O 82: Plasmonics and Nanooptics: Fabrication, Characterization and Applications II

Time: Thursday 10:30–12:30 Location: H8

O 82.1 Thu 10:30 H8

Femtosecond Direct Laser Writing of Conductive and Electrically Switchable PEDOT:PSS Optical Nanostructures — •Dominik Ludescher[1], Pavel Ruchka[1], Leander Siegle[1], Yanzhe Huang[2], Philipp Flad[1], Monika Ubl[1], Sabine Ludwigs[2], Mario Hentschel[1], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany — [2]IPOC - Functional Polymers, Institute of Polymer Chemistry, University of Stuttgart, Germany

Conducting polymers, exemplified by PEDOT:PSS, exhibit distinctive electronic and polymeric attributes. When subjected to CMOS-compatible voltages (-3 V and +2 V), PEDOT:PSS transitions between insulating and metallic states via an intrinsic electrochemical redox reaction. Consequently, this conducting polymer is suited perfectly for AR/VR applications, advanced display technologies, dynamic sensors, and integration with printed optics. The latter application requires a robust foundation in fabrication and the ability to combine 3D printed optics with switchable materials to open the route to dynamic miniaturized optics. We present an alternative fabrication method based on the photon-induced solubility modulation that combines conventional, static photopolymer structures (IP-S) with the dynamic behavior of PEDOT:PSS. Additionally, we demonstrate that the electrical, optical, and dynamic material properties remain even after structuring based on direct laser writing, present the resolution limit at 400 nm structure width, and investigate the switching speed and sample longevity.

O 82.2 Thu 10:45 H8

Revolutionizing OLED Performance and Efficiency with Core-Shell Nanoparticles in HTL and Carbon Dots in ETL Layers — •Zoi Georgiopoulou[1,2], Apostolis Verykios[1], Theodoros Triadis[1], and Maria Vasilopoulou[1] — [1]Institute of Nanoscience and Nanotechnology, National Center for Scientific Research *Demokritos* — [2]Solid State Physics Section, Department of Physics, National and Kapodistrian University of Athens

The development of efficient organic light-emitting diodes (OLEDs) is essential for advancing modern displays and flexible electronics. This presentation explores two methodologies to enhance OLED performance through innovative material integration. The first involves incorporating core-shell nanoparticles into the hole transport layer (HTL). Metal nanoparticles (M-NPs) are encapsulated in a tungsten polyoxometalate (POM) compound and embedded in the PEDOT:PSS layer, leveraging the Localized Surface Plasmon Resonance (LSPR) effect. Analyses, including UV-Vis spectroscopy, atomic force microscopy, and electrical measurements, reveal enhanced optoelectronic properties with POM-M-NP integration. The second approach enhances OLED efficiency by combining carbon dots and a porphyrin layer in the electron transport layer (ETL). Carbon dots improve electron mobility and reduce recombination losses, while the porphyrin layer facilitates charge injection and blocks backflow. This synergy optimizes charge balance, lowers operating voltage, and improves luminous efficiency. These strategies underscore the importance of advanced material engineering in OLED development

O 82.3 Thu 11:00 H8

Engineered disorder metasurfaces for near-field light shaping — •Luca Schmid[1], Julian Schwab[1], Chi Li[2], Stefan Maier[2], Harald Giessen[1], Haoran Ren[2], and Mario Hentschel[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]School of Physics and Astronomy, Monash University, Clayton, Victoria, Australia

Plasmonic and dielectric nanophotonic building blocks allow for shaping the flow of light at boundaries and interfaces. They have opened the field of metasurfaces, which until now mostly allow for the creation of nearly arbitrary far-field intensity distributions in the far field. Drawing inspiration from this concept, we introduce metasurfaces for near-field light shaping. Desired near-field intensity distributions can be created by engineering the distribution of individual scatterers on metallic surfaces and hence the interference of the individually launched surface plasmons. Using this ansatz, we demonstrate engineered-disorder metasurfaces which enable to direct, focus, and demultiplex incident light. We implement these structures by a peel-off process from molds, which results in ultra-smooth metallic surfaces, maximizing the plasmon propagation length. Far-field measurements based on a k-space spectroscopy setup allow us to image the local near-field and show excellent agreement with modelling and simulation. We envision that the creation of nearly arbitrary near-field distributions will enable nanoscale routing and sorting of light based on polarization, orbital angular momentum, and wavelength, as well as help realize novel coupling schemes to emitters and nanoscale systems.

O 82.4 Thu 11:15 H8

Strong polarization-tuned optical nonlinearity via femtosecond-laser plasmonic nanolithography in lithium niobate — •Han Zhu[1,2], Shengqiang Zhou[1], and Feng Chen[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [2]Shandong University, Jinan 250100, China

Despite the advantages of lithium niobate (LN)-based photonic integration platforms in various applications, the inherently weak third-order nonlinear optical response of conventional materials limits the miniaturization and energy efficiency of nonlinear optical devices in compact optical systems. Localized surface plasmons (LSPs) provide a promising solution to this miniaturization challenge by confining and enhancing light fields at deep subwavelength scales. However, due to nanofabrication limitations, strongly coupled single-crystal LN-LSP structures have yet to be realized. Here, we demonstrate Au nanorod-LN hybrid plasmonic structures assembled via plasmonic nanolithography. By leveraging plasmon-mediated energy deposition and photon momentum transfer under femtosecond laser irradiation, the nanoparticles within the single-crystalline region are formed from implanted elements. With plasmons excited in distinct axial directions, the resulting nanorod-LN hybrid plasmonic material exhibits polarization-dependent nonlinearity, with the nonlinear absorption coefficient for long-axis polarized light augmented by five orders of magnitude compared to the pure LN. Utilizing this feature, we develop a Q-switched laser exhibiting pronounced polarization-dependent behavior.

O 82.5 Thu 11:30 H8

Nonlocal Substrate Influence on the Plasmon of a Supported Silver Nanoparticle — Kevin Oldenburg, Karl-Heinz Meiwes-Broer, and •Ingo Barke — ELMI-MV, Department *Life, Light & Matter*, and Institute of Physics, University of Rostock

The effect of a substrate on a particle plasmon (Localized Surface Plasmon Resonance, LSPR) is often considered to be of local nature, where the substrate primarily affects the plasmon at short distances [1]. Here we present spatially resolved plasmon excitation probabilities of a single 11 nm silver nanoparticle deposited from the gas phase onto a narrow rim of a carbon substrate ("cliffhanger"), thus providing a cross-sectional view. We employ electron energy loss spectroscopy (EELS) with a scanning transmission electron microscope (STEM) where we find the strongest substrate effect, i.e., the largest red shift, when the plasmon is excited farthest away. As will be discussed, this non-local substrate influence is a consequence of the simplicity and size of the system. These results are corroborated by simulations based on the boundary element method (BEM), which also help extract the full mode structure from the experimental data. Furthermore, we observe pronounced symmetry breaking, lifting the threefold degeneracy of the dominating dipole modes, potentially resolving long-standing discrepancies in the literature regarding plasmon energies of silver clusters in this size regime [2].

[1] S. Mazzucco, et al., Nano Letters 12, 1288 (2012).
[2] H. Haberland, Nature (2013), 494 E1-E2; A. Campos et al., Nature Physics (2019), 15, 275

O 82.6 Thu 11:45 H8

Dynamic beam switching using individually adressable plasmonic gratings made from switchable metallic polymer in planar technology — •Jonas Herbig, Dominik Ludescher, Monika Ubl, Mario Hentschel, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

The ability to steer light in an optical system is vital for light detection and ranging (LiDAR) applications as required for autonomous driving and technology based on artificial intelligence (AI). One relevant drawback of conventional LiDAR platforms is their large size, making

them unsuitable for integration into compact devices. Here, we demonstrate a compact and programmable electrode nanopattern utilizing the structuring of indium tin oxide (ITO) layer in conjunction with the conducting polymer poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS). This structure demonstrates the individual addressability of multiple subgratings, enabling switching between different superlattice periods with CMOS-compatible voltages, resulting in multiple diffraction angles of up to 26° at a wavelength of 2150 nm. This work lays the foundation for adaptive optics as well as single addressable pixels necessary for advanced display systems and other active devices, such as spatial amplitude and phase modulators exceeding 1000 l/mm.

O 82.7 Thu 12:00 H8

Disorder-driven localization of surface plasmon resonances in disordered assemblies of gold nanoparticles — •Kristina Weinel[1,2,3], Johannes Schultz[1], Mohammed Fayis Kalady[1], Daniel Wolf[1], Leonardo Agudo Jácome[3], and Axel Lubk[1,2] — [1]Leibniz Institute for Solid State and Materials Research (IFW) Dresden, Dresden, Germany — [2]Technical University Dresden (TUD) Dresden, Dresden, Germany — [3]Federal Institute of Materials Research and Testing (BAM), Berlin, Germany

The general wave phenomenon of Anderson localization, which is the absence of diffusion of waves in disordered systems, is studied for surface plasmon waves in two-dimensional disordered systems. To that end disordered assemblies of plasmonic gold nanoparticles (NPs) on an insulating silicon oxide substrate were synthesized by a newly developed synthesis method where an electron beam in a scanning electron microscope is used to heat a gold microparticle precursor until evaporation and deposition of the gold atoms on the substrate forming NPs of varying sizes. To reveal the surface plasmons and their localization behavior, electron energy loss spectroscopy in the transmission electron microscope is applied and compared with self-consistent dipole model simulations. Disorder-driven spatial and spectral localization of the hybridized localized surface plasmon modes was found experimentally and via simulation. Moreover, the localization exhibits a characteristic thickness dependency determining the localization length dependency on the plasmon energy.

O 82.8 Thu 12:15 H8

Nanophotonics of ultra-thin gold flakes — •Gayathri Haridas, Farid Aghashirinov, Julian Schwab, Bettina Frank, and Harald Giessen — 4-th Physics Institute, University of Stuttgart, Germany

In our work, we focus on fabricating ultrathin single-crystalline gold platelets using an electrochemical synthesis approach. This process involves the reduction of gold atoms from the electrode surface to form gold ions, which then nucleate as seeds and grow into well-defined crystalline platelets. By systematically adjusting and controlling the growth parameters, we aim to optimize the synthesis conditions to achieve reproducible and stable fabrication of platelets with precise control over their lateral size and thickness. The characterization of the synthesized platelets is carried out using spectroscopic techniques such as Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM), to understand the surface morphologies and height profiles of the crystals.

The primary objective is to reduce the thickness of platelets to the single-digit nanometer scale while maintaining their lateral sizes. At this regime, the gold platelets exhibit unique optical and electrical properties that are highly sensitive to their size. This arises from the quantization of electronic states. We are particularly interested in probing these quantum effects, which can give rise to further research in the field of quantum plasmonics and thereby establishing gold as a suitable platform for it.