MONo: Opening Session

Chaired by Nikolay Zheludev & Herald Giessen

Time: Monday 7:50–8:00 Location: Olympia

Opening remarks by Nikolay Zheludev & Harald Giessen

MON1o: Plenary Talk 1

Chaired by Mordechai Sergev, Technion, Haifa, Israel

Time: Monday 8:00–8:45 Location: Olympia

Plenary Talk MON1o.1 *(23)* Mon 8:00

Nanowire Photonics & Single Cell Endoscopy — •Peidong Yang — Department of Chemistry, University of California, Berkeley

Semiconductor nanowires represent a new class of semiconductor materials for investigating light generation, propagation, detection, amplification and modulation. I will present an overview on the current status of nanowire synthesis/assembly as well as their photonic applications.

Break

Time: Monday 8:45–8:55 Location: Olympia

Break

MON2o: New Materials

Chaired by Steven Cummer, Duke University, Durham, USA

Time: Monday 8:55–10:05 Location: Olympia

Invited MON2o.1 *(222)* Mon 8:55

From Metatronics to Graphene Nanocircuits — •Nader Engheta — University of Pennsylvania, Philadelphia, USA

We develop a unifying platform that brings together the fields of electronics, photonics, and magnetics, using metamaterials, present experimental realization of metatronic circuits at IR wavelengths, and propose extension of this paradigm to graphene circuitry.

Talk MON2o.2 *(25)* Mon 9:20

Arrays of Carbon Nanotubes as Ideal Backward-Wave Terahertz Metamaterials — •Igor Nefedov, Sergei Tretyakov, and Constantin Simovski — Dept. of Radio Science and Engineering, Aalto University, Finland

We show that arrays of carbon nanotubes (CNT) behave as negative-epsilon materials where spatial dispersion is suppressed by kinetic inductance. As a result, arrays of finite-length CNT support backward waves in extremely wide frequency ranges.

Talk MON2o.3 *(252)* Mon 9:35

Tuning metamaterial properties by a single-layer of graphene — •Nikitas Papasimakis[1], Andrey Nikolanenko[1], Zhiqiang Luo[2], Ze Xiang Shen[2], Francesco De Angelis[3,4], Enzo Di Fabrizio[3,4], Stuart Boden[5], Takashi Uchino[5], and Nikolay Zheludev[1] — [1]Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, SO17 1BJ, UK — [2]School of Physical and Mathematical Sciences, Nanyang Technological University, 637371 Singapore — [3]Italian Institute of Technology, 16163 Genova, Italy — [4]University of Magna Graecia, 88100 Catanzaro, Italy — [5]Department of Electronics and Computer Science, University of Southampton, SO17 1BJ UK

We report on the observation of strong, nontrivial interactions between a plasmonic metamaterial and a graphene single-layer. We argue that these result from the periodic physical deformation of the graphene by the structured metamaterial substrate.

Talk MON2o.4 *(58)* Mon 9:50

Novel plasmonic platform based on nanorod metamaterials — •Wayne Dickson[1], Stephen Beckett[1], Christina McClatchey[2], John McPhillips[2], Robert Pollard[2], Gregory Wurtz[3], and Anatoly Zayats[1] — [1]Department of Physics, King's College London, UK — [2]Centre for Nanostructured Media, Queen's University Belfast, UK — [3]3Department of Applied Physics, University of North Florida, Jacksonville, USA

In this talk, properties and applications of plasmonic nanorod metamaterials will be overviewed for designing new types of nanoscale waveguides, biosensing platforms and nonlinear optical devices with enhanced properties.

MON2s: Bio-nano photonics

Chaired by Monika Ritsch-Marte, Innsbruck Medical University, Austria

Time: Monday 8:55–10:05 Location: Seefeld-Tirol

Invited MON2s.1 *(267)* Mon 8:55

Coherent processes and triggered actuation in plasmonic systems — •Naomi Halas — Rice University, Houston, TX, USA

The combination of plasmonic nanoparticles and DNA provides a controlled approach to label-free DNA detection and to the plasmon-triggered release of molecules, compatible with living cells.

Talk MON2s.2 *(191)* Mon 9:20

Strong Coupling Between Hydrophilic Porphyrin Molecules and Gold Nanorods in Aqueous Solution — •Martin Djiango and Thomas Klar — Institute for Applied Physics, Johannes Kepler University, Linz, Austria

In this contribution, we demonstrate strong coupling effects between hydrophilic Pt-porphyrins and gold nanorods. Due to the hydrophilicity of these porphyrins, they might be better suited to biosensing applications than the hydrophobic porphyrins used in previous experiments.

Talk MON2s.3 *(32)* Mon 9:35

Follow the Fate of Nanomaterials within Biological Systems with CARS — •Julian Moger[1], Natalie Garrett[1], Ijeoma Uchegbu[2], and Charles Tyler[1] — [1]University of Exeter, UK. EX44QL — [2]London School of Parmacy, University of London, 29 - 39 Brunswick square, London WC1N 1AX

The mechanisms by which nanomaterials travel through and modify tissues is not fully understood. We demonstrate the exceptional capability of Coherent Anti-Stokes Raman Scattering (CARS) microscopy for monitoring the fate of nanotechnology within biological systems.

Talk MON2s.4 *(61)* Mon 9:50

Plasmonic Nanopore Array for DNA translocation — •seong soo Choi[1], Myoung Jin Park[2], Nam Kyu Park[3], Dai Sik Kim[4], Seung Min Park[5], Seung Gweon Hong[5], and Luke Lee[5] — [1]Research Center for NanoBio Science, SunMoon University, Ahsan, Chungnam, 336-708 Korea — [2]Deparment of Physic, Korea Military Academy, Seoul Korea — [3]Photonic Systems Laboratory, School of EECS, Seoul National University, Seoul 151-744, Korea — [4]Center for Subwavelength Optics and Department of Physics and Astronomy, Seoul National University, Seoul, Korea — [5]Deparment of Bioengineering, University of California at Berkeley, Ca, USA

Plasmonic nanopores are fabricated on top of the pyramidal probe array. Huge transmission through nanopore is obtained and DNA translocation will be carried out through the nanopres.

Coffee Break

Time: Monday 10:05–10:25 Location: Lobby

Coffee Break

MON3o: THz metamaterials and plasmonics

Chaired by Willie Padilla, Boston College, Chestnut Hill, MA, USA

Time: Monday 10:25–11:55 Location: Olympia

Invited MON3o.1 *(126)* Mon 10:25

Phase Conjugation and Negative Refraction Using Nonlinear Active RF Metamaterials — •Steven Cummer[1], Alexander Katko[1], and Gennady Shvets[2] — [1]Duke University, Durham, NC, USA — [2]The University of Texas at Austin, Austin, TX, USA

We demonstrate experimentally that an array of parametrically pumped active nonlinear radio-frequency metamaterial elements acts as a phase-conjugating, and thus time-reversing and negatively-refracting thin material slab.

Invited MON3o.2 *(261)* Mon 10:50

MEMS Enhanced Metamaterials at Terahertz Frequencies — •Richard Averitt — Boston University, Dept. of Physics and Photonics Center

Metamaterials have enabled the development of new functional electromagnetic devices. The potential repertoire can be increased through the marriage of metamaterials with MEMS. I will present recent examples highlighting the development of thermal THz detectors.

Talk MON3o.3 *(172)* Mon 11:15

Nonlinear THz Response Based on Strong Field Enhancement in Nanostructured Metamaterials — •Hannes Merbold[1], Andreas Bitzer[1], Florian Enderli[1], Anja Weber[2], Laura Heyderman[2], Bruce Patterson[2], Hans Sigg[2], Mostafa Shalaby[3], Marco Peccianti[3], Roberto Morandotti[3], Tsuneyuki Ozaki[3], and Thomas Feurer[1] — [1]Institute of Applied Physics, University of Bern, Silderstrasse 5, CH-3012 Bern, Switzerland — [2]Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland — [3]Institut National de la Recherche Scientifique (INRS-EMT), Université du Québec, 1650 Boulevard Lionel-Boulet, Varennes, QC J3X 1S2, Canada

We investigate the THz response of nanoslit ($\lambda/75{,}000$) arrays in metal films and nanogap split-ring resonators. Both structures exhibit strong field enhancements which can be

used to induce nonlinearities in adjacent materials.

Invited MON3o.4 *(124)* Mon 11:30
THz Generation from Plasmonic Nanoparticle and Nanohole Arrays — •Dmitry Polyushkin — University of Exeter, School of Physics, Exeter EX4 4Ql, UK

We report on the generation of THz pulses via irradiation of arrays of silver nanoparticles and nano-holes by laser pulses. A strong dependence of emission on the incident angle is attributed to enhanced plasmon fields.

MON3s: Nano Antennas 1

Chaired by Javier Garcia de Abajo, IO-CSIC, Madrid, Spain

Time: Monday 10:25–11:55 Location: Seefeld-Tirol

Invited MON3s.1 *(281)* Mon 10:25
Leveraging Enhancement for Advanced Metamaterials — •David Smith — Center for Metamaterials and Integrated Plasmonics and Department of Electrical and Computer Engineering, Duke University, Durham, North Carolina, USA

At visible wavelengths, metamaterials formed from metallic inclusions can exhibit strong field enhancement through the same mechanism as plasmonic nanostructures. This enhancement can form the basis for a class of active and nonlinear metamaterials.

Invited MON3s.2 *(248)* Mon 10:50
Real-Space Imaging of Optical Nanoantennas by apertureless SNOM — •Jens Dorfmüller[1], Ralf Vogelgesang[2], Klaus Kern[2,3], and Harald Giessen[1] — [1]4. Physikalisches Institut and Research Center Scope, Pfaffenwaldring 57, Universität Stuttgart, 70569 Stuttgart, Germany — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, 70569 Stuttgart, Germany — [3]Institut de Physique de la Matière Condensée, École Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

We use apertureless Scanning Near-field Optical Microscopy to study the reception properties of optical nanoantennas. Our experimental results successfully validate a simple analytical model of linear wire antennas and reveal the directivity of Yagi-Uda antennas.

Talk MON3s.3 *(122)* Mon 11:15
Spatially resolved directional emission from plasmonic Yagi Uda antennas — •Toon Coenen, Ernst Jan R. Vesseur, A. Femius Koenderink, and Albert Polman — FOM Institute AMOLF, Amsterdam, The Netherlands,

We present angle-resolved emission spectra from antennas consisting of five Au nanoparticles, measured using a novel cathodoluminescence spectroscopy technique. We find evidence for directional emission of light that depends strongly on the emitter position.

Invited MON3s.4 *(272)* Mon 11:30
Requirements and Limits for Optical Interconnect Devices — •David Miller — Ginzton Lab, Stanford University, Stanford CA 94305-4088

We summarize recent work in device requirements for optical interconnects, in novel device approaches using germanium quantum wells and nanophotonic and nanometallic structures, and in fundamental limits to optical components.

Lunch Break

Time: Monday 11:55–17:00

Lunch Break

MON4o: Advanced Nano-Fabrication 1

Chaired by Byoungho Lee, Seoul National University, South Korea

Time: Monday 17:00–18:15 Location: Olympia

Invited MON4o.1 *(271)* Mon 17:00
Metamaterials Program at Sandia National Laboratories — •Rick McCormick — Sandia National Laboratories, P.O. Box 5800 MS 1415, Albuquerque, NM, 87185, USA

Sandia National Laboratories Metamaterial Science and Technology Program has developed novel HPC-based design tools, wafer scale 3D fabrication processes, and characterization tools to enable thermal IR optical metamaterial application studies.

Invited MON4o.2 *(29)* Mon 17:25
Electrovariable nanoplasmonics and self-assembling smart mirrors — •Alexei A. Kornyshev — Department of Chemistry, Imperial College London

The talk will summarize basic calculations of reflection spectra for various types of functionalized NPs, including core-shell nanoparticles for optimization of the spectrum and fast switching, as well as first experiments, that demonstrate the feasibility of this principle.

Invited MON4o.3 *(132)* Mon 17:50
Sub-10-nm Plasmonic Nanogap Arrays — Hyungsoon Im[1], Kyle Bantz[2], Nathan Lindquist[1], Christy Haynes[2], and •Sang-Hyun Oh[1] — [1]Department of Electrical and Computer Engineering, University of Min-

nesota, Twin Cities, Minneapolis, Minnesota, U.S.A. — [2]Department of Chemistry, University of Minnesota, Twin Cities, Minneapolis, Minnesota, U.S.A.

We demonstrate sub-10-nm metallic nanogap arrays with precise control of the gap's size, position, shape and orientation. We show increasing local SERS enhancements of up to 10^9 as the gap size decreases to 5 nm.

MON4s: Quantum Phenomena

Chaired by Boris Luk'yanchuk, A *STAR, Singapore

Time: Monday 17:00–18:15 Location: Seefeld-Tirol

Invited MON4s.1 *(274)* Mon 17:00

Quantum Plasmonics and Plexcitonics — •Peter Nordlander — Department of Physics, MS 61, Rice University, Houston, TX77005, USA

Quantum effects such as electron tunneling and nonlocal screening can have a pronounced effect on the optical properties of plasmonic and excitonic nanoparticles and lead to new phenomena not present in classical electromagnetic descriptions.

Invited MON4s.2 *(275)* Mon 17:25

Integrated Quantum Photonics — •Jeremy O'Brien — Centre for Quantum Photonics, University of Bristol

We report our latest work on integrated quantum photonics– using integrated optics to implement quantum circuits for quantum metrology, quantum information processing and quantum walks.

Invited MON4s.3 *(162)* Mon 17:50

Quantum aspects of electron-plasmon interaction — •Javier Garcia de Abajo — Instituto de Optica - CSIC, Serrano 121, 28006 Madrid, Spain

Before the blossoming of plasmonics as a distinct, fast-growing field, plasmons were the territory of electron microscopy. Electron beams will be shown to provide exciting opportunities, including unique access to quantum aspects of these excitations.

Coffee Break

Time: Monday 18:15–18:30 Location: Lobby

Coffee Break

MON4oBis: Advanced Nano-Fabrication 1

Chaired by Byoungho Lee, Seoul National University, South Korea

Time: Monday 18:45–19:15 Location: Olympia

Talk MON4oBis.1 *(227)* Mon 18:45

A resonant metamaterial made from nano antennas — •Sabine Dobmann[1,2,3], Daniel Ploss[1,2,3], and Ulf Peschel[1,2,3] — [1]Erlangen Graduate School in Advanced Optical Technologies — [2]EAM Cluster of Excellence, Engineering of Advanced Materials, Erlangen — [3]Max-Planck-Institute for the Science of Light, Erlangen, Germany

Transmission of ultrathin metal films is suppressed by nanostructuring, a feature which can improve the performance of lithographic masks. This effect is based on the antenna like action of the individual building blocks.

Talk MON4oBis.2 *(105)* Mon 19:00

Intaglio and Bas-Relief Metamaterials: Controlling the Colour of Metals — •Jianfa Zhang[1], Jun Yu Ou[1], Nikitas Papasimakis[1], Yifang Chen[2], Kevin F. MacDonald[1], and Nikolay I. Zheludev[1] — [1]Optoelectronics Research Centre & Centre for Photonic Metamaterials, University of Southampton, UK — [2]Rutherford Appleton Laboratory, Didcot, UK

We demonstrate two new families of metamaterial: indented (intaglio) and raised (bas-relief) subwavelength periodic patterns - the manufacturing of which on a metal surface provides a mechanism for controlling the colour of the metal.

MON4sBis: Quantum Phenomena 1

Chaired by Boris Luk'yanchuk, A *STAR, Singapore

Time: Monday 18:30–19:10 Location: Seefeld-Tirol

Talk MON4sBis.1 *(243)* Mon 18:30

Twisting Surface Plasmon by Photon Spin — Nicholas X. Fang and •Kin Hung Fung — Massachusetts Institute of Technology, Cambridge, MA 02139, U.S.A.

We discuss our recent progress in enhanced transfer of angular momentum from photon to plasmonic nanostructures with broken rotational symmetry. This could pave the way

to miniaturize quantum electrodynamic (QED) devices for information processing.

Invited MON4sBis.2 *(22)* Mon 18:45
Tailoring Light-Matter Interactions from the Bottom-Up — •Min Ouyang — Department of Physics, University of Maryland, College Park, USA

Fundamental physical properties can be tailored through bottom-up nanomaterials engineering. This allows to explore novel plasmon-exciton coupling for enhanced light-matter interactions with manifestation of optical Stark effect, that can be further applied for spin manipulation.

MON5o: Breakthrough 1

Chaired by Peter Nordlander, Rice University, Houston, TX, USA

Time: Monday 19:15–19:45 Location: Olympia

Breakthrough Talk MON5o.1 *(284)* Mon 19:15
Metallization of Nanofilms in Strong Adiabatic Fields — •Mark I. Stockman[1,2], Maxim Durach[1], Anastasia Rusina[1], and Matthias F. Kling[2] — [1]Department of Physics and Astronomy, Georgia State University, Atlanta, Georgia 30303, USA — [2]Max Planck Institute for Quantum Optics, Hans Kopfermann Str. 1, D-85748 Garching, Germany

We introduce an effect of metallization of dielectric nanofilms by strong, adiabatically varying electric fields. The metallization causes optical properties of a dielectric film to become similar to those of a plasmonic metal.

MON5s: Breakthrough 2

Chaired by Vlad Shalaev, Purdue University, West Lafayette, IN, USA

Time: Monday 19:15–19:45 Location: Seefeld-Tirol

Breakthrough Talk MON5s.1 *(5)* Mon 19:15
Bacterial ratchet motors — •Roberto Di Leonardo — CNR-IPCF, Dipartimento di Fisica, Università di Roma Sapienza, 00185, Roma, Italy

We show that micron sized objects, designed with a proper asymmetric shape, can be used to convert chaotic bacterial motions into a predictable movement and propel micromachines.

TUE1o: Plenary Talk 2

Chaired by Naomi Halas, Rice University, Houston, TX, USA

Time: Tuesday 8:00–8:45 Location: Olympia

Plenary Talk TUE1o.1 *(131)* Tue 8:00
Seeing electrons in 1- and 2-dimensions: The optical properties of carbon nanotubes and graphene — •Tony Heinz — Departments of Physics and Electrical Engineering, Columbia University, New York, NY 10027 USA

Two fascinating nanoscale materials are based on sp2-hybridized carbon monolayers: nanotubes and graphene. We will discuss the unusual properties of electrons in these model 1- and 2-D materials and the corresponding distinctive optical properties.

Break

Time: Tuesday 8:45–8:55 Location: Olympia

Break

TUE2o: Sensors 1

Chaired by Min Ouyang, University of Maryland, Dept. of Physics, College Park, USA

Time: Tuesday 8:55–10:05 Location: Olympia

Invited TUE2o.1 *(31)* Tue 8:55
Optical Transparency by Detuned Electrical Dipoles — •Sergey Bozhevolnyi — University of Southern Denmark, Niels Bohrs Allé 1, DK-5230 Odense, Denmark

It is demonstrated that the effect of scattering suppression (optical transparency) can be realized with plasmonic metamaterials based on detuned electric dipolar scatterers, mimicking thereby the dressed-state picture of electromagnetically induced transparency in atomic physics.

Talk TUE2o.2 *(195)* Tue 9:20
Cavity-enhanced localized plasmon resonance sensing — •Ralf Ameling, Lutz Langguth, Mario

Hentschel, Martin Mesch, and Harald Giessen — 4th Physics Institute, University of Stuttgart, Stuttgart, Germany

We present a method to enhance the sensing properties of a localized plasmon resonance sensor. The concept is based on the combination of particle plasmons in metal nanorods and a photonic microcavity.

Talk TUE2o.3 *(71)* Tue 9:35

Tip-enhanced Raman Scattering from Bridged Nanocones — •Mikko J Huttunen[1], Satish Rao[2], Juha M Kontio[3], Jouni Mäkitalo[1], Milla-Riina Viljanen[3], Janne Simonen[3], Martti Kauranen[1], and Dmitri Petrov[2] — [1]Department of Physics, Tampere University of Technology, Tampere, Finland — [2]ICFO - The Institute of Photonic Sciences, Castelldefels (Barcelona), Spain — [3]Optoelectronics Research Centre, Tampere University of Technology, Tampere, Finland

We fabricate arrays of silver nanocones where the cones are pairwise connected by a silver bridge. The structures give rise to higher tip-enhanced Raman scattering than single cones and relax its polarization requirements.

Talk TUE2o.4 *(87)* Tue 9:50

A single gold nanorod for label-free detection of biomolecular binding — •Peter Zijlstra, Paul V. Ruijgrok, and Michel Orrit — MoNOS, Institute of Physics, Leiden University, The Netherlands

We demonstrate plasmonic detection of biotin-streptavidin conjugation on a single gold nanorod. By employing an interferometric detection technique we monitor the plasmon of very small rods (10x30nm) with the potential to detect single binding events.

TUE2s: Nonlinear Plasmonics

Chaired by Thomas Pertsch, Friedrich Schiller University, Jena, Germany

Time: Tuesday 8:55–10:05 Location: Seefeld-Tirol

Invited TUE2s.1 *(280)* Tue 8:55

Plasmonic Metamaterials: from negative-index materials in the blue to ultra-thin solar cells in the red — •Albert Polman — FOM Institute AMOLF, Amsterdam, The Netherlands

We present novel metallo-dielectric nano-architectures that show a negative index of refraction for blue light and serve as efficient red-light trapping geometries for ultra-thin film solar cells.

Talk TUE2s.2 *(194)* Tue 9:20

Nonlinear Optical Plasmonic Nanocavities — •Ye Pu[1], Rachel Grange[1], Chia-Lung Shieh[1,2], and Demetri Psaltis[1] — [1]School of Engineering, EPFL, Station 17, 1015 Lausanne, Switzerland — [2]Department of Electrical Engineering, California Institute of Technology, Pasadena, California 91125, USA

We demonstrate significantly enhanced second harmonic generation in nanoengineered plasmonic core-shell nanocavities with nonlinear optical core. An enhancement factor of over 500 is measured in the second harmonic scattering efficiency compared to the bare core.

Talk TUE2s.3 *(183)* Tue 9:35

Towards the Origin of Optical Nonlinearities in Hybrid Plasmonic Systems — •Tobias Utikal[1,2], Thomas Zentgraf[3], Thomas Paul[4], Carsten Rockstuhl[4], Falk Lederer[4], Markus Lippitz[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany — [2]Max Planck Institute for Solid State Research Stuttgart, Germany — [3]Department of Mechanical Engineering, University of California, Berkeley, USA — [4]Institute for Condensed Matter Theory and Solid State Optics, University of Jena, Germany

We perform third-harmonic generation spectroscopy on particle plasmon polaritons hybridized with photonic waveguide modes. From the nonlinear spectra, which show pronounced spectral features, we distinguish the nonlinear contributions of the metal and of the dielectric.

Talk TUE2s.4 *(39)* Tue 9:50

Nonlinear plasmonics beyond the spectral limit — •Vladimir Zharov — Philips Classic Laser and Nanomedicine Laboratories, University of Arkansas for Medical Sciences, 4301, West Markham St., Little Rock, Arkansas, the USA, 72205-7199; Phone: 501-603-1213; Fax: 501-686-8029

The dramatic narrowing of plasmonic resonances during nonlinear laser-nanoparticle interaction are discovered. The experimental data demonstrates tremendous potential of these phenomena for super-resolution laser spectroscopy beyond conventional spectral limits, multispectral imaging, and multicolor cytometry.

Coffee Break

Time: Tuesday 10:05–10:25 Location: Lobby

Coffee Break

TUE3o: New Materials 2

Chaired by Gennady Shvets, University of Texas, Austin, USA

Time: Tuesday 10:25–11:55 Location: Olympia

Invited TUE3o.1 *(266)* Tue 10:25

On Auxetics and Thermo-Mechanical Metamaterials — •Joseph N Grima, Daphne Attard, and Ruben Gatt — Metamaterials Unit, Faculty of Science, University of Malta, Msida MSD 2080, Malta

Recent advances made in the field of materials which exhibit unusual mechanical and/or thermal properties, in particular, materials having a negative Poisson's ratio which get fatter when stretched (auxetic) are reviewed and discussed.

Invited TUE3o.2 *(265)* Tue 10:50

Ferroelectric Nanoparticles for Photonic and Meta Applications — •Dean Evans[1], G. Cook[1,2], V. YU. Reshetnyak[3], S.A. Basun[1,4], A. Ponce[5], and R. Ziolo[5] — [1]Air Force Research Laboratory, Ohio, USA — [2]Azimuth Corp., Dayton, Ohio, USA — [3]National Taras Shevshenko University, Kyiv, Ukraine — [4]Universal Technology Corporation, Dayton, Ohio, USA — [5]Centro de Investigacion en Quimica Aplicada, Saltillo, Coahuila, Mexico

The effect of stress on ferroelectric nanoparticles will be described. 9 nm BaTiO3 particles has been achieved, the smallest size to date, by harvesting stressed nanoparticles in an gradient field. These materials enhance the performance in liquid crystal switches and photorefractive hybrid devices. Because of their large spontaneous polarization, these materials may also find use in photonic and meta applications.

Talk TUE3o.3 *(81)* Tue 11:15

Do we need metals to obtain extraordinary absorption? — •Maria Bayard Dühring and Ole Sigmund — Department of Mechanical Engineering, Solid Mechanics, Technical University of Denmark, Kgs. Lyngby, Denmark

It is shown by parameter studies and topology optimization that extraordinary optical absorption can be enhanced when employing subwavelength slits in a Si thin-film instead of using metallic thin-films.

Invited TUE3o.4 *(33)* Tue 11:30

Semiconductors for Plasmonic Metamaterials in the Near-Infrared — Gururaj Naik[1] and •Alexandra Boltasseva[1,2] — [1]School of Electrical & Computer Engineering and Birck Nanotechnology Center, Purdue University IN 47906 USA — [2]DTU Fotonik, Technical University of Denmark, Lyngby 2800, Denmark

Low loss, heavily doped semiconductors as plasmonic materials offer many advantages over conventional metals for plasmonic applications in the near-infrared (NIR) range. We will present a comparative study of the performances of transparent-oxide-semiconductors-based metamaterial devices.

TUE3s: Superresolution 1

Chaired by Said Zouhdi, Université Paris Sud, France

Time: Tuesday 10:25–11:55 Location: Seefeld-Tirol

Invited TUE3s.1 *(76)* Tue 10:25

Plasmonic Vortex, Focusing, and Hot Spot Generation — •Byoungho Lee[1], Junghyun Park[1], Hwi Kim[2], Seong-Woo Cho[1], Seung-Yeol Lee[1], and Il-Min Lee[1] — [1]Seoul National University, Seoul, Korea — [2]Korea University, Yeongi-gun, Korea

We present synthesis and manipulation of the plasmonic vortex with its applications such as focusing and hot spot generation. Dependency of the plasmonic vortex on the polarization state will also be discussed.

Invited TUE3s.2 *(233)* Tue 10:50

Apertureless Nearfield Optical Microscopy Investigations of Amorphous Metamaterials — •Ralf Vogelgesang[1], Worawut Khunsin[1], Jens Dorfmüller[1], Moritz Esslinger[1], Klaus Kern[1,2], Carsten Rockstuhl[3], Falk Lederer[4], Börn Brian[5], and Alexandre Dmitriev[5] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, 70569 Stuttgart, Germany — [2]Institut de Physique des Nanostructures, Ecole Politechnique Fédérale de Lausanne, Bâtiment PH, station 3, CH-1015 Lausanne, Switzerland — [3]Institut für Festkörpertheorie und Optik, Friedrich-Schiller-Universität, Max-Wien-Platz 1, 07743 Jena, Germany — [4]Institut für angewandte Physik, Friedrich-Schiller-Universität, Max-Wien-Platz 1, 07743 Jena, Germany — [5]Department of Applied Physics, Chalmers University of Technology, Sweden

Statistical nearfield optical microscopy analysis of amorphous metamaterials reveals long-range interactions between distant metaatoms, not observed with farfield optical spectroscopy.

Talk TUE3s.3 *(201)* Tue 11:15

Three-dimensional Plasmonic Nanofocusing — Nathan Lindquist[1], Prashant Nagpal[2], Antoine Lesuffleur[1], David Norris[3], and •Sang-Hyun Oh[1] — [1]Department of Electrical Engineering, University of Minnesota, Minneapolis, MN, USA — [2]Los Alamos National Laboratory, Los Alamos, NM, USA — [3]Swiss Federal Institute of Technology, Zurich, Switzerland

We demonstrate three-dimensional plasmonic nanofocusing of light with patterned metallic pyramids obtained via template stripping. Gratings on the pyramid faces generate plasmons that converge towards a 10 nm apex, focusing into a $5 \times 10^{-5}\lambda^3$ volume.

Invited TUE3s.4 *(50)* Tue 11:30

Resonant Metalens for Breaking the Diffraction Barrier in the Visible Range — •Fabrice Lemoult, Geoffroy Lerosey, and Mathias Fink — Institut Langevin, CNRS & ESPCI ParisTech, 10 rue Vauquelin, 75005 Paris, France

We have recently introduced the "resonant metalens" to image below the diffraction limit with microwaves. Here, we transpose this concept in optics, and obtain images with resolution near $\lambda/10$ using an array of silver nanorods.

Lunch Break

Time: Tuesday 11:55–16:30

Lunch Break

TUESI1: Special Interests Talk 1

Time: Tuesday 16:30–16:50 Location: Seefeld-Tirol

Talk TUESI1.1 *(212)* Tue 16:30

Near-field Spectra from Broadband-Infrared Nanoscope — •Sergiu Amarie and Fritz Keilmann — Max Planck Institute of Quantum Optics and Center for NanoScience, Garching, Germany

on site

TUE4f: Poster Session 1

Chaired by Ian Osborne, "Science" & John Dudley, University of Franche-Comté, France

Time: Tuesday 17:00–18:30 Location: Foyer

TUE4f.1 *(218)* Tue 17:00

The Impedance of Metamaterials — •Thomas Paul[1], Carsten Rockstuhl[1], Falk Lederer[1], and Philippe Lalanne[2] — [1]Institute for Condensed Matter Theory and Solid State Optics, Friedrich Schiller Universität Jena, Germany — [2]Laboratoire Charles Fabry de l'Institut d'Optique, CNRS, Univ. Paris-Sud, RD 128, 91127 Palaiseau, France

We show that the assignment of an effective impedance to a metamaterial requires that an external illumination couples only to a single Bloch mode. The impedance is then linked to the field of that mode.

TUE4f.2 *(28)* Tue 17:00

Femtosecond Pulses in Media with Non-Stationary Optical and Magnetic Response — •Lubomir Kovachev — Institute of Electronics, Bulgarian Academy of Sciences, Sofia, Bulgaria

Near to paramagnetic resonances, in semiconductors and metals, it is possible to obtain negative group velocity and group velocity higher than the phase velocity.

TUE4f.3 *(161)* Tue 17:00

Reconfigurable Photonic Metamaterials (RPM) — •Jun-Yu Ou[1], Eric Plum[1], Liudi Jiang[2], and Nikolay I. Zheludev[1] — [1]Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, SO17 1BJ, UK — [2]School of Engineering Sciences, University of Southampton, Southampton SO17 1BJ, UK

We demonstrate the first temperature driven mechanically reconfigurable photonic metamaterial (RPM) providing tunability at optical frequencies.

TUE4f.4 *(217)* Tue 17:00

A Bloch Mode Picture for Understanding Nonlinear Metamaterials — •Thomas Paul, Carsten Rockstuhl, and Falk Lederer — Institute for Condensed Matter Theory and Solid State Optics, Friedrich Schiller Universität Jena, Germany

We derive equations for Bloch mode amplitudes describing the nonlinear light propagation in bulk metamaterials. We apply them to second harmonic generation (SHG) at a finite metamaterial and compare these results to rigorous simulations.

TUE4f.5 *(225)* Tue 17:00

Controlling Ultrafast Light with Dispersive Metamaterials — •Dean P. Brown[1], Shumin Xiao[2], Alexander Kildishev[2], Vladimir P. Drachev[2], and Augustine Urbas[1] — [1]3005 Hobson Way, Wright Patterson, OH 45433 — [2]1285 Electrical Engineering, West Lafayette, IN 47907

We utilize a multiphoton intrapulse interference phase scan (MIIPS) technique to measure the group velocity dispersion (GVD) of metamaterials and find it to be four orders of magnitude larger than that of dispersive optical glasses.

TUE4f.6 *(176)* Tue 17:00

Few-cycle laser driven strong-field above-threshold photoemission from nanometric metal tips — •Markus Schenk, Michael Krüger, and Peter Hommelhoff — Max-Planck-Insitut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching bei München, Germany

We present energy-resolved measurements of electron emission from nanometric tungsten tips driven with few-cycle oscillator pulses. We observe high order above-threshold photoemission and strong-field effects like peak shifting and suppression, harnessing (plasmonic) field enhancement.

TUE4f.7 *(156)* Tue 17:00

About the Energy Density in Absorbing Media — •Michael Bergmair[1], Kurt Hingerl[1], and Helga

Böhm[2] — [1]ZONA, Johannes Kepler University Linz, 4040 Linz, Austria — [2]Institute for Theoretical Physics, Johannes Kepler University Linz, 4040 Linz, Austria

The energy density for dispersive, absorbing media has often been reviewed. We generalize the familiar expression and show that the energy density depends strongly on the excitation and the averaging procedure.

TUE4f.8 *(82)* Tue 17:00

A new route toward the description of disordered metamaterials: Merging statistical methods and the multipole expansion — •Arkadi Chipouline, Srikanth Sugavanam, Christian Helgert, Joerg Petschulat, Andreas Tuennermann, and Thomas Pertsch — IAP-FSU, Jena, Germany

Metamaterials consisting of randomly positioned unit cells are considered analytically on the basis of a multipole expansion taking into account dipole-dipole interactions between adjacent resonators. Our findings agree sufficiently well with the experimental data.

TUE4f.9 *(84)* Tue 17:00

Multipole expansion and spatial dispersion in metamaterials — •Arkadi Chipouline and Srikanth Sugavanam — IAP-FSU, Jena, Germany

The equivalence of the microscopic and phenomenological approaches of homogenization of metamaterials is established. Spatial dispersion arising due to the interaction between meta-atoms is modeled using a harmonic oscillator chain model.

TUE4f.10 *(114)* Tue 17:00

Strong collective response of large metamaterial systems — •Janne Ruostekoski[1], Stewart Jenkins[1], and Nikolay Zheludev[2] — [1]School of Mathematics and Centre for Photonic Metamaterials, University of Southampton, SO17 1BJ Southampton, United Kingdom — [2]Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, SO17 1BJ Southampton, United Kingdom

We develop a theoretical formalism for collective interactions of meta-molecules. We find that a co-operative response of meta-molecules explains the recent experimental observations of system-size and disorder dependent resonance transmission quality factors.

TUE4f.11 *(120)* Tue 17:00

The beauty of anisotropy in extraordinary transmission fishnet metamaterials — •Miguel Navarro-Cía, Miguel Beruete, and Mario Sorolla — Millimeter and Terahertz Waves Laboratory, Universidad Pública de Navarra, Pamplona, Spain

In this work, we explore both numerically and experimentally, the possibility to obtain positive and negative refraction regimes that depend on the wave polarization, exploiting the strong anisotropy of extraordinary transmission fishnet metamaterials

TUE4f.12 *(128)* Tue 17:00

Negative refractive index induced by surface plasmon polaritons in sub-wavelength apertures array — •Riad Yahiaoui[1], Patrick Mounaix[1], Hynek Němec[2], Filip Kadlec[2], Christelle Kadlec[2], and Petr Kužel[2] — [1]Centre de Physique Moléculaire Optique et Hertzienne, Université Bordeaux1, UMR CNRS 5798, 351 Cours de la Libération, 33405 Talence cedex, France — [2]Institute of Physics, Academy of Sciences of the Czech Republic, Na Slovance 2, 182 21 Prague 8, Czech Republic

We present a theoretical and experimental investigations on sub-wavelength apertures array made through metal-dielectric-metal structure. The result reveals the Extraordinary Optical Transmission behaviour that allows negative refractive index.

TUE4f.13 *(159)* Tue 17:00

On electromagnetic characterization of nanoclustered metamaterials — •Dmitry Morits and Constantin Simovski — School of Science and Technology, Aalto University, P.O. Box 13000, FI-00076 AALTO, Finland

We generalize an existent method of electromagnetic characterization of metasurfaces and develop an original electrodynamic method of extraction of the effective material parameters of bulk composites from a single metasurface reflection and transmission coefficients.

TUE4f.14 *(210)* Tue 17:00

Confined modes in particle arrays — •Xesús Manoel Bendaña[1], Baptiste Auguie[2], William L. Barnes[3], and Francisco Javier García de Abajo[1] — [1]Instituto de Óptica - CSIC, Madrid, Spain — [2]Departamento de Química Física, Universidade de Vigo, Vigo, Spain — [3]School of Physics, University of Exeter, Exeter, UK

We study the existence and characteristics of the modes propagating along a planar array of particles and its prevention when they are place close to a substrate interface.

TUE4f.15 *(216)* Tue 17:00

Conical refraction in the fine-stratified structure consisting of alternate semiconductor and dielectric layers — •Iliya Fedorin[1] and Aleksey Bulgakov[2] — [1]National Technical University Kharkiv Polytechnical Institute, Kharkiv, Ukraine — [2]Institute for Radiophysics and Electronics of NAS of Ukraine, Kharkiv, Ukraine

The periodic fine-stratified structure consisting of alternate semiconductor and dielectric layers in an external magnetic field is considered. It has been shown that such structure represents the biaxial crystal. The phenomenon of a conic refraction in such structure is considered

TUE4f.16 *(80)* Tue 17:00

Strong Dependence of Plasmon Resonances on Mutual Orientation of Anisotropic Metal Nanoparticles — •Martti Kauranen[1], Hannu Husu[1], Roope Siikanen[1], Jouni Mäkitalo[1], Henna Pietarinen[1], Goëry Genty[1], Joonas Lehtolahti[2], Janne Laukkanen[2], and Markku Kuittinen[2] — [1]Department of Physics, Tampere University of Technology, P. O. Box 692, FI-33101, Tampere, Finland — [2]Department of Physics and Mathematics, University of Eastern Finland, P. O. Box 111, FI-80101 Joensuu, Finland

We order anisotropic metal nanoparticles in a lattice with

sub-wavelength period. Changes in the relative particle orientation double the period, allowing diffractive coupling between the particles and resulting in large changes in plasmonic extinction spectra.

TUE4f.17 *(254)* Tue 17:00

Tunable ultra-compact stub plasmonic filter — •Mohsen Bahramipanah, Iman Zand, Mohammad Sadegh Abrishamian, and Abdollah Mirtaheri — K.N.Toosi University of Technology, Department of Electrical Engineering, Tehran, Iran

Abstract: In this paper, a novel tunable plasmonic stub filter based on anisotropic core is proposed, investigated numerically and compared with conventional stub filters.

TUE4f.18 *(255)* Tue 17:00

Tunable plasmonic ring resonator filter based on anisotropic material — Iman Zand, •Mohsen Bahramipanah, and Mohammad Sadegh Abrishamian — K.N.Toosi University of Technology, Department of Electrical Engineering, Tehran, Iran

Abstract: In this paper, a novel tunable plasmonic add/drop filter based on anisotropic ring resonator is proposed and investigated numerically. The Liquid Crystal is used as a core of the ring.

TUE4f.19 *(258)* Tue 17:00

Ultra compact plasmonic bandpass filter — •Elnaz Nazemi and Nosrat allah Granpayeh — K.N.Toosi University of Technology, Department of Electrical Engineering, Tehran, Iran

Abstract: In this paper, a novel efficient ultra compact plasmonic bandpass filter based on stub structure is proposed and investigated numerically.

TUE4f.20 *(43)* Tue 17:00

Plasmonic Metamaterials in the Near Infrared: Large Tunability by Concave Unit Cells — •Nikolai Berkovitch, Pavel Ginzburg, and Meir Orenstein — Department of Electrical Engineering,Technion, Haifa 32000, Israel

Broadband tunable plasmonic metamaterials based on concave nanostructures were demonstrated.Tuning range of over 350nm is achieved even for aspect ratios of ˜1. Interpretation by interaction of local geometry with surface dipole distributions is provided

TUE4f.21 *(234)* Tue 17:00

THz uniaxial metamaterials based on polar media composites — •Stavroula Foteinopoulou[1], Maria Kafesaki[2], Eleftherios N. Economou[2], and Costas M. Soukoulis[2] — [1]School of Physics, CEMPS, University of Exeter, Exeter, EX4 4QL, United Kingdom — [2]Institute of Electronic Structure and Lasers (IESL), Foundation for Research and Technology-Hellas (FORTH), Heraklion GR71110, Greece

We developed a criterion establishing an angular effective medium signature for two-dimensional composites. Based on this criterion we designed polar material structures functioning as extraordinary uniaxial metamaterials highly suitable for optical components at THz.

TUE4f.22 *(192)* Tue 17:00

Artificial magnetism in Titanium Dioxide (TiO2) micro-particles array for terahertz applications — Riad Yahiaoui[1], Patrick Mounaix[1], Valérie Vigneras[2], U-Chan Chung Chung[3], Mario Maglione[3], Catherine Elissalde[3], •Sylvain Lannebere[4], and Ashod Aradian[4] — [1]Centre de Physique Moléculaire Optique et Hertzienne, Université Bordeaux1, UMR CNRS 5798, 351 Cours de la Libération, 33405 Talence cedex, France — [2]Laboratoire de Lintégration du Matériau au Système, Université Bordeaux 1, UMR 5218, 16 avenue Pey Berland 33607 Pessac Cedex, France — [3]Institut de Chimie de la Matière Condensée de Bordeaux CNRS - UPR 9048, France — [4]Centre de Recherche Paul Pascal UPR 8641, 115 av. du Dr Schweitzer 33600 Pessac, France

In this present paper, we theoretically and experimentally investigated a disordered Titanium Dioxide (TiO2) microparticles array that exhibits negative effective permeability at terahertz frequencies.

TUE4f.23 *(66)* Tue 17:00

Determination of Effective Optical Properties of Metamaterials Targeted for Terahertz Spectral Range — •Hynek Němec[1], Filip Kadlec[1], Christelle Kadlec[1], Petr Kužel[1], Riad Yahiaoui[2], and Patrick Mounaix[2] — [1]Institute of Physics, Academy of Sciences of the Czech Republic, Na Slovance 2, 182 21 Prague 8, Czech Republic — [2]Centre de Physique Moléculaire Optique et Hertzienne, Université Bordeaux 1, UMR CNRS 5798, 351 Cours de la Libération, 33405 Talence cedex, France

Time-domain terahertz spectroscopy is employed for the characterization of thin flexible fishnet metamaterials. We developed a robust method for unambiguous simultaneous determination of complex dielectric permittivity and magnetic permeability of metamaterials.

TUE4f.24 *(21)* Tue 17:00

Electro Optic Imaging of the THz Response of Metamaterials — •Florian Enderli, Hannes Merbold, Fabian Brunner, Andreas Bitzer, and Thomas Feurer — University of Bern, Switzerland

We present three electro-optic imaging methods based on THz time-domain spectroscopy and polaritonics. In combination they are ideal to resolve the spatial and frequency dependent response of metamaterials in the near- and far-field regime.

TUE4f.25 *(245)* Tue 17:00

Nonlinear Oscillator Model for a Metamaterial with a Magnetic Response: Experimental Verification — •Ekaterina Poutrina, Da Huang, Yaroslav Urzhumov, and David R. Smith — Center for Metamateials and Integrated Plasmonics, Duke University, ECE, 130 Hudson Hall, Durham, NC 27708, Tel: (919)660-8469, Fax: (919)660-5293 ekaterina.poutrina@duke.edu

We verify experimentally the expressions for the effective nonlinear susceptibilities of a metacrystal formed from elements with a magnetic resonant response. A numerical procedure is developed incorporating a dispersive nonlinear response in time-domain simulations.

TUE4f.26 *(231)* Tue 17:00

Electrodynamic Properties of the Surface Waves Propagated Along the Interface of Periodic Structure with Magnetoactive Layers — •Olga V. Kostylyova[1] and Oksana V. Shramkova[2] — [1]12 Ac. Proskura Str., 61085 Kharkiv, Ukraine — [2]Belfast, BT3 9DT, U.K.

The surface waves propagated along the contact of ferrite-semiconductor periodic structure and semiconductor medium are investigated. Possibility of the magnetic field control of these waves' properties both for the cases of TM- and TE-polarization is shown.

TUE4f.27 *(207)* Tue 17:00

Thresholdless THz Lasing from a Semiconductor Nanostructure in a Strongly-Coupled Plasmonic Microcavity. — Johannes Gambari[1], Antonio Fernandez-Dominguez[1], Stefan Maier[1], •Chris Phillips[1], Ben Williams[2], Sushil Kumar[3], Qing Hu[3], and John Reno[4] — [1]Physics Dept., Imperial College, London, SW7 2AZ UK. — [2]Dept of Electrical Engineering and California NanoSystems Institute, UCLA, California 90095, USA — [3]MIT, EECS Dept., Research Laboratory of Electronics, Cambridge, Mass., 02139, USA. — [4]Sandia National Laboratories, Dept. 1123, MS 0601, Albuquerque, New Mexico, 87185-0601, USA

We make an SC system from QW transitions in a gold-semiconductor microstructure. It lases without threshold and generates sharp *sideband* spectra that track the polariton density and offer a passive wavelength shifting mechanism for telecommunications.

TUE4f.28 *(136)* Tue 17:00

Design of a near field superlens in the THz regime — •Seunghwa Baek and Kyoungsik Kim — School of Mechanical Engineering, Yonsei University, Seoul, Republic of Korea

We design a near-field superlens in THz regime(3~6THz) beyond the diffraction limit. This superlens is consist of carbon nano tube sandwiched between two layers of positive-permittivity materials.

TUE4f.29 *(155)* Tue 17:00

Dynamics of Photo-induced Terahertz Optical Activity in Metal Chiral Gratings — •Natsuki Kanda[1], Kuniaki Konishi[1,2], and Makoto Kuwata-Gonokami[1,2,3] — [1]The University of Tokyo, Department of Applied Physics, and CREST (JST), Tokyo, Japan — [2]The University of Tokyo, Photon Science Center, Tokyo, Japan — [3]The University of Tokyo, Department of Physics, Tokyo, Japan

We measured the temporal responses of photo-induced terahertz optical activity in metal chiral gratings, and revealed that the decay time is much faster than the carrier lifetime because of diffusion effect, which is morphology sensitive.

TUE4f.30 *(164)* Tue 17:00

Metamaterial-Inspired First-Order Probe for Spherical Near-Field Antenna Measurements — •Oleksiy S. Kim and Olav Breinbjerg — Department of Electrical Engineering, Technical University of Denmark, Kgs. Lyngby, Denmark

A first-order probe based on a two-element split ring resonator (SRR) array is presented. The probe is applicable at low frequencies due to its small size and excellent mode content.

TUE4f.31 *(119)* Tue 17:00

New regimes to achieve enhanced transmission through subwavelength hole arrays — •Miguel Navarro-Cía[1], Miguel Beruete[1], Mario Sorolla[1], Vitaliy Lomakin[2], and Sergei Kuznetsov[3,4] — [1]Millimeter and Terahertz Waves Laboratory, Universidad Pública de Navarra, Pamplona, Spain — [2]Department of Electrical and Computer Engineering, University of California, San Diego, La Jolla, California, USA — [3]Novosibirsk State University, Research-and-Education Centre Nanosystems and Modern Materials, Novosibirsk, Russia — [4]Budker Institute of Nuclear Physics SB RAS, Novosibirsk, Russia

In this communication we present millimetre- and THz-waves experimental confirmation of enhanced transmission through subwavelength hole arrays with rectangular lattice when the incident electric field is parallel to the short periodicity.

TUE4f.32 *(118)* Tue 17:00

Analysis of surface-plasmon-like modes under an engineering perspective — •Miguel Navarro-Cía[1], Miguel Beruete[1], Mario Sorolla[1], and Stefan Maier[2] — [1]Millimeter and Terahertz Waves Laboratory, Universidad Pública de Navarra, Pamplona, Spain — [2]Experimental Solid State Group, Physics Department, Imperial College London, London, UK

In this communication we show how one can exploit equivalent circuits to analyze surface-plasmon-like modes (slit and hole arrays, Sievenpiper mushrooms and coaxial hole arrays) and to propose new designs with outstanding features.

TUE4f.33 *(49)* Tue 17:00

Laterally confined microwave surface waves — •Elizabeth Brock, Euan Hendry, and Alastair Hibbins — Electromagnetic Materials Group, School of Physics, University of Exeter, Exeter EX4 4QL,UK

We experimentally demonstrate that the dispersion of electromagnetic surface waves supported by a chain of closely spaced, grounded metallic cuboids (dominos), is insensitive to the chain's width, which can even be made subwavelength.

TUE4f.34 *(34)* Tue 17:00

Microwave response of metamaterial-dielectric stacks — •Alastair Hibbins, Celia Butler, Melita Taylor, Euan Hendry, and Roy Sambles — Electromagnetic Materials Group, School of Physics,University of Exeter, Exeter EX4 4QL. UK

We discuss a variety of multilayer metallic-mesh structures. The holes are beyond cutoff, and their periodicity is subwavelength. Each mesh layer can therefore be considered as a lossless plasmonic-like metamaterial with negative effective permittivity.

TUE4f.35 *(11)* Tue 17:00

Transformation optics in three-dimensional plasmonic structures — •Antonio I. Fernandez-Dominguez, Stefan A. Maier, and John B. Pendry — Department of Physics, Imperial college, London, UK

In this work, we show how three-dimensional transformation optics can be used to obtain analytical solutions for the excitation of Surface Plasmon Polariton modes in metallic structures with geometric singularities.

TUE4f.36 *(113)* Tue 17:00

Confining and Guiding Surface Plasmon Polaritons on Non-uniform Metallic Structures with Transformation Optics — •Jingjing Zhang, Sanshui Xiao, Martijn Wubs, and Niels Asger Mortensen — DTU Fotonik - Department of Photonics Engineering, Technical University of Denmark, DK-2800 Kongens Lyngby, Denmark

We use transformation optics to confine and guide surface plasmon polaritons (SPPs) on imperfect metallic nanostructures, including a rough metal surface, a metal film with variant thickness and a cylindrical wire with non-uniform cross sections.

TUE4f.37 *(163)* Tue 17:00

Controlling surface plasmon polaritons in transformed coordinates — •Muamer Kadic, Guillaume Dupont, Sébastien Guenneau, and Stefan Enoch — Institut Fresnel, CNRS, Aix-Marseille Université, Campus Universitaire de Saint-Jérôme, 13013 Marseille, France

Transformational optics allow for a markedly enhanced control of electromagnetic waves. We present a review of curved anisotropic heterogeneous metasurfaces designed using the tool of transformational plasmonics to achieve the control of surface plasmon polaritons.

TUE4f.38 *(42)* Tue 17:00

Perfect invisibility in isotropic media based on plus-minus construction — •Tomoshiro Ochiai[1] and Jose Nacher[2] — [1]Otsuma Women's University, Tokyo, Japan — [2]Future University Hakodate, Hokkaido, Japan

We propose a new design of cloaking devices that creates perfect invisibility in isotropic media. A combination of positive and negative refractive indices, called plus-minus construction, is essential to achieve perfect invisibility.

TUE4f.39 *(109)* Tue 17:00

Topology optimization of all-dielectric cloak in the optical frequency range — •Jacob Andkjaer and Ole Sigmund — Department of Mechanical Engineering, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

A systematic methodology based on topology optimization for designing low-contrast all-dielectric cloaks operating in the optical range is presented. Furthermore it is demonstrated that the methodology can be used to purely minimize backscattering.

TUE4f.40 *(168)* Tue 17:00

Using a spatial light modulator to optimize the performance of a wide-field CARS-Microscope — Gregor Thalhammer, Alexander Jesacher, Stefan Bernet, and •Monika Ritsch-Marte — Innsbruck Medical University, Innsbruck, Austria

A spatial light modulator in a wide-field CARS-microscope allows one to tailor the phase matching of the excitation beams and to implement structured illumination techniques which promise to give super-resolved chemically selective images of nanoparticles.

TUE4f.41 *(244)* Tue 17:00

Mid-infrared high resolution imaging with quantum metamaterials. — Ki Youl Yang, Vincenzo Giannini, Stefan Maier, and •Chris Phillips — Experimental Solid State Group, Physics Department, Imperial College

We show theoretically that using quantum wells it is possible engineering metamaterials that present tunable negative refraction with relatively low losses and good factor of merit (˜200) in the infrared region.

TUE4f.42 *(170)* Tue 17:00

The Super-oscillating Superlens — Edward Rogers[1], •Tapashree Roy[1], Tsung Sheng Kao[1], Jun Yu Ou[1], Vassili Savinov[1], Salvatore Savo[1], Jari Lindberg[2], Mark Dennis[2], and Nikolay Zheludev[1] — [1]Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, SO17 1BJ, UK — [2]H. H. Wills Physics Laboratory, University of Bristol, BS8 1TL, UK

We demonstrate a lens that creates a sub-wavelength focal spot beyond the near-field by exploiting the phenomenon of super-oscillation.

TUE4f.43 *(63)* Tue 17:00

Focusing of Light and Matter Waves by Negative Refraction Media: New Problem Definition and Applications — •Vasily Klimov — 53 Leninskii prospekt,119991,Moscow ,Russia

New nontrivial solutions are found for light and matter waves propagation in negative index slabs, spheres, cylinders, wedges. The found solutions pave a natural way to provide effective excitation transfer from one atom to another.

TUE4f.44 *(72)* Tue 17:00

Right-handed plasmonic material as a superlens for visible light — Johan Christensen and •Javier Garcia de Abajo — Institute of Optics, Spanish National Research Council (CSIC), Serrano 121, 28006 Madrid, Spain

In this work, we show how slabs made out of closely packed nanoparticles containing large positive effective permittivities in the spectral region right to the red of the plasma frequency, function as superlenses.

TUE4f.45 *(19)* Tue 17:00

The Role of Plasmonic Covers to Enhance the Resolution of Aperture and Aperture-Less NSOM Tips — •Filiberto Bilotti, Simone Tricarico, and Lucio Vegni — Roma Tre University, Department of Applied Electronics, Via della Vasca Navale 84, 00146 Rome, Italy

In this contribution, we show that plasmonic covers based on the scattering cancellation can be used to successfully enhance imaging resolution of Near-Field-Scanning-Optical-Microscopy (NSOM) systems, based on the employment of

both aperture and aperture-less tips.

TUE4f.46 *(256)* Tue 17:00

Near Field characterization of plasmon concentrators for nanoscale opto-eletronics devices — •Francesco Tantussi[1], Priya Vasanthakumar[1], Michele Cortelezzi[1], Francesco Fuso[1], Maria Allegrini[1], Johann Berthelot[2], Alexandre Bouhelier[2], Nicolai Hartmann[3], and Achim Hartschuh[3] — [1]CNISM, Dipartimento di Fisica Enrico Fermi, Università di Pisa, Pisa, Italy — [2]Laboratoire Interdisciplinaire Carnot de Bourgogne, Université de Bourgogne, Dijon, France — [3]Ludwig-Maximilians-Universität, Department Chemie and CeNS, München, Germany

Custom Near Field Optical Microscopy has been applied to investigate, at nanometric scale, the plasmon propagation in gold Plasmon waveguides ending with triangular-shaped concentrators, designed for novel opto-electronics nanodevices.

TUE4f.47 *(226)* Tue 17:00

Exploiting disorder for perfect control of light — •Allard Mosk — MESA+, Universiteit Twente, Enschede, The Netherlands

Using wavefront shaping, we control propagation of light in strongly scattering materials. We show that scattering in some cases even improves our control over light, improving the resolution with which the light is focused.

TUE4f.48 *(89)* Tue 17:00

Resonant Transmission in Multi-Meander Stacks with Layers of varying Periodicities for sub-lambda Imaging — •Philipp Schau[1], Karsten Frenner[1], Wolfgang Osten[1], Liwei Fu[2], and Heinz Schweizer[2] — [1]Institut für Technische Optik, Universität Stuttgart, Pfaffenwaldring 9, 70569 Stuttgart, Germany — [2]4th Physics Institute, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

We investigate how a stack of multiple meander sheets of varying periodicity can be designed to show high resonant transmission. Such a stack can be used to transform evanescent modes to traveling wave modes.

TUE4f.49 *(249)* Tue 17:00

Metal/dielectric coated substrates for high contrast imaging near sample interfaces — •Kareem Elsayad[1], Alexander Urich[2], Maria Nemethova[3], Karl Unterrainer[2], John V. Small[3], and Katrin Heinze[1] — [1]Research Institute of Molecular Pathology (IMP), Dr.-Bohr-Gasse 7, Vienna 1030, Austria — [2]für Photonik Technische Universität Wien, Gusshausstraße 27-29 / 387, 1040 Vienna, Austria — [3]IMBA - Institute of Molecular Biotechnology GmbH, Dr. Bohr-Gasse 3, 1030 Vienna, Austria

We demonstrate that by optimizing a metal/dielectric coating on a microscope cover slide it becomes possible to image a fluorescently labelled sample in the <50nm vicinity of the substrate surface with an extremely high contrast.

TUE4f.50 *(169)* Tue 17:00

Demonstration of elliptical plasmonic Lens illuminated with "radially-like" polarized field — •Gilad Lerman, Avner Yanai, Nissim Ben Yosef, and Uriel Levy — Department of Applied Physics, The Benin School of Engineering and Computer Science, The Center for Nanoscience and Nanotechnology, The Hebrew University of Jerusalem, Jerusalem, 91904, Israel

We demonstrate an elliptical plasmonic lens illuminated by a TM "radially-like" polarization field. The surface plasmons interference generates a wavelength dependent structured pattern that can be used in structured illumination microscopy, particles trapping and sensing.

TUE4f.51 *(214)* Tue 17:00

The Realization of Wide Polarization Gap and Experimental Verification of Negative efraction in helix metamaterial — •Hongqiang Li — Tongji University, Physics Department, Shanghai, China

A Multiple Scattering Technique based on modified Bessel functions is developed to rigorously explain the wide polarization gap and the dispersion of helix metamaterials. Beam shift measurements directly verify negative refraction via a chiral route.

TUE4f.52 *(213)* Tue 17:00

Zig-Zag Gratings — •Thomas Constant, Alastair Hibbins, and Roy Sambles — . University of Exeter, School of Physics, Stocker Road, Exeter EX4 4QL, U.K.

This work explores a new geometry for continuous metallic gratings and the coupling of plane polarised light to the Surface Plasmon (SPs) supported by them.

TUE4f.53 *(4)* Tue 17:00

Nonradiative Energy Transfer forCharacterization of Photonic Crystals Morphology — •Yurii Orlovskii, Elena Samsonova, Nikolay Glushkov, Alexander Orlovskii, and Tasoltan Basiev — Prokhorov General Physics Institute RAS, 38 Vavilov st., Moscow, 119991, Russia

We demonstrated that energy transfer probe can be a powerful tool to monitor the way of filling of photonic crystal voids by luminescent material when fluorescence is quenched by intrinsic acceptors.

TUE4f.54 *(232)* Tue 17:00

Physics of CMOS compatible Silicon Photonic Crystals — Leon A. Woldering[1], Simon H. Huisman[1], Bart H. Husken[1,2], Merel Leistikow[1,2], Rajesh V. Nair[1], R. Willem Tjerkstra[1], •Allard P. Mosk[1], and Willem L. Vos[1] — [1]MESA+, Universiteit Twente, Enschede, The Netherlands — [2]AMOLF, Amsterdam, The Netherlands

We have developed new CMOS compatible fabrication methods to realize three-dimensional diamond-like photonic crystals, using standard silicon nanofabrication techniques such as deep reactive ion etching and deep UV lithography.

TUE4f.55 *(138)* Tue 17:00

Hybrid Metal-Dielectric Colloidal Ensembles - from Photonic Crystals to Metamaterials — •Sergei Romanov, Alois Regensburger, Alexander Korovin, and Ulf Peschel — Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Günther-

Scharowsky-Str.1, 91058 Erlangen, Germany

Manipulation with optical spectra of hybrid 3-dimensional metal-dielectric colloidal crystals has been accomplished by changing the topology of the metal film and/or the photonic crystal environment through adding a variety of additional resonances.

TUE4f.56 *(94)* Tue 17:00

Merging Effects of Diffraction and Dispersion in Photonic Crystal Gratings — •Andriy Serebryannikov[1] and Ekmel Ozbay[2] — [1]Hamburg University of Technology, E-3, D-21071 Hamburg, Germany — [2]Nanotechnology Research Center, Bilkent University, 06800 Ankara, Turkey

A review of the basic transmission and reflection regimes in the non-symmetric photonic crystal gratings is presented. The emphasis is put on the potential of these structures in achievement of the strong directional selectivity.

TUE4f.57 *(37)* Tue 17:00

Three Dimensional GaN Photonic Crystal for Solid State Lighting — •Ganapathi Subramania, Qiming Li, Arthur J. Fischer, and George T. Wang — P.O. Box 5800, Sandia National Laboratories, Albuquerque, NM 87185,USA

We demonstrate an all GaN logpile photonic crystal with a visible bandgap achieved using templated epitaxial growth representing an important step in the direction of 3DPC based high brightness and high efficiency GaN LEDs.

TUE4f.58 *(36)* Tue 17:00

Can Silicon be a Viable Material for Visible Three Dimensional Photonic Crystals? — •Ganapathi Subramania and Arthur J. Fischer — P.O. Box 5800,Sandia National Laboratories, Albuquerque, NM 87185,USA

Using silicon logpile three-dimensional photonic crystals we demonstrate that silicon can be a viable material at visible wavelengths due to silicon's indirect electronic bandgap resulting in a slow change in its absorption.

TUE4f.59 *(188)* Tue 17:00

Experimental Demonstration of Locally Oxidized Hybrid Silicon-Plasmonic Waveguide — •Ilya Goykhman, Boris Desiatov, and Uriel Levy — The Hebew University, Jerusalem , Ilsrael

We demonstrate self-aligned approach for fabrication of hybrid silicon plasmonic waveguide. The demonstrated structure provides both nanoscale confinement together with propagation length of 100 microns. Near-field measurements of propagation and coupling loss are also presented.

TUE4f.60 *(149)* Tue 17:00

Plasmonic Waveguides with Photonic Bandgab Confinement — •Carsten Reinhardt[1], Andrey Evlyukhin[1], Wei Cheng[1], Roman Kiyan[1], Arseniy Kuznetsov[1], Boris Chichkov[1], Maksim Skorobogatiy[2], and Andrey Markov[2] — [1]Laser Zentrum Hannover, Hollerithallee 8, D-30419 Hannover, Germany — [2]Department of Engineering Physics, Ecole Polytechnique de Montréal, C.P. 6079, succ. Centre-Ville, Montreal, Quebec, H3C 3A7, Canada

Optical properties of photonic bandgap plasmonic waveguides are investigated experimentally by leakage radiation microscopy and numerically using finite element method. Excitation conditions of various plasmonic modes including their propagation and localization characteristics are discussed.

TUE4f.61 *(93)* Tue 17:00

Metamaterial Light Sources Driven by Electron Beams — •Giorgio Adamo[1], Kevin MacDonald[1], Francesco De Angelis[2], Enzo Di Fabrizio[2], and Nikolay Zheludev[1] — [1]Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, SO17 1BJ, U.K — [2]BIONEM Lab, University of Magna Graecia, Campus S. Venuta, Germaneto, 88100 Catanzaro, Italy

We demonstrate a new generation of free-space and fibre coupled tuneable light sources based on nanostructured photonic metamaterials driven by free-electrons beams. Emission wavelengths are determined by metamaterial resonant modes and electron energies

TUE4f.62 *(104)* Tue 17:00

Photonic crystal fiber with central gold nanowire maintaining azimuthally-polarized modes — •Patrick Uebel, Markus Schmidt, Michael Scharrer, and Philip Russell — Max-Planck-Institute for the Science of Light, Guenther-Scharowky-Strasse 1, 91058 Erlangen, Germany

An air-silica photonic crystal fiber with gold nanowire at core-centre is shown to support an azimuthally-polarized mode with low loss, acting as azimuthal single-polarization fibre over a broad spectral range * from 500 to 1500 nm.

TUE4f.63 *(97)* Tue 17:00

Graded-index surface plasmon-polariton devices — •Giuseppe Della Valle and Stefano Longhi — Dipartimento di Fisica and IFN-CNR, Politecnico di Milano, Piazza L. da Vinci 32, I-20133 Milan, Italy

We propose and numerically demonstrate a parabolic graded-index (GRIN) waveguide for surface plasmon-polaritons (SPPs) allowing sub-wavelength self-imaging of SPP waves. The graded-index structure is applied to design a 4x4 cross-connect device for dielectric-loaded SPP waveguides.

TUE4f.64 *(129)* Tue 17:00

On-Chip Optical Propagation and Photodetection in Nanometer-Scale Two-Conductor Plasmonic Waveguides — •Dany-Sebastien Ly-Gagnon[1], Krishna C. Balram[1], Justin S. White[2], Pierre Wahl[1,3], Mark L. Brongersma[2], and David A.B. Miller[1] — [1]Edward L. Ginzton Laboratory, Stanford University, Stanford CA 94305-4088, USA — [2]Geballe Laboratory for Advanced Materials, Stanford, California 94305, USA — [3]Dept. of Appl. Physics and Photonics, Vrije Universiteit Brussel, Brussels 1050, Belgium

We demonstrate the propagation of a highly confined optical mode in two-conductor plasmonic waveguides and its on-chip detection with integrated photodetectors. Our measurements show good agreement with simulations, indicat-

ing propagation lengths of ˜10μm at 850nm.

TUE4f.65 *(44)* Tue 17:00

Wire Connected Plasmonic Nanoparticles — •Nikolai Berkovitch and Meir Orenstein — Department of Electrical Engineering,Technion, Haifa 32000, Israel

Behavior of coupled plasmonic nanoparticles connected by narrow conducting bridge is demonstrated experimentally and numerically. Introduction of conducting bridge between particles results in abrupt red-shift of the plasmonic resonance and significant field enhancement.

TUE4f.66 *(140)* Tue 17:00

Analysis and Fabrication of Plasmonic Beam Splitter Based on the Evanescent Plasmon Mode — •Seung-Yeol Lee, Junghyun Park, Il-Min Lee, and Byoungho Lee — National Creative Research Center for Active Plasmonics Application Systems,Inter-University Semiconductor Research Center and School of Electrical Engineering,Seoul National University, Gwanak-Gu Gwanakro 599, Seoul 151-744, Korea

We propose a finely tunable surface plasmon beam splitter which is composed of double triangular dielectric structure patterned on thin silver film.

TUE4f.67 *(139)* Tue 17:00

High-Efficiency Dielectric-Bridge Interconnection for Metal-Dielectric-Metal Plasmonic Waveguides — •Seung-Yeol Lee, Minsu Kang, Il-Min Lee, and Byoungho Lee — National Creative Research Center for Active Plasmonics Application Systems, Inter-University Semiconductor Research Center and School of Electrical Engineering, Seoul National University, Gwanak-Gu Gwanakro 599, Seoul 151-744, Korea

An efficient plasmonic interconnector based on a novel coupling mechanism between metal-dielectric-metal plasmonic waveguides with a dielectric slab waveguide, is proposed. The power transfer efficiency could be obtained up to 90 %.

TUE4f.68 *(203)* Tue 17:00

Ultra-Thin Composite Polarizing Splitter — •Sergey Moiseev — Kotelnikov Institute of Radio Engineering and Electronics of RAS, Ulyanovsk Branch, 48/2, Goncharov Str., Ulyanovsk 432011, Russia — Ulyanovsk State University, 42, L.Tolstoy Str., Ulyanovsk 432700, Russia — Ulyanovsk State Technical University, 32, S.Venets Str., Ulyanovsk 432027, Russia

The optical properties of an ultra-thin composite slab with uniformly oriented silver nanoparticles are investigated theoretically. It is shown that anisotropic plasmonic absorption in nanoparticles leads to strong polarization-dependent reflectance and transmittance in the visible region of light.

TUE4f.69 *(158)* Tue 17:00

Sub-wavelength Field Localization in Multimode MIM Nanocavities — •Joerg Petschulat[1], Christian Helgert[1], Michael Steinert[1], Norbert Bergner[1], Arkadi Chipouline[1], Andreas Tuennermann[1], Thomas Pertsch[1], Ernst-Bernhard Kley[1], Carsten Rockstuhl[2], and Falk Lederer[2] — [1]Institute of Applied Physics, Friedrich-Schiller-Universitaet Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Institute of Condensed Matter Theory and Solid State Optics, Friedrich-Schiller-Universitaet Jena, Max-Wien-Platz 1, 07743 Jena, Germany

We present the design and analyze the optical effects in subwavelength MIM waveguide cavities at optical frequencies. The highly confined plasmonic modes inside such cavities are investigated numerically and analytically.

TUE4f.70 *(235)* Tue 17:00

All-optical active element for integrated plasmonic circuitry — •Alexey Krasavin[1], Jean-Sebastien Bouillard[1], Anatoly Zayats[1], Sukanya Randhawa[2], Jan Renger[2], and Romain Quidant[2] — [1]King's College London, Department of Physics, Strand, London WC2R 2LS, U.K. — [2]ICFO-Institut de CienciesFotoniques, 08860 Castelldefels (Barcelona), Spain

We demonstrate both numerically and experimentally a compact and efficient all-optical SPP switch utilising a highly-sensitive ring resonator component. This leads to the realisation of fully functional integrated photonic circuitry based on dielectric-loaded SPP waveguides.

TUE4f.71 *(47)* Tue 17:00

Micromagnetic study of collective spin wave mode in magnetic element arrays — •Dong-Hyun Kim[1], Hong-Guang Piao[1], Je-Ho Shim[1], Seong-Cho Yu[1], Suhk Kun Oh[1], and Jong-Ryul Jeong[2] — [1]Chungbuk National University, Cheongju, South Korea — [2]Chungnam National University, Daejeon, South Korea

We report our micromagnetic simulation result on the possible magnonic mode of spin waves in ferromagnetic nanoelements array, where spectra of collective spin wave modes are carefully investigated.

TUE4f.72 *(83)* Tue 17:00

Optimal Design of Dielectric-Filled Surface Plasmon Polariton Slot Waveguide with Genetic Algorithm — •Jaehoon Jung[1] and Byoungho Lee[2] — [1]Department of Electronics and Electrical Engineering, Dankook University, Yongin-Si, 448-701, Korea — [2]National Creative Research Center for Active Plasmonics Application Systems Inter-University Semiconductor Research Center and School of Electrical Engineering Seoul National University, Gwanak-Gu Sillim-Dong, Seoul 151-744, Korea

An optimization method for a dielectric-filled plasmonic slot waveguide using a genetic algorithm is proposed with an appropriate figure of merit including mode confinement and propagation length.

TUE4f.73 *(179)* Tue 17:00

Plasmonic Optical Vortex Tomography — •Philip Chimento, Gert 't Hooft, and Eric Eliel — Huygens Laboratory, Leiden University, Netherlands

We analyze optical vortices' wavefronts with surface plasmons. Using subwavelength slits in gold, we excite plasmons and measure their diffraction. Moving the slits across the vortex, we create a tomogram which shows the vortex charge.

TUE4f.74 *(202)* Tue 17:00

Stored Light in a Subwavelength Plasmonic Cavity

— •Dmitry Fedyanin and Aleksey Arsenin — Laboratory of Nanooptics and Femtosecond Electronics, Department of General Physics, Mocsow Institute of Physics and Technology (State University), 9 Institutsky lane, Dolgoprudny, 141700, Moscow Region, Russian Federation

We propose novel schemes of the high-Q cavities based on the metal-insulator waveguides. Their Q-factors are determined mainly by the intrinsic properties of the metal rather than the geometries of the cavities.

TUE4f.75 *(206)* Tue 17:00

Size and shape effects in the ultrafast dynamics of electronic energy transfer between a nanoparticle and a molecule — Ahmed Ghalgaoui, Aimeric Ouvrard, Serge Carrez, Wanquan Zheng, and •Bernard Bourguignon — Institut des Sciences Moléculaires d'Orsay, ISMO-CNRS, Université Paris-Sud, Bât. 350, F-91405 Orsay cedex, France

Electronic coupling between metallic nanoparticles and adsorbed molecules is investigated as a function of particle size and adsorption site in pump-probe sum frequency generation experiments.

TUE4f.76 *(67)* Tue 17:00

Split Ring Resonators as Point Scatterers — •Femius Koenderink[1], Ivana Sersic[1], Christelle Tuambilangana[1], and Tobias Kampfrath[1,2] — [1]FOM Institute AMOLF, Amsterdam, The Netherlands — [2]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany

We present an electrodynamic scattering theory to quantify the scattering behaviour of arbitrary systems of point-like magneto-electric scatterers. Our theory sheds new light on the polarizability, cross sections and structural chirality of split ring scatterers.

TUE4f.77 *(209)* Tue 17:00

Signal transfer between planar waveguides — •Xesús Manoel Bendaña and Francisco Javier García de Abajo — Instituto de Óptica-CSIC, Madrid, Spain

We study the interaction between different kinds of planar waveguides. We propose an experiment in which the transferred power is measured, with potential application for integrated nanooptics circuits.

TUE5o: Chiral and Toroidal Media

Chaired by Manolis Antonoyiannakis, American Physical Sociey, USA

Time: Tuesday 18:30–19:55 Location: Olympia

Invited TUE5o.1 *(79)* Tue 18:30

Metamaterials: Demonstrating Toroidal Moment in the Frame of Classical Electrodynamics — Thomas Kaelberer, •Vassili Fedotov, Nikitas Papasimakis, Alexandra Rogacheva, and Nikolay Zheludev — Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, SO17 1BJ, UK

We present electromagnetic metamaterials the resonant response of which cannot be attributed to the excitation of conventional magnetic or charge multipoles and can only be explained by the existence of the induced toroidal dipole.

Talk TUE5o.2 *(173)* Tue 18:55

Circular Dichroism in 3D Bi-Chiral Plasmonic Crystals Fabricated via Direct Laser Writing and Electroless Silver Plating — •André Radke, Timo Gissibl, and Harald Giessen — 4th Physics Institute, University of Stuttgart, Germany

We establish direct laser writing and subsequent electroless silver plating as a viable fabrication method for three-dimensional plasmonic nanostructures by fabricating and characterizing bi-chiral plasmonic crystals that show circular dichroism in the mid-infrared.

Talk TUE5o.3 *(68)* Tue 19:10

Control of Chiral Molecule Radiation with Chiral Left Handed Nanoparticles — •Vasily Klimov[1] and Dmitry Guzatov[2] — [1]Lebedev Physical Institute, 53, Leninskij prospekt, Moscow, 119991, Russia — [2]Yanka Kupala Grodno State University, 22 Ozheshko str., 230023 Grodno, Belarus

Radiation of chiral molecule placed near chiral sphere is investigated. It is shown that optical discrimination of right and left molecules is possible. Applications of results to separate racemic mixtures of drug enantiomers are suggested.

Talk TUE5o.4 *(177)* Tue 19:25

Circularly-Polarized Photoluminescence from Semiconductor Chiral Photonic Nanostructures — •Kuniaki Konishi[1], Makoto Kuwata-Gonokami[1], Masahiro Nomura[2,3], Naoto Kumagai[2,3], Satoshi Iwamoto[2,3], and Yasuhiko Arakawa[2,3] — [1]Photon Science Center, The University of Tokyo and JST-CREST — [2]Institute for Nano Quantum Information Electronics, The University of Tokyo — [3]Institute of Industrial Science, The University of Tokyo

We demonstrated that circular anisotropy of vacuum filed modes is induced in on-waveguide semiconductor chiral nanostructures and such structures radiate circularly polarized light with more than 25% of degree of polarization.

Talk TUE5o.5 *(40)* Tue 19:40

Electromagnetic diode for circularly polarized waves — •Ilya Shadrivov[1], Vassili Fedotov[2], David Powell[1], Yuri Kivshar[1], and Nikolay Zheludev[2] — [1]Australian National University, Canberra, Australia — [2]University of Southampton, United Kingdom

We demonstrate a chiral metamaterial-based electromagnetic diode, which is a direct analogue of an electronic diode: it allows for asymmetric transmission of circularly polarized electromagnetic waves.

TUE5s: Superresolution 2

Chaired by Xiang Zang, University of California, Berkeley, USA

Time: Tuesday 18:30–20:05 Location: Seefeld-Tirol

Invited TUE5s.1 *(125)* Tue 18:30

Sparsity-based sub-wavelength imaging, and super-resolution in time and frequency — Alexander Szameit[1], Yoav Shechtman[1], Pavel Sidorenko[1], Snir Gazit[1], Yonina Eldar[2], Oren Cohen[1], and •Mordechai Segev[1] — [1]Physics Department, Technion, Haifa, Israel — [2]Department of Electrical Engineering, Technion, Haifa, Israel

We demonstrate recovery of sub-wavelength optical images based on prior knowledge that the object is sparse, and analogous concept in the time domain, recovering temporal features much shorter than the response time of a photodetector.

Talk TUE5s.2 *(74)* Tue 18:55

Coherent control of nanoscale light localization: positioning a hot-spot at will — •Tsung Sheng Kao[1], Stewart Jenkins[2], Janne Ruostekoski[2], and Nikolay Zheludev[1] — [1]Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, Southampton, U.K. — [2]School of Mathematics and Centre for Photonic Metamaterials, University of Southampton, Southampton, U.K.

A new paradigm for achieving prescribed nanoscale energy localization at subwavelength scale is demonstrated in this paper. Well isolated energy hot-spots as small as $\lambda/10$ can be created and positioned at will on the metamaterial landscape.

Talk TUE5s.3 *(175)* Tue 19:10

Imaging single molecules at room temperature by optical absorption — •Michele Celebrano[1], Philipp Kukura[2], Alois Renn[1], and Vahid Sandoghdar[1] — [1]Laboratory for Physical Chemistry, ETH Zürich, Wolfgang Pauli Strasse 10, 8093 Zürich, Switzerland — [2]Department of Chemistry, Physical and Theoretical Chemistry Laboratory, University of Oxford, Oxford OX1 3QZ, UK

We demonstrate that conventional modulation-free transmission microscopy can achieve single molecule detection sensitivity. Performing single molecule absorption imaging we could retrieve their absorption cross section under ambient condition even when they do not emit light.

Talk TUE5s.4 *(147)* Tue 19:25

Imaging Through Scattering Media by Digital Phase Conjugation Using Second-Harmonic Beacon Nanoparticles — •Chia-Lung Hsieh[1,2], Ye Pu[1], Rachel Grange[1], Grégoire Laporte[1], and Demetri Psaltis[1] — [1]School of Engineering, EPFL, Station 17, 1015 Lausanne, Switzerland — [2]Department of Electrical Engineering, California Institute of Technology, Pasadena, California 91125, USA

We demonstrate a phase-conjugate scanning microscope which allows us to image through a scattering layer by using second-harmonic beacon nanoparticles. A clear image is obtained by scanning the phase-conjugated second-harmonic radiation from a nanoparticle.

Invited TUE5s.5 *(269)* Tue 19:40

"Seeing" magnetic fields — •Kobus Kuipers — FOM Institute AMOLF, Amsterdam, The Netherlands

In this presentation I will highlight our recent progress in the visualization and manipulation of optical vector fields at the nanoscale.

WED1o: Plenary Talk 3

Chaired by David Smith, Duke University, Durham, NC, USA

Time: Wednesday 8:00–8:45 Location: Olympia

Plenary Talk WED1o.1 *(123)* Wed 8:00

Transforming Metamaterials — •Vladimir Shalaev — Purdue University

The recent progress in the field will be reviewed.

Break

Time: Wednesday 8:45–8:55 Location: Olympia

Break

WED2o: Quantum Phenomena 2

Chaired by Subhasish Dutta Gupta, University of Hyderabad, India

Time: Wednesday 8:55–10:05 Location: Olympia

Invited WED2o.1 *(279)* Wed 8:55

A Technique for Nanoscale Plasmonic Imaging via Photoemission — •Daniel Pickard, Vignesh Viswanathan, and Zhongkai Ai — National University of Singapore, Singapore

Photoemission can reveal localized optical fields with both

high spatial (˜10nm) and temporal (fs) resolution when combined with a PEEM. We present our experimental efforts to expand the technique with a new contrast mechanism.

Talk WED2o.2 *(112)* Wed 9:20

Quantum optics with single optical plasmons — •Alexey Akimov — Harvard University, Physical Department, 17 Oxford St, Cambridge, MA 02138, USA — P.N. Lebedev Institute RAS, 119991, Moscow, Leninskiy prospect, 53

New, broadband approach for engineering photon emitter interactions via subwavelength confinement of guided optical fields in metallic nanowires as well as possibility of tight dipole trap based on nanowires is discussed.

Talk WED2o.3 *(60)* Wed 9:35

Deterministic single-photon generation in a linear-waveguide — •Alejandro Manjavacas and Javier Garcia de Abajo — Insitituto de Optica, Serrano 121 28006 Madrid, Spain

The decay rate of a quantum emitter, placed inside the central element of a linear chain of dielectric particles, is nearly completely released through the chain itself, providing the basis for deterministic highly-directional photon sources.

Talk WED2o.4 *(70)* Wed 9:50

Surface Plasmon Polaritons Mediated Heat Transfer between Metamaterials — •Philippe Ben-Abdallah[1,2], Karl Joulain[3], and Jérémie Drevillon[3] — [1]Laboratoire Charles Fabry, Institut d'Optique, CNRS, Université Paris-Sud, Campus Polytechnique, RD128, F-91127 Palaiseau Cedex, France — [2]Laboratoire de Thermocinétique, CNRS, Ecole Polytechnique de l*Université de Nantes, 44 306 Nantes cedex 03, France — [3]Institut P', CNRS-Université de Poitiers-CNRS UPR 3346, 86022 Poitiers Cedex, France

Dielectric and magnetic losses within metamaterials are responsible for an electromagnetic field emission in their surrounding. Here we investigate the non-contact heat exchanges mediated by this field between two metamaterials closely separated.

WED2s: Nano-Antennas 2

Chaired by Alexey Ustinov, Universität Karlsruhe, Germany

Time: Wednesday 8:55–10:05 Location: Seefeld-Tirol

Invited WED2s.1 *(146)* Wed 8:55

Antennas for Light: interfacing antennas to single photon emitters — •Niek van Hulst — ICFO - the Institute of Photonic Sciences, Castelldefels (Barcelona) Spain

We address the control of emission properties of a single quantum system coupled to an optical antenna: directional emission, controlled polarization and strongly modified radiative lifetime.

Talk WED2s.2 *(101)* Wed 9:20

Optical nanoantennas enhance ultrafast nonlinear spectroscopy of single nanodiscs — •Thorsten Schumacher[1,2], Kai Kratzer[1,2], Mario Hentschel[1,2], Harald Giessen[2], and Markus Lippitz[1,2] — [1]Max Planck Institute for Solid State Research, Heisenbergstraße 1, 70569 Stuttgart, Germany — [2]4th Physics Institute, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart Germany

We enhance the nonlinear pump-probe spectroscopy of a single 40 nm nanodisc by coupling it to a nanoantenna, resulting in an amplification by a factor of ten and a spectral shift to the antenna mode.

Talk WED2s.3 *(215)* Wed 9:35

Enhanced vibrational near-field spectroscopy of PMMA with infrared antennas — •Jón Mattis Hoffmann, Jens Richter, and Thomas Taubner — I. Institute of Physics (IA), RWTH Aachen University, Sommerfeldstrasse 14, 52074 Aachen, Germany

The sensitivity of infrared far-field spectroscopy can be enhanced with infrared antennas. We want to measure a resonantly enhanced infrared near-field spectrum of PMMA in a scattering-type near-field optical microscope (s-SNOM) in amplitude and phase.

Talk WED2s.4 *(16)* Wed 9:50

Plasmonic nanoantenna nonlinear switches — •Martina Abb[1], Nicolas Large[2], Javier Aizpurua[2], and Otto Muskens[1] — [1]University of Southampton, Southampton, United Kingdom — [2]CSIC-UPV/EHU and DIPC, Donostia-San Sebastian, Spain

We present theoretical and experimental studies of ultrafast optical switching using nonlinear plasmonic nanoantennas. Nanoantenna switches will enable new applications involving nonlinear optics and SERS, quantum emitters, and coherent control.

Coffee Break

Time: Wednesday 10:05–10:25 Location: Lobby

Coffee Break

WED3o: Advanced Nano-Fabrication 2

Chaired by Richard Averitt, Boston University, MA, USA

Time: Wednesday 10:25–11:55 Location: Olympia

Invited WED3o.1 *(250)* Wed 10:25

Self Assembly of Nano and Micro-scale Metamaterials — •David Gracias — The Johns Hopkins University, Baltimore, USA

I describe the concept of the self-assembly of 3D nano and micro-scale metamaterials using self-folding of lithographically patterned 2D templates. I describe versatility in composition, shape size and precise patterning to enable novel electromagnetic properties.

Invited WED3o.2 *(108)* Wed 10:50

The direct writing of plasmonic nanostructures and metamaterials — •Katja Hoeflich[1,2], Michael Becker[1,2], Joerg Petschulat[3], Norik Janunts[3], Thomas Pertsch[3], Gerd Leuchs[4], and Silke Christiansen[4,2] — [1]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany — [2]Institute of Photonic Technology, Albert-Einstein-Str.9, D-07745 Jena, Germany — [3]Institute of Applied Physics, Friedrich Schiller University of Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [4]Max Planck Institute for the Science of Light, Guenther-Scharowsky-Str.1, Bau 24, D-91058 Erlangen, Germany

The electron beam induced deposition process makes use of a precursor gas which is locally cracked due to the electron beam impact. Therewith, we fabricate three-dimenensional metamaterial nanostructures with structural details smaller than 50 nm.

Talk WED3o.3 *(205)* Wed 11:15

Laser Fabrication and Optical Properties of Vertical Silver Nanowires — •Mircea Giloan — Babes - Bolyai University, Institute for Interdisciplinary Research in Bionanoscience, Nanobiophotonics Center, T. Laurian 42, 400271 Cluj-Napoca, Romania

Vertical silver nanowires have been fabricated by two-photon microfabrication. The light propagation along the 5-micron length nanowires has been characterized by three-dimensional wide-field transmission microscopy, and analyzed by FDTD simulations.

Invited WED3o.4 *(75)* Wed 11:30

3D Metamaterials and Transformation Optics — •Martin Wegener — Karlsruhe Institute of Technology, Karlsruhe, Germany

After briefly reviewing our recent experimental progress regarding 3D metamaterials operating at optical frequencies, we focus on discussing presently unpublished experiments on 3D invisibility cloaking structures operating in the visible.

WED3s: Plasmonics Waveguides

Chaired by Sergei Bozhevolni, University of Southern Denmark

Time: Wednesday 10:25–11:55 Location: Seefeld-Tirol

Invited WED3s.1 *(46)* Wed 10:25

Plasmonic Photonic Crystal Fibers — •Markus Schmidt — Max Planck Institute for the Science of Light, Guenther-Scharowsky-Str.1, 91058 Erlangen, Germany

We present a novel concept merging plasmonics and fiber optics on the basis of metal-modified photonic crystal fibers. We show excitation of plasmons on single wires, in wire arrays and by mode coupling.

Invited WED3s.2 *(24)* Wed 10:50

Nano fibers: connecting fiber optics with nanophotonics, plasmonics and quantum optics — •Limin Tong — Department of Optical Engineering, Zhejiang University, Hangzhou 310027, China

Nano fiber exhibits interesting properties including tight optical confinement, high fractional evanescent waves, steep field gradient and abnormal dispersion, which opens opportunities for connecting fiber optics with nanophotonics, plasmonics and quantum optics on the nanoscale.

Talk WED3s.3 *(99)* Wed 11:15

Topological surface plasmon-polariton waveguides — •Giuseppe Della Valle and Stefano Longhi — Dipartimento di Fisica and IFN-CNR, Politecnico di Milano, Piazza L. da Vinci 32, I-20133 Milan, Italy

By using multiple-scale asymptotic analysis of vectorial Maxwell's equations we demonstrate that a gently curved metal-dielectric interface can induce localization of surface plasmon-polaritons (SPPs), thus leading to the formation of a topological SPP waveguide.

Invited WED3s.4 *(257)* Wed 11:30

Highly Confined Hybrid Spoof Surface Plasmons in Ultra-thin Metal/Dielectric Heterostructures — •Gennady Shvets[1], Hossein Mousavi[1], Alexander Khanikaev[1], Burton Neuner[1], Yoav Avitzour[1], Dmitriy Korobkin[1], and Gabriel Ferro[2] — [1]Department of Physics, The University of Texas at Austin, One University Station, RLM C1500, Austin, Texas 78712,USA — [2]Laboratoire des Multimateriaux et Interfaces, Universite Claude Bernard Lyon 1, 69622 Villeurbanne, France

Highly confined "spoof" surface plasmon (SSP) modes are predicted to exist in a perforated metal film coated with a thin dielectric layer. SSPs are shown to turn thin, weakly-absorbing semiconductor films into perfect absorbers.

Lunch Break

Time: Wednesday 11:55–16:15

Lunch Break

WEDSI2: Special Interests Talk 2

Time: Wednesday 16:15–17:00 Location: Seefeld-Tirol

Dr Manolis Antonoyiannakis, Editor of Physical Review Letters "Publishing a paper in Physical Review Letters"

WED4f: Poster Session 2

Chaired by Ian Osborne, "Science", & John Dudley, University of Franche-Comté, France

Time: Wednesday 17:00–18:30 Location: Foyer

WED4f.1 *(287)* Wed 17:00

Monitoring Cellular Uptake of Gold Nanoshells Using CARS Microscopy — •Natalie Garrett and Julian Moger — Biomedical Physics Group, School of Physics, University of Exeter, Exeter, EX4 4QL

The cellular uptake and photo-thermal effects of gold-coated silica spheres of 200 nm diameter are investigated using CARS microscopy of live cells.

WED4f.2 *(237)* Wed 17:00

Gold nano-particles self-assembly achieved within liquid crystal pattern — •Delphine Coursault[1], Habib Ayeb[1], Emmanuelle Lacaze[1], Johan Grand[2], and Nordin Félidj[2] — [1]Institut des Nano-Sciences de Paris (INSP), UMR-CNRS 7588, Université Pierre et Marie Curie-Paris 6, 4 pl Jussieu 75005 PARIS, France — [2]Université Denis Diderot-Paris 7, Laboratoire Interfaces, Traitements, Organisation et Dynamique des Systèmes, 15, Rue Jean de Baïf, 75205 PARIS cedex 13, France

We mix gold nanoparticles with liquid crystal (LC) patterns which allow to tune the LSPR thanks to LC anisotropy. Reversibly, the LSPR provides a way to understand where nanoparticles are trapped in the LC matrix.

WED4f.3 *(137)* Wed 17:00

Near-field enhancement and light confinement in microcavities fabricated using soft-lithography and etching techniques — •Manuel Gonçalves[1], Taron Makaryan[1], Tobias Paust[1], Othmar Marti[1], Stefan Wiedemann[2], Fabian Enderle[2], Alfred Plettl[2], and Paul Ziemann[2] — [1]Ulm University, Institute of Experimental Physics, Albert-Einstein-Allee 11, 89069 Ulm, Germany — [2]Ulm University, Institute of Solid State Physics, Albert-Einstein-Allee 11, 89069 Ulm, Germany

Microcavities were fabricated using nanosphere- and soft-lithography and plasma etching techniques. These structures can confine light and enhance near-fields. Light confinement is desired in energy conversion applications while strong near-field enhancements are required for SERS.

WED4f.4 *(98)* Wed 17:00

Fabrication of Circular Si/SiO2 Waveguides from Bulk Si Exploiting Laser Reformation Technique — •Shih-Che Hung[1], Shu-Cha Shiu[1], Jiun-Jie Chao[1], and Ching-Fuh Lin[2] — [1]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei, Taiwan — [2]Graduate institute of Photonics and Optoelectronics, Graduate Institute of Electronics Engineering and Department of Electrical Engineering, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei, Taiwan

A method to fabricate Si/SiO2 waveguides from bulk silicon using laser reformation technique. By applying high-power laser, the Si ridges would be melted and reshaped to circular-profile structure. This method allows the architect full flexibility.

WED4f.5 *(197)* Wed 17:00

Fabrication of high-quality large-area plasmonic oligomers with reproducible sub-50 nm structure sizes and 10 nm gap sizes — •Jun Zhao, Bettina Frank, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

We demonstrate fabrication of high-quality large-area plasmonic oligomers with reproducible sub-50 nm structure sizes and 10 nm gap sizes and examine the pronounced optical spectra in terms of mode symmetry.

WED4f.6 *(35)* Wed 17:00

Fabrication and characterization of novel 3D isotropic plasmonic materials — •Marcin Gajc[1], Andrzej Klos[1], Ryszard Diduszko[1], Barbara Surma[1], Nikolay I. Zheludev[2], Andrey Nikolaenko[2], and Dorota A. Pawlak[1] — [1]Institute of Electronic Materials Technology, Wolczynska 133 01-919 Warsaw, Poland — [2]Optoelectronics Research Centre, University of Southampton, Highfield, Southampton, SO17 1BJ, United Kingdom

In the present work metallodielectric materials, obtained by directional growth of dielectric fibers with incorporated silver nanoparticles, have been investigated. Description of novel fabrication process together with structural/optical characterization results will be presented.

WED4f.7 *(48)* Wed 17:00

Highly absorbing nanowire polarizers — •Anni Lehmuskero[1], Toni Saastamoinen[1], Ismo Vartiainen[1], Tapani Alasaarela[2], and Markku Kuittinen[1] — [1]University of Eastern Finland, Department of Physics and Mathematics, P.O.Box 111, FI-80101 Joensuu, Finland — [2]Aalto University, Micronova, P.O. Box 13500, FI-00076 Aalto, Finland

We introduce polarizers that absorb either TM- or TE-

component. Absorption of 0.9967 % with contrast TTE/TTM = 6600 is achieved with only 140 thick metal wire. Absorption is based in guided mode resonance and particle plasma resonance.

WED4f.8 *(78)* Wed 17:00

Fabrication of V-shaped Optical Antennas — •Andrey Denisyuk — Saint-Petersburg State University of Informational Technologies, Mechanics and Optics, 49 Kronverksky Avenue, 197101 St. Petersburg, Russia

The possibility of V-shaped optical antenna fabrication was experimentally demonstrated using the technique of electron beam induced deposition of carbon. Fabricated structures consisted of pairs of closely-spaced carbon nanorods coated with gold.

WED4f.9 *(196)* Wed 17:00

Diverse Formation of Au-Nanoparticles in the LC PPI Dendrimer — •Marius Franckevicius[1], Nicolas Cheval[2], Amir Fahmi[2], Augustinas Kulbickas[1], Mercedes Marcos[3], Jose Luis Serrano[3], and Rimas Vaisnoras[1] — [1]Liquid Crystals Laboratory, Faculty of Physics and Technology, Vilnius Pedagogical University, Studentu st. 39, LT-08106 Vilnius, Lithuania — [2]Department of Mechanical, Materials and Manufacturing Engineering, University of Nottingham, University Park, Nottingham, NG7 2RD, United Kingdom — [3]Instituto de Ciencia de Materiales de Aragón (ICMA), Universidad de Zaragoza-Consejo Superior de Investigaciones Científica (CSIC), 50009 Zaragoza, Spain

PPI dendrimer - Au nanoparticle was studied. Results have show that size and location of nanoparticle depends on the dendrimer generation. By changing generation it is possible to tune the size and shape of nanoparticle.

WED4f.10 *(228)* Wed 17:00

Mimicking the Cosmological Redshift with Time Dependent Transformation Optics — •Vincent Ginis[1], Philippe Tassin[1,2], Ben Craps[3], and Irina Veretennicoff[1,3] — [1]Vrije Universiteit Brussel, Brussels, Belgium — [2]Iowa State University, Ames, USA — [3]Vrije Universiteit Brussel and The International Solvay Institutes, Brussels, Belgium

We apply the framework of transformation optics to mimic the cosmological redshift inside metamaterials and describe how a medium with well-defined time-dependent material parameters changes the optical frequency even though it supports linear electromagnetic waves.

WED4f.11 *(121)* Wed 17:00

Surface Plasmon Polaritons on Cone — •Vera B. Zon[1,2] and Boris A. Zon[1] — [1]Voronezh State University, University sq. 1, 394006 Voronezh, Russia — [2]Walter Schottky Institut, Am Coulombwall 3, D-85748 Garching, Germany

An analytical solution for the electromagnetic field, produced by surface plasmon polaritons (SPPs), on the surface of a conductive cone in insulating medium is derived. The solution predicts no conversion into photons at the cone's apex for all propagating SPPs.

WED4f.12 *(171)* Wed 17:00

Quasi-cylindrical Waves at the Interface of a Semiconductor Device — •Choon How Gan[1], Philippe Lalanne[1], Loic Lalouat[2], and Lionel Aigouy[2] — [1]Institut d'Optique, CNRS, Univ Paris-Sud, Campus Polytechnique, 91127 Palaiseau Cedex, France — [2]ESPCI, CNRS UMR 8213, 75231 Paris Cedex 5, France

We study the wave launched by 1D subwavelength indentations on a semiconductor surface that does not support any surface mode, and find that it resembles a quasi-cylindrical wave similar to that observed on metallo-dielectric interfaces.

WED4f.13 *(167)* Wed 17:00

Cylindrical wave contribution observed in random hole structures — •Frerik van Beijnum[1], Martin van Exter[1], and Chris Rétif[2] — [1]Leiden University, Huygens Laboratory, P.O. Box 9504, 2300 RA Leiden, The Netherlands — [2], FOM Institute for Atomic and Molecular Physics, Science Park 104, 1098 XG Amsterdam, The Netherlands

We study the transmission of random hole structures with varying hole density. This data contains a wealth of information about the transmission mechanisms: direct transmission, surface plasmon assisted transmission and a cylindrical wave contribution.

WED4f.14 *(90)* Wed 17:00

Time reversal in matter-wave optics — •Jacques Baudon, Mehdi Hamamda, Thierry Taillandier-Loize, Francisco Perales, Gabriel Dutier, and Martial Ducloy — Laboratoire de Physique des Lasers, CNRS-UMR 7538, Université Paris 13, 99 avenue J.B. Clement, 93430-Villetaneuse, France

A novel process, specific of matter waves in negative-index media, is evidenced. The transient narrowing of wave packets is the clear manifestation of a time reversal effect, a general property of such media.

WED4f.15 *(135)* Wed 17:00

Color Filter Based on Chromatic Plasmonic Vortex — •Junghyun Park[1], Hwi Kim[2], Seong-Woo Cho[1], Seung-Yeol Lee[1], and Byoungho Lee[1] — [1]Seoul National University, Seoul, Korea — [2]Korea University, Yeongi-gun, Korea

We present a novel color filter by using the chromatic plasmonic vortex. Cylindrical apertures with different radii are inscribed on a thin metal film to selectively transmit the plasmonic vortex with various primary ring sizes.

WED4f.16 *(239)* Wed 17:00

Characterization of strongly focused laser beams by the knife-edge method — •Christian Huber[1,2], Pavel Marchenko[1,2], Peter Banzer[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, D-91058 Erlangen, Germany — [2]Friedrich-Alexander University Erlangen-Nuremberg, D-91052 Erlangen, Germany

To measure the intensity distribution of the focal spot for high NA focusing experimentally we use the so called knife-edge method. The polarization dependent effects of this method at nano-scale dimensions are investigated.

WED4f.17 *(55)* Wed 17:00

Radiative heat transfer between nanoparticles — •Alejandro Manjavacas and Javier Garcia de Abajo — Insitituto de Optica, Serrano 121 28006 Madrid, Spain

We derive the radiative heat transfer between nanoparticles, which includes the surrounding thermal bath as well as the scattering processes. Corrections to previous results are obtained that are dominant in many common situations.

WED4f.18 *(14)* Wed 17:00

Casimir force on amplifying metamaterials — •Agnes Sambale[1], Dirk-Gunnar Welsch[1], Stefan Yoshi Buhmann[2], and Dung Trung Ho[3] — [1]Theoretisch-Physikalisches Institut, Friedrich-Schiller Universität Jena, Germany — [2]Quantum Optics and Laser Science, Blackett Laboratory, Imperial College London, United Kingdom — [3]Institute of Physics, Academy of Sciences and Technology, Ho Chi Minh city, Vietnam

We show how the Casimir force on an arbitrary system of linear partially amplifying bodies can be calculated within the framework of macroscopic QED and Lorentz force approach.

WED4f.19 *(242)* Wed 17:00

Coupling of CdSe/CdS Nanocrystals to a Self-assembled Plasmonic Crystal — Hugo Frederich[1], Fangfang Wen[1], Julien Laverdant[1], Laurent Coolen[1], Catherine Schwob[1], •Agnès Maître[1], Dubertret Benoît[2], Alexander Grusintsev[3], and V. Masalov[4] — [1]Université Pierre et Marie Curie-Paris 6, UMR 7588, INSP, Campus Boucicaut, 140 rue de Lourmel, Paris, F-75015 France. CNRS, UMR7588, INSP, Paris, F-75015 France. — [2]Laboratoire Photons Et Matière, CNRS UPR5, ESPCI 10 rue Vauquelin, 75231 Paris, France — [3]Institut of Microelectronic Technology and High Purity Materials, Russian academy of science, 142 432 Chergonolovka, Russia — [4]Institut of Solid State Physics, Russian academy of science, 142 432 Chergonolovka, Russia

Periodically patterned gold surfaces are produced by an original method using self-assembled opals. Light coupling to crystal surface plasmons is demonstrated. CdSe/CdS nanocrystals located in the vincinity of suchstructured surface experience fluorescence modifications.

WED4f.20 *(187)* Wed 17:00

Optical Properties of Metallic Nanoshells with Fluorescent Liquid Cores — •Zaiba Soraya — Laboratoire de Spectrométrie Physique CNRS 5588 Université Joseph Fourier, Grenoble, France

Encapsulating fluorescent molecules in gold nanoshell makes them bright and photoresistant. This improvement is due to the strong interaction of the molecule and metallic surface, leading to near field enhancement and the decrease of the excited state lifetime.

WED4f.21 *(127)* Wed 17:00

Optical response of hybrid metal-semiconductor nano-dimer — •Andrey Malyshev[1,3] and Victor Malyshev[2] — [1]Departamento de Física de Materiales, Universidad Complutense, 28040 Madrid, Spain — [2]Zernike Institute for Advanced Materials, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands — [3]A. F. Ioffe Physico-Technical Institute, St. Petersburg, Russia

We consider a system comprising an Au-CdSe/ZnSe nano dimer and predict optical bistability and hysteresis in its esponse, which suggests various applications, in particular, all-optical processing and optical memory.

WED4f.22 *(174)* Wed 17:00

Organic photovoltaic cells - enhanced absorption by patterned Au nano disks in the active layer — Iddo Dukman, Lior Tzabari, •Meir Orensteein, and Nir Tessler — EE Dept. Technion, Haifa Israel

External-quantum-efficiency for organic photovoltaic device is enhanced by incorporating patterned Au nanodisk arrays, extending into the active layer. Enhancement mechanisms and design rules are verified. Enhancement stems from resonances of localized plasmon and nanopatch antennas.

WED4f.23 *(64)* Wed 17:00

Enhancing the Photoluminescence Properties of Single Epitaxial GaAs Quantum Dots Using Optical Antennas — •Klas Lindfors[1,2], Markus Pfeiffer[1,2], Paola Atkinson[3], Mohamed Benyoucef[3], Armando Rastelli[3], Oliver G. Schmidt[3], Harald Giessen[1], and Markus Lippitz[1,2] — [1]4. Physics Institute, University of Stuttgart, Pfaffenwaldring 57, D-70550 Stuttgart, Germany — [2]Max Planck Institute for Solid State Research, Heisenbergstrasse 1, D-70569 Stuttgart, Germany — [3]IFW Dresden, Helmholtzstrasse 20, D-01069 Dresden, Germany

We use optical antennas to modify the optical properties of single epitaxial GaAs quantum dots. We demonstrate an enhancement up to a factor of 8 in the excitation efficiency of the emitters using plasmonic antennas.

WED4f.24 *(100)* Wed 17:00

Plasmonic Nano-antennas for Absorption Enhancement in Thin-Film Silicon Solar Cells — •Khai Quang Le[1], Aimi Abass[2], Bjorn Maes[1], and Peter Bienstman[1] — [1]Ghent University-IMEC, INTEC, 41 Sint-Petersnieuwstraat, Ghent, Belgium — [2]Ghent University, ELIS, 41 Sint-Petersnieuwstraat, Ghent, Belgium

In this contribution, we theoretically demonstrate significant light absorption enhancement by adding plasmonic nano-antennas on top of thin-film amorphous silicon solar cells. This enhancement is attributed to resonance light scattering of core-shell (silica-silver) nanostructures.

WED4f.25 *(52)* Wed 17:00

Controlling the Coupling of Nitrogen Vacancy Centers to a Silver Nanowire — •Alexander Huck, Shailesh Kumar, and Ulrik Lund Andersen — Department of Physics, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

We demonstrate the controlled coupling of nitrogen vacancy centers in diamond to silver nanowires by nano-positioning with an atomic force microscope. A decrease in emitter lifetime by a factor of 3.7 is measured.

WED4f.26 *(110)* Wed 17:00

Using Gain to Overcome Losses in Trapped Rainbow Metamaterial Heterostructures — •Kosmas Tsak-

MAKIDIS, EDMUND KIRBY, JOACHIM HAMM, TIM PICKERING, and ORTWIN HESS — Advanced Technology Institute and Department of Physics, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, GU2 7XH, United Kingdom

We analytically and numerically calculate the losses/gain for complex-frequency and complex-wavevector modes in passive/active trapped rainbow waveguides. We obtain excellent agreement between five distinct sets of results, all showing that losses can be fully overcome.

WED4f.27 *(166)* Wed 17:00

A Generic Model for Analysis Metamaterals with Gain — •ARKADI CHIPOULINE[1], JOERG PETSCHULAT[1], ANDREAS TÜNNERMANN[1], THOMAS PERTSCH[1], and VASSILI FEDOTOV[2] — [1]Institute of Applied Physics, Friedrich-Schiller-Universität Jena, Max-Wien Platz 1, 07743, Jena, Germany — [2]Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, SO17 1BJ, UK

We have developed a generic model for fast and accurate evaluation of optical properties of plasmonic metamaterials with gain. Simulation results show that compensation of losses may substantially reduce the strength of metamaterial's magnetic response.

WED4f.28 *(85)* Wed 17:00

Semiclassical model of nano laser — •ARKADI CHIPOULINE[1], MARKUS MUNDUS[1], THOMAS PERTSCH[1], and ANATOLY CHIRKIN[2] — [1]IAP-FSU, Jena, Germany — [2]MSU, Moscow, Russia

An analytical model for nano laser based on density matrix for gain media and harmonic oscillator for the plasmonic excitation is presented. Statistical characteristics and dynamics of symmetric (dipole) and asymmetric (quadrupole) modes are investigated.

WED4f.29 *(62)* Wed 17:00

Optimization of phase transfer function to compensate for the loss problem in metamaterials — •KYOUNGSIK KIM — School of Mechanical Engineering, Yonsei University, 262 Seongsanno, Seodaemun-gu, Seoul, Korea

We developed the phase transfer function analysis method to enhance the superresolution of the lossy near-field superlens by compensating for the loss problem, similarly with the phase retrieval method in the far-field optics.

WED4f.30 *(51)* Wed 17:00

Gain Induced Optical Transparency in Meta-Subunits — •GIUSEPPE STRANGI and ANTONIO DE LUCA — University of Calabria, Dept. of Physics, Rende - Italy

Experimental studies concerning the reduction of radiation damping in optical metamaterials based on gain functionalized gold nano-particles assembly are reported. By optimizing material parameters, resonant excitation energy transfer occuring via non-radiative process is promoted.

WED4f.31 *(220)* Wed 17:00

Semiconductor Surface Plasmon Sources: from Plasmon-Emitting Diodes to SPASERs — •DMITRY FEDYANIN — Laboratory of Nanooptics and Femtosecond Electronics, Department of General Physics, Mocsow Institute of Physics and Technology (State University), 9 Institutsky lane, Dolgoprudny, 141700, Moscow Region, Russian Federation

I propose semiconductor surface plasmon sources based on a minority carrier injection in a metal-insulator-semiconductor (MIS) diode, analyse them analytically and numerically and examine different materials with the purpose of practical realization.

WED4f.32 *(86)* Wed 17:00

Nanowire Optical Antennas: Multipolar Radiation of Quantum Emitters — •ALBERTO G. CURTO[1], TIM H. TAMINIAU[1], GIORGIO VOLPE[1], MARK P. KREUZER[1], ROMAIN QUIDANT[1,2], and NIEK F. VAN HULST[1,2] — [1]ICFO - The Institute of Photonic Sciences — [2]ICREA - Institucio Catalana de Recerca i Estudis Avançats

We report multipolar emission of quantum dots coupled to metal nanowire optical antennas of increasing resonance order. We study polarization, angular radiation pattern and emitter-antenna coupling for each mode. Experimental and theoretical results are compared.

WED4f.33 *(144)* Wed 17:00

Polarized multiphoton emission of resonant Al, Ag and Au nanoantennas — •MARTA CASTRO-LOPEZ[1], DAAN BRINKS[1], RICCARDO SAPIENZA[1], and NIEK VAN HULST[1,2] — [1]ICFO-The Institute of Photonic Sciences, Castelldefels, Barcelona — [2]ICREA - Inst. Catalana de Recerca i Estudis Avancats, Barcelona, Spain

We present an experimental study of resonant Au, Ag and Al nanorods which show shifted resonance lengths and large polarization differences. We control TPL polarization by shaping the aspect ratio of the nanorods.

WED4f.34 *(77)* Wed 17:00

Optical Antenna Probes Based on Metallic Nanoshells with Nanoknobs — •ANDREY DENISYUK[1], ALEXANDER ANKUDINOV[2], and MIHAIL PETROV[3] — [1]Saint-Petersburg State University of Informational Technologies, Mechanics and Optics, 49 Kronverksky Avenue, 197101 St. Petersburg, Russia — [2]Ioffe Physical-Technical Institute of the Russian Academy of Sciences, 26 Polytechnicheskaya, 194021, St. Petersburg, Russia — [3]University of Eastern Finland, Yliopistokatu 7, Joensuu, 80101, Finland

We investigate the possibility of using complex metallic nanostructures consisting of metallic nanoshells with nanoknobs as near-field optical probes. The structures were created by means of precise manipulation and local metal deposition under electron beam.

WED4f.35 *(7)* Wed 17:00

Optical emission enhancement by coupled metal nanospheres — •GREG SUN[1] and JACOB KHURGIN[2] — [1]University of Massachusetts Boston, USA — [2]Johns Hopkins University, USA

We present an analytical approach to evaluate the enhancement of optical emission of an active molecule placed in the gap of two coupled metal nanoparticles.

WED4f.36 *(6)* Wed 17:00

Analysis of field enhancement by coupled metal nanoparticles — •Greg Sun[1] and Jacob Khurgin[2] — [1]University of Massachusetts Boston, USA — [2]Johns Hopkins University, USA

We develop an analytical model to evaluate the field enhancement in the gap of two coupled metal nanospheres and compare the result with that obtained by a single sphere.

WED4f.37 *(10)* Wed 17:00

Transmission Properties of Bow-Tie-Shaped Aperture Array in Ag/Si Structure — •Shao-Yu Huang, Yi-Tsung Chang, Hung-Hsin Chen, Yu-Wei Jiang, Hao-Fu Huang, and Si-Chen Lee — Department of Electrical Engineering, Graduate Institute of Electronics, National Taiwan University, Taipei, 10617 Taiwan, Republic of China

Transmission of bow-tie-shaped aperture array in Ag/Si structure with various tip separation and angles were investigated. The result indicates that high-order SP modes are enhanced and strongly influenced by these parameters.

WED4f.38 *(18)* Wed 17:00

Controlling light with nanoantennas — •Nicolas Bonod[1], Alexis Devilez[1], Brice Rolly[1], Sebastien Bidault[2], and Brian Stout[1] — [1]Institut Fresnel, Domaine Universitaire de Saint Jerome, 13013 Marseille, France — [2]Institut Langevin, UMR 7587 ESPCI ParisTech, 10 rue Vauquelin 75231 Paris cedex 05, France

We show that it is possible to design ultracompact nanoantenna combining radiative properties and directionality.

WED4f.39 *(236)* Wed 17:00

Macroscopic Tuning of Broadband Directional Plasmonic Nano-Antennae — Andrey Malyshev[1,3], •Victor Malyshev[2], and Javier Munarriz[1] — [1]Departamento de Física de Materiales, Universidad Complutense, 28040 Madrid, Spain — [2]Zernike Institute for Advanced Materials, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands — [3]A. F. Ioffe Physico-Technical Institute, St. Petersburg, Russia

Linear graded arrays of silver nano-particles operate as broadband highly directional nano-antennae; various properties of such systems located near a dielectric-semiconductor interface can be tuned by changing electron concentration in the semiconductor.

WED4f.40 *(241)* Wed 17:00

Nanoantenna Coupled Plasmonic Nanodots in a Three-dimensional Cavity for Uniform and Ultrahigh Surface-Enhanced Raman Scattering (SERS) over Large Area — •Wen-Di Li, Fei Ding, Jonathan Hu, and Stephen Chou — Nanostructure Laboratory, Department of Electrical Engineering, Princeton University, NJ 08544 USA

A new SERS substrate with plasmonic nanodots coupled with nanodisk antenna in a 3-D cavity is proposed and demonstrated to have an ultrahigh average enhancement factor of >1E9 over large area with variation below 26%.

WED4f.41 *(246)* Wed 17:00

Nanoantenna Enhanced Transmission through Blocked Metallic Subwavelength Holes — •Wen-Di Li, Jonathan Hu, and Stephen Chou — Nanostructure Laboratory, Department of Electrical Engineering, Princeton University, Princeton, NJ 08544 USA

Metallic nanoholes blocked by metallic nanodisks are observed to transmit up to 70% more light than open holes. It is attributed to the nanoantenna effects by the metallic nanodisk blockers placed above the holes.

WED4f.42 *(145)* Wed 17:00

Optical Transmission Enhancement in Vertically-Tapered Bowtie-Aperture — •Jun-Bum Park, Dong-Ho Oh, Dawoon Choi, Il-Min Lee, Seung-Yeol Lee, and Byoungho Lee — Seoul National University, Gwanak-Gu Gwanakro 599, Seoul 151-744, Korea

We propose a vertically-tapered bowtie-aperture in a metallic film for the sake of enhancing the optical transmission properties over wide spectral range of 0.5*2.0 um.

WED4f.43 *(181)* Wed 17:00

Mapping infrared antenna resonances of particle arrays fabricated by nanosphere lithography — •Jens Richter[1], Andrea Hartung[1], Jón Mattis Hoffmann[1], Xinghui Yin[2], and Thomas Taubner[1,2] — [1]1st Institute of Physics, RWTH Aachen University, Sommerfeldstrasse 14, 52074 Aachen, Germany — [2]Fraunhofer Institute for Laser Technology, Steinbachstr. 15, 52074 Aachen, Germany

Infrared antennas exhibit large local field enhancement, showing potential for enhanced vibrational spectroscopy. We determine the resonance position of antenna arrays created by nanosphere lithography as a function of lateral size, height and substrate refractive index.

WED4f.44 *(17)* Wed 17:00

Nonlocal Effects in the Optical Response of Plasmonic Devices — •Christin David and Francisco Javier García de Abajo — Instituto de Óptica, CSIC, Serrano 121, 28006 Madrid, Spain

We show that nonlocality in the optical response plays an important role in geometries involving small metal features or narrow gaps. We present two advanced material models to account for nonlocality in nanosized metallic structures.

WED4f.45 *(185)* Wed 17:00

Nanoshells: calculation of the work function using non-standard methods — •Katrijn Putteneers and Fons Brosens — Theory of Quantum and Complex Systems, Universiteit Antwerpen, Universiteitsplein 1, 2610 Wilrijk, Belgium

We propose a conceptually transparent methodology to calculate the work function of a nanoshell which has a number of advantages over more standard methods.

WED4f.46 *(107)* Wed 17:00

Symmetry breaking and selective mode excitation in plasmonic trimers — •Lev Chuntonov — Department of Chemical Physics, Weizmannn Institute of Science, Rehovot, Israel

We perform plasmon spectroscopy on a homologous series

of silver nanoparticle trimers. Gradual symmetry breaking lifts mode degeneracy and enables mode-selective excitation with polarized light, revealing cluster orientation in the lab frame.

WED4f.47 *(115)* Wed 17:00

Imprints At A Glass Surface Due To Nanovoids Formed By Laser-Induced Dissolution Of Silver Nanoparticles — •M. C. Sow, F. Goutaland, N. Ollier, and F. Vocanson — Laboratoire Hubert Curien - UMR CNRS 5516 - 18 rue du Professeur Benoit Lauras - 42000 Saint-Etienne - France

We demonstrate the pattern of a glass-metal composite surface. The imprints consist of nanovoids resulting from the laser-induced dissolution of silver nanoparticles. The UV energy density controls the amount of nanoparticles being dissolved.

WED4f.48 *(111)* Wed 17:00

Optical imaging and tracking of nanoparticles in colloids — •Ivan Fedosov[1], Igor Nefedov[2], Boris Khlebtsov[3], and Valery Tuchin[1] — [1]Dept. of Optics & Biophotonics, Saratov State University, 83, Astrakhanskaya, 410012, Saratov, Russian Federation — [2]SMARAD Department of Radio Science and Engineering, Helsinki University of Technology (TKK) P.O. 3000, FI-02015 TKK, Finland — [3]Inst. of Biochemistry and Physiology of Plants and Microorganisms of RAS, 13, Enthusiastov, 410049, Saratov, Russian Federation

We present optical technique based on selective plane illumination microscopy and digital image processing for simultaneous measurements of local nanoparticles diffusivity in fluid and velocity field of their ordered motion with submicrometer spatial resolution.

WED4f.49 *(221)* Wed 17:00

Plasmonic modes of gold nano-particle arrays on thin gold films — •Alfred Leitner, Andreas Hohenau, Joachim R. Krenn, and Norbert Reitinger — Institute of Physics, Karl-Franzens University, Graz, Austria

Regular gold nanoparticle arrays on 25 nm thick gold films allow to excite asymmetric surface plasmon modes featuring a much better field confinement compared to the symmetric modes used in conventional surface plasmon resonance setups.

WED4f.50 *(152)* Wed 17:00

Spectra-Temporal Dynamics of Carbon Nanotubes in Plasmonic Metamaterial — •Andrey Nikolaenko[1], Mengxin Ren[1], Francesco De Angelis[2], Enzo Di Fabrizio[2], and Nikolay Zheludev[1] — [1]Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, SO17 1BJ, UK — [2]Italian Institute of Technology, 16163 Genova, Italy

By aggregating carbon nanotubes with plasmonic metamaterial we achieve giant optical nonlinearity with sub-500 fs response time. Dispersion of the optical response dynamics of this coupled exciton-plasmon system is studied for the first time.

WED4f.51 *(45)* Wed 17:00

Metallodielectric eutectic structures for photonics: Bi2O3-Ag and CuO-Ag — •Katarzyna Sadecka[1], Marcin Gajc[1], Andrzej Kłos[1], Ryszard Diduszko[1], Barbara Surma[1], Dorota Pawlak[1], Andrey Nikolaenko[2], and Nikolay Zheludev[2] — [1]Institute of Electronic Materials Technology (ITME), 133 Wolczynska Str, 01-919 Warsaw, Poland — [2]Optoelectronics Research Centre, University of Southampton, Highfield, Southampton, SO17 1BJ, UK.

Metal-oxide eutectics such as Bi2O3-Ag and CuO-Ag have been obtained and characterized. Eutectics were directionally solidified by the micro-pulling down method. Results of optical measurements in the visible and infrared region will be presented.

WED4f.52 *(182)* Wed 17:00

Second harmonic generation by resonant excitation of coupled surface plasmon — •Marco Centini, Alessio Benedetti, Concita Sibilia, and Mario Bertolotti — Dipartimento di Scienze di Base e Applicate per l'Ingegneria- Sez Fisica. Sapienza Università di Roma.

We report numerical results showing that second harmonic generation can be enhanced and tailored by resonant excitation of coupled localized plasmon polariton modes in chains made of multiple gold blocks acting as coupled plasmon resonators.

WED4f.53 *(13)* Wed 17:00

Application of photochromic polymers in plasmonics — •Pawel Karpinski and Andrzej Miniewicz — Institute of Physical and Theoretical Chemistry, Wroclaw University of Technology ul. Smoluchowskiego 23, 50-372 Wroclaw, Poland

Structures composed of photochromic polymers on a metal surface are investigated. We used the Finite-Difference Time-Domain method to numerically model excitation, waveguiding and switching of Surface Plasmon Polaritons under changes of refractive index of polymer.

WED4f.54 *(240)* Wed 17:00

Controlling optical bistability of plasmonic systems at nanoscale — •Andrey Malyshev — Departamento de Física de Materiales, Universidad Complutense, 28040 Madrid, Spain — A. F. Ioffe Physico-Technical Institute, St. Petersburg, Russia

We show that a CdSe/ZnSe nano-particle in the proximity of a dielectric-semiconductor interface can manifest optical bistability which can be controlled macroscopically, e.g. by changing electron concentration in the semiconductor.

WED4f.55 *(208)* Wed 17:00

Low threshold optical bistability with supermodes — •Ali Naqavi[1], Masoud Edalatipour[2], Hooman Abediasl[3], and Khashayar Mehrany[2] — [1]EcolePolytechnique Fédérale de Lausanne (EPFL), Neuchâtel, Switzerland — [2]Sharif University of Technology,Tehran,Iran — [3]GLSE Institute of Technology, CA, USA

Coupled standing-wave resonators are analyzed in nonlinear regime in the general case. It is shown theoretically that the operation power levels of the device and its threshold power

can decrease using supermodes.

WED4f.56 *(200)* Wed 17:00

Second Harmonic Generation Enhancement with Surface Plasmon Resonance for 3D Gold Nanoantennas — •Alessio Benedetti — Dipartimento di Scienze di Base e Applicate per l'Ingegneria- Sezione Fisica, Sapienza Università di Roma.

Abstract. Using a Green's tensor method we investigated the SHG effects for arbitrarily shaped gold nanoantennas under SPP resonance. We find the possibility to select dipolar and quadrupolar sources for more realistic samples.

WED4f.57 *(288)* Wed 17:00

Size, gap, and material dependence of third harmonic generation from bowtie — •Mario Hentschel[1,2], Tobias Utikal[1,2], Markus Lippitz[1,2], and Harald Giessen[1] — [1]University of Stuttgart, Germany — [2]Max-Planck-Institute for Solid State Research, Stuttgart, Germany

We study third harmonic generation (THG) from arrays of nanoantennas. Specifically, we investigate the size and gap dependence of the conversion efficiency and find it to be a function of the plasmon resonance energies.

WED4f.58 *(133)* Wed 17:00

Plasmonic Nanopore Arrays with Pore-Spanning Lipid Membranes For Membrane Protein Biosensing — Hyungsoon Im, Nathan Wittenberg, Antoine Lesuffleur, Nathan Lindquist, and •Sang-Hyun Oh — Department of Electrical and Computer Engineering, University of Minnesota, Twin Cities, Minneapolis, Minnesota, U.S.A.

Periodic nanopore arrays in free-standing gold films act as surface plasmon resonance biosensors to detect the incorporation of a transmembrane protein into a pore-spanning lipid membrane and to measure subsequent antibody binding kinetics in real-time.

WED4f.59 *(253)* Wed 17:00

Simulation of a plasmonic gas sensor used for detection of gaseous particles and their refractive index in environment — •Elnaz Nazemi and Nosrat allah Granpayeh — K.N.Toosi University of Technology, Department of Electrical Engineering, Tehran, Iran

Abstract: In this study, we propose a novel plasmonic gas sensor based on metallic photonic crystal slab to detect the gaseous particles and their refractive index.

WED4f.60 *(30)* Wed 17:00

SERS-active Ag ion-exchanged high-iron glass — •Lasse Karvonen, Ya Chen, Antti Säynätjoki, Ari Tervonen, and Seppo Honkanen — Aalto University School of Science and Technology, Micronova, P.O. Box 13500, FIN-00076 Aalto, Finland

We study SERS-activity of Ag ion-exchanged and post-annealed commercial microscope slides and high-iron float glasses. The density of Ag nanoparticles was observed to be better for SERS in the high-iron glass sample.

WED4f.61 *(103)* Wed 17:00

Laser Fabrication of Large-Scale Periodic Nanoparticle Arrays for Sensing Applications — •Arseniy Kuznetsov[1], Andrey Evlyukhin[1], Carsten Reinhardt[1], Boris Chichkov[1], Manuel Gonçalves[2], and Othmar Marti[2] — [1]Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany — [2]Institute of Experimental Physics, Ulm University, 89069 Ulm, Germany

Laser fabrication of large-scale nanoparticle arrays is demonstrated. Optical transmission spectra of these arrays possess narrow peaks due to diffractive coupling of localized plasmons. Sensing applications of these structures are discussed.

WED4f.62 *(116)* Wed 17:00

Numerical simulation of surface enhanced Raman scattering in plasmonic — •Sergey Boyarintsev[1] and Andrey Sarychev[2] — [1]Moscow Institute of Physics and Technology, Moscow, Russia — [2]Institute for Theoretical and Applied Electrodynamics, Russian Academy of Sciences, Moscow, Russia

We have proposed an algorithm, which makes it possible to calculate the local fields in percolation systems, which size reaches micron scale.We obtained dependence of the signal on the frequency and the Stokes shift.

WED4f.63 *(189)* Wed 17:00

Ag coated quartz nanoarrays for SERS — •Henrik Schneidewind[1], Matthias Zeisberger[1], Uwe Hübner[1], Roland Mattheis[1], Karina Weber[2], Dana Cialla[2], and Jürgen Popp[1,2] — [1]Institue of Photonic Technology, Albert-Einstein-Strasse 9, 07745 Jena, Germany — [2]Institute of Physical Chemistry, Friedrich-Schiller-University Jena, Helmholtzweg 4, 07743 Jena, Germany

We show results on SERS active substrates built using silver films deposited on nano-structured periodic quartz arrays. The contribution includes the ED modelling, preparation, characterization, and SERS measurements of the reusable substrates.

WED4f.64 *(69)* Wed 17:00

Optical Metamaterials based on Detuned Electrical Dipoles — •Anders Pors[1], Morten Willatzen[1], Ole Albrektsen[2], and Sergey I. Bozhevolnyi[2] — [1]Mads Clausen Institute, University of Southern Denmark, Alsion 2, DK-6400 Sønderborg, Denmark — [2]Institute of Sensors, Signals and Electrotechnics, University of Southern Denmark, Niels Bohrs Allé 1, DK-5230 Odense M, Denmark

We demonstrate that a pair of electrical dipolar scatterers resonating at different frequencies can be used to construct metamaterials with a magnetic response leading to directional dependent optical properties and high group refractive indices.

WED4f.65 *(148)* Wed 17:00

Self-induced back-action optical trapping of nanometric objects — •Mathieu L. Juan[1], Reuven Gordon[1,2], Yuanjie Pang[2], Fatima Eftekhari[2], and Romain Quidant[1,3] — [1]ICFO-Institut de Ciences Fotoniques, Mediterranean Technology Park, 08860 Castelldefels, (Barcelona), Spain — [2]Department of Electrical and Computer Engineering, University of Victoria, Victoria, British Columbia, V8W 3P6, Canada — [3]ICREA-Institució

Catalana de Recerca i Estudis Avançats, Barcelona, 08010, Spain

We propose a novel optical trapping approach in which the trapped particle provides its own back-action. This so-called Back-Action Self Induced trapping allows the trapping of nanometric particles at low intensity.

WED4f.66 *(180)* Wed 17:00

Rotational brownian motion of a single gold nanorod in an optical trap — •Paul V. Ruijgrok, Nico R. Verhart, Peter Zijlstra, Anna L. Tchebotareva, and Michel Orrit — Institute of Physics, Leiden University, P.O. Box 9504, 2300 RA Leiden, The Netherlands.

We demonstrate stable three-dimensional trapping of single gold nanorods (25 nm diameter, 60 nm length) in water, and quantify the optical torque on the nanorod by characterizing its rotational Brownian motion.

WED4f.67 *(153)* Wed 17:00

Study of spinning nanoparticles interacting with an EM field — •Ana Asenjo-García, Alejandro Manjavacas, and F. Javier García de Abajo — Instituto de Óptica - CSIC, c/ Serrano 121, 28006, Madrid, Spain

The dynamics of illuminated nanoparticles exhibits a non-trivial dependence of the torque on the rotation velocity, accompanied by a frequency shift of the scattered light. Fast acceleration rates are obtained without melting the particle.

WED4f.68 *(199)* Wed 17:00

Palladium-based perfect plasmonic absorber in the visible and its application to hydrogen sensing — Andreas Tittl[1], Patrick Mai[1], •Richard Taubert[1], Thomas Weiss[1], Na Liu[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, 70569 Stuttgart, Germany — [2]Department of Chemistry, University of California, Berkeley, and Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California, 94720, USA

We report on the first experimental realization of a palladium-based perfect plasmonic absorber at visible wavelengths and its application to hydrogen sensing.

WED5o: Tunable and Nonlinear Metamaterials

Chaired by Vassili Fedotov, University of Southampton, United Kingdom

Time: Wednesday 18:30–19:55 Location: Olympia

Invited WED5o.1 *(277)* Wed 18:30

Metamaterials for Dynamic Control of Surface Electromagnetic Waves and Plasmons — •Willie Padilla[1], Wenchen Chen[1], and Tahsin Akalin[2] — [1]Department of Physics, Boston College, 140 Commonwealth Ave., Chestnut Hill, Massachusetts 02467, USA — [2]Inst. d'Electron. de Microelectron. et de Nanotechnol. (IEMN), Univ. de Lille 1, Villeneuve d'Ascq, France

Abstract: A compact planar Goubau line is coupled to metamaterials which enable control of surface electromagnetic waves from GHz to THz frequencies. High quality factor resonances (Q=17.64) and modulation depths up to 80 percent are achieved.

Talk WED5o.2 *(165)* Wed 18:55

Nonlinear Dynamics of Active Negative-Refractive-Index Metamaterials — Sebastian Wuestner, Andreas Pusch, Kosmas Tsakmakidis, Joachim Hamm, and •Ortwin Hess — University of Surrey, Guildford, GU2 4JX, UK

Using a time-domain full-vectorial Maxwell-Bloch approach we study, based on pump/probe numerical experiments, the nonlinear dynamics of active, negative-refractive-index, double-fishnet metamaterials. We elucidate the nonlinear process by which loss-compensation and 'negative absorption' are accomplished.

Talk WED5o.3 *(178)* Wed 19:10

Tunable plasmonic filtering by controlling the interactions of plasmonic and photonic modes between two corrugated Metallic Plates — Avner Yanai, Meir Grajower, and •Uriel Levy — Department of Applied Physics, The Benin School of Engineering and Computer Science, The Center for Nanoscience and Nanotechnology, The Hebrew University of Jerusalem, Jerusalem, 91904, Israel

We study the interactions of plasmonic and photonic modes within a two corrugated metallic plate structure for tunable filtering applications. Tuning is obtained by shifting the plate's relative position. Preliminary experimental results will be shown.

Talk WED5o.4 *(247)* Wed 19:25

Size dependence of the metal-insulator transition in a metamaterial incorporating vanadium dioxide — •Richard Haglund, Kannatessan Appavoo, and Joyeeta Nag — Vanderbilt University, Nashville TN, USA

We show that metamaterials comprising gold split-ring resonators with variable gap size, fabricated on a vanadium dioxide thin film, can be used to probe the size dependence of the metal-insulator transition in the vanadium dioxide.

Talk WED5o.5 *(190)* Wed 19:40

Metamaterials for Surface Enhanced Nonlinear Four-Wave Mixing — •Jan renger[1], Romain Quidant[1], and Lukas Novotny[2] — [1]ICFO-Institut de Ciencies Fotoniques, 08860 Castelldefels (Barcelona), Spain — [2]Institute of Optics, University of Rochester, Rochester, NY 14627, USA

We demonstrate enhanced nonlinear four-wave mixing in plasmonic metamaterials. We show how the nonlinear response can be strongly enhanced by engineering the electromagnetic modes through structuring the metal along the surface or perpendicular to it.

WED5s: Nano-Antennas 3

Chaired by Mark Brongersma, Stanford University, CA, USA

Time: Wednesday 18:30–19:55 Location: Seefeld-Tirol

Invited WED5s.1 *(73)* Wed 18:30

Plasmon hybridization studies using electron energy loss and optical spectroscopies in designer plasmon cavities — •Stefan Maier — Imperial College London

We present electron energy loss spectroscopy studies of plasmon hybridization in metallic nanoantennas fabricated using top-down lithography on silicon nitride membranes. This allows the determination of the full mode spectrum, including the elusive dark modes.

Talk WED5s.2 *(211)* Wed 18:55

Narrowband thermal emission by a single SiC antenna — Jon A. Schuller[1], •Thomas Taubner[1,2], and Mark L. Brongersma[1] — [1]Geballe Laboratory of Advanced Materials, Stanford University, 476 Lomita Mall, Stanford, CA 94305, USA — [2]1st Institute of Physics IA, RWTH Aachen University, Sommerfeldstr. 14, 52074 Aachen, Germany

Optical antennas can operate as both receiving and broadcasting elements. We demonstrate narrowband thermal emission from a single SiC rod-shaped optical antenna and argue theoretically that such structures are nearly ideal black-body antennas.

Talk WED5s.3 *(8)* Wed 19:10

Plasmonic sensing of phonon polaritons using multipolar nanoantenna excitations — •Frank Neubrech[1], Daniel Weber[1], Jörg Bochterle[1], Annemarie Pucci[1], Gui Han[2], Tadaaki Nagao[2], Pablo Albella[3], and Javier Aizpurua[3] — [1]University Heidelberg, Heidelberg, Germany — [2]World Premier International Research Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS), Tsukuba,Japan — [3]Center for Materials Physics, Spanish Council for Scientific Research CSIC-UPV/EHU, Donostia International Physics Center DIPC, San Sebastian, Spain

We utilized the resonant coupling between plasmonic nanoantennas and thin film phonon polaritons of a natural SiO2 layer beneath the antennas to characterize the resonant near field enhancement of multipolar resonances.

Talk WED5s.4 *(53)* Wed 19:25

Tandem of Plasmonic Nano-antennas for Resonant Scattering Enhancement — •Pavel Ginzburg[1], Amir Nevet[1], Nikolai Berkovitch[1], Alexander Normatov[1], Gilad M. Lerman[2], Avner Yanai[2], Uriel Levy[2], and Meir Orenstein[1] — [1]EE department, Technion - Israel Institute of Technology, Technion City, Haifa 32000, Israel — [2]Department of Applied Physics, The Benin School of Engineering and Computer Science, The Center for Nanoscience and Nanotechnology, The Hebrew University of Jerusalem, Jerusalem, 91904, Israel

Three orders of magnitude improvement in scattering crossection of plasmonic wire antenna by its coupling to additional focusing receiver antenna is demonstrated. Spectral Far-field transmission measurements of radially-polarized light indicate Fabry-Perot resonances of antenna modes.

Talk WED5s.5 *(92)* Wed 19:40

Probing the Local Density of States in complex photonic structures — •Riccardo Sapienza[1], Pierre Bondareff[1], Benjamin Habert[1], Romain Pierrat[2], Remi Carminati[2], and Niek van Hulst[1,2] — [1]ICFO-Institut de Ciencies Fotoniques, Castelldefels (Barcelona), Spain — [2]Langevin Institute, ESPCI, (Paris), France

In the context of unconventional lasing we report on local density of states measurements in random dielectric complex media and arrays of gold nano-antennas by studying the decay rate of point like sources.

THU1o: Plenary Talk and IOP Special Lecture

Chaired by Albert Polman, AMOLF, Amsterdam, Netherlands

Time: Thursday 8:00–8:45 Location: Olympia

Plenary Talk THU1o.1 *(286)* Thu 8:00

Electrodynamical forces at the nanoscale — •Federico Capasso — Harvard School of Engineering and Applied Sciences

At the sub-wavelength scales typical of nanophotonics optical components interact via a variety of classical electromagnetic and quantum-electrodynamical forces. The former include evanescent wave bonding/antibonding due to mode hybridization and the latter attractive/repulsive Casimir forces.

Break

Time: Thursday 8:45–8:55 Location: Olympia

Break

THU2o: Sensors 2

Chaired by Augustine Urbas, US Air Force Research Laboratory, USA

Time: Thursday 8:55–10:05 Location: Olympia

Invited THU2o.1 *(260)* Thu 8:55

Ultra-sensitive SEIRA with Plasmonic Nanoantennas — •Hatice Altug — Boston University, Boston, USA

We will demonstrate ultra-sensitive surface-enhanced infrared spectroscopy detecting molecular signatures of proteins at zeptomole-level sensitivities. Approach exploits diffractive couplings among plasmonic nano-antenna arrays. We will also present high-throughput fabrication of these substrates with nanostencil lithography.

Talk THU2o.2 *(26)* Thu 9:20

Localized plasmonic resonator sensors: the strive for improved figure-of-merit — Claus Jeppesen[1], Sanshui Xiao[2], Anders Kristensen[1], and •Niels Asger Mortensen[2] — [1]DTU Nanotech, Technical University of Denmark — [2]DTU Fotonik, Technical University of Denmark

We employ dark/bright mode concepts to design and fabricate gold split-ring resonators, with the fundamental LC resonance at 1200 nm supporting a FOM of 54. Quasi-static considerations are used to access oppotunities for further improvements.

Talk THU2o.3 *(251)* Thu 9:35

Hollow-core photonic crystal fibers for biomedical applications — •Valery V. Tuchin[1,2], Julia S. Skibina[1,3], Anton V. Malinin[1,3], Mikhail V. Chainikov[3], Valentin I. Beloglazov[3], and Igor Yu. Silohin[3] — [1]Saratov State University, Department of Optics and Biophotonics — [2]Institute of Precise Mechanics and Control — [3]LLC SPE Nanostructure Glass Technology

Hollow core photonic crystal fibers, showing unique nonlinear optical properties and high sensitivity to refraction index, absorption and scattering properties change of a medium inside a hollow core, were designed and tested as biosensors.

Talk THU2o.4 *(88)* Thu 9:50

Nanostars for nonlinear probing of near-fields — •Martin Kuttge[1], Niek F. van Hulst[1], Ramon A. Alvarez Puebla[2], Luis M. Liz-Marzan[2], and F. Javier Garcia de Abajo[3] — [1]ICFO - The Institute of Photonic Sciences, Castelldefels (Barcelona), Spain — [2]Colloid Chemistry Group, Universidade de Vigo, Vigo, Spain — [3]Instituto de Optica - CSIC, Madrid, Spain

We show that gold nanostars are ideal nonlinear probes for electromagnetic fields on the nanoscale. As examples we present a nonlinear ruler for sub-nanometer distances and a detector for surface plasmon propagation.

THU2s: Plasmonic Nanostructures

Chaired by Rachel Won, Nature Photonics

Time: Thursday 8:55–10:05 Location: Seefeld-Tirol

Invited THU2s.1 *(193)* Thu 8:55

Plasmonic Oligomers — •Mario Hentschel[1,2], Michael Saliba[1,2], Ralf Vogelgesang[2], Harald Giessen[2], A. Paul Alivisatos[3], and Na Liu[3] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, D-70569 Stuttgart, Germany — [2]Max-Planck-Institute for Solid State Research, Heisenbergstr. 1, D-70569 Stuttgart, Germany — [3]Department of Chemistry, University of California, Berkeley, and Materials Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

We demonstrate the transition from isolated to collective optical modes in plasmonic oligomers. Specifically, we investigate the resonant behavior of planar plasmonic hexamers and heptamers with gradually decreasing the inter-particle gap separation.

Talk THU2s.2 *(65)* Thu 9:20

Photoexcitation of volume plasmons in metallic nanoshells — •Katja Hoeflich[1,2], Ulrich Goesele[1], and Silke Christiansen[3,2] — [1]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany — [2]Institute of Photonic Technology, Albert-Einstein-Str.9, D-07745 Jena, Germany — [3]Max Planck Institute for the Science of Light, Guenther-Scharowsky-Str.1, Bau 24, D-91058 Erlangen, Germany

Volume plasmons are collective eigenmodes of the free-electron gas inside a metal. We show unexpected photoexcitation of volume plasmons for metallic nanoshells using analytical solutions of the classical scattering problem for plane wave incidence.

Talk THU2s.3 *(186)* Thu 9:35

From Near-Field to Far-Field: Radiative Coupling of Particle Plasmon Resonances in Three-Dimensional Geometries — •Richard Taubert, Ralf Ameling, Thomas Weiss, André Christ, and Harald Giessen — 4th Physics Institute, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart

We show that particle plasmons cannot only be coupled by their near fields but also by their radiative far fields. This leads to interesting new effects such as enhanced radiative linewidth and collective re-emission.

Talk THU2s.4 *(95)* Thu 9:50

On-demand Engineering of Multiple Resonances of Plasmonic Particles — •Pavel Ginzburg, Itay Shor, Nikolai Berkovitch, Amir Nevet, and Meir Orenstein — EE department, Technion - Israel Institute of Technology, Technion City, Haifa 32000, Israel

Engineering resonance spectra of plasmonic particles by exploiting the interaction of local geometry with surface charge distribution and applying evolutionary algorithm is presented. New particle families with overlapping dipole-quadrupole resonances are also generated.

Coffee Break

Time: Thursday 10:05–10:25 Location: Lobby

Coffee Break

THU3o: Superconducting Metamaterials and Plasmonics

Chaired by Nader Engheta, University of Pennsylvania, USA

Time: Thursday 10:25–11:55 Location: Olympia

Invited THU3o.1 *(41)* Thu 10:25

Josephson Plasmons in Superconducting Metamaterials — •Alexey Ustinov — Physikalisches Institut, Karlsruhe Institute of Technology (KIT) , Wolfgang-Gaede-Str. 1, D-76131 Karlsruhe, Germany

Superconducting thin-films allow for designing metamaterials with extremely low losses, well-controlled nonlinearity, and frequency tunability. Moreover, superconducting metamaterials offer an intriguing and unique possibility of exploring the quantum effects using Josephson plasmons.

Invited THU3o.2 *(27)* Thu 10:50

Detection of the Aharonov-Bohm-type phase shift induced by a single quantized vortex in a superconductor — •Vladimir Krasnov — Department of Physics, Stockholm University, AlbaNova University Center, SE-10691 Stockholm, Sweden

We probe the phase shift induced by a single Abrikosov vortex. It appears to be equal to the polar angle of the vortex, corresponding to a surprisingly rigid rotation of the phase.

Talk THU3o.3 *(106)* Thu 11:15

Superconducting plasmonics and metamaterials: from extraordinary transmission to Fano resonances — •Andrew Buckingham[1], Anagnostis Tsiatmas[2], Vassili Fedotov[2], Yifang Chen[3], Peter de Groot[1], and Nikolay Zheludev[2] — [1]School of Physics and Astronomy, University of Southampton, Southampton, SO17 1BJ, United Kingdom — [2]Optoelectronics Research Centre, University of Southampton, Southampton, SO17 1BJ, United Kingdom — [3]Rutherford Appleton Laboratory, Harwell Science and Innovation Campus, Didcot, OX11 0QX, United Kingdom

By varying temperature superconductors can be converted from lossy to ideal metals, permitting the control of both extraordinary transmission in arrays of subwavelength holes, and quality factors of Fano resonances in superconducting metamaterial films.

Invited THU3o.4 *(223)* Thu 11:30

Realization of Electromagnetically Induced Transparency with Planar Superconducting Metamaterials — •Cihan Kurter[1], Alexander Zhuravel[2], Alexey Ustinov[3], Lei Zhang[4,5], Thomas Koschny[4,5], Costas Soukoulis[4,5], and Steven Anlage[4,5] — [1]Center for Nanophysics and Advanced Materials, Physics Department, University of Maryland, College Park, Maryland 20742-4111, USA — [2]B. Verkin Institute for Low Temperature Physics & Engineering, National Academy of Sciences of Ukraine, 61164 Kharkov, Ukraine — [3]Physikalisches Institut and DFG-Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology D-76131 Karlsruhe, Germany — [4]Ames Laboratory-U.S. DOE, Ames, Iowa 50011, USA — [5]Department of Physics and Astronomy, Iowa State University, Ames, Iowa 50011, USA

We present a low loss metamaterial composed of two superconducting split rings symmetrically located around a normal metal strip that displays a classical version of electromagnetically induced transparency (EIT).

THU3s: Waveguides

Chaired by Vasily Klimov, P.N. Lebedev Physical Institute, Moscow, Russia

Time: Thursday 10:25–11:55 Location: Seefeld-Tirol

Invited THU3s.1 *(268)* Thu 10:25

Mitigating Loss in Plasmonic Structures and Metamaterials — •Jacob Khurgin — Johns Hopkins University, Baltimore MD 21218 USA

Metals that are lossy at low frequencies can become lossless in mid-IR region at larger inter-atomic distances While this condition is not met in Nature, advances in nano-assembly may render lossless metals feasible.

Invited THU3s.2 *(184)* Thu 10:50

Integrated Metaphotonics — •Allan D. Boardman, Peter Egan, and Rhiannon C. Mitchell-Thomas — Joule Physics Laboratory, University of Salford, Greater Manchester, M5 4WT, United Kingdom

A comprehensive discussion of complex waveguides constructed from a variety of metamaterials are presented. Linear, nonlinear and magnetooptic guides will be investigated and some degrees of complexity will be formulated in terms of transformation optics.

Talk THU3s.3 *(130)* Thu 11:15

Gradient Index Plasmonics — •Jason Valentine[1], Thomas Zentgraf[2], Yongmin Liu[2], Maiken Mikkelsen[2], and Xiang Zhang[2] — [1]Vanderbilt University, 2301 Vanderbilt Place, PMB 351592, Nashville, TN 37235, USA — [2]University of California, Berkeley, 3112 Etcheverry Hall, Berkeley, CA 94720, USA

We experimentally demonstrate an approach to manipulate surface plasmon polaritons by adiabatically tailoring the topology of a dielectric layer adjacent to the metal surface. Using this methodology we demonstrate a gradient refractive index Luneburg lens.

Invited THU3s.4 *(54)* Thu 11:30

Amorphous waveguide lattices with photonic band gaps — •Alexander Szameit[1], Mikael Rechtsman[1], Felix Dreisow[2], Matthias Heinrich[2], Robert Keil[2], Stefan Nolte[2], and Mordechai Segev[1] — [1]Technion, Haifa, Israel — [2]Friedrich-Schiller-Universität, Jena, Germany

We present, theoretically and experimentally, amorphous photonic lattices exhibiting band-gap and negative effective mass, yet lacking Bragg diffraction. Here, bands comprise of Anderson states, but defect states residing in the gap are always more localized.

Lunch Break

Time: Thursday 11:55–14:00

Lunch Break

THU4o: Effective Media

Chaired by Jacob Khurgin, John Hopkins University, Baltimore, MA, USA

Time: Thursday 14:00–15:30 Location: Olympia

Invited THU4o.1 *(134)* Thu 14:00

Novel meta-surfaces for perfect light absorption and wave manipulation — Shiyi Xiao, Shulin Sun, Qiong He, and •Lei Zhou — Physics Department, Fudan University, Shanghai 200433, China

We designed meta-surfaces with anomalous electromagnetic properties that allowed perfectly absorbing light or freely manipulating light beam directions at particular frequencies, and performed microwave experiments to demonstrate these ideas.

Invited THU4o.2 *(276)* Thu 14:25

Metamaterial Based Enhanced Transmission from Deep Subwavelength Apertures — •Ekmel Ozbay — Nanotechnology Research Center, Bilkent University, Ankara, TURKEY

We obtained enhanced transmission of electromagnetic waves through a subwavelength aperture by using split ring resonators (SRRs). We experimentally observed as high as 70,000 times transmission enhancement from our samples.

Talk THU4o.3 *(3)* Thu 14:50

Plasmons reveal the direction of magnetization in nickel nanostructures — •Ventsislav Valev[1], Alejandro Silhanek[2], Werner Gillijns[2], Yogesh Jeyaram[2], Hanne Paddubrouskaya[3], Alexandre Volodin[3], Ben De Clercq[4], Marcel Ameloot[4], Oleg Aktsipetrov[5], Victor Moshchalkov[2], and Thierry Verbiest[1] — [1]Molecular Electronics and Photonics, INPAC, Katholieke Universiteit Leuven, Leuven, Belgium — [2]Superconductivity and Magnetism & Pulsed Fields Group, INPAC, Katholieke Universiteit Leuven, Leuven, Belgium — [3]Laboratory of Solid-State Physics and Magnetism, Katholieke Universiteit Leuven, Celestijnenlaan 200 D, 3001 Leuven, Belgium — [4]University Hasselt and transnational University Limburg, BIOMED, Diepenbeek, Belgium — [5]Department of Physics, Moscow State University, 11992 Moscow, Russia

We have applied the surface-sensitive nonlinear optical technique of Magnetization-induced Second Harmonic Generation to plasmonic, magnetic nanostructures made of Ni. We report novel magneto-optical properties and suggest the possibility for large magneto-chiral effects in metamaterials.

Invited THU4o.4 *(278)* Thu 15:05

Characterization of the complex transfer matrix of metamaterials — •Thomas Pertsch, Ekaterina Pshenay-Severin, Christian Helgert, Arkadi Chipouline, Ernst-Bernhard Kley, Christoph Menzel, Carsten Rockstuhl, and Falk Lederer — Friedrich-Schiller-Universität Jena, Germany

We report on the experimental and theoretical analysis of metamaterials with asymmetric transmission. The experiments analyze samples with three-dimensional low-symmetry metaatoms. The theoretical study is generalized to arbitrarily complex media.

THU4s: Hybrids structures

Chaired by Allan Boardman, Salford University, United Kingdom

Time: Thursday 14:00–15:30 Location: Seefeld-Tirol

Invited THU4s.1 *(15)* Thu 14:00

Ultrafast phase breaking in a multiple scattering nanowire material — •Otto Muskens[1], Martina Abb[1], Paul Venn[1], and Erik Bakkers[2] —

[1]University of Southampton, Southampton, United Kingdom — [2]Eindhoven University of Technology, Eindhoven, The Netherlands

We demonstrate a new, ultrafast regime of phase breaking in a strongly scattering nanowire material. The new phase breaking phenomenon opens up avenues for ultrafast control of random lasers, nanophotonic switches, and photon localization.

Invited THU4s.2 *(264)* Thu 14:25

Single Nanoparticle Photocatalysts: Towards Solar-Fuels with Nonlinear Optics and Plasmonics — •Jennifer Dionne — Stanford University, CA, USA

This talk will discuss the unexpected optical and electrical nonlinearities present in individual hydrogen-evolving nanoparticles composed of a nanometer-scale metal-semiconductor heterojunction. Prospects for plasmon-enhanced solar-fuel photocatalysis will also be discussed.

Talk THU4s.3 *(96)* Thu 14:50

Towards quantum magnetic metmaterials — •Arkadi Chipouline[1] and Vassili Fedotov[2] — [1]IAP-FSU, Jena, Germany — [2]ORC, Southampton, UK

We propose a concept of quantum magnetic metamaterials, artificial media composed of clusters of coupled quantum dots supporting asymmetric mode of excitation at optical frequencies, and study their response for various coupling mechanisms and regimes of excitation.

Invited THU4s.4 *(59)* Thu 15:05

Nanophotonics for Energy Conversion — •Marin Soljacic — MIT; 77 Massachusetts Avenue; Cambridge, MA 02139; USA

Nanophotonics can play an important role in enabling optimal energy conversion schemes. In this talk, we present some of our recent work in this area.

Coffee Break

Time: Thursday 15:30–16:00 Location: Lobby

Coffee Break

THU4oBis: Effective Media

Chaired by Jacob Khurgin, John Hopkins University, Baltimore, MA, USA

Time: Thursday 16:00–16:45 Location: Olympia

Talk THU4oBis.1 *(91)* Thu 16:00

Surface Plasmon Mode Steering and Negative Refraction — •Benedikt Stein, Jean-Yves Laluet, Eloïse Devaux, Cyriaque Genet, and Thomas W. Ebbesen — ISIS, Université de Strasbourg & CNRS, 8 allée Gaspard Monge, 67000 Strasbourg, France

Large beam steering and negative refraction of surface plasmon polaritons in singly and doubly periodic metal gratings are demonstrated. We address how such gratings could enhance the sensitivity of surface plasmon based refractive index sensors.

Talk THU4oBis.2 *(12)* Thu 16:15

From Whitney Forms to Metamaterials: a Rigorous Homogenization Theory — •Igor Tsukerman — Department of Electrical and Computer Engineering, The University of Akron, OH 44325-3904, USA

A rigorous homogenization theory of metamaterials is derived from Whitney forms. All coarse-grained fields are unambiguously defined and satisfy Maxwell's equations exactly. High numerical accuracy is demonstrated, with several systematic routes for further improvement.

Talk THU4oBis.3 *(117)* Thu 16:30

Three-dimensional negative index metamaterials at optical frequencies — •Ewold Verhagen, René de Waele, Laurens Kuipers, and Albert Polman — FOM Institute AMOLF, Amsterdam, The Netherlands

We identify a route towards achieving a negative index of refraction at optical frequencies based on plasmonic waveguide coupling. We design a one-dimensional multilayer stack that exhibits an isotropic index of -1 at 400 nm.

THU4sBis: Hybrids structures

Chaired by Allan Boardman, Salford University, United Kingdom

Time: Thursday 16:00–16:45 Location: Seefeld-Tirol

Talk THU4sBis.1 *(198)* Thu 16:00

Localized surface plasmons on disordered metallic films probed by fluorescence lifetime fluctuations — •Etienne Castanié, Valentina Krachmalnicoff, Yannick De Wilde, and Rémi Carminati — Institut Langevin, ESPCI ParisTech, CNRS, 10 rue Vauquelin, 75231 Paris Cedex 05, France

We report on the experimental study of lifetime fluctuations at the surface of disordered metallic films. We find that the lifetime distribution is a signature of the presence of localized surface plasmon modes.

Talk THU4sBis.2 *(229)* Thu 16:15

Observation of fluctuations of the local density of state in random photonic media — •Muhammad Danang Birowosuto[1], Sergey E.

Skipetrov[2], Willem L. Vos[1], and Allard P. Mosk[1] — [1]COPS, MESA+ Institute, University of Twente, Enschede, The Netherlands — [2]Universite Joseph Fourier and CNRS, Grenoble, France

We have observed fluctuations of the local density of states in random photonic media made of strongly scattering powders. The strength of the fluctuations is explained by a model taking into account the nearest scatterer

Talk THU4sBis.3 *(219)* Thu 16:30

Influence of particle plasmons on radiationless energy transfer between CdSe/ZnS nanocrystals — •Alfred Leitner, Norbert Reitinger, Andreas Hohenau, Franz Aussenegg, and Joachim R. Krenn — Institute of Physics, Karl-Franzens University, Graz, Austria

CdSe/ZnS quantum dots in ultrathin PMMA layers show spectral reddening and fluorescence decay time reduction, indicating radiationless energy transfer from smaller to larger QDs. Interaction with plasmons in gold nanoparticles strongly reduces the transfer.

THU5o: Transformation Optics and Novel Concept

Chaired by Joerg Heber, Nature Materials

Time: Thursday 17:00–18:20 Location: Olympia

Invited THU5o.1 *(20)* Thu 17:00

Negative refractive material as a tool to create cloaking and illusion effects — Yun Lai and •Che-Ting Chan — Department of Physics, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, China

We demonstrate a way of creating stereoscopic illusions by using a remote device that is created with negative index metamaterials. This device can turn the image of an object into something else.

Invited THU5o.2 *(38)* Thu 17:25

Transformation optics and extreme elastic materials — •Ole Sigmund and Allan Roulund Gersborg — Mechanical Engineering, Technical University of Denmark, Lyngby, Denmark

Only few transformation optics results are realizable by purely dielectric materials. This paper shows that all-dielectrically realizable transformations may be obtained from non-linear elasticity with extremal material properties like negative Poisson's ratio.

Talk THU5o.3 *(230)* Thu 17:50

Analytical Description of Singular Plasmonic Structures — •Yu Luo, Alexandre Aubry, and John Pendry — Imperial College London, London, United Kingdom

On the basis of transformation optics, we present an analytical approach to study systematically a variety of singular plasmonic structures and discuss their applications in nanofocusing and single molecule detection.

Talk THU5o.4 *(151)* Thu 18:05

Hidden progress: broadband plasmonic invisibility — Jan Renger[1], •Muamer Kadic[2], Guillaume Dupont[2], Sébastien Guenneau[2], Srdjan S. Acimovic[1], Romain Quidant[1], and Stefan Enoch[2] — [1]ICFO-Institut de Ciencies Fotoniques, Mediterranean Technology Park, 08860 Castelldefels (Barcelona), Spain — [2]Institut Fresnel, CNRS, Aix-Marseille Université, Campus Universitaire de Saint-Jérôme, 13013 Marseille, France

We show both theoretically and experimentally that we can harness surface plasmon polaritons at a metal surface structured with a dielectric material designed using transformational plasmonics to obtain a unique control of their propagation.

THU5s: Hybrids and Gain

Chaired by Rick McCormick, Sandia National Laboratories, Albuquerque, USA

Time: Thursday 17:00–18:20 Location: Seefeld-Tirol

Invited THU5s.1 *(263)* Thu 17:00

Plasmonic and Semiconductor Building Blocks for Nanophotonics — •Mark Brongersma — Stanford

Metamaterials and nanophotonic devices are most commonly constructed from metallic (i.e. plasmonic) nanostructures. However, recent research has begun to also exploit the optical resonances of high-permittivity semiconductor and dielectric nanostructures to realize similar optical functionalities.

Invited THU5s.2 *(262)* Thu 17:25

Hybrid Plasmonic Lasers at Deep Sub-Wavelength Scale — •Guy Bartal — University of California, Berkeley, USA — Technion, Haifa, Israel

We show that a hybrid of semiconductor nanowire and metallic surface modes produces an efficient laser device with $\lambda 2/100$ mode area and discuss the broader impact of plasmon-based light sources and integrated optical components.

Talk THU5s.3 *(224)* Thu 17:50

Drastic enhancement of giant single CdSe-CdS nanocrystals emission through their direct coupling with a gold semicontinuous film — •Ikbel Mallek-Zouari[1], Stéphanie Buil[1], Xavier Quélin[1], Pierre Maso[1], Benoit Mahler[2], Benoit Dubertret[2], and Jean-Pierre Hermier[1] — [1]Groupe d'Etude de la Matiere Condensee, Universite de Versailles-Saint-Quentin-

en-Yvelines, CNRS UMR8635, 45 avenue des Etats-Unis, 78035 Versailles, France. — [2]Laboratoire de Physique et d'Etude des Materiaux, CNRS UMR8213, ESPCI, 10 rue Vauquelin, 75231 Paris Cedex 05, France

We demonstate the possibility to enhance drastically the emission of giant single CdSe-CdS nanocrystals using the surface plasmon resonances of random gold films close to the percolation threshold.

Talk THU5s.4 *(160)* Thu 18:05

Multi-fold Quantum Dot Luminescence Enhancement in a Plasmonic Metamaterial — Kenji Tanaka[1,2], •Eric Plum[1], Jun Yu Ou[1], Takashi Uchino[3], and Nikolay Zheludev[1] — [1]Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, Southampton, UK — [2]Sony Corporation, Shinagawa-ku, Tokyo, Japan — [3]School of Electronics and Computer Science and Centre for Photonic Metamaterials, University of Southampton, Southampton, UK

We report that hybridizing quantum dots with plasmonic metamaterial leads to a multi-fold intensity increase and narrowing of their photoluminescence spectrum, which is linked to the Purcell effect and has crucial importance for gain metamaterials.

Coffee Break

Time: Thursday 18:20–18:40 Location: Lobby

Coffee Break

THU5oBis: Transformation Optics and Novel Concepts

Chaired by Chaired by Joerg Heber, Nature Materials

Time: Thursday 18:40–19:10 Location: Olympia

Talk THU5oBis.1 *(143)* Thu 18:40

Sub-diffraction Imaging in the Far-field by Positive Index Materials — •Susanne C. Kehr[1], Sahar Sahebdivan[1], Thomas Philbin[1], Ulf Leonhardt[1], Aaron J. Danner[2], Tomáš Tyc[1,3], and Yun Gui Ma[4] — [1]University of St Andrews, School of Physics and Astronomy, Fife KY16 9SS, UK — [2]Dept. of Electrical and Computer Engineering, National University of Singapore, Singapore 117576 — [3]Institute of Theoretical Physics, Masaryk University, 61137 Brno, Czech Republic — [4]Temasek Laboratories, National University of Singapore, Singapore 119260

We discuss different approaches for sub-diffraction imaging. In particular we show theoretically and experimentally that Maxwell's fish-eye creates a perfect image several wavelengths away from the object with a purely positive refractive index profile.

Talk THU5oBis.2 *(56)* Thu 18:55

Vacuum can stop spinning particles — •Alejandro Manjavacas and Javier Garcia de Abajo — Insitituto de Optica, Serrano 121 28006 Madrid, Spain

We study the frictional torque acting on particles spinning in empty space, which arises from the interaction with the surrounding electromagnetic vacuum field. Implications for the behavior of cosmic dust are discussed.

THU5sBis: Hybrids and Gain

Chaired by Rick McCormick, Sandia National Laboratories, Albuquerque, USA

Time: Thursday 18:40–19:10 Location: Seefeld-Tirol

Talk THU5sBis.1 *(238)* Thu 18:40

Optical Gain in Rolled-up Semiconductor/Metal Metamaterials — Stephan Schwaiger, Markus Broell, Ricardo Costa, Matthias Klingbeil, Christian Heyn, Detlef Heitmann, and •Stefan Mendach — Institute for Applied Physics, University of Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

We present gain measurements on rolled-up semiconductor/metal hybrid metamaterials containing InGaAs quantum wells. We find a characteristic increase and decrease of the transmission through the metamaterial when optically pumping the quantum well.

Talk THU5sBis.2 *(102)* Thu 18:55

Stimulated emission of surface plasmon polaritons by lead-sulphide quantum dots at near infra-red wavelengths — •Ilya P. Radko, Michael G. Nielsen, Ole Albrektsen, and Sergey I. Bozhevolnyi — University of Southern Denmark, Odense, Denmark

Amplification of surface plasmon polaritons in planar metal-dielectric structure through stimulated emission is investigated using leakage-radiation microscopy configuration. The gain medium is a thin polymethylmethacrylate layer doped with lead-sulphide nanocrystals emitting at near-infrared wavelengths.

THU6o: Breakthrough 3

Chaired by Tony Heinz, Columbia University, NY, USA

Time: Thursday 19:10–19:40 Location: Olympia

Breakthrough Talk THU6o.1 *(283)* Thu 19:10
Phonon Lasers — •Kerry Vahala — 1200 E. California Blvd, Pasadena, CA 91125 USA

Optical forces exerted in microcavities or to trapped-ions can cause phonon, stimulated emission, leading to mechanical amplification and coherent motion. Demonstration of the resulting phonon laser action will be reviewed and new directions of research described.

THU6s: Breakthrough 4

Chaired by Mark Spector, Office of Naval Research, Arlington VA, USA

Time: Thursday 19:10–19:40 Location: Seefeld-Tirol

Breakthrough Talk THU6s.1 *(282)* Thu 19:10
Negative Radiation Pressure — •Henri Lezec[1], Amit Agrawal[1], and Kenneth Chau[1,2] — [1]Center for Nanoscale Science and Technology, NIST, Gaithersburg, MD, USA — [2]University of British Columbia, Okanagan, Kelowna B.C., Canada

We demonstrate that an electromagnetic plane wave at green and blue frequencies is able to exert a negative radiation pressure on a flat slab of left-handed plasmonic metamaterial.

THU7: Closing Session and Poster Prizes

Chaired by Nikolay Zheludev & Herald Giessen

Time: Thursday 19:40–20:20 Location: Olympia

Poster Prizes awards ceremony by Ian Osborne and John Dudley
Closing Remarks by N. Zheludev and H. Giessen