O 96: Plasmonics and nanooptics: Fabrication, characterization and applications

Time: Friday 9:30–12:30 Location: HSZ/0403

O 96.1 Fri 9:30 HSZ/0403

How to fix silver for plasmonics ? — •Jonas Graf[1], Björn Ewald[1], Leo Siebigs[1], Cheng Zhang[2], Achyut Tiwari[3], Max Rödel[1], Sebastian Hammer[1], Vladimir Stepanenko[4], Frank Würthner[4], Bruno Gompf[3], Bert Hecht[2], and Jens Pflaum[1] — [1]Experimental Physics 6, Univ. Würzburg, 97074 Würzburg — [2]Experimental Physics 5, Univ. Würzburg, 97074 Würzburg — [3]1. Physikalisches Institut, Univ. Stuttgart, 70569 Stuttgart — [4]Institute for Organic Chemistry, Univ. Würzburg, 97074 Würzburg

Silver (Ag) is an ideal plasmonic material for applications in the visible regime, but its use is hindered by poor chemical stability and structural quality of thermally evaporated thin films and nanostructures. Here, we present a simple approach to overcome these limitations by alloying Ag thin films with small amounts of gold (Au) through thermal co-evaporation. We analyzed $Ag_{100-x}Au_x$ thin films with Au contents ranging from 5 to 20 at.% with respect to their surface and bulk crystal quality, optical properties and chemical stability. Remarkably, already $Ag_{95}Au_5$ thin films exhibit a drastically enhanced chemical stability and excellent plasmonic properties outperforming pure Ag. This is related to the high film quality achieved without metallic wetting layers, epitaxial substrates or template stripping. As a proof of concept, we fabricate $Ag_{95}Au_5$ plasmonic nanoantennas demonstrating excellent long-term durability over one month under ambient conditions. Our approach thus demonstrates a simple and effective strategy to overcome the general limitations of Ag in plasmonic applications. B. Ewald et al., ACS Photonics 2025, DOI: 10.1021/acsphotonics.5c01659

O 96.2 Fri 9:45 HSZ/0403

Topological quasiparticles in a bucket: water waves as an experimental platform for emulating optical nearfields — •Alexander Neuhaus, Pascal Dreher, Philipp Gessler, Michael Horn-von Hoegen, Karin Everschor-Sitte, and Frank Meyer zu Heringdorf — Faculty of Physics and Center for Nanointegration, Duisburg-Essen (CENIDE), University of Duisburg-Essen, 47048 Duisburg, Germany

Optical near fields can host a variety of topological quasiparticles, including merons, skyrmions, skyrmion bags and optical vortices, but their nanometric spatial scales and femtosecond time dynamics make them difficult to access experimentally. Modern techniques, such as time resolved photoemission microscopy or nearfield scanning optical microscopy can image these field configurations, but they are both experimentally challenging. Here, we demonstrate a much simpler 3d printed experiment that can be used as a model system to emulate the behavior of optical nearfields with capillary-gravity water waves. Although water waves and surface polaritons are vastly different wave phenomena, the displacement vector field in the water can be described by surface wave equations that are similar to the equations used to describe surface polaritons. We reconstruct the displacement field of the water wave by fast checkerboard decomposition of videos of the water wave propagation. Water-wave experiments yield the same topological quasiparticles as observed in optical nearfields, yet they do so in seconds instead of hours of experimental time.

O 96.3 Fri 10:00 HSZ/0403

Layer-Resolved Optical Metrology of MoS_2 Using Surface Plasmon Resonance Imaging — •Priyanka Thawany[1,2], Hesam Amiri[1], Lina Jäckering[2], Andrei Vescan[3], Thomas Taubner[2], Sven Ingebrandt[1], and Vivek Pachauri[1] — [1]Institute of Materials in Electrical Engineering 1 (IWE1), RWTH Aachen University — [2]I. Institute of Physics (IA), RWTH Aachen University — [3]Compound Semiconductor Technology, RWTH Aachen University

Conventional techniques such as scanning probe microscopy, Raman spectroscopy [1], ellipsometry [2], and terahertz microscopy [3] provide crucial information on optical and electronic parameters of 2D materials. However, they remain limited in measurement speed and spatial coverage for large-area characterization. To address these limitations, we demonstrate the use of surface plasmon resonance imaging (SPRi) as a complementary wide-field technique for mapping few-layer MoS_2 stacks. Thickness-dependent shifts in the SPR resonance angle and corresponding reflectance contrast allow clear discrimination of atomic-layer regions, consistent with theoretical predictions for MoS_2 optical permittivity changes. SPRi therefore offers a rapid, scan-free approach for real-time metrology of few-layer MoS_2, and similar measurements on other 2D materials show the same suitability for rapid optical characterization. [1] Malard et al., *Phys. Chem. Chem. Phys.* **23**, 23428 (2021). [2] Amiri et al., *Nano Trends* **111**, 100130 (2025). [3] Whelan et al., *Sci. Rep.* **14**, 3163 (2024).

O 96.4 Fri 10:15 HSZ/0403

Launching and confining In-Plane Hyperbolic Phonon Polaritons in α-MoO_3 with In_3SbTe_2 nanostructures — •Umberto Saldarelli[1], Lina Jäckering[1], Lukas Conrads[1], Matthias Wuttig[1], Pablo Alonso-González[2,3], and Thomas Taubner[1] — [1]I. Institute of Physics (IA), RWTH Aachen University — [2]Department of Physics, University of Oviedo — [3]Center of Research on Nanomaterials and Nanotechnology, CINN (CSIC-Universidad de Oviedo)

Alpha-phase molybdenum trioxide (α-MoO_3), a van der Waals material, supports in-plane hyperbolic phonon polaritons (HPPs) with high confinement, low losses, and extremely directional propagation [1]. Rapid prototyping of nanostructures for tailoring polaritons can be achieved with the plasmonic phase-change material In_3SbTe_2 (IST) [2], switchable between amorphous and crystalline phases via laser-induced heating. This has been already shown for programmable resonator structures within hBN [3]. Here we combine α-MoO_3 with IST. We use scattering-type scanning near-field optical microscopy (s-SNOM) to explore HPP launching by antennas of different orientations. Next, we optically program a circular launching structure to focus polaritons. Finally, adding a second focusing disk and reconfiguring the disk distance, we tailor field enhancement and confinement. Our results enable rapid design of reconfigurable structures and provide an all-optical material platform for controlling in-plane HPPs. [1] Ma et al. *Nat.* **562**, 557-562, (2018) [2] Conrads et al. *Opt. Mat. Expr.* **15**, 2664-2687, (2025) [3] Jäckering et al. *Nano Lett.* **25**, 15809, (2025)

O 96.5 Fri 10:30 HSZ/0403

Nanoscale Optical Readout of Antiferromagnetic Order by Photocurrent Nanoscopy — •Dario Siebenkotten[1], Anna Schmid[2], Dinghe Dai[1], Joao Godinho[2], Sam Fairman[1], Arne Hoehl[1], Tomas Janda[2], Tomas Ostatnicky[3], Bernd Kästner[1], and Jörg Wunderlich[2] — [1]Physikalisch-Technische Bundesanstalt, Berlin, Germany — [2]Institute of Experimental and Applied Physics, University of Regensburg, Regensburg, Germany — [3]Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic

Antiferromagnets are prime candidates for next-generation spintronic technologies as they allow for rapid switching and miniaturization compared to ferromagnets. However, readout of their magnetic state remains an open challenge, as their vanishing net magnetisation suppresses conventional magnetic readout schemes. Therefore, new mechanisms are required to measure the state of antiferromagnetic domains, which are often confined to the nanoscale. Here, we report on the experimental observation of a previously only theoretically predicted light-induced, Néel-order-dependent transverse photocurrent that we refer to as the optical nonlinear anomalous Hall effect. We demonstrate the effect by nanoscale imaging of the photocurrent generated in PT-symmetric CuMnAs cross-bar devices by mid-infrared near fields at the apex of a sharp metal tip. We exclude purely thermal mechanisms by showing that the photocurrent reverses sign when the Néel vector is rotated by 180° via current-induced switching of nanoscale antiferromagnetic domains of a few hundred nanometers in size, consistent with a time-reversal-odd nonlinear anomalous Hall photocurrent.

O 96.6 Fri 10:45 HSZ/0403

Plasmonic Effects in a honeycomb metasurface of Ag Nanotriangles and Nanoholes — •Paul-G. Nitsch[1], Paul Oleynik[1], Markus Ratzke[1], David Stolarek[2], Jon Schlipf[2], Oliver Skibitzki[2], Rudi Tschammer[3], Carlos Morales[3], Jan I. Flege[3], Christian Wenger[2], and Inga A. Fischer[1] — [1]Experimentalphysik und funktionale Materialien, BTU-CS, Cottbus, Germany — [2]IHP - Leibniz- Institut für innovative Mikroelektronik, Frankfurt (Oder), Germany — [3]Angewandte Physik und Halbleiterspektroskopie, BTU-CS, Cottbus, Germany

Coupled lattices of metal nanoparticle and nanohole arrays can support spectrally narrow plasmonic resonances with potential applications, e.g., in biosensing. In nanohole arrays, the interplay of surface plasmon polaritons at metal-dielectric interfaces and Rayleigh anomalies can lead to Fano resonances, whose spectral positions are well described by Bragg coupling conditions. For nanoparticle arrays with small interparticle distances, the coupling of neighboring particles via their overlapping evanescent fields leads to resonances, whose dispersion relation has been described by tight-binding models. Here, we investigate resonances in coupled nanoparticle and nanohole lattices both experimentally and in simulation. We show that a variation in angle of incidence can be used to tune mode coupling and present results on the detection of near-surface refractive index changes with high sensitivities and figures-of-merit in our samples.

O 96.7 Fri 11:00 HSZ/0403

Hybrid Gold–Vanadium-Dioxide Tunable Plasmonic Devices — Rostislav Řepa, Jiří Kabát, Jiří Liška, Peter Kepič, Michal Horák, Tomáš Šikola, and •Vlastimil Křápek — Brno University of Technology, Brno, Czechia

Vanadium dioxide (VO_2) exhibits a metal-insulator transition near room temperature, which can be exploited in tunable plasmonic devices with compelling functions. However, devices based solely on VO_2 suffer from a large optical absorption and low chemical stability of VO_2 [1].

We present a hybrid material platform that combines high-quality crystalline self-assembled VO_2 nanoparticles [2] with lithographically defined gold nanostructures in a lateral arrangement In this way, we benefit from both the tunability of VO_2 and the high conductivity of gold. The lateral arrangement minimizes the amount of VO_2 and thus contributes to the high quality of the devices.

We demonstrate two tunable plasmonic devices based on the above-mentioned material platform: (1) Electric-magnetic switches, in which either an electric or magnetic hot spot is formed, following a design from Ref. [3]. (2) Resonance-energy switches, in which the spectral profile of the scattering or absorption is controlled, with possible applications in selectively-enhanced photoluminescence.

[1] Krpenský et al., Nanoscale Adv. **6**, 3338–3346 (2024).
[2] Horák et al., arXiv:2408.11972.
[3] Křápek et al., Nanophotonics **9**, 623–632 (2020).

O 96.8 Fri 11:15 HSZ/0403

Phonon Polariton Materials Discovery from First Principles — Elena Gelzinyte[1], Giulia Carini[1], Niclas S. Mueller[1], Martin Wolf[1], Karsten Reuter[1], •Johannes T. Margraf[2], Alexander Paarmann[1], and Christian Carbogno[1] — [1]Fritz-Haber-Institut der MPG, Berlin — [2]Universität Bayreuth

Phonon Polaritons (PhPs), quasi-particles that arise from strong coupling between infrared photons and optical lattice vibrations, are promising in nanophotonic applications for highly directional and confined light propagation with low optical loss [1]. So far, PhP studies have been mostly focused on a few canonical materials, and the trends in the material space that influence the emergence and properties of PhPs remain largely unexplored. To consider the suitability of various polar crystals for the formation of PhPs, we compute the infrared permittivity functions [2] of 3,000 materials in the JARVIS-DFT database [3]. We then categorize these compounds by their normalized light-matter coupling strength and Reststrahlen band width, whereby we also decompose these in terms of individual phonon mode contributions. A broad range of materials emerges with comparable or better properties than those of typically studied PhP compounds. Using orthorhombic PbO, monoclinic TiO_2, and trigonal $CdCN_2$ as representative examples, we validate our approach and discuss the PhP property trends that allow to identify and design promising PhP candidates.

[1] E. Galiffi *et al.*, Nat. Rev. Mater. **9**, 9 (2024).
[2] X. Gonze and C. Lee, Phys. Rev. B **55**, 16 (1997).
[3] K. Choudhary *et al.*, npj Comput. Mater. **6**, 1 (2020).

O 96.9 Fri 11:30 HSZ/0403

Infrared beam-shaping via geometric phase metasurfaces with the plasmonic phase-change material In_3SbTe_2 — •Lukas Conrads, Florian Bontke, Matthias Wuttig, and Thomas Taubner — I. Institute of Physics (IA), RWTH Aachen University

Conventional optical elements are bulky and limited to specific functionalities, contradicting the increasing demand of miniaturization and multi-functionalities. Optical metasurfaces enable tailoring light-matter interaction at will, especially important for the infrared spectral range which lacks commercially available beam-shaping elements. While the fabrication of those metasurfaces usually requires cumbersome lithography techniques, direct laser writing promises a simple and convenient alternative. Here, we exploit the non-volatile laser-induced insulator-to-metal transition of the plasmonic phase-change material In_3SbTe_2 (IST) [1,2] for optical programming of large-area metasurfaces for infrared beam-shaping. We tailor the geometric phase of metasurfaces with rotated crystalline IST rod antennas to achieve beam steering, lensing, and beams carrying orbital angular momenta. Finally, we investigate multi-functional and cascaded metasurfaces exploiting enlarged holography, and design a single metasurface creating two different holograms along the optical axis. Our approach facilitates fabrication of large-area metasurfaces within hours, enabling rapid-prototyping of customized infrared meta-optics for sensing, imaging and quantum information.[3] [1] Heßler et al. *Nat. Com.* **12**, 924 (2021) [2] Conrads et al. *Opt. Mat. Ex.* **15**, 2664-2687 (2025) [3] Conrads et al. *Nat. Com.* **16**, 3698 (2025)

O 96.10 Fri 11:45 HSZ/0403

Ab Initio Theory of Chemical Interface Damping of Surface Plasmons — •Jordan Edwards[1], Johannes Lischner[1], Andrei Stefancu[2], Wenxuan Tang[3], Ming Fu[3], Ross Schofield[3], Toby Millard[3], Rupert Oulton[3], Pilar Carro[4], Naomi Halas[5], Peter Nordlander[5], and Emiliano Cortes[2] — [1]Imperial College London, London, United Kingdom — [2]Ludwig-Maximilians-Universität (LMU), Munich, Germany — [3]Imperial College London, London, United Kingdom — [4]University of Laguna, La Laguna, Spain — [5]Rice University, Houston, United States

Metallic nanostructures support surface plasmons, collective electron oscillations that give rise to unique optical properties. Molecular adsorption can strongly modify plasmon behaviour; for example, experiments showing that functionalisation reduces their propagation length, a phenomenon is known as chemical interface damping (CID). However, the origin behind CID remains debated, with two proposed mechanisms being: (1) excitation of electron-hole pairs involving the adsorbate orbitals, and (2) electronic scattering by adsorbate-induced dipoles.

To investigate the physical origin of CID, we perform first-principles density-functional theory calculations for different molecules adsorbed on Au(111) surfaces. We calculate the density of states projected onto the adsorbate orbitals to analyse surface-plasmon decay channels associated with mechanism (1). We also use cluster models of the surface to investigate mechanism (2). These results are compared to experimental measurements, offering insights into the origin of CID.

O 96.11 Fri 12:00 HSZ/0403

Tailoring hyperbolic phonon polaritons in hexagonal boron nitride with the phase-change material In_3SbTe_2 — •Lina Jäckering, Aaron Moos, Lukas Conrads, Matthias Wuttig, and Thomas Taubner — I. Institute of Physics (IA), RWTH Aachen University

Polaritons in van-der-Waals materials (vdWM)[1] promise high confinement and multiple tailoring options by resonators and launching structures which conventionally require cumbersome lithography techniques. Optical programming of phase-change materials (PCMs) offers fast and reconfigurable fabrication of these structures. As the plasmonic PCM In_3SbTe_2 (IST) can be switched between a dielectric and metallic phase, IST is promising for nanophotonics[2], especially for optical programming of metallic launching structures to tailor and confine polaritons in vdWM. Here, we combine the vdWM hexagonal boron nitride (hBN) with IST.[3] We optically program circular resonators for hBN's phonon polaritons into IST through the hBN flake. We investigate the polariton resonators with near-field optical microscopy. Demonstrating the reconfigurability, we decrease the resonator diameter to increase the confinement up to $\lambda/39$ and achieve a quality factor of 72. Finally, we fabricate a focusing structure for hBN's polaritons whose focal point we reconfigure. We promote IST as a versatile platform for rapid prototyping of polariton optics in various vdWM such as α-MoO_3, β-Ga_2O_3 and $MoOCl_2$. [1] Basov et al. Science **354**, 6309 (2025) [2] Conrads et al. Opt. Mater. Express **15**, 2664 (2025). [3] Jäckering et al. Nano Letters **25**, 15809 (2025).

O 96.12 Fri 12:15 HSZ/0403

Self-assembled dielectric network metamaterials based on vanadium oxide — •Marcello Pozzi[1], Jeremi Setz[1], Noel von Wattenwyl[1], Georg Haberfehlner[2], Arnold Müller[3], Ralph Spolenak[1], and Henning Galinski[1] — [1]Laboratory for Nanometallurgy, ETH Zürich, Switzerland — [2]FELMI-ZFE, TU Graz, Austria — [3]Laboratory of Ion Beam Physics, ETH Zürich, Switzerland

Among scalable optical nanomaterials, network metamaterials stand out because of their large-area compatibility, versatility and low footprint. These systems are created by self-assembly in a reaction-diffusion process called "chemical dealloying", resulting in complex network structures with broadband optical response driven by plasmonic mode equipartition [1]. Typical network metamaterials consist of noble metallic elements and show plasmonic behavior. Here we propose a material system that extends the design space of network metamaterials to dielectrics. Using magnetron co-sputtering of aluminum-vanadium followed by chemical dealloying, we fabricate network metamaterials based on vanadium oxide. Through the combination of Rutherford backscattering spectroscopy (RBS) and focused ion beam (FIB) tomography we analyze the dynamics of pattern formation, while the light-matter interaction is studied combining full-wave simulations and various spectroscopy techniques. Finally, we determine the degree of hyperuniformity of the dielectric networks by measuring the scaling behavior of the volume fraction variance of the systems.

[1] Adv. Optical Mater. 2023, 11, 2300568