O 91: Plasmonics and Nanooptics V: Waveguides and Antennas

Time: Friday 10:30–12:45 Location: CHE 89

O 91.1 Fri 10:30 CHE 89

Intermediate-field coupling of single epitaxial quantum dots to plasmonic nanowires — •Michael Seidel[1], Yuhui Yang[2], Saimon Covre Da Silva[3], Thorsten Schumacher[1], Armando Rastelli[3], Stephan Reitzenstein[2], and Markus Lippitz[1] — [1]Experimental Physics III, University of Bayreuth, Germany — [2]Institute of Solid State Physics, TU Berlin, Germany — [3]Institute of Semiconductor and Solid State Physics, Johannes Kepler University Linz, Austria

Integrated plasmonic nanocircuits are highly promising building blocks for future quantum optical applications. In combination with self-assembled epitaxially grown GaAs quantum dots as stable, bright and narrow-band single-photon sources, ultra-compact nanocircuits operating below the diffraction limit can be designed [1]. A crucial aspect is the coupling of the quantum dot emission into plasmonic waveguide modes. Typically, quantum emitters are placed in the optical near-field of a waveguide, imposing high demands on controlled nanofabrication. Furthermore, plasmonic waveguiding is drastically attenuated near high-index dielectrics due to radiative losses. We overcome these challenges by introducing a 100nm thick dieletric spacer layer, which effectively increases the propagation length and preserves acceptable coupling efficiency, resulting in a robust coupling scheme which is difficult to achieve in the near-field. We characterize the nanostructure by low-temperature photoluminescence and cathodoluminescence imaging and find good agreement to numerical simulations.

[1] Wu et al., Nano Lett. 2017, 17, 7, 4291-4296

O 91.2 Fri 10:45 CHE 89

How to obtain modes in optical fibers — •Sergei Gladyshev, Adria Canos Valero, and Thomas Weiss — Institute of Physics, University of Graz, Universitätsplatz 5, 8010 Graz, Austria

Nowadays, new and complex types of optical fibers such as bandgap photonic crystal fibers and antiresonant fibers are actively studied. To understand the physical mechanisms in such fibers, numerical modeling is of great importance. However, numerical calculations for these fibers are extremely challenging. We present an efficient numerical method for obtaining fiber modes in these systems. More specifically, we adapt the contour integral method, a method for solving nonlinear eigenvalues problems, to derive the propagation constant and the electromagnetic near fields of several modes simultaneously.

O 91.3 Fri 11:00 CHE 89

Directional transport in plasmonic waveguide arrays in the presence of disorder — •Anna Sidorenko and Stefan Linden — Physikalisches Institut, Friedrich-Wilhelms-Universität Bonn, Kreuzbergweg 24, 53115-Bonn, Germany

Evanescently coupled waveguides provide a convenient platform for the simulation of various quantum phenomena whose experimental realization in analogous condensed matter systems is otherwise difficult. The basis for this is the mathematical equivalence of the coupled mode theory equations and the discrete Schrödinger equation in the tight-binding approximation. Here we present a comparative study of the robustness of directional transport in presence of disorder in two periodically driven waveguides systems - ratchets [1] and fast Thouless pumps [2]. Directional transport in a ratchet requires fine-tuning of the driving parameters. In contrast, directional transport in Thouless pumping is a topological effect that exists for a range of driving frequencies considering the closed cycle in parameter space. We analyze the effect of topological protection on directional transport by introducing identical disorder distributions to both systems.

References:

[1] Z. Fedorova, C. Dauer, A. Sidorenko, S. Eggert, J. Kroha, S. Linden, ”Dissipation engineered directional filter for quantum ratchets”. Physical Review Research 3(1), 013260 (2021).

[2] Z. Fedorova, H. Qiu, S. Linden, J. Kroha, ”Observation of topological transport quantization by dissipation in fast Thouless pumps,” Nature communications 11, 3758 (2020).

O 91.4 Fri 11:15 CHE 89

Spatially resolved nonlinear plasmonics — •Johannes Schust, Florian Mangold, Niklas Metz, Mario Hentschel, Bettina Frank, and Harald Giessen — 4th Physics Institute, Research Center SCoPE, and IQST, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Nonlinear optical plasmonics investigates plasmonic nanoantenna fields with the help of nonlinear spectroscopy. Here we introduce nonlinear spatially resolved spectroscopy (NSRS) which is capable of imaging the k-space as well as spatially resolved single antennas while it is still possible to carry out spectroscopy.

These additional abilities give us the possibility to spatially resolve the THG signal of gold nanoantenna arrays and investigate the homogeneity of the antenna field. Furthermore, we are able to spatially resolve the THG emission centers of the third-order mode and observe their response to tuning the wavelength over the resonance.

In addition, we discovered that by increasing the laser intensity, certain antennas in our array became exceptionally bright. By correlating our spatially resolved nonlinear image with structural SEM data, we can prove that these bright antennas have deformed into a peanut shape. Thus our NSRS setup enables the investigation of the nonlinear self-enhancement process of nanoantennas under intense laser heating.

O 91.5 Fri 11:30 CHE 89

Spatio-spectral metrics in electron energy loss spectroscopy as a tool to resolve nearly degenerate plasmon modes — Michal Horák, Andrea Konečná, Tomáš Šikola, and •Vlastimil Křápek — Brno University of Technology, Czechia

Electron energy loss spectroscopy (EELS) is utilized to characterize localized surface plasmon modes supported by plasmonic antennas (PAs) with excellent spatial resolution, including studies of hybridized modes in dimer PAs [1,2,3]. However, the spectral resolution of EELS is often insufficient to resolve the hybridized modes for weakly coupled dimers.

Here we address this issue for a case study of the dimer PA composed of two gold discs. We analyze four nearly degenerate hybridized dipole modes. With a traditional approach, the modes cannot be experimentally identified with EELS. Therefore, we propose several metrics that employ the spatial and spectral sensitivity of EELS simultaneously. We apply the metrics to experimental EELS data, demonstrating their ability to resolve three of the above-mentioned modes (with transverse bonding and antibonding modes still unresolved), identify them unequivocally, and determine their energies. In this respect, the spatio-spectral metrics increase the information extracted from EELS applied to PAs.

[1] V. Křápek *et al.*, Nanophotonics **9**, 623 (2020).

[2] O. Bitton *et al.*, Nat. Commun. **11**, 487 (2020).

[3] J.-H. Song *et al.*, Nat. Commun. **12**, 48 (2021).

O 91.6 Fri 11:45 CHE 89

From Static to Dynamic Modulation of Second Harmonic Generation from Plasmonic Hotspots — •Jessica Meier[1], Luka Zurak[1], Andrea Locatelli[2], Thorsten Feichtner[1], René Kullock[1], and Bert Hecht[1] — [1]Nano-Optics and Biophotonics Group, Experimental Physics 5, University of Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Department of Information Engineering, University of Brescia, Italy

Plasmonic dimer antennas feature strong intensity enhancement squeezed into nanoscale gaps, which makes them highly attractive for boosting nonlinear processes, such as multiphoton excitation and harmonic generation [1]. Such phenomena, alongside large field enhancement, often require control over the field symmetry in the gap, which is challenging considering the nanometer length scales. Here, by means of strongly enhanced second harmonic (SH) generation, we demonstrate unprecedented control over the field distribution by systematically introducing geometrical asymmetry. We use focused helium ion beam milling of mono-crystalline gold to realize asymmetric-gap dimer antennas in which an ultra sharp tip with 3 nm apex faces a flat counterpart [2]. By tuning the tip opening angle, we systematically vary the field asymmetry, which in turn modulates the release of SH radiation to the far-field. We further extend the concept of inducing local field asymmetry to reversible tuning of the SH signal from a single antenna by applying an external voltage.

[1] P. Dombi et al., Reviews of Modern Physics 92, 025003 (2020).

[2] J. Meier et al., arXiv:2210.14105 (2022).

O 91.7 Fri 12:00 CHE 89

Laser Printing of Plasmonic Dimers on Optical Fiber Tips for Fiber-based SERS — •Paul Vosshage, Francis Schuknecht, and Theobald Lohmüller — Chair for Photonics and Optoelectronics, Nano-Institute Munich, Department of Physics, Ludwig-Maximilians-Universität, Königinstraße 10, 80539 Munich, Germany

Raman Spectroscopy through optical fibers offers great flexibility for conducting measurements both in situ and in vivo, but shows limitations due to the weak Raman scattering cross-sections of most molecules and a considerable background introduced by the fiber material itself. However, a strong signal amplification can be obtained via surface enhanced Raman scattering (SERS) by introducing plasmonic hot-spots on the optical fiber tip.
Here, we demonstrate a single-step approach to pattern plasmonic dimer antennas directly onto glass fibers by optical means. A focused laser beam is used to transform a gold nanorod into two nanospheres of equal size via heating. Simultaneously, optical forces are harnessed to print the two spheres onto the fiber tip as a strongly coupled dimer. The resulting plasmonic dimers feature nm-sized gaps, which provide a strong electromagnetic field enhancement required for fiber-based SERS.

O 91.8 Fri 12:15 CHE 89

Reconfiguring magnetic resonances with plasmonic and dielectric phase-change materials — Lukas Conrads, Andreas Hessler, Sebastian Meyer, Konstantin Wirth, Matthias Wuttig, Dimitry Chigrin, and •Thomas Taubner — I. Institute of Physics (IA), RWTH Aachen University

For miniaturized active nanophotonic components, resonance tuning of nanoantennas is a key ingredient. Phase-change materials (PCMs) have been established as prime candidates for non-volatile resonance tuning based on a change in refractive index [1]. Currently, a novel material class of switchable infrared plasmonic PCMs, like In_3SbTe_2 (IST), is emerging. Since IST can be locally optically switched between dielectric (amorphous phase) and metallic (crystalline phase) states in the whole infrared range, it becomes possible to directly change the geometry and size of nanoantennas to tune their infrared resonances [2]. Here, crystalline IST split-ring resonators (SRRs) are directly optically written and reconfigured in their arm size to continuously tune their magnetic dipole resonances over a range of 2.4 μm without changing their electric dipole resonances. Furthermore, electric and magnetic dipole resonances of aluminum SRRs covered by the conventional PCM $Ge_3Sb_2Te_6$ can be individually tuned by addressing the hotspots locally [3]. Our concepts are well-suited for rapid prototyping, speeding up workflows for engineering ultrathin, tunable, plasmonic devices for infrared nanophotonics, telecommunications or (bio)sensing.

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

O 91.9 Fri 12:30 CHE 89

Nanoantenna Electro-Optical-Transducer Utilizing Monolayer WSe_2 — •Patrick Pertsch, René Kullock, Monika Emmerling, Romana Ganser, and Bert Hecht — NanoOptics & Biophotonics Group, Experimental Physics 5, University of Würzburg, Am Hubland, 97074 Würzburg, Germany

Using light for the communication on computer chips could decrease the power consumption and increase the data bandwidth [1]. To this end, transition-metal-dichalcogenides (TMD), and especially monolayers thereof, are a very promising material class, because they can be used in electronic computing [2] as well as in optical applications [3]. To achieve high integration densities of logical elements, the transducers between electronic and optical signals should be of the same size as the nanoscale transistors used in modern electronics. But so far the photodetectors and emitters based on TMDs are usually much larger.

By combining TMDs with plasmonic nanostructures, the size of the optical elements can be decreased due to the large absorption cross section afforded by the plasmonic nanoantennas. In this work, we demonstrate single plasmonic nanoantennas on monolayer WSe_2 acting as optically-active material. This combination allows to emit and detect light by using only one single nanoscale device.

[1] C. Sun, et. al., Nature 528, 534-538 (2015).
[2] C. Liu, et. al., Nat. Nanotechnol. 15, 545-557 (2020).
[3] Q. Wang, et. al., Nat. Nanotechnol. 7, 699-712 (2012).