O 6 Scanning probe techniques I

Time: Monday 11:15–13:00 Room: WIL B321

O 6.1 Mon 11:15 WIL B321

Scanning optical nearfield investiagtion of thin metal films — •Maximilian Assig, Kai Hodeck, and Mario Dähne — Institut für Festkörperphysik, Technischen Universität Berlin, D-10623 Berlin

We present a setup to investigate the optical nearfield of thin film samples such as metal films with subwavelength spatial resolution. Simultaneously observing the topography and the luminescence of the sample we are able to correlate structural and optical properties. When illuminating the sample from reverse in total reflection geometry, we are able to probe the near field of the sample either by collection through an etched fiber tip or by scattering with a gold tip. In the latter case, the scattered light is collected in the far field, using distance modulation to detect selectively the scattered nearfield-signal of the sample. We present first results on the nearfield properties of a thin gold film containing nanometer scale holes with two different diameters.

O 6.2 Mon 11:30 WIL B321

Scattering scanning near-field optical microscopy on anisotropic dielectrics using a free electron laser light source — •Susanne Schneider[1], J. Seidel[1], S. Grafström[1], C. Loppacher[1], M. Cebula[1], L. M. Eng[1], S. Winnerl[2], D. Stehr[2], and M. Helm[2] — [1]Institute of Applied Photophysics, University of Technology Dresden, D-01062 Dresden — [2]Forschungszentrum Rossendorf, D-01328 Dresden

Scattering scanning near- field optical microscopy (s-SNOM) is based on the interaction between an optically scattering nano-particle (AFM tip) and a dielectric sample. The size of the scatterer defines the optical resolution of the microscope, which is on the order of a few nanometers. On that scale, the optically anisotropic properties of most samples have to be taken into account [1].

To examine the influence of optical anisotropy on the scattering signal, we excite a ferroelectric sample close to its phonon resonance in the mid infrared regime. As the precisely tunable light source at infrared wavelengths we used a free electron laser (FEL). We have measured the near-field signal at several wavelengths while scanning the sample, as well as the tip-sample distance dependence of the scattered light signal for the 1st, 2nd, and 3rd harmonic signal. The anisotropy is revealed for different sample orientations. Not only are we presenting the first tunable IR near-field measurements on ferroelectric lithium niobate and barium titanate single crystals, but furthermore are our measurements in excellent accordance with recent calculations of optical anisotropy in such systems [1].

[1] S. Schneider, et al., Phys. Rev. B 71, 115418 (2005)

O 6.3 Mon 11:45 WIL B321

Optical versus mechanical contrast mechanism in dynamic apertureless SNOM — •Ralf Vogelgesang, Alpan Bek, Ruben Esteban, and Klaus Kern — Max Planck Institut für Festkörperforschung

In dynamic mode apertureless or scattering-type scanning near-field optical microscopy (SNOM) an oscillating scanning probe tip excites optical interactions at a surface. Ideally, the local optical information can be extracted by lock-in amplification at a higher harmonic of the oscillation frequency. This signal, however, is easily contaminated by mechanical crosstalk.

We have developed a quantitative model to specify the proper conditions [1]. We show that the contrast mechanism is in general a combination of both spatially nonlinear optical interaction and temporally anharmonic mechanical tip motion. Our algebraic analysis provides a systematic framework to identify and control the relative influence of the competing contrast origins.

[1] A. Bek, R. Vogelgesang, and K. Kern, Appl. Phys. Lett., 87, 163115 (2005)

O 6.4 Mon 12:00 WIL B321

Plasmon propagation through a border between different layered systems observed by SNOM — •Andreas Englisch, Stefan Griesing, and Uwe Hartmann — Institute of Experimental Physics, University of Saarbrücken, P.O. Box 151150, D-66401 Saarbrücken, Germany

Quasi-twodimensional optics with plasmons involving refraction and reflection can be realized by different approaches. One possibility is to use elements consisting of a structured thin dielectric layer deposited on the plasmon-supporting surface. The resulting individual layers are the metal film with and without dielectric coating. The electromagnetic eigen modes are characterized by an effective refractive index which determines the propagation parallel to the plane of the layers (x-y plane). The behavior of plasmons or other modes incident to a border between two different multilayers is not known in detail. SNOM measurements are presented which show the intensity distribution at the border between different layerd systems: Due to the different decay length perpendicular to the x-y plane within both subsystems a near-field is formed at the border which extends across an area of several tens of microns. Although the intensity is confined to the x-y plane it cannot be modelled just by the interference of plasmons or other eigen modes of the given layered structure. In order to explain the observed intensity pattern an approach is introduced which is based on three-dimensional diffraction theory. Under particular conditions the border causes strong electromagnetic losses. The origin of these intrinsic or radiative losses is discussed in particular.

O 6.5 Mon 12:15 WIL B321

Nonlinear nano-optics: tip-enhanced spectroscopy based on optical frequency conversion at a metal tip — •Matthias Danckwerts, Michael Beversluis, and Lukas Novotny — Institute of Optics, University of Rochester, Rochester NY 14627 (USA)

At a sharp gold tip illuminated with pulsed laser light at 800 nm, the interaction of the electromagnetic field with the metal leads to the generation of frequency-doubled light as well as a supercontinuum arising from 2-photon excited interband transitions. In the case of multi-wavelength illumination, mixing signals such as DFG and SFG and higher-order processes like 4-wave mixing are observed. Due to the local field enhancement, the source of this radiation is highly confined to within nanometers at the apex of the tip, hence the tip is acting as a nanometric light source.

This offers a range of nanoscopic optical spectroscopies, where the tip acts as a source, not as a scatterer of light emitted from an object. The measured light is spectrally well-separated from the excitation, allowing for essentially background-free detection. For an application, we show optical extinction measurements with a lateral resolution of 30 nm. Further, experiments utilizing the continuum radiation from the tip for elastic scattering measurements at nanostructures such as carbon nanotubes are discussed.

O 6.6 Mon 12:30 WIL B321

Video-rate Scanning Probe Microscopes: solving the problem of resonances induced by the non-linear piezo material. — •G.J.C. van Baarle[1,2], W.M. van Spengen[1], W.A. van Loo[1], R. Schakel[1], L. Crama[1], J.W.M. Fenken[1], M.J. Rost[1,2], and T.H Oosterkamp[1] — [1]Kamerlingh Onnes Laboratory, Leiden University, P.O. box 9504, 2300 RA Leiden, The Netherlands — [2]Leiden Probe Microscopy BV, P.O. box 9504, 2300 RA Leiden, The Netherlands

For a wide variety of surface and interface phenomena in both fundamental and applied contexts, it is becoming increasingly important to visualize them with atomic or molecular resolution combined with high speeds. We report on the recent progress we made in the development of fast scanning probe techniques, and demonstrate that the current bottleneck for fast imaging is given by the mechanical properties of the scanner rather than the control electronics. This has been confirmed by testing several home-built and commercial instruments. In order to optimize the scanners for high speeds, we take into account the influences of piezo non-linearity. We present experimental results showing the existence of both non-linear super- and subharmonic resonances. In addition, we also consider the strength of the non-linear effects as a function of piezo geometry. Preliminary results indicate that the above problems can be circumvented by actuating the piezo scanner with the well-known, but in the context of SPM technology not commonly used, 'charge control' technique instead of the more standard method of 'voltage control'.

O 6.7 Mon 12:45 WIL B321

Using the Constant-Excitation Mode as a Spectroscopy Tool in Ambient Conditions — •Jan-Erik Schmutz, Marcus Schäfer, and Hendrik Hölscher — Center for Nanotechnology (CeNTech) and Physics Institute, University of Münster

Dynamic modes are often used in scanning force microscopy in order to improve the resolution compared to conventional contact mode. In air and liquids the so-called "tapping mode" is often applied where the cantilever is oscillated with a fixed frequency near the sample surface. In vacuum, however, the so-called frequency modulation mode (FM mode) - based on a self-driven cantilever - has several advantages. Nonetheless, this technique is not limited to vacuum conditions as shown for ambient conditions and liquids. Recently, we demonstrated that the closely related constant excitation mode (CE mode) [1] allows dynamic force spectroscopy in ambient conditions [2,3]. This technique delivers not only high resolution pictures but also information about material properties like adhesion and elasticity. In difference to the tapping mode it enables the continuous measurement of the tip-sample interaction potential. Here we present an extension of this approach towards a 3D technique. By mapping systematically the frequency shift on top a single DNA strand, we created an iso-potential map of the sample potential [4]. We discuss advantages compared to conventional techniques.

[1] H. Ueyama, Y. Sugawara, S. Morita, Appl. Phys. A 66, S295 (1998). [2] H. Hölscher, B. Gotsmann, A. Schirmeisen, Phys. Rev. B 68, 153401 (2003). [3] H. Hölscher, B. Anczykowski, Surf. Sci. 579,21 (2005). [4] J.-E. Schmutz, M.M. Schäfer, H. Hölscher (submitted).