O 77: Methods: Scanning Probe Techniques I

Time: Thursday 15:30–17:30 Location: MA 041

O 77.1 Thu 15:30 MA 041

Advanced Spherical Probes for Atomic Force Microscopy — •Jan-Erik Schmutz, Marcus M. Schäfer, and Hendrik Hölscher — CeNTech, Universität Münster, Heisenbergstr. 11, 48149 Münster, Germany

In some areas of scanning probe microscopy it is highly important to use tips with a well defined radius [1]. This problem is commonly solved by glueing a microsphere onto the end of a tipless cantilever [2]. Though this technique is widely used we found some drawbacks especially for spheres with a radius smaller than 5 μm. Both in friction force microscopy (FFM) and in dynamic force microscopy (DFM) the effective tip height is an important parameter. In FFM the torsional spring constant is inversely propotional to the square of the tip height. Therefore, increasing the tip height decreases the torsional spring constant which leads to an enhanced sensitivity. Moreover with an increased tip height the risk of the cantilever edge touching a rough surface is being reduced. The main problem in DFM with a small tip height is the increased damping due to the compressed air in the gap between the cantilever and the surface [3]. Here we present a new cantilever design which avoids these disadvantages.

[1] W. A. Ducker et al., Nature **353**, 239 (1991)
[2] L. H. Mak et al., Rev. Sci. Instrum. **77**, 046104 (2006)
[3] O. I. Vinogradova et al., Rev. Sci. Instrum. **72**, 2330 (2001)

O 77.2 Thu 15:45 MA 041

Detection of Ferroelectric Domain Boundaries with Lateral Force Microscopy — Tobias Jungk, Akos Hoffmann, and •Elisabeth Soergel — Institute of Physics, University of Bonn, Wegelerstrasse 8, 53115 Bonn, Germany

The contrast mechanism for the visualization of ferroelectric domain boundaries with lateral force microscopy is generally assumed to be caused by mechanical deformation of the sample due to the converse piezoelectric effect. We show, however, that electrostatic interactions between the charged tip and the electric fields arising from the surface polarization charges dominate the contrast mechanism. A quantitative estimate of the expected electrostatic forces as well as comparative measurements on LiNbO3 and KTP crystals sustain this explanation.

O 77.3 Thu 16:00 MA 041

Evaluating Electrostatic Force Microscopies for the Investigation of Near-Surface Dopant Distribution in Silicon — •Markus Ratzke[1], Mario Birkholz[2], Joachim Bauer[2], Detlef Bolze[2], and Juergen Reif[1] — [1]LS Experimentalphysik II, BTU Cottbus und IHP/BTU JointLab, Konrad-Wachsmann-Allee 1, D-03046 Cottbus — [2]IHP, lm Technologiepark 25, D-15236 Frankfurt (Oder)

The still ongoing decrease in semiconductor device dimensions, both laterally and in depth, requires a sub-micron-scale mapping of surface potential, surface capacitance and near surface dopant distribution. Corresponding methods should operate non-invasively, leaving the specimen intact. Scanning-probe based techniques like Scanning Kelvin Probe Microscopy (SKM) and non-contact Scanning Capacitance Microscopy (SCM) represent promising tools.

To evaluate these techniques doping patterns produced by standard CMOS technology on silicon were investigated experimentally. Lattices of alternating p- and n-type doping in the 10^{17} to 10^{19} cm^{-3} range and a pitch of 360 nm were prepared by As^{+} ion implantation. The results are compared to FEM calculations for a correlation with the expected carrier distributions. It turns out that SCM, mapping electrostatic forces at the second or third harmonic frequency of the AC driving voltage, yields higher resolution and contrast compared to SKM. In addition this technique appears to be less influenced by the actual surface conditions like roughness and surface charge. The physical significance of the higher harmonics will be considered.

O 77.4 Thu 16:15 MA 041

Fe/W(001) - a structurally, electronically and magnetically inhomogeneous system studied by force microscopy — •Rene Schmidt, Ung Hwan Pi, Alexander Schwarz, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Jungiusstr. 11, 20355 Hamburg

Since force microscopy detects all kinds of electromagnetic forces simultaneously, imaging of inhomogeneous samples is particularly challenging. We studied Fe films of around 1.3 atomic layers epitaxially grown on W(001), which are in this respect a prototypical sample system, as the structural, electronic and magnetic properties differ between first and second layer. Iron grows pseudomorphically on W(001) whereby the layers are highly strained. When imaging the surface, an electrostatic contrast with bias dependent apparent step heights can be observed, which is related to different work functions of first and second layer. Kelvin Probe Force Microscopy allows to map the work function and to measure the correct topography. Interestingly, we found that even on the same layer, different work functions are observed. Moreover, the first and second layer are magnetically different. The first layer is antiferromagnetically ordered, while double layers are ferromagnetic. As a result, a magnetostatic contrast from double layer islands is visible at relatively large tip-sample distances with ferromagnetic tips, while no magnetic signal is obtained on monolayer areas. However, at small separations the antiferromagnetic c(2x2) structure of the iron monolayer can be resolved by detecting the short-ranged magnetic exchange force between tip and sample.

O 77.5 Thu 16:30 MA 041

Resolution improvement for mid infrared nearfield optical microscopy through gold nanoparticle scatterers — •Marc Tobias Wenzel[1], Susanne C. Schneider[1], Lukas M. Eng[1], Stephan Winnerl[2], and Manfred Helm[2] — [1]Institute of Applied Photophysics, Technische Universität Dresden, 01062 Dresden — [2]Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf, 01314 Dresden

We present the implementation of 80 nm sized gold nanoparticles as tips for scattering nearfield optical investigations in the mid IR using a tunable free electron laser source (available frequency range 4 - 200 μm). At IR frequencies an efficient electric field confinement is advantageous for deducing the local dielectric and optical properties such as phonon vibration modes and local refractive indices of nm-sized implants. Our approach is based on confining the scattering volume by using gold-nanoparticles of different diameters. First, every single nanoparticle is characterized optically and then attached to an ordinary AFM cantilever tip. The cantilever is used as a spatial manipulator for the metal-nanoparticle scatterer in an AFM based scattering scanning nearfield optical microscope set-up (s-SNOM). Using these enhanced tips, we optically inspected anisotropic dielectrics at mid IR frequencies. As a result, we obtain a considerably improved confinement of the optical signal as demonstrated by tip/sample approach curves and theoretical modelling. Our experimental findings are in good agreement with our dipolar scattering theory.

O 77.6 Thu 16:45 MA 041

Frequency Modulation Atomic Force Microscopy and Spectroscopy on DPPC in Liquid — •Daniel Ebeling[1,2], Hendrik Hölscher[1,2], and Boris Anczykowski[3] — [1]Center for Nanotechnology (CeNTech), Heisenbergstr. 11, 48149 Münster — [2]Physikalisches Institut, Wilhelm-Klemm-Str. 10, 48149 Münster — [3]nanoAnalytics GmbH, Heisenbergstr. 11, 48149 Münster

The application of dynamic force spectroscopy in vacuum allows the mapping of tip-sample forces down to the atomic-scale. However, it has been shown that dynamic force spectroscopy works also in ambient conditions [1] and liquids [2] enabling the precise measurement of tip-sample forces. By adding a Q-Control electronics to the set-up of the constant-excitation mode of the frequency-modulation atomic force microscope we are able to increase the effective Q-factor of a self-oscillated cantilever in liquid to values comparable to ambient conditions [3]. During imaging of a DPPC bilayer on a mica substrate we observed an increased corrugation of the topography with increased Q-factors. This effect is caused by the reduction of tip-sample indentation forces [4]. Furthermore, dynamic force spectroscopy allows to measure the tip-sample forces and can be used as a powerful tool to determine the mechanical properties of the DPPC bilayer.

[1] H. Hölscher and B. Anczykowski. Surf. Sci. **579**, 21 (2005).
[2] T. Uchihashi et al., Appl. Phys. Lett. **85**, 3575 (2004).
[3] D. Ebeling, H. Hölscher, B. Anczykowski, Appl. Phys. Lett. **89**, 203511 (2006).
[4] D. Ebeling and H. Hölscher, J. Appl. Phys (accepted).

O 77.7 Thu 17:00 MA 041

Metal cross–substitution in the misfit layer compound $(PbS)_{1.13}TaS_2$ — •Matthias Kalläne[1], Hans Starnberg[2], Kai Rossnagel[1], Martin Marczynski-Bühlow[1], Sven Stoltz[2], and Lutz Kipp[1] — [1]Institute for Experimental and Applied Physics, University of Kiel, D-24098 Kiel, Germany — [2]Department of Physics, Göteborg University, SE-412 96 Göteborg, Sweden

Bonding in layered materials is a challenging problem because it includes various types of interactions ranging from strong local covalent bonds over electrostatic interactions to rather weak nonlocal van der Waals forces. Consisting of alternatingly stacked slabs of hexagonally ordered transition metal dichalcogenides (TMDCs) and cubic monochalcogenides, the layered TMDC misfit compounds are hetero–structures with a complex layer–to–layer interface due to the different symmetries of the subsystems. Their incommensurability, the alternation of different layers, and the occurrence of monochalcogen bilayers all act against a low total energy. It is thus surprising that they show such a remarkable stability. To investigate the nature of the interlayer bonding, angle– as well as spatially–resolved photoelectron spectroscopy measurements were performed on the layered misfit compound $(PbS)_{1.13}TaS_2$. The results provide direct evidence for metal cross–substitution between the layers which alters the charge balance between alternating layers and can explain the remarkable stability of misfit compounds.

Photoemission experiments were carried out at HASYLAB, MAXLAB, and the ALS. Work supported by DFG FOR 353.

O 77.8 Thu 17:15 MA 041

Plan view and UHV-cross-sectional STM of GaN structures — •David Krüger, Thomas Schmidt, Stephan Figge, Detlef Hommel, and Jens Falta — Institute of Solid State Physics, University of Bremen, Germany

GaN-growth technology, though still mainly on sapphire substrates today, will be more and more directed towards homoepitaxial growth. Here, not only the polar c-plane of GaN is of interest, especially the non-polar perpendicular planes (e.g. m-plane) may be of even greater importance. XSTM investigations of GaN substrates cleaved under UHV conditions have been untertaken to reveal structural properties of their cross-sections. Moreover, STM-investigations of InGaN grown on sapphire based c-plane GaN-templates will be presented.