O 70: Poster: Plasmonics and Nanooptics II

Time: Wednesday 18:00–20:00 Location: P2/EG

O 70.1 Wed 18:00 P2/EG

Phase correction and stability of a Mach-Zehnder interferometer for 2D electronic spectroscopy — •Simon Durst, Sanchayeeta Jana, Christoph Schnupfhagn, and Markus Lippitz — University of Bayreuth

Fluorescence detected 2D electronic spectroscopy (F-2DES) allows the measurement of ultrafast electron dynamics in complex systems, while disentangling this spectral information from energetically similar phenomena, such as molecular vibration.

The technique requires an excitation signal of four time-delayed laser pulses, which we create via a four-arm Mach-Zehnder interferometer. This interferometer receives a single pulse as an input, and, through the use of delay stages and acusto-optical modulators, outputs a desired pulse train with frequency-modulated phase profiles, used for lock-in detection.

When exciting a sample with this pulse train, special attention must be given to the phase relation between the individual pulses. A mismatch or instability in their spectral phase leads to an excitation with pulses of different lengths or unknown delays and will overall worsen the performance of the setup.

Therefore, this poster highlights the techniques and instruments we use to characterize and compensate the relative phase between the different interferometer arms: GVD correction using a spatial light modulator, a prism compressor setup and interferometric delay scans.

O 70.2 Wed 18:00 P2/EG

In-Situ TEM Study of Structural and Optical Changes by Laser-Induced Grain-Growth — •Jakob Hagen, Murat Sivis, and Claus Ropers — Max-Planck-Institute for Multidisciplinary Sciences, Göttingen, Germany

Resonantly excited surface-plasmons (SP) can be exploited in various scientific fields [1] and have thus sparked widespread attention. One major characteristic of these collective free-electron oscillations is the ability to localize and enhance electromagnetic fields beyond the diffraction limit [2]. Here, we created Aluminum nanodiscs by electron beam lithography (EBL), which are poly-crystalline in nature. In general, single-crystalline structures are preferred because high optical quality can be obtained due to the absence of propagation-damping grain boundaries [3]. Using annealing in an ultrafast transmission electron microscope (TEM) with a pulsed laser source, a grain-growth process could be driven where the boundary migration was observed frame by frame. Upon illumination, the number of grains reduced drastically, leading to almost perfect mono-crystals while preserving the shape. In addition, optical characterization of SPs by photon-induced near-field electron microscopy (PINEM) [4] was carried out before and after annealing. Our approach fuses the precise, nanometric positioning from EBL with the benefits of mono-crystalline plasmonics [5].

[1] S. Lal et al., Nat. Photonics 1, 641-648 (2007), [2] K. B. Crozier et al., J. Appl. Phys., 94, 4632 (2003), [3] M. Bosman et al., Sci. Rep. 4, 5537 (2014), [4] L. Piazza et al., Nat. Commun. 6, 6407 (2015), [5] J.-S. Huang, Nat. Commun., 1:150 (2010)

O 70.3 Wed 18:00 P2/EG

Gold nanoparticles as scannable plasmonic light source for STM enabled electroluminescence — •Cinja S. Müller, Berk Zengin, Aleš Cahlík, and Fabian D. Natterer — Department of Physics, University of Zurich, Winterthurerstrasse 190, CH-8057, Switzerland

The preparation of high quantum yield tips for electroluminescence includes the use of plasmonic metals, by either making tips from wires of coinage metals or coating of tungsten (or Pt/Ir) tips by violent indentation into Au or Ag crystals. While the former appears as the most logical choice, tips made from ductile coinage metals tend to be mechanically unstable. The plunging of tungsten tips into metal substrates, on the other hand, is rather crude and irreproducible. Here, we attempt to use concepts from both extremes by attaching gold nanoparticles (AuNP) onto the apex of tungsten or Pt/Ir tips. We drop-cast commercially available colloidal AuNP onto a graphite substrate from which the AuNP may be transferred to the STM tip by gentle contact. We describe our setup and characterize the electroluminescence using a fiber-coupled single photon counter.

O 70.4 Wed 18:00 P2/EG

Neuromorphic plasmonic computing - Surface plasmon polariton neurons — •Mario F. Pfeiffer[1], Tobias Eul[1], Eva Prinz[1], Benjamin Stadtmüller[1,2], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]Institute of Physics, Johannes Gutenberg University Mainz, Germany

Today, the classical electronic computer architecture is the limiting factor for faster, and energy efficient data processing. In combination with the rapidly increasing use of artificial intelligence in science and industry, additional approaches for a suitable hardware architecture are necessary. For this reason, neuromorphic photonics emerged as a novel research field for new classes of information processing devices that incorporate photonically integrated neural networks [1].

The hybrid nature of surface plasmon polaritons (SPPs) combines photonic advantages such as high bandwidth and speed with strong electronic interactions. These properties have the potential to further advance the development of new hardware. Here we present a concept for building an artificial neuron based on SPP interactions. We have designed initial building blocks of the neuron based on finite-difference time-domain simulations of the plasmonic response. Finally, we imaged this response using a photoemission electron microscope.

[1] Shastri, B.J., Tait, A.N., Ferreira de Lima, T. et al., Nat. Photonics 15, 102-114 (2021)

O 70.5 Wed 18:00 P2/EG

Optical writing of switchable mid-infrared surface phonon polariton resonators with the plasmonic phase-change material In_3SbTe_2 — •Luis Schüler, Lukas Conrads, Konstantin Georg Wirth, Matthias Wuttig, and Thomas Taubner — I. Institute of Physics (IA), RWTH Aachen University

Chalcogenide-based phase-change materials (PCMs) are prime candidates for active nanophotonics. They can be reversibly switched between an amorphous and a crystalline state, which exhibit a strong contrast in optical and electrical properties [1]. Therefore, PCMs can be used, for example, to tune surface phonon polariton (SPhP) resonances in the infrared [2]. The recently introduced PCM In_3SbTe_2 (IST) possesses a crystalline phase which is metallic in the entire infrared range. It allows for direct writing of arbitrary resonant structures in a dielectric surrounding [3], which could also confine SPhPs in cavities of subwavelength size. However, an investigation of different confined modes in those cavities with IST has not been performed yet. Here, we investigate IST on a SiC substrate. By laser-induced phase switching, we define various SPhP resonator structures, such as circular cavities, and measure their resonant behavior with optical near- and far-field methods. This study is a first step towards rapid prototyping of switchable SPhP resonators of arbitrary shape that could be employed, for example, in chemical sensing and active metasurfaces.

[1] Wuttig, M. et al. *Nature Photonics* **11**, 465-476 (2017).
[2] Sumikura, H. et al. *Nano Letters* **19**, 2549-2554 (2019).
[3] Heßler et al. *Nature Communications* **12**, 924 (2021).

O 70.6 Wed 18:00 P2/EG

Enhanced Second Harmonic Generation from Silver Nanoantennas — •Fabian Scheidler, Johanna Klos, Jessica Meier, Luka Zurak, and Bert Hecht — Nano-Optics and Biophotonics Group, Experimental Physics 5, University of Würzburg, Am Hubland, 97074 Würzburg, Germany

Plasmonic gold nanostructures allow to achieve large field enhancement in nanoscale volumes and are therefore appealing to boost nonlinear processes such as second harmonic generation (SHG). Especially intense near-field hot spots emerge in the gaps of symmetric dimer antennas, yet strong SH sources created in the gap region oscillate out-of-phase and thus destructively interfere in the farfield [1]. Introducing local asymmetry by careful design of the antenna gap geometry allows to mitigate the so-called silencing effect and leads to enhanced SHG [2].

In the ultraviolet-visible spectral range, however, the SH efficiency for gold nanoantennas is limited due to high damping below 500 nm. Here we present silver nanoantennas fabricated from epitaxial grown single-crystalline microplatelets to boost SHG below 500 nm, where silver shows significantly less absorption losses compared to gold. The antenna design is optimised for SHG taking into account the linear scattering response with a resonance at the SH.

[1] J. Berthelot et al., Optics express, 20(10), 10498-10508 (2012).
[2] J. Meier et al., arXiv:221014105 (2022).

O 70.7 Wed 18:00 P2/EG

A room temperature tunable scanning fiber Fabry-Pérot cavity microscope — •Lars Denzer, Paul Steinmann, and Stefan Linden — Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn, Germany

Since the technological advancements in the fabrication of ultra-smooth concave fiber surfaces, fiber-based Fabry-Pérot cavities (FFPCs) are a field of ongoing research. Many applications emerged, ranging from light-matter coupling utilizing very small mode volumes over cavity-enhanced sensing, to cavity microscopy. Here, we report on the construction and test of a tunable scanning fiber Fabry-Pérot cavity microscope operating at room temperature. To this end, we fabricated a concave metallic mirror on the facet of an optical fiber. Using a focused CO2 laser beam, we achieve an ultra-smooth Gaussian depression at the fiber facet. Afterwards, the fiber is gold-coated in an evaporation chamber. Coarse tuning of the cavity is possible by the use of a 3D-piezo stage and the cavity length is fine-tuned by a shear piezo. Laterally scanning the cavity enables a mapping of the sample surface. As a first test, we investigate the coupling of a MoSe2 monolayer to the cavity field.

O 70.8 Wed 18:00 P2/EG

Near-field scanning optical microscopy of topologically protected excitons in molecular aggregates — Sidhartha Nayak, Christopher W. Wächtler, and •Alexander Eisfeld — MPIPKS, Dresden, Germany

Delocalized excitonic eignestates of molecular aggregates are responsible for the energy transfer from an incoming radiation into the aggregate. Static disorder, which can arise from an imperfect environment of each molecule, reduces the exciton transport and large disorders can even localize the exciton. It has been shown theoretically that a two-dimensional periodic array of tilted and interacting molecules in a homogeneous magnetic field shows topologically protected edge states [1]. With a scattering scanning near-field optical microscope setup, one can not only record position dependent absorption spectra [2] but also reconstruct the wavefunctions from these specta [3]. We study theoretically the near field spectra of the aforementioned 2D aggregates in which the molecules experience a disordered environment because of the probing metallic tip. Due to the topological protection, the edge states are robust even in the presence of the metallic nanoparticle, such that the spectrum shows clear signatures of these states.

[1] J. Y. Zhou, S. K. Saikin, N. Y. Yao and A. Aspuru-Guzik, *Nature materials* 13, 1026-1032 (2014)
[2] S. Nayak, F. Zheng and A. Eisfeld, *J. Chem. Phys.* 155, 134701 (2021)
[3] F. Zheng, X. Gao and A. Eisfeld, *Phys. Rev. Lett.* 123, 163202 (2019)

O 70.9 Wed 18:00 P2/EG

Nanoantenna Conjugated Graphene Photodetectors — •Abhinav Raina, Mo Lu, Max Reimer, Vasilii Osipov, Klaus Meerholz, and Klas Lindfors — Department für Chemie, Universität zu Köln, 50939, Köln, Germany

Optical communications is a technology that utilizes light for the wireless transduction of signals. Over the past few decades, the rapid development of nanoscale fabrication techniques has allowed for a significant improvement in the control over the transduction of optical signals. For example, optical nanoantennas have been used in steerable wireless links.[1] In an effort to detect the signals in optical nanoantenna links as an electrical signal, we couple nanoantenna arrays with a graphene photodetector. Such a device would act as a demonstration of tunable, on-chip, wireless transmission and detection of optical signals.

[1] Dregely, D., Lindfors, K., Lippitz, M., Engheta, N., Totzeck, M., Giessen, H., Nat. Commun., 2014, 5, 4354.

O 70.10 Wed 18:00 P2/EG

Fabrication of STM+AFM+TERS tips — •Petr Kahan, Jiří Doležal, Amandeep Sagwal, Rodrigo Ferreira, and Martin Švec — Institute of Physics, Czech Academy of Sciences; Cukrovarnická 10/112, CZ16200 Praha 6, Czech Republic

Although many highly reproducible techniques[1,2,3] exist for scanning tunneling microscopy (STM) tip preparation suitable for Tip-enhanced Raman spectroscopy (TERS), none of them was employed in non-contact atomic force microscopy (nc-AFM) relying on a lightweight tip glued to the tuning fork. Here we investigate the effects of commercially available and safe metallurgy etchants[3] on STM/nc-AFM tip fabrication from plasmonic metals[4]. We devised a simple optical apparatus for quick tip quality assessment. This allows us to see the Raman and plasmon scattering of the tip surface in various stages of preparation and determine its suitability for TERS. This might pave the way towards the first demonstration of combined STM/nc-AFM and TERS with submolecular resolution with the same tip [5] .

[1] Sasaki, S. S. et al. Rev. Sci. Instrum 84, 096109 (2013) [2] Yang, B. et al. JPCC 122, 16950-16955 (2018) [3] Walker, P. & Tarn, W. H. CRC handbook of metal etchants (CRC press, 1990) [4] Murray, W. A. & Barnes, W. L. Adv. Mater. 19, 3771-3782 (2007) [5] Xu, J. et al. Science 371 818-822 (2021)