verified by using second harmonic generation (SHG) from gold meta-atom with three-fold rotational symmetry. By introducing nonlinear phase singularity into the metasurface devices, we successfully generate and measure the topological charges of spin-controlled OAM mode of SHG through an on-chip metasurface interferometer.

**08:00 - 10:10 — Sala Desirée**

**Session 5A2**

**Novel Guided Wave Configurations with Nanostructures for Emerging Applications**

Organized by: Alina Karabchevsky

Chaired by: Alina Karabchevsky

**08:00 : Invited talk**

**Anti-Reflective All-Dielectric Metasurfaces Engraved on an Optical Waveguide Facet**

**Alina Karabchevsky, Yakov Galutin**

*Ben-Gurion University (Israel)*

For each value of refractive index  $n$ , there exists an optimum shape of the particle that produces a minimum back-scattering together with a maximum forward scattering. This effect can be metasurface-engineered. Here we show, that randomly-distributed anti-reflective structures (RAS) have a superior anti-reflective (far-field back-scattering) properties compared to the periodic anti-reflective surfaces - both engraved on the optical waveguide facet.

**08:20 : Invited talk**

**Metamaterial substrates for optomechanical applications**

**Aliaksandra Ivinskaya<sup>1</sup>, Natalia Kostina<sup>1</sup>, Mihail I. Petrov<sup>1</sup>, Andrey A. Bogdanov<sup>1</sup>, Sergei Sukhov<sup>2</sup>, Pavel Ginzburg<sup>3</sup>, Alexander S. Shalin<sup>1</sup>**

<sup>1</sup>ITMO University (Russia), <sup>2</sup>University of Central Florida (USA), <sup>3</sup>Tel Aviv University (Israel)

The optical force acting on a nanoparticle near a planar substrate is governed by incident light and excitation of surface and volume modes of the substrate. We study system configurations leading to significant enhancement of optical forces, for example, plane wave results in pulling forces towards the source for certain types of anisotropic substrates.

**08:40 : Invited talk**

**Low-contrast photonic hook manipulator for cellular differentiation**

**Angeleene Ang<sup>1</sup>, Igor Minin<sup>2</sup>, Oleg Minin<sup>2</sup>, Sergey Sukhov<sup>3</sup>, Alexander Shalin<sup>4</sup>, Alina Karabchevsky<sup>1</sup>**

<sup>1</sup>Ben-Gurion University (Israel), <sup>2</sup>Siberian Scientific Research Institute of Metrology (Russia), <sup>3</sup>University of Central Florida (USA), <sup>4</sup>ITMO University (Russia)

By illuminating an asymmetric cuboid, the photonic hook is generated, a specialized curved photonic jet. In this work, we numerically explored the optical forces generated by the photonic hook's field, and found that the cuboid system can move large objects along a curved trajectory. We considered the interaction of this cuboid in the presence of a backing substrate, as our system is simple enough to be embedded in a 'lab-on-a-chip' platform, and possible applications for cellular differentiation.

**09:00 : Coupling of Phononic Cavities in a Corrugated Nanobeam and Control of Transmission**

**A. V. Korovin, Y. Pennec, B. Djafari Rouhani**

*University of Lille (France)*

We study theoretically the acoustic wave propagation in a corrugated nanobeam structure containing two coupled phononic cavities. The coupling of their localized modes can be used for the modulation of the frequency and the quality factors of the cavity modes and their contribution to transmission. Additionally, when a phonon source is inserted in each cavity (potentially by optomechanical effect), the emission of phonons to the nanobeam waveguide can be tuned and become different towards the left or the right

**09:15 : Invited talk**

**Si Nanostrip Optical Waveguide for Molecular Overtone Spectroscopy**

**Aviad Katiyi, Alina Karabchevsky**

*Ben-Gurion University (Israel)*

The ability to probe the molecular fundamental or overtone vibrations is central to modern health-care monitoring techniques because it provides an information about the molecular structure. However, since the absorption cross-section of molecular vibrations overtones is much smaller compared to the absorption of the fundamental vibrations, their detection is challenging. Here, a silicon rib waveguide is proposed for label-free on-chip overtone spectroscopy in near-infrared. Our spectrometer distinguished several organic liquids such as N-methylaniline and aniline without any surface modification.

**09:35 : Invited talk**

**Advances in Shaping Light Using Photonic Metasurfaces**

**Jian Wang**

*Huazhong University of Science and Technology (China)*

In the past few years, photonic metasurfaces (meta-structures) and structured light have both attracted increasing interest in many emerging applications. Here, we will talk about very recent advances in flexible structured light manipulation using photonic metasurfaces. Shaping light with plasmonic and dielectric metasurfaces on a diversity of platforms such as metal film, silica, silicon and fiber will be presented. Future challenges and perspectives will be also discussed in the end.

**09:55 : Residue Number System Arithmetic based on Integrated Nanophotonics**

**Jiixin Peng, Shuai Sun, Vikram K. Narayana, Volker J. Sorger, Tarek El-Ghazawi**

*The George Washington University (USA)*

Residue number system (RNS) enables dimensionality reduction of an arithmetic problem by representing a large number as a set of smaller integers. Here we show an optical RNS adder and multiplier based on integrated nanophotonic in digit-wise shifting, expressed as spatial routing of an optical signal in 2x2 hybrid photonic-plasmonic switches. Our photonic arithmetic processor reaches 10's ps computational execution time given by the optical propagation delay through integrated nanophotonic router, showing in-the-network photonic processing.

**08:30 - 09:50 — Discoteca Pietra di Luna**

**Session 5A3**

**Nonlinear Metasurfaces and Plasmonics IV**

Organized by: Guixin Li and Dangyuan Lei

Chaired by: Guixin Li and Tun Cao

**08:30 : Invited talk**

**Refractometric Sensing Using Gradient Plasmonic Nanostructures: Mapping Spectral Information to Spatial Patterns**

**Wen-Di Li, Siyi Min, Shijie Li, Zhouyang Zhu, Chuwei Liang, Jingxuan Cai**

*The University of Hong Kong (China)*

We report a spectrometer-free, pattern-based refractometric sensing scheme. This new detection scheme uses gradient plasmonic nanostructures to map spectral information to spatial locations and then use commercial imaging sensors, rather than spectrometers, to detect pattern change induced by local refractive index

change due to adsorbed analyte molecules. Our preliminary results show the sensitivity performance of this new method can be comparable to conventional spectrometer-based methods, but with much more compact and cost-effective setup.

**08:50 : Invited talk**

**Generation and Enhancement of UV-Harmonic Wave at Nonlinear Interfaces**

**Xiaohui Zhao<sup>1</sup>, Yuanlin Zheng<sup>2</sup>, Yanqi Gao<sup>1</sup>, Yong Cui<sup>1</sup>, Daxing Rao<sup>1</sup>, Xianfeng Chen<sup>2</sup>**

<sup>1</sup>China Academy of Engineering Physics (China), <sup>2</sup>Shanghai Jiao Tong University (China)

We investigate the enhancement of ultraviolet second-harmonic radiation at a nonlinear interface with large disparity in second-order susceptibility. The intensity of second harmonic wave generated at the nonlinear interface was up to 11.6 times at the crystal boundary.

**09:10 : Invited talk**

**Metasurface-assisted plasmonic wavefront modulation with incident polarization**

**Luping Du, Chonglei Zhang, Jiao Lin, Xiacong Yuan**

Shenzhen University (China)

I will introduce our recent work on manipulating and harnessing surface plasmon polaritons (SPPs) with incident polarization. A pair of rectangular-shaped nano-grooves as a meta-atom is employed for launching the SPPs. This kind of novel structured surfaces provides us more degrees of freedom on manipulating the SPPs, yielding many attractive techniques such as super-resolved imaging, on-chip nano-devices, etc.

**09:30 : Invited talk**

**Controlling Light by Metasurfaces in the Linear and Nonlinear Regimes**

**Mengxin Ren, Di Zhang, Ninghui Gao, Wei Wu, Jingjun Xu**

Nankai University (China)

Manipulation of light-matter interactions by tailored artificial microstructures is a key aspect of optics. During past decades, the developments of metamaterials or metasurfaces have provided a range of possibilities, for example nano-focusing, ultra-compact wave-plates, and low threshold optical switching, and so forth. In this talk we will give introductions to our recent works about controlling light in the matters of linear and nonlinear interactions in plasmonic metasurfaces, including light polarization control, beam splitting, and chromatic beam dispersing.

**08:00 - 08:35 — Birreria Dresden Green**

**Session 5A4**

**Functional Materials and Devices for Lighting and Display**

Chaired by: Yang Zhao

**08:00 : Invited talk**

**Control Photon Dynamics in Circuit Quantum Electrodynamics by Manipulating Qubits through a Phonon Bath**

**Fulu Zheng<sup>1</sup>, Yuyu Zhang<sup>2</sup>, Lu Wang<sup>3</sup>, Yadong Wei<sup>3</sup>, Yang Zhao<sup>1</sup>**

<sup>1</sup>Nanyang Technological University (Singapore), <sup>2</sup>Chongqing University (China), <sup>3</sup>Shenzhen University (China)

Bath induced effects on a circuit quantum electrodynamics (QED) system are investigated with the Dirac-Frenkel time-dependent variational principle combined with the multiple Davydov D2 ansatz. The target system is a Rabi dimer with the qubits coupled to a phonon bath. It is found that the photon dynamics can be controlled by tuning the qubit bath coupling strength. The QED device proposed here is experimentally feasible and can be applied for the studies of fundamental quantum physics.

**08:20 : Some electronic transport properties of nanostructure HgTe/CdTe superlattice for mid infrared and terahertz detection**

**Nassima Benchtaber, Abdelhakim Nafidi, Abderrazak Boutramine, Driss Barkissy, Rachid Ben Koujan,**



**Ahmed Tirbiyine***University Ibn Zohr (Morocco)*

We report here on electronic bands structure and effective mass of HgTe/CdTe nanostructured superlattice (SL). We interpreted Hall Effect and calculated the density of states and the Fermi level as a function of temperature. The later reveal that temperature induced transitions p type to n type conductivity and quasi bidimensional to three dimensional holes and electrons, respectively.

**08:35 - 09:15 — Birreria Dresden Green****Session 5A5****Wave Propagation in Acoustic and Elastic Metamaterials: Novel Design and Practical Applications III**

Organized by: Marco Miniaci and Guancong Ma

Chaired by: Marco Miniaci and Guancong Ma

**08:35 : Invited talk****Extraordinary wave dynamics in time-Floquet acoustic systems****Theodoros Koutserimpas, Romain Fleury***Ecole Polytechnique Fédérale de Lausanne (EPFL) (Switzerland)*

We discuss our recent research advances about wave control and manipulation using periodic temporal modulation of a system's properties. By using the unique properties of time-Floquet systems, we construct acoustic metamaterials with extreme effective properties, such as zero index of refraction. Furthermore, the interaction with a periodic drive can lead to power exchange with the wave, providing a unique route to non-Hermiticity. We demonstrate non-Hermitian acoustic systems based on time modulation, such as Parity-Time symmetric parametric amplifiers.

**08:55 : Invited talk****Asymmetrical sound transmission through acoustic metasurfaces****Yun Jing***North Carolina State University (USA)*

This paper will discuss two different designs to achieve asymmetrical sound transmission. The first design consists of a layer of gradient-index metasurface and a layer of low refractive index metasurface. Numerical simulations show that the approach provides high transmission contrast between the two incident directions within the designed frequency band. In the second design, we show that robust and tunable acoustic asymmetric transmission can be achieved through gradient-index metasurfaces by harnessing judiciously tailored losses. We further experimentally demonstrate this novel phenomenon.

**Session 5P1****Poster Session IV****10:15 - 11:00****P1: Large Enhancement of the Goos-Hanchen shift and Fragmentation of the Reflected Beam due to the Excitation of Surface Plasmons****Sangbum Kim, Kihong Kim***Ajou University (Korea)*

It is shown theoretically that, when a p wave Gaussian beam is incident on a meta-dielectric boundary and excites surface plasmons, the Goos-Hanchen shift can be enhanced greatly. The maximum size of the negative Goos-Hanchen shift is shown to decrease as the beam width decreases. The spatial distribution of the field intensity associated with the reflected beam shows that there appears a fragmentation of the reflected

beam when the width of the incident beam is sufficiently small.

### **P2: Lasing Cavity based on Defect Modes in 2D Groove Metal Array inside MIM Structure**

**Seong-Han Kim, Chul-Sik Kee**

*Advanced Photonics Research Institute GIST (Korea)*

We propose and numerically investigate a metallic resonant cavity for lasing infrared light based on guided spoof SPPs on 2D groove metal array. To design a resonant cavity, we demonstrate guiding modes on 2D groove metal array with a line defect inside metal-insulator-metal structure. Furthermore, we examine the lasing performance of the resonant cavity by introducing gain medium.

### **P3: On-Chip Sensing and Multiplexing Platform for miRNA in Cancer Cell based on Nanoplasmonics**

**Sang-Heon Park, Jihye Lee, Jong-Souk Yeo**

*Yonsei University (Korea)*

We demonstrate on-chip colorimetric sensing platform by using nanoplasmonics. By using an emitting and quenching characteristic of quantum dot and gold nanoparticle, we can distinguish the different type of miRNA in gastric cancer cell, thus enabling the multiplexing platform for maximizing the usefulness for clinical sensing applications.

### **P4: Hybrid plasmonic-vanadium dioxide electro-optical switch based modulator**

**Mohamed Y. Abdelatty<sup>1</sup>, Mohamed A. Swillam<sup>2</sup>**

*<sup>1</sup>American University in Cairo (Egypt), <sup>2</sup>The British University in Egypt (Egypt)*

This work presents the study and the design of optical switch based on a hybrid plasmonic-vanadium dioxide based waveguide, with a power-attenuating mechanism that takes the advantage of the phase change properties of vanadium dioxide that exhibits a change in the real and complex refractive indices upon switching from the dielectric phase to the metallic phase. The proposed switch designed to operate under the telecommunication wavelength. The switch was analyzed by 3D full electro-magnetic simulations.

### **P5: Extraordinary Transmission in Mid-IR through a perforated doped silicon film**

**Hosam Mekawey, Yehea Ismail, Mohamed Swillam**

*American University in Cairo (Egypt)*

In this work, the plasma dispersion effect is introduced into silicon film with an array of subwavelength holes. The effect on the modes of the rectangular hole and their dispersion is studied. The transmission through such hole array is investigated showing an extraordinary transmission (EOT). In case of doped silicon, the EOT is observed in the near and mid-IR range instead of the visible range. By tuning the doping level, the EOT characteristics can be tuned and engineered.

### **P6: Analytical study of the chiral optical force on spherical nano-objects**

**Hipolito A. Arredondo Champi, Rina H. Bustamante, Walter J. Salcedo**

*Polytechnic School of the University of Sao Paulo (Brazil)*

We analytically studied the chiral optical force on dielectric nano-objects with spherical shape and we have found optimal conditions so that they can be captured and repelled depending on their chirality parameter. The results showed that the mechanism of the trap depends strongly on the near-field intensification and the non-orthogonality of external fields. Finally, we demonstrate that a racemic sample can be separated enantiomerically for low contrasts of material between the particle and the host medium.

### **P7: Silicon-based Nanoscale Plasmonic Bowtie Nanoantenna in the Mid-IR**

**Hosam Mekawey, Yehea Ismail, Mohamed Swillam**

*American University in Cairo (Egypt)*

Much research was conducted on enhancing of the localized field through the Plasmonic effect on metallic nanostructures. Here, we investigate replacing metals such as gold with doped silicon for designing a bowtie nanoantenna operating in the mid-IR. The objective is to be able to integrate such nanoantenna into optoelectronic circuits manufactured using standard Complimentary-Metal-Oxide Semiconductor (CMOS) fabrication process. A study of the effect of manipulating the geometrical design parameters on the enhancement level and spectral range was also conducted.

### **P8: Biased-modulating photodetector using graphene embedded carbon film/n-Si heterojunction**

**Xi Zhang, Luping Du**

*Shenzhen University (China)*

We proposed a bias-modulating graphene embedded carbon (GEC) film/n-Si photodetector with electron trapping centers enabled by high-density edges of standing structured graphene-nanocrystallines. The bias-induced tunability of the relative positions of the Fermi levels that enables a high photocurrent responsivity of 0.35A/W. A fast response time of 2.2 $\mu$ s was also achieved.

#### **P9: Phase resonances in all dielectric compound silicon gratings**

**Jian Qiang Liu, Yu Xiu Zhou, Guang Hou Sun, Xia Qin Zeng**

*Jiujiang University (China)*

We theoretically demonstrate phase resonances occur at all dielectric compound silicon gratings consisting of three identical pillars in each unit cell. It is shown phase resonance with out of phase distribution of magnetic field within the silicon pillars of each unit cell appear mainly at the first order Mie resonance under TM polarized normal incidence.

#### **P10: Performance-enhanced side-polished fiber sensor by exciting long-range surface plasmon polariton**

**Hui Zhang<sup>1</sup>, Xinjie Feng<sup>2</sup>, Yaofei Chen<sup>2</sup>, Kai Xia<sup>2</sup>, Miao He<sup>1</sup>, Yunhan Luo<sup>2</sup>**

<sup>1</sup>*Guangdong University of Technology (China)*, <sup>2</sup>*Jinan University (China)*

A side-polished fiber sensor with magnesium fluoride as a dielectric buffer layer has been proposed to enhance performances by exciting long-range surface plasmon polariton (LRSPP) mode. Utilizing transfer matrix method, the theoretical design optimization was carried out and the corresponding experimental validation was performed and analyzed. The optimized result indicated that with the introduction of MgF<sub>2</sub> buffer layer, the sensing performances were enhanced and the FOM of LRSPP-based sensor exceeded that of CSPR-based sensor by a factor of 1.14.

#### **P11: New Type of Switching Cell Based on Optical Metamaterial and Optically Transparent Ferrite**

**Konstantin Vytovtov<sup>1</sup>, E. Barabanova<sup>1</sup>, Said Zouhdi<sup>2</sup>**

<sup>1</sup>*Astrakhan State Technical University (Russia)*, <sup>2</sup>*Paris-Sud University (France)*

In this work we offer the brand new type of switching cell with four inputs and four outputs. The operation principle is based on spatial deviation of the optical beam due to a change in the magnetic permeability of the transparent ferrite garnet. Additionally the spatial diversity of the rays is achieved through the use of metamaterial.

#### **P12: Application of Semiconductor into Solar Cells using Lorentzian-Drude Model**

**Rifa J. El-Khozondar, Hala J. El-Khozondar, Mohammad M. Shabat**

*Islamic University of Gaza (Palestine)*

In this work, a four layer solar cell is introduced. The active layer are nanoparticles (Ag) embedded in a dielectric media and semiconductor layer (Si) layer surrounded by air and glass layers. Hybrid transmission Matrix is used to find the average reflection and transmission power. Results are promising to solar cell designers.

#### **P13: Light manipulation through plasmonic metasurfaces based on functional patterns**

**Mario Miscugli<sup>1</sup>, Davide Spirito<sup>2</sup>, Davide Spirito<sup>2</sup>, Beatriz Martin-Garcia<sup>2</sup>, Remo Proietti Zaccaria<sup>2</sup>, Alexander Weber-Bargioni<sup>1</sup>, Roman Krahn<sup>2</sup>**

<sup>1</sup>*Lawrence Berkeley National Lab (USA)*, <sup>2</sup>*Istituto Italiano di Tecnologia (Italy)*

We investigate the plasmonic effects in gold functional patterns using numerical simulations, near field and two-photon spectroscopy. These patterns consist of gold rhomboidal elements whose size and position is defined according to a grating function. By a proper choice of this function, the near field intensity and phase in the pattern can be redistributed in non-trivial ways, by exploiting multiple localized surface resonances and near field coupling between the elements.

#### **P14: Direct Observation of Semiconductor-Metal Phase Transition in Bilayer Tungsten Diselenide Induced by Potassium Surface Functionalization**

**Bo Lei<sup>1</sup>, Yuanyuan Pan<sup>2</sup>, Zehua Hu<sup>1</sup>, Jialin Zhang<sup>1</sup>, Du Xiang<sup>1</sup>, Yue Zheng<sup>1</sup>, Rui Guo<sup>1</sup>, Cheng Han<sup>3</sup>, Lianhui Wang<sup>4</sup>, Jing Lu<sup>5</sup>, Li Yang<sup>2</sup>, Wei Chen<sup>1</sup>**

<sup>1</sup>*National University of Singapore (Singapore)*, <sup>2</sup>*Washington University in St. Louis (USA)*, <sup>3</sup>*Shenzhen University (China)*, <sup>4</sup>*Nanjing University of Posts and Telecommunications (China)*, <sup>5</sup>*Peking University (China)*

Structures determine properties of materials and controllable phase transitions are, therefore, highly desirable for exploring exotic physics and fabricating devices. We report a direct observation of a controllable semiconductor-metal phase transition in bilayer tungsten diselenide (WSe<sub>2</sub>) with potassium (K) surface functionalization.

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