HL 17: Plasmonic Systems

Time: Monday 15:00–16:45 Location: EW 203

HL 17.1 Mon 15:00 EW 203

Observation of plasmonic mirages — •Felix Bleckmann[1], Johannes Lenz[2], Nikolas Grünwald[2], Stephan Irsen[2], and Stefan Linden[1] — [1]Physikalisches Institut, Universität Bonn, Nußallee 12, 53115 Bonn, Germany — [2]Research Center Caesar, Ludwig-Erhard-Allee 2, 53175 Bonn, Germany

Surface plasmon polaritons (SPPs) are electromagnetic waves propagating at the interface between a metal and an insulator. Recently, it has been demonstrated, that SPPs can be controlled by adding a dielectric film on top of the metal. The effective refractive index of the SPPs of such a three layer system depends on the thickness and the refractive index of the dielectric film. For PMMA on top of gold, the effective refractive index of the SPPs for near-infrared frequencies can be tuned between approximately 1.0 and 1.5 by changing the PMMA thickness from 0 nm to 200 nm.

Simple optical components like lenses and prisms can be fabricated by adding dielectric elements with constant thickness and appropriate shape on top of the metal. The local modification of the thickness of the dielectric film also allows for graded index profiles for propagating SPPs.

Here, we use grey-scale lithography to fabricated different functional elements for the manipulation of SPPs. We demonstrate that a dielectric gradient structure can be used to bend the propagation direction of a SPP mimicking the mirage effect.

HL 17.2 Mon 15:15 EW 203

Near-field Study on Plasmonic Oligomers — •Thorsten Weber[1,2], Felix von Cube[1,2], Stephan Irsen[2] und Stefan Linden[1,3] — [1]Physikalisches Institut, Universität Bonn, Nußallee 12, 53113 Bonn, Germany — [2]Research center caesar, Ludwig-Erhard-Allee 2, 53175 Bonn, Germany — [3]Intitut für Nanotechnologie, Karlsruher Institut für Technologie (KIT), 76021 Karlsruhe, Germany

Plasmonic nano-structures have recently been proposed to be a useful tool in sensing. The corresponding sensors are based on the spectral shift of a mode of the plasmonic nano-structure upon change of the refractive index of the surrounding medium. The interaction of metallic nano-particles, arranged in an oligomer-like structure, gives rise to Fano resonances. The small spectral width of the Fano resonance makes plasmonic oligomers an interesting candidate for sensing applications. Furthermore, Fano resonances can easily be tuned in frequency by rearranging the oligomer's nano-particles in space or size. So far, interactions of the oligomer's particles have been mainly studied in optical far-field-measurements.

We employ electron energy loss spectroscopy in combination with scanning transmission electron microscopy to map the near-field of plasmonic oligomer structures for different energies. Our experiments give us a remarkable insight into the near-field interactions between the different particles of the oligomer. We study heptamers, which are six particles arranged around one central particle. Dissecting these into single particles, dimers, trimers, and hexamers allows a systematic study of how the separated parts of an oligomer interact.

HL 17.3 Mon 15:30 EW 203

Terahertz Metamaterials Based on Arrays of Rolled-Up Gold/(In)GaAs Tubes — •Andreas Rottler, Markus Bröll, Nils Gerken, Detlef Heitmann, and Stefan Mendach — Institute of Applied Physics, University of Hamburg, Germany

Metamaterials are artificial structures where permittivity and permeability can be designed on demand and may exhibit values which are not observed in nature. Recently it has been shown that three-dimensional metal/semiconductor microtube metamaterials with multiple rotations can be fabricated [1].

In this talk, we demonstrate with finite-integration technique simulations that arrays of rolled-up gold/(In)GaAs tubes with slightly more than one winding interact resonantly with the magnetic component of an incident electromagnetic field and exhibit a negative permeability at terahertz frequencies [2]. We show that the frequency interval of negative permeability can be tailored to desired values by changing the winding number. Additionally, we also demonstrate that this dependence can be removed, if desired, by the incorporation of an additional slit into the gold layer. In an experiment such a slit can be prepared by lithographic means prior to the rolling-up process.

We gratefully acknowledge support by the DFG via the Graduiertenkolleg 1286.

[1] S. Schwaiger et al., Phys. Rev. Lett. 102, 163903 (2009).
[2] A. Rottler et al., Opt. Lett. in press.

HL 17.4 Mon 15:45 EW 203

Rolled-up active plasmonic metamaterials — •Stephan Schwaiger, Aune Koitmäe, Lena Simone Fohrmann, Matthias Klingbeil, Andreas Rottler, Jochen Kerbst, Markus Bröll, Yuliya Stark, David Sonnenberg, Christian Heyn, Detlef Heitmann, and Stefan Mendach — Institut für Angewandte Physik, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg

Using the relaxation process of strained semiconductor layers [1] we fabricate microtubes whose wall represent three-dimensional metamaterials consisting of alternating layers of metal (Ag) and semiconductor (AlIn)GaAs. I will present the results of the optical investigations of these microtube metamaterials including our latest findings. Be means of transmission measurements and finite difference time domain simulations we could show that these microtube metamaterials are promising candidates for rolled-up hyperlenses [2]. Furthermore, we demonstrated that the transmission through the metamaterial can be enhanced by integrating an optically active quantum well into the semiconductor [3]. In the next step we embedded a grating into the metamaterial to investigate the interaction of the embedded quantum well and possible surface plasmon polariton excitation on the Ag grating. We gratefully acknowledge support from the Deutsche Forschungsgemeinschaft (DFG) through GrK 1286. [1] V. Ya. Prinz et al., Physica E 6, 828 (2000). [2] S. Schwaiger et al., Phys. Rev. Lett. 102, 163903 (2009). [3] S. Schwaiger et al., Phys. Rev. B 84, 155325 (2011).

HL 17.5 Mon 16:00 EW 203

Bandgap Tuning in Plasmonic Gratings — •Jens Ehlermann, Hoan Vu, Markus Bröll, Robert Blick, Detlef Heitmann, and Stefan Mendach — Institute of Applied Physics, University of Hamburg, Germany

We investigate plasmon excitations on thin goldfilms coated with PMMA grating structures both, in the near field, using a scanning nearfield optical microscope (SNOM), and in the far field. Particular interest is being paid to the characteristics of the bandgap at $k = 0$ in the plasmon dispersion relation.

The dependence of the bandgap's size and energetic position on structural parameters like grating height and filling factor f, i.e. the ratio between grating bar width and period, is examined. We discovered a shift of the bandgap's position to lower energies with increasing f and we noticed a significant change in the bandgap's size.

Our results enabled us to trace back the measured far field effects to the filling factor dependent variation of the effective refractive index.

Experimental data can be well modeled using FDTD and RCWA simulations. Based on these findings it is possible to manufacture structures with tailor-made plasmonic properties whose application covers a broad range of topics.

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HL 17.6 Mon 16:15 EW 203

Optical properties of metal-organic hybrid microcavities — •Robert Brückner, Markas Sudzius, Susanne Hintschich, Hartmut Fröb, Vadim Lyssenko, and Karl Leo — Institut für Angewandte Photophysik, Technische Universität Dresden, D-01062 Dresden, Germany

We investigate the impact of the incorporation of a thin silver layer into a planar dielectric microcavity (MC). The MC is composed of a $\frac{\lambda}{2}$-layer of the organic media Alq_3 doped with 2wt% DCM sandwiched between two dielectric distributed Bragg reflectors (21 alternating layers of TiO_2 and SiO_2). Using a μ-photoluminescence setup, we systematically study the transition from a single cavity mode into *two* optical Tamm states depending on the thickness of the embedded silver layer [1]. Even for a silver layer of 40 nm thickness both new modes are only slightly damped, enabling lasing in these metal organic hybrid devices. The eigenenergies of these modes strongly depend on both the thickness of the silver layer and the adjacent dielectric layers.

We show that both resonances cannot have the same wavelength indicating a clear anticrossing behavior. We confirm the experimentally observed shift and splitting of the cavity mode into two anticrossing resonances via transfer matrix calculations.

[1] R. Brückner, *et al.* Phys. Rev. B, **83**, 033405 (2011).

HL 17.7 Mon 16:30 EW 203

Functionality and Dielectric Function Retrieval of a Rolled-Up Hyperlens — •Andreas Rottler, Stephan Schwaiger, Markus Bröll, Detlef Heitmann, and Stefan Mendach — Institute of Applied Physics, University of Hamburg, Germany

Three-dimensional metamaterials made of rolled-up metal/semiconductor microtubes have recently gained much attention due to their ability to work as hyperlenses in the visible regime [1]. In this talk we present finite-difference time-domain (FDTD) simulations to analyze the functionality of such hyperlens systems together with a dielectric function retrieval. The real and imaginary part of the dielectric function of a rolled-up metal/semiconductor hyperlens is retrieved from experimental reflection and transmission data and from data calculated by the transfer matrix formalism. The retrieved dielectric function is compared to a well-known effective medium model for metal/semiconductor superlattices [2]. It turned out that for the fabricated samples there is some agreement with the effective medium model for frequencies below the plasma frequency. However, for higher frequencies, the retrieved permittivity strongly deviates. In additional FDTD simulations we show that, interestingly, the hyperlens functionality of our realized structures is preserved, even far beyond the effective plasma frequency.

We gratefully acknowledge support by the DFG via the Graduiertenkolleg 1286.

[1] S. Schwaiger et al., Phys. Rev. Lett. 102, 163903 (2009).
[2] B. Wood et al., Phys. Rev. B 74, 115116 (2006).