O 38: Nano-optics of metallic and semiconducting nanostructures (experiments I)

Time: Wednesday 15:00–17:30 Location: SCH A216

O 38.1 Wed 15:00 SCH A216

Nanometer scale imaging and spectroscopy of an organic semiconductor film — •Alfred J. Meixner[1], Dai Zhang[1], Ute Heinemeyer[2], Frank Schreiber[2], and Reinhard Scholz[3] — [1]Institute of Physical and Theoretical Chemistry, University of Tübingen — [2]Institute of Applied Physics, University of Tübingen — [3]Walter Schottky Institute, TU-München

The local electronic and optical properties of molecular semiconductors depend sensitively on the local film morphology such as grain boundaries and localized defects. However, quantitative spectroscopic measurements with a resolution matching the molecular morphology of organic semiconductor films has been plagued either by a lack of resolution, contrast or sensitivity. We have investigated an organic molecular semiconductor film (diindenoperylene, DIP) grown by molecular beam deposition on a Si (100) substrate covered with a native oxide layer by tip-enhanced nanometer scale spectroscopic imaging by the use of a novel parabolic-mirror assisted near-field optical microscope. We could for the first time resolve grain boundaries and defects both in the topography and in the near-field optical image and relate them to local PL- and Raman spectra with a spatial resolution on the order of 10 nm.

O 38.2 Wed 15:15 SCH A216

Investigation of Geometry-dependent Dipole Coupling using Near-field Optical Microscopy of Au-nanoantennas — •Kai Braun[1], Dai Zhang[1], Monika Fleischer[2], Dieter P. Kern[2], and Alfred J. Meixner[1] — [1]Institut fuer Physikalische und Theoretische Chemie, Auf der Morgenstelle 8, 72076 Tuebingen — [2]Institut fuer Angewandte Physik, Auf der Morgenstelle 10, 72076 Tuebingen

The plasmon coupling between two dipoles is strongly dependent on their relative positions. Theoretical simulations predicted a red shift of the localized plasmon resonance (LPR) for a dipole top-on-top geometry while a blue shift for a dipole side-by-side geometry[1]. However the corresponding experiments are hard to be realized due to the difficulties of aligning two dipoles into desired configurations. We will use a newly developed parabolic mirror assisted near-field optical microscope (SNOM) to precisely position a gold tip at different positions with respect to a gold cone. By replacing the objective lens with a parabolic mirror, this setup provides the unique possibility of obtaining a 14 times stronger electric field distribution in the longitudinal direction than that of the transversal direction[2]. Since both the gold tip and cone have strong oscillating dipoles in the longitudinal direction, this microscope allows us to study the geometry-dependent dipole coupling more accurately and flexibly. [1] Prashant K. Jain et al (2006), J. Phys. Chem. B, 110 18243-18253 [2] Fleischer M. et al (2008), Applied Physical Letters, 93 1

O 38.3 Wed 15:30 SCH A216

Antenna enhanced Pump-Probe Spectroscopy of Single Metal Nanoparticles — •David Molnar[1,2] and Markus Lippitz[1,2] — [1]Max-Planck-Institut für Festkörperforschung, Stuttgart — [2]4. Physikalisches Institut, Universität Stuttgart

Tailoring a nanoparticle's properties for technological applications requires a profound understanding of its different characteristics compared to those of its bulk material. One arising question is: Down to which lengths can a material be expected to show bulk behaviour?

Acoustical eigenfrequencies of a single gold nanoparticle give insight to its mechanical properties such as density or Young's modulus. A laser induced mechanical oscillation yields a periodical change of the electron density, i.e., a periodically changing plasmon resonance. This change is optically detectable using a pump-probe technique and reveals the dynamics of the particle's oscillation.

As absorption is proportional to the third power of the particle's radius the optical detection of mechanical oscillations of a single metal particle with a diameter of 40nm or less is almost impossible. However using an adequate antenna enhancing the signal oscillations of a single particle, 10nm in size or less, become detectable.

We will show calculations of the signal enhancement by an antenna as well as first experimental results in this field.

O 38.4 Wed 15:45 SCH A216

A Simple Fabrication of Nanoantennae over Large Areas — •Reto Giannini[1], Arda Kristopuryan[1], Yasin Ekinci[1], Pratap K. Sahoo[2], and Jörg F. Löffler[1] — [1]Laboratory of Metal Physics and Technology, Department of Materials, ETH Zurich, 8093 Zurich, Switzerland — [2]Laboratory of Micro- and Nanotechnology, Paul Scherrer Institute, 5232 Villigen, Switzerland

Metallic nanoparticles are very promising candidates for the creation of nanoantennae. Such nanoantennae can be used to excite flourophores more efficiently or to increase the emission of molecules and quantum dots leading to applications in biosensing, nanophotonics and Raman-/fluorescence spectroscopy. The basis of using metallic nanoparticles as nanoantennae is their capability to create a huge electromagnetic enhancement. This enhancement is a consequence of the resonant excitation of charge density oscillations, known as surface plasmons. A further significant increase of the enhancement can be achieved by coupling of two closely-spaced nanoparticles (dimers). Reproducible and cost-effective methods, applicable to large areas, are readily available for single nanoparticles, whereas well-defined dimers are difficult to obtain with comparable simple methods. We have fabricated gold and silver nanoantennae using colloidal lithography and thermal evaporation providing nanoparticle dimers with small gaps over large areas. We measured the plasmon resonances of individual gold and silver dimers with different structural parameters and performed surface-enhanced Raman spectroscopy to determine the relative near-field enhancement factors of the fabricated nanoantennae.

O 38.5 Wed 16:00 SCH A216

Three-dimensional metal photonic nanostructures using direct laser writing and electrodeposition — •Justyna Kinga Gansel[1], Michael Thiel[1], Klaus Bade[2], Volker Saile[2], Georg von Freymann[1], Stefan Linden[1], and Martin Wegener[1] — [1]Institut für Nanotechnologie, Forschungszentrum Karlsruhe; DFG-Center for Functional Nanostructures (CFN) and Institut für Angewandte Physik, Universität Karlsruhe (TH) — [2]Institut für Mikrostrukturtechnik, Forschungszentrum Karlsruhe

An interesting part of the field of photonic nanostructures are metamaterials. Particularly, three-dimensional (3D) structures like 3D negative index metamaterials [1] or optical cloaking devices [2] attract increasing attention. Yet, few techniques for the fabrication of true 3D metamaterials exist [3, 4]. Here we present a method for the fabrication of 3D metal nanostructures. A positive or negative photoresist layer can be structured by direct laser writing, facilitating a wide amount of structure designs. The template is backfilled with gold using electrodeposition, where an ITO-layer below the photoresist acts as a cathode. After removal of the resist, free-standing gold nanostructures emerge. A structure design that can be realized using this method are 3D gold spirals. Corresponding simulations have shown that these structures possess interesting chiral properties.

[1] J. Valentine et al., Nature **455**, 376 (2008)
[2] J. B. Pendry et al., Science **312**, 1780 (2006)
[3] M. S. Rill et al., Nature Mater. **7**, 543 (2008)
[4] N. Liu et al., Nature Mater. **7**, 31 (2008)

O 38.6 Wed 16:15 SCH A216

Fabrication and optoelectronic properties of individual gold nanostructures — •Monika Fleischer[1], Sebastian Jäger[2], Marcus Sackrow[2], Dai Zhang[2], Rudolf Ehlich[3], Catrinel Stanciu[2], J.K. Heinrich Hörber[3], Alfred J. Meixner[2], and Dieter P. Kern[1] — [1]Institut für Angewandte Physik, Eberhard Karls Universität Tübingen, Deutschland — [2]Institut für Physikalische und Theoretische Chemie, Eberhard Karls Universität Tübingen, Deutschland — [3]H.H. Wills Laboratory, University of Bristol, England

When interacting with the electromagnetic field of a focused laser beam, individual gold nanostructures can act as optical antennas. For efficient excitation, the shape and size of the nanostructures need to be adjusted to the applied laser mode and wavelength. Cone structures e.g. are particularly well suited for excitation with a radially polarized beam [1]. In a process based on electron beam lithography and ion milling, individual gold nanostructures are fabricated in a range of different shapes, whose critical dimensions are varied systematically. The structures are characterized by means of confocal microscopy, NSOM, SEM, AFM and STM. Results of these studies are presented together with spectra indicating the shape and size dependent resonance fre-