DS 26: Plasmonics and Nanophotonics O-III (jointly with HL and O)

Time: Tuesday 11:15–13:00 Location: WIL A317

DS 26.1 Tue 11:15 WIL A317

Tip-enhanced Spectroscopic Mapping — •Dai Zhang, Xiao Wang, and Alfred J. Meixner — Inst. Phys. Theo. Chem.

When a sharp Au tip approaching very closely to the sample surface, the tip-sample system behaves as an optical antenna. It confines and enhances the excitation field to a small sub-diffraction volume in the gap between the tip-apex and the surface and retrieving emitted or scattered photons to the far field for detection.

In my talk, the influence of several parameters, such as the gap distance, the material properties of the tip and the substrate as well as the size of the tip, on the performance of the gap-mode near-field optical microscopy will be systematically discussed. Gap-mode near-field spectroscopic mapping technique has been recently developed in our lab. I will demonstrate the Raman and photoluminescence spectroscopic imaging of the chemical distribution in the polymer:fullerene organic solar cell blend film [1]. From the simultaneously recorded morphology and spectroscopic information, the interplay among the blend film morphology, the local donor and acceptor molecular distributions, and the photoluminescence quenching efficiency will be discussed. With the above demonstrations, we propose that the gap-mode near-field optical microscopy is a promising, high-resolution and multi-function characterization technique for material science [1,2].

References [1] X. Wang et al, Advanced Functional Materials 20, 492 (2010). [2] D. Zhang et al, Physical Revew Letters, 104, 056601 (2010).

DS 26.2 Tue 11:30 WIL A317

Near-Field Imaging of Directive Optical Yagi-Uda Nanoantennas — •Jens Dorfmüller[1], Daniel Drégely[1], Moritz Esslinger[2], Worawut Khunsin[2], Ralf Vogelgesang[2], Klaus Kern[2,3], and Harald Giessen[1] — [1]4. Physikalisches Institut und Research Center SCoPE, Pfaffenwaldring 57, Universität Stuttgart, 70569 Stuttgart, Germany — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, 70569 Stuttgart, Germany — [3]Institut de Physique de la Matière Condensée, École Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

Apertureless Scanning Near-field Optical Microscopy (aSNOM) in a cross-polarization scheme allows us to map the E-fields of plasmonic nano-structures in real-space with a resolution far beyond the diffraction limit [1,2]. Maps of near-field amplitude and phase allow us to determine the excitation mode. Analyzing the amplitude at elements of optical nano-antennas allows us to measure the receptivity in dependence of antenna geometry as well as illumination conditions.

Here, we investigate the reception directionality of optical Yagi-Uda antennas. Depending on the illumination direction, the electromagnetic energy is either concentrated at the feed element or distributed over several antenna elements. Comparison with simulations shows a very good agreement.

[1] J. Dorfmüller, R. Vogelgesang, R. T. Weitz, C. Rockstuhl, C. Etrich, T. Pertsch, F. Lederer, K. Kern, *Nano Lett.* **9**, 2372 (2009).
[2] J. Dorfmüller, R. Vogelgesang, W. Khunsin, C. Rockstuhl, C. Etrich, K. Kern, *Nano Lett.* **10**, 3596 (2010).

DS 26.3 Tue 11:45 WIL A317

Surface-Plasmon-Polariton interation with gratings — •Andreas Englisch, Stefan Griesing, Uwe Schmitt, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, Postfach 151150, D-66041,

Surface-Plasmon-Polaritons (SPP) couple with light through suitable periodical structures. In the case of SPP-excitation a typical decrease of the intensity in the diffracted orders can be observed. Two different kinds of gratings are investigated: periodically corrugated metal surfaces on the one hand and structured dielectric layers on flat metal surfaces on the other hand. The intensities of the diffracted orders as well as the near-field intensities are measured in dependence of the grating profile. The near-field is characterized with respect to the amplitude and the phase by the use of a phase-sensitive scanning near-field optical microscope (SNOM. Numerical modeling based on finite element simulations in Fourier space as well as in real space were performed and compared with the measurements.

DS 26.4 Tue 12:00 WIL A317

Nonlocal, grating-coupled scattering-type near-field scanning optical microscopy of individual gold nano-particles — •Diyar Sadiq[1], Javid Shirdel[1], Jae Sung Lee[2], Namkyoo Park[2], and Christoph Lienau[1] — [1]Institut für Physik, Carl von Ossietzky Universität, 26111 Oldenburg, Germany — [2]Photonic Systems Laboratory, School of EECS, Seoul

Scattering-type near-field scanning optical microscopy (s-NSOM) is now routinely used for (sub-) 10-nm-resolution optical imaging of surfaces. The performance is, however, often limited by a rather substantial signal background resulting from a direct optical illumination of the scattering antenna. Various ideas for a nonlocal optical excitation have therefore been proposed, e.g., by grating-coupling of surface plasmon polaritons (SPP) onto adiabatic metallic tapers and three-dimensional focusing of SPP wavepackets towards the tip apex [1]. Recently, first line-scan images recorded by using such probes demonstrated 20 nm resolution and coupling of about 15% of the SPP intensity onto the tip apex [2]. Here, we use such a grating-coupled SPP microscope for the first time for s-NSOM imaging of single metallic nano-particles. We demonstrate sub-20-nm-resolution imaging of localized SPP fields and observe that more than 40% of the grating-coupled SPP field is localized at the taper apex. The results are supported with numerical simulation based on the finite-difference time-domain (FDTD) method.

[1] C. Ropers et al. Nano Letters 7, 2784 (2007). [2] C. C. Neacsu et al, Nano Letters 10, 592 (2010).

DS 26.5 Tue 12:15 WIL A317

Enhanced vibrational near-field spectroscopy of PMMA with infrared antennas — •Jón Mattis Hoffmann, Jens Richter, and Thomas Taubner — I. Institute of Physics (IA), RWTH Aachen University, Sommerfeldstraße 14, 52074 Aachen, Germany

Infrared spectroscopy allows for the investigation of chemical properties of a sample material by directly probing molecular vibrations. Combined with scattering-type near-field optical microscopy (s-SNOM), which relies on the scattering of light at a sharp metallic tip, it is possible to obtain such spectroscopic information in images with strongly subwavelength resolution [1]. For the probing of weakly absorbing samples, such as molecular vibrations in thin polymer layers [2], increased sensitivity of infrared near-field spectroscopy is needed. It has been shown that signals in near-field vibrational spectroscopy of thin films can be enhanced by reflecting substrates [3]. For even higher enhancement factors we investigate the possibility of using resonant substrates.

Here we employ triangular nanostructures fabricated by nanosphere lithography that exhibit strong resonances in the infrared region as substrate. We want to measure the resonant enhanced near-field spectra of a thin PMMA film on top of these infrared antennas.

[1] F. Keilmann et al. in Nano-Optics and Near-Field Optical Microscopy ed. by A. Zayats and D. Richards, 235 (ArtechHouse, 2009).
[2] T. Taubner et al., Applied Physics Letters 85, 5064 (2004).
[3] J. Aizpurua et al., Optics Express 16, 1529 (2008).

DS 26.6 Tue 12:30 WIL A317

scattering near-field microscopy in the THz using a free-electron laser — •Hans-Georg von Ribbeck[1], Marc Tobias Wenzel[1], Rainer Jacob[2], and Lukas M. Eng[1] — [1]Institut für Angewandte Photophysik, TU Dresden, 01062 Dresden, Germany — [2]Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden, Germany

We present scattering-type scanning near-field optical micro spectroscopy (s SNOM) investigations successfully operated in the THz range with a wavelength independent spatial resolution of 90 nm. Our microscopy set-up bases on a true noncontact atomic force microscope (nc-AFM) combined with the free-electron laser (FEL) source at the Helmholtz-Zentrum Dresden-Rossendorf. This laser provides tunability from 30 to 250 μm. We were able to record, for the first time ever, s-SNOM signatures with a FEL at wavelengths ranging from 30 μm to 180 μm (10 to 1.67 THz). In addition to the near-field dependent optical signals we also demonstrate the imaging and spectroscopy capabilities of our THz-s-SNOM. Image scans were performed on a specially designed test structure consisting of a topography-free composite of a polymer/gold sample. On these samples a topography independent strong optical material contrast could be demonstrated at 150 μm wavelength. Furthermore we achieve a resolution of better than

90 nm on a Fischer-Pattern test structure, corresponding to an optical improvement of better than 1500 times the wavelength.

DS 26.7 Tue 12:45 WIL A317

Background-Free Imaging with an Apertureless Scanning Nearfield Optical Microscope — •Moritz Esslinger[1], Jens Dorfmüller[1,2], Ralf Vogelgesang[1], Worawut Khunsin[1], and Klaus Kern[1,3] — [1]Max-Planck-Institut für Festkörperforschung, 70569 Stuttgart, Germany — [2]presently at 4. Physikalisches Institut, Universität Stuttgart, 70550 Stuttgart, Germany — [3]de Physique de la Matière Condensée, École Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

We present advances in experimental techniques of apertureless nearfield optical microscopy (aSNOM). This technique achieves high spatial resolution by utilizing the field enhancement at the apex of sharp tips. Many conventional setups utilize p-polarized light in the illumination as well as in the detection path. The detected light of such a setup not only contains the optical near field signal, but is affected also by coupling effects between tip and sample.

By using p-polarized light for illumination and detecting the s-polarized component of the backscattered light we are able to measure the z-component of the electric field on the sample essentially without coupling effects. Here we outline how the proper choice of tip position, together with optimizing polarizer and analyzer angles of our cross-polarization scheme ensures plasmonic eigenmode mapping with a background of exactly zero. By comparison with simulation data not including the tip we show that the measurement has little to no influence on the eigenmodes.