O 83: Plasmonics and Nanooptics VII

Time: Friday 11:15–13:00 Location: H32

O 83.1 Fri 11:15 H32

Metamaterial sensor for glucose and molecular monolayers using the plasmonic analog of EIT — •Martin Mesch[1], Na Liu[1], Thomas Weiss[1], Carsten Sönnichsen[2], and Harald Giessen[1] — [1]4th Physics Institute, University of Stuttgart, Germany — [2]Institute of Physical Chemistry, University of Mainz, Germany

We utilize the plasmonic analog[1] of electromagnetically induced transparency (EIT) to construct an optical LSPR (localized surface plasmon resonance) sensor. A combination of stacked gold dipole and quadrupole antennas exhibits a sharp spectral resonance, which shifts for changes in the structures' dielectric environment. To characterize the sensor, aqueous glucose solutions with concentrations between 0% and 25% have been measured in a custom flow cell by Fourier transform infrared spectroscopy. The results reveal a sensitivity of 374 nm per refractive index unit, corresponding to a figure of merit (sensitivity/linewidth) of 4.1. We compare our measurements to S-matrix simulations and give a recipe to determine the most sensitive structure geometry. To our knowledge, this is up to date the most sensitive lithographically manufactured LSPR sensor design. Additional experiments demonstrate the ability to detect a single molecular layer of biotin/streptavidin. [1] N. Liu et al., Nature Materials 8, 758 (2009)

O 83.2 Fri 11:30 H32

Optical properties of a metallic meander Fabry-Perot cavity — •Liwei Fu[1], Heinz Schweizer[1], Thomas Weiss[2], Harald Giessen[1], Philipp Schau[3], Karsten Frenner[3], Steffen Maisch[3], and Wolfgang Osten[3] — [1]4th Physics Institute, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]LASMEA, Université Blaise Pascal, F-63177 Aubière Cedex, France — [3]Institut für Technische Optik, University of Stuttgart, Pfaffenwaldring 9, 70550 Stuttgart, Germany

A single layer metallic meander structure is favorable to couple photons with surface plasmon polaritons and, as a result, a resonant enhanced transmission can be observed. A combination of two single-meander layers forms a Fabry-Perot cavity with frequency selective mirrors. In this contribution we investigate its optical properties. At the proper distance, the cavity behaves as a single layer meander, in which enhanced transmission and negative mode dispersion are present. In contrast to the single layer, however, the surface waves from the two mirrors are still coupled together, resulting in an amplified longitudinal E-field propagating backwards inside the cavity. The backward wave can be observed at visible frequencies with low loss and high transmittance for structural parameters that are well suited for nanofabrication. Such a compact realization of negative refraction is a promising approach for applications of subwavelength imaging, polarization beam splitting, and delay line approaches.

O 83.3 Fri 11:45 H32

Dynamical response of split-ring molecules for metamaterials — •Stephan Bernadotte[1,2,3], Wim Klopper[1,2], and Ferdinand Evers[1,3] — [1]Institut für Nanotechnologie, Karlsruher Institut für Technologie — [2]Lehrstuhl für Theoretische Chemie, Institut für Physikalische Chemie, Karlsruher Institut für Technologie — [3]Institut für Theorie der Kondensierten Materie, Karlsruher Institut für Technologie

We investigate the dynamical properties of molecular crystals (matrices) built up from nanometer sized ring shaped, conjugated molecules, which are candidate systems for negative index materials with frequencies in the optical regime. The response properties of such materials near their dynamical resonances can be understood in terms of an LRC circuit. In the conventional modeling of metamaterials, the circuit parameters enter (essentially) as phenomenological quantities. By contrast, in the present work they will be calculated from a microscopic tight binding model of a molecular Hamiltonian employing the Kubo approach.

We find that the LRC resonances of the molecular structures correspond to plasmonic excitations. By comparing to an analytical calculation, we can study in which way the plasmon resonances (and residues) depend on the molecule's electronic structure. On a qualitative level, our study also includes an investigation of the sensitivity of the dynamical response to the damping of the plasmons. Finally, we analyze the impact of cross-talk among the molecules within the matrix and the importance of birefringence terms.

O 83.4 Fri 12:00 H32

Negative refraction in natural ferromagnetic metals — •Sebastian Engelbrecht, Alexey Shuvaev, and Andrei Pimenov — Experimentelle Physik 4, Universität Würzburg

It is generally believed that nature does not provide materials which show negative refraction. Up to now, the experiments with negative refraction have been realized with metamaterials or photonic crystals. As has been suggested recently, negative refraction in natural materials can be realized in ferromagnetic metals. Close to the ferromagnetic resonance (FMR) the real part of the magnetic permeability can reach negative values. This may lead to negative refraction as long as the dielectric permittivity is dominated by metallic response. This talk will provide experimental data of ferromagnetic metals (Fe,Co) which indeed show a range of negative refraction close to FMR in millimeter frequency range. In these materials the negative refractive index can be achieved even at room temperature.

O 83.5 Fri 12:15 H32

Bragg Plasmonics — •Richard Taubert, Ralf Ameling, Lutz Langguth, Daniel Drégely, and Harald Giessen — University of Stuttgart, Germany

The investigation of plasmon-plasmon coupling has focused on near-field coupling until now. Only little work has been done on far-field interaction in plasmonic structures. We investigate a so-called 3D plasmonic crystal: four layers of nanowires are stacked in Bragg fashion, where the vertical distance matches half the resonance wavelength of the individual nanowire particle plasmon. The resonant far field coupling leads to the formation of a plasmonic band gap spanning almost one octave.

The structure was fabricated using layer-by-layer stacking. We investigate the dependence of the optical spectra on layer number and distance tuning. Scattering matrix calculations agree very well with our experimental findings.

O 83.6 Fri 12:30 H32

Al nanostructures for metamaterials in visible region and biosensing — •Shankar K. Jha[1], Yogesh Jeyaram[1], Mario Agio[2], Jörg F. Löffler[1], and Yasin Ekinci[1,3] — [1]Laboratory of Metal Physics and Technology, ETH Zurich, 8093 Zurich, Switzerland — [2]Laboratory of Physical Chemistry, ETH Zurich, 8093 Zurich, Switzerland — [3]Paul Scherrer Institute, 5232 Villigen-PSI, Switzerland

Metamaterials are artificially engineered materials having electromagnetic material properties that are not readily found in nature. Owing to their potential applications like sub-wavelength imaging, negative refractive index, optical cloaking etc., these materials have been extensively studied in the microwave and optical regimes including in red wavelengths. We report development of metamaterials down to blue range. We studied optical properties of two-dimensional arrays of aluminum nanosandwiches. Strong magnetic response and negative permeability are observed down to 400 nm wavelength, paving the way towards metamaterials operating in the visible range. In addition we discuss the superior performance of such structures in biosensing.

O 83.7 Fri 12:45 H32

Electromagnetic polarisation twisting mediated by plasmon / nanostructure interaction — •Brian Ashall[1], Brian Vohnsen[1], Stephan Schwieger[2], Erich Runge[2], Michael Berndt[3], and Dominic Zerulla[1] — [1]School of Physics, University College Dublin, Dublin 4, Ireland. — [2]Theoretical Physics I, Technische Universität Ilmenau, 98684 Ilmenau, Germany. — [3]Max Planck Institute of Molecular Cell Biology and Genetics, 01307 Dresden, Germany.

The design and architecture of nanostructures for the purpose of controlling and manipulating Surface Plasmon Polariton (SPP) dynamics is currently a focal point of research. Here, we present the first instance of plasmon mediated polarisation reorientation observed in the farfield with no associated reemission directional change [1]. Specifically, it is demonstrated that, as a result of the interaction between SPPs and tailor designed nanostructures of 3-fold symmetry characteristics [2], a polarisation twisting of the SPP mediated reradiated light is attained.

It is shown that the dynamics of such an interaction can be controlled externally, enabling active control of the out-going polarisation orientation. In order to further understand the origin of the processes involved, Green's function based simulations of the interactions are presented and confirm that the origin of the polarisation twisting can be explained via asymmetrical in-plane SPP scattering.

[1] B. Ashall, B. Vohnsen, M. Berndt, D. Zerulla; Phys. Rev. B, 80(20) (2009)

[2] B. Ashall, M. Berndt, D. Zerulla; Appl. Phys. Lett. 91(20), 203109 (2007)