O 49: Plasmonics and Nanooptics I: Fabrication and Application

Time: Wednesday 10:30–12:45 Location: WIL A317

O 49.1 Wed 10:30 WIL A317

Towards dynamic holograms with electrically switchable polymer metasurfaces: materials apsects — •Dominik Ludescher, Julian Karst, Mario Hentschel, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

Holography is considered as an innovative technology that is predicted to have a significant impact on numerous fields of application such as virtual, mixed, augmented reality, medical technology, and future displays. Overlaying digital information with the real world is the general concept of augmented reality. Yet, for concepts such as 3D holographic video conferencing or surgery planning, high-resolution and high-performance dynamic holograms are inevitable. To achieve this goal, nanophotonic plasmonic approaches are considered as a very promising platform. Here, we introduce active plasmonic metasurfaces for dynamic holography based on electrically switchable metallic polymer nanoantennas. The used polymer material incorporates a metal-to-insulator phase transition in the infrared spectral range which is driven by CMOS compatible voltages of only +/-1 V. In combination with possible pixel sizes below 1 micron, this makes the polymer metasurface ideally suited for holographic display applications. Additionally, using variable angle spectroscopic ellipsometry, we investigate the optical properties of such metallic polymers. In particular, we analyze their complex dielectric function and the associated zero epsilon region around the plasma wavelength. This will lay the foundation to shift the plasmonic metasurface operation to the visible spectral range.

O 49.2 Wed 10:45 WIL A317

Sampling polar THz nearfields using nonpolar Stark-effect — •Moritz B. Heindl[1], Nicholas Kirkwood[2], Tobias Lauster[3], Markus Retsch[3], Paul Mulvaney[2], and Georg Herink[1] — [1]Experimental Physics VIII, University of Bayreuth, Germany — [2]ARC Centre of Excellence in Exciton Science, School of Chemistry, University of Melbourne, Australia — [3]Physical Chemistry I, University of Bayreuth, Germany

Quantum-Probe Field Microscopy (QFIM) enables the imaging of ultrafast THz nearfield waveforms with a conventional fluorescence microscope at optical resolution [1]. Although the underlying quantum-confined Stark-effect scales quadratically in typical configurations, we are able to resolve the full polarity of the THz nearfields utilizing alternative approaches. Specifically, we employ a carrier-envelope phase shift of the driving THz waveform or external biasing of the THz nearfield, as we discuss in this contribution.

[1] Heindl, M. B. et al. Light Sci. Appl. 11, 5 (2022)

O 49.3 Wed 11:00 WIL A317

Double resonant, monocrystalline plasmonic gratings evolutionary optimized for enhanced SERS sensing — •Thorsten Feichtner[1], Katja Höflich[2], Enno Schatz[1], Amro Swedan[3], Paul Mörk[1], and Muhammad Bashouti[3,4] — [1]Nanooptics & Biophotonics Group, Experimental Physics 5, RCCM, JMU Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]Photonic Quantum Technologies, FBH gGmbH Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, D-12489 Berlin, Germany — [3]IKI for Nanoscale Science & Technology, BGU of the Negev, Beer-Sheva 8410501, Israel — [4]Department of Solar Energy and Environmental Physics, SIDEER, J. Blaustein Institutes for Desert Research, BGU of the Negev, Midreshet Ben-Gurion, 8499000, Israel

Surface enhanced Raman spectroscopy (SERS) is an extremely sensitive non-linear method to detect vibrational energy levels of molecules using visible light. However, most SERS substrates available today are quite inhomogeneous.

Here we provide experimental evidence of an efficient and homogeneous SERS substrate consisting of numerically evolutionary optimized two-dimensional gratings made from straight monocrystalline metal wires. The combination of grating resonance and plasmonic gap resonance allows to enhance both excitation of the molecules and emission of the Raman signal, which have to be treated separately to unlock the full potential of SERS. Many experiments comparing gratings, materials and analytes will be presented to illustrate the underlying physical mechanisms and the huge potential for applications.

O 49.4 Wed 11:15 WIL A317

Topological insulating phase in non-Hermitian plasmonic waveguide arrays — •Helene Wetter[1], Stefan Linden[1], and Julian Schmitt[2] — [1]Physikalisches Institut, Universität Bonn, Kreuzbergweg 24, 53115-Bonn, Germany — [2]Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115-Bonn, Germany

Arrays of evanescently coupled plasmonic waveguides are a powerful platform to investigate topological properties of one-dimensional lattices. The underlying principle is the mathematical equivalence between the single-particle tight-binding Schrödinger equation and the coupled mode equation. By tailoring the loss distribution, we utilize non-Hermiticity as a new approach to induce topological phases in otherwise trivial systems. We employ dielectric loaded surface plasmon polariton waveguides fabricated on a thin gold film. Additional losses are introduced to specific waveguides by deposition of a thin layer of chromium below the respective waveguides. Considering a unit cell of four waveguides, a topologically nontrivial lattice can be created by adding an equal amount of losses to the two central waveguides of the unit cell. In contrast, losses on either the first or the last two waveguides of a unit cell correspond to a trivial lattice. Using leakage radiation microscopy, we observe localized states at the edge of the nontrivial lattice (edge mode) as well as at the interface between the nontrivial and the trivial lattice (interface mode). Conversely, the trivial lattice does not provide a localized edge mode. Thus, the topological properties can solely be controlled by the design of the unit cell.

O 49.5 Wed 11:30 WIL A317

Plasmonics of Silica Encapsulated Au@Ag Nanoparticles — •Johannes Schultz[1], Felizitas Kirner[2], Pavel Potapov[1], Bernd Büchner[1,3], Axel Lubk[1,3], and Elena Sturm[2] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden e. V., Helmholtzstraße 20, 01069 Dresden — [2]Department of Chemistry, University of Konstanz, Universitätsstraße 10, 78457 Konstanz — [3]Institute of Solid State and Materials Physics, Haeckelstraße 3, 01069 Dresden

Localized Surface Plasmons (LSPs) are collective charge oscillations arising at interfaces between media of opposite sign of the corresponding dielectric functions. Here, spatial confinement of the LSPs, e.g. in nanoparticles (NPs), may lead to resonant amplification of the corresponding electromagnetic (e.m.) fields. This effect is exploited in several application, e.g., surface enhanced Raman spectroscopy or plasmonic solar cells. Depending on the application, this requires specific control of the spectral positions of the LSPs. Since the latter depend on both, the dielectric function of the NP and the surrounding, tuning of the LSPs can be realized by varying the dielectric environment of the NP. Here, a novel synthesis method was used to encapsulate silver nanocubes with silica layers of uniform and adjustable thickness in the range between 8 and 22 nm to tune the dielectric environment and hence the excitation energies of the LSPs with high precision over a broad spectral range between 2.55 and 3.25 eV. Furthermore, resonant coupling between Mie-type resonances at the silica-vacuum interface and the LSPs was found which leads to an e.m. field enhancement in the range of 100 %.

O 49.6 Wed 11:45 WIL A317

Strain-driven thermal and optical instability in Ag/a-Si hyperbolic metamaterials — •Lea Forster[1,2], Jose L. Ocana-Pujol[1], Ralph Spolenak[1], and Henning Galinski[1] — [1]Laboratory of Nanometallurgy, ETH Zurich, Switzerland — [2]Laboratory for Multifunctional Ferroic Materials, ETH Zurich, Switzerland

In a hyperbolic metamaterial system of silver/amorphous-silicon multilayers we investigated the thermal instability which arises upon heating. Our analysis demonstrates that this instability is governed by the minimization of interfacial energy and anisotropic elastic strain energy caused by the mismatch of thermal expansion coefficients. Interestingly, the stacking order of the multilayer influences which of these two energy contributions dominates. We observed this behavior by a combination of FIB-SEM tomography, finite element simulations, and optical spectroscopy. Our results show that the thermal instability initiates at 300 °C, while the hyperbolic dispersion despite increased structural disorder persists up to 500 °C. These findings can lead to a better understanding of thermal instabilities in multilayers and may assist in the design of hyperbolic metamaterials for high-temperature applications.

O 49.7 Wed 12:00 WIL A317

Optical grating couplers for the excitation of Bloch surface waves — •Sebastian Henn, Marius Grundmann, and Chris Sturm — Universität Leipzig, Faculty of Physics and Earth Sciences, Felix Bloch Institute for Solid State Physics, Linnéstr. 5, 04103 Leipzig, Germany

In this contribution we demonstrate experimentally the control of the propagation of Bloch Surface Waves (BSW) in the transparent spectral range. BSW exist along the interface of a distributed Bragg reflector (DBR) with a thin top layer of a specified thickness to the ambient. Using shallow optical diffraction gratings with a sub-micron lattice constant, incident light is coupled into and out of the Bloch modes, which propagate along the surface between the gratings. The low-loss nature of evanescent BSW leads to long-range lateral propagation, on the order of micrometers, making this an interesting candidate for on-chip devices, for example by coupling to excitons, i.e. exciton-polariton applications. We give an overview of the fabrication processes as well as the results regarding the optical excitation of BSW by means of imaging ellipsometry, which is supported by rigorous coupled-wave analysis modelling.

O 49.8 Wed 12:15 WIL A317

Reconfigurable and polarization-dependent perfect absorber for large-area emissivity control based on the plasmonic phase-change material In_3SbTe_2 — •Lukas Conrads[1], Natalie Honné[1], Andreas Ulm[2], Andreas Hessler[1], Matthias Wuttig[1], Robert Schmitt[2], and Thomas Taubner[1] — [1]I. Institute of Physics (IA), RWTH Aachen University — [2]Fraunhofer IPT

Metasurfaces with perfect infrared absorption promise integrated filters and compact, tailorable detector elements for thermal radiation. Phase-change materials (PCMs) are prime candidates for active, nonvolatile absorption tuning [1]. In this work, we show flexible encoding of different absorption/emission properties within a metasurface. We employ the plasmonic PCM In_3SbTe_2 (IST) [2] to obtain control over the emissivity by patterning an adaptable perfect absorber metasurface. Using a commercial direct laser writing setup, we locally switch the IST from an amorphous dielectric into a crystalline metallic state and write nanoscale stripe gratings of cm-size above a reflecting mirror. We demonstrate modification of already written patterns by changing the laser power and thus the IST stripe width to encode different polarization-sensitive patterns with nearly perfect absorption into the same metasurface. Finally, we measure an apparent local temperature pattern due to our large-area emissivity shaping metasurface with a conventional thermal camera [3]. Our results pave the way towards low-cost, large-area and adaptable patterning of metasurfaces.

[1] Wuttig et al. *Nat. Photon.* **11**, 465 (2017) [2] Heßler et al. *Nat. Commu.* **12**, 924 (2021) [3] Conrads et al. *Adv. Opt. Mat.* submitted

O 49.9 Wed 12:30 WIL A317

Sensing at the ultimate volume limit: Refractive index sensing in attoliter volumes using Mie voids — •Serkan Arslan[1], Huong Tran[1], Julian Karst[1], Lida Shamsafar[1], Thomas Weiss[2], Harald Giessen[1], and Mario Hentschel[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Stuttgart, Germany — [2]Institute of Physics, University of Graz, and NAWI Graz, 8010 Graz, Austria

Traditional nanophotonic sensing schemes utilize dielectric or metallic nanoparticles, which confine far-field radiation in dispersive and lossy media. Apart from ill-defined sensing volumes and moderate sensitivities, these structures suffer from the generally limited access to the modal field, which is key for sensing performance. Recently, a novel strategy for dielectric nanophotonics has been demonstrated, namely, the resonant confinement of light in air. Voids created in high-index dielectric host materials support localized resonant modes with exceptional properties. In particular, due to the confinement in air, these structures benefit from the full access to the modal field inside the void. We utilize these so-called Mie voids for refractive index sensing on the single void level with unprecedented small sensing volumes in the range of 100 attoliter and sensitivities on the order of 500 nm per refractive index unit. Strikingly, the sensitivity as well as the scattering cross sections of the voids are large enough to even identify different analytes with bare eye in an optical microscope. The combination of our Mie void sensor platform with appropriate surface functionalization will even enable specificity to biological or other analytes of interest.