O 11: Methods: Scanning probe techniques II

Time: Monday 15:00–17:30 Location: H32

O 11.1 Mon 15:00 H32

Light emission from single Ag atom contacts — •Natalia Schneider[1], Guillaume Schull[2], and Richard Berndt[1] — [1]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany — [2]Institut de Physique et de Chimie de Strasbourg, CNRS UMR 7504, 67034 Strasbourg, France

Using a cryogenic scanning tunneling microscope, we investigated the transition from tunneling to a single atom contact on Ag(111) at voltages between 1.4 and 2.0 V. Contrary to Au/Au(111) junctions, Ag/Ag(111) junctions do not exhibit a jump. This enables a detailed study of the junction luminescence at each step of the contact formation. Optical spectra reflect single and multiple electron processes and their distinct evolution as a single-atom contact is formed.

O 11.2 Mon 15:15 H32

Investigating the voltage dependence of the apparent barrier height in scanning tunneling microscopy — •Michael Becker and Richard Berndt — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany

Scanning tunneling microscopy measurements of the apparent height of the tunneling barrier on noble metal (111) surfaces and for Pb islands on Ag(111) are analyzed. The apparent barrier height (ABH) is found to vary significantly with the bias voltage. In particular for the coinage metal surfaces, the ABH is asymmetric with respect to the bias polarity, in contrast to simple interpretations in terms of an average work function of tip and sample. For Pb/Ag(111) the bias dependence leads to drastic changes and even inversion of contrast in spatial maps of the ABH. Model calculations of the tunneling current, which take band structure effects into account, describe the experimental observations. Financial support by the Deutsche Forschungsgemeinschaft through SFB 668 is acknowledged.

O 11.3 Mon 15:30 H32

Deconvolution of the local density of states from constant-current tunneling spectra — •Holger Pfeifer, Berndt Koslowski, and Paul Ziemann — Institut für Festkörperphysik, Universität Ulm, D-89069 Ulm, Germany

In recent years, measurement of the differential conductivity at constant current (z-V spectroscopy) has been established as a powerful tool in scanning tunnelling spectroscopy to analyze the local density of states (LDOS) of a sample. An undoubted advantage over I-V measurements at constant tip-sample separation is a wider accessible range of bias especially on delicate samples such as those involving organic molecules. While now-a-days numerical methods are available to include effects of the tunnelling barrier and even to deconvolve the LDOS of tip and sample from I-V measurements [1], for z-V spectroscopy such an analysis is still missing. Recently, Ziegler et al. applied an adopted method to remove effects of the tunnelling barrier from z-V measurements [2]. Here, we introduce an adopted method from [1] to obtain a deconvolution of the LDOS from z-V measurements taken at different set currents on Nb(110) at low temperature.

[1] B. Koslowski, H. Pfeifer, P. Ziemann, PRB 80, 165419 (2009).
[2] M. Ziegler, N. Néel, A. Sperl, J. Kröger, R. Berndt, Phys. Rev. B 80, 125402 (2009).

O 11.4 Mon 15:45 H32

Local density of states from constant-current tunneling spectra — Martin Ziegler, Nicolas Néel, •Alexander Sperl, Jörg Kröger, and Richard Berndt — Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany

Scanning tunnelling spectroscopy of the differential conductance is often performed at constant tip-surface distance. Sometimes it is advantageous to acquire spectra at constant current. However, the latter method may significantly affect peak positions and line shapes in spectra as well as patterns in spatial maps of the differential conductance. A normalization procedure for constant-current data, which relies on experimental current-distance data, is shown to yield spectral information on the local density of states. Financial support by the Deutsche Forschungsgemeinschaft through SFB 668 and SFB 677 is acknowledged.

O 11.5 Mon 16:00 H32

Structure and Charge State Characterization of Line Defects in the Alumina Film on NiAl(110) by Dynamic Force Microscopy — •Leonid Lichtenstein, Lars Heinke, Georg Hermann Simon, Thomas König, Markus Heyde, and Hans-Joachim Freund — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14196 Berlin, Germany

Metal oxides play a decisive role in many technological applications such as microelectronics and heterogeneous catalysis. To understand their catalytic performance in detail, it is important to determine the atomic and electronic structure of their surfaces. For this purpose, the thin aluminum oxide film grown on NiAl(110) often serves as model system in catalysis. It has been shown that line defects like step edges and antiphase domain boundaries (APDB) are particularly active sites for, e.g., the decomposition of NO [1]. In this context, frequency modulated dynamic force microscopy (FM-DFM) and scanning tunneling microscopy (STM) are applied to unveil the atomic structure of the thin film and its line defects in ultra high vacuum at 5 K [2]. By means of bias spectroscopy [3] differences in the density of electronic states between domains and line defects were determined. The contact-potential spectroscopy shows different local work functions indicating different charge states for both. This study links catalytic processes to the electronic structure of line defects.

[1] S. Schauermann et al., Chem. Phys. Lett. 381 (2003) 298-305
[2] G. H. Simon et al., New J. Phys. 11 (2009), 093009
[3] N. Nilius et al., Phys. Rev. B 69 (2004), 121401

O 11.6 Mon 16:15 H32

Lateral Piezoelectric Response at Domain Boundaries in Bulk Single Crystals — Florian Johann, Tobias Jungk, Martin Lilienblum, Akos Hoffmann, and •Elisabeth Soergel — Physikalisches Institut, Universität Bonn, Wegelerstrasse 8, 53115 Bonn

The lateral signal at domain boundaries using piezoresponse force microscopy has first been described by Wittborn et al. [1] and was later investigated by Scrymgeour et al. [2]. They assumed the signal to originate from the topographical slope of the surface at the domain boundary. A different approach by Jungk et al. [3] ascribed domain specific surface charge distributions to cause the signal. Calculations by Morozovska et al. [4] explained the signal by a sideways motion of the sample surface at the domain boundary. In this contribution, we try to clarify the situation by experimental data obtained on different materials and crystallographic cuts.

[1] J.Wittborn, C.Canalias, K.V.Rao, R.Clemens, H.Karlsson, and F.Laurell, Appl. Phys. Lett. 80, 1622 (2002). [2] D.A.Scrymgeour and V.Gopalan, Phys. Rev. B 72, 024103 (2005). [3] T.Jungk, A.Hoffmann, and E.Soergel, Appl. Phys. Lett. 89, 042901 (2006). [4] A.N.Morozovska, E.A.Eliseev, S.L.Bravina, and S.V.Kalinin, Phys. Rev. B 75, 174109 (2007).

O 11.7 Mon 16:30 H32

Infrared near-field optical microscopy on sub-surface doped silicon — •Rainer Jacob[1], Manfred Helm[1], Stephan Winnerl[1], Harald Schneider[1], Marc Tobias Wenzel[2], Hans-Georg von Ribbeck[2], and Lukas M. Eng[2] — [1]Institut für Ionenstrahlphysik und Materialforschung, Forschungszentrum Dresden, 01314 Dresden, Germany — [2]Institut für Angewandte Photophysik, TU Dresden, 01062 Dresden, Germany

Scattering-type scanning near-field optical microscopy (s-SNOM) has proven as a useful tool for surface science. Materials can be distinguished by their interaction with the local probe, hence yielding different intensities of the near-field signal. In semiconductors this can be achieved through doping, allowing a significant variation in the dielectric function. This becomes even more interesting when probing sub-surface interactions of such dopants.

Although s-SNOM is mainly used as a surface sensitive technique, we present here the ability to probe sub-surface doped silicon. To this end we prepared samples by implanting gallium and boron with different energies at a variable depth. Afterwards, the samples were annealed in order to activate the dopants. The carriers were then investigated with IR-s-SNOM using wavelengths between 9 and 15 μm from the free-electron laser at the FZD. We were able to probe doping layers up

to 100 nm below the surface. Furthermore, we could show contrast inversion between doped and undoped areas in the Si-wafer for different wavelengths. From these measurements the carrier density in doped regions can be extracted directly using the Drude model.

O 11.8 Mon 16:45 H32

Sol-gel derived ferroelectric nanoparticles investigated by piezoresponse force microscopy — •Florian Johann[1], Tobias Jungk[1], Susanne Lisinski[2], Akos Hoffman[1], Lorenz Ratke[2], and Elisabeth Soergel[1] — [1]Institute of Physics, University of Bonn, Wegelerstr. 8, 53115 Bonn, Germany — [2]Institute for Material Physics in Space, DLR, Linder Höhe, 51147 Cologne, Germany – *Present address of F. Johann: Max Planck Institut for Microstructure Physics, Weinberg 2, 06120 Halle, Germany

Piezoresponse force microscopy (PFM) was used to investigate the ferroelectric properties of sol-gel derived $LiNbO_3$ nanoparticles. To determine the degree of ferroelectricity we took large-area images and performed statistical image-analysis. The ferroelectric behavior of single nanoparticles was verified by poling experiments using the PFM tip. Finally we carried out simultaneous measurements of the in-plane and the out-of-plane piezoresponse of the nanoparticles, followed by measurements of the same area after rotation of the sample by 90° and 180°. Such measurements basically allow to determine the direction of polarization of every single particle.

O 11.9 Mon 17:00 H32

Mid-Infrared Broadband s-SNOM — •Sergiu Amarie and Fritz Keilmann — Max Planck Institute for Quantum Optics, 85741 Garching, Germany

We demonstrate continuous infrared spectra from 20 nm sample spots, by combining dispersive Fourier-transform infrared spectroscopy (FTIR) with scattering near-field microscopy (s-SNOM). As a next step we aim for spectroscopic near field images with 20 nm spatial resolution, at 6 cm-1 spectral resolution. The method is to be applied for biomedical imaging.

S. Amarie, T. Ganz, and F. Keilmann, "Mid-infrared near-field spectroscopy," Opt. Express (2009) 17, 21794-21801.

O 11.10 Mon 17:15 H32

Imaging short-range forces with a scanning tunnelling microscope — •Temirov Ruslan, Weiss Christian, Wagner Christian, Kleimann Christoph, and Tautz Stefan — Institut für Bio- und Nanosysteme 3, Forschungszentrum Jülich, JARA Fundamentals of Future Information Technology, Germany

One of the unresolved issues in the field of scanning tunnelling microscopy (STM) is the lack of chemical sensitivity. The STM probes the density of states (DOS) close to the Fermi level while the details of the chemical structure are mostly encoded by lower lying orbitals. Thus it is desirable to measure the total electron density (TED) rather than the DOS. Since the TED defines Pauli repulsion, imaging of short-range forces should directly reveal the chemical structure. Indeed, it was demonstrated recently that non-contact atomic force microscopy (AFM) resolves the structure of a complex organic molecule by probing short-range repulsive interactions [1]. In our contribution we show that STM can also be used to map short-range forces and resolve chemical structures. The key to the new functionality is a single hydrogen molecule confined in the STM junction [2]. The molecule acts as a force-sensor/signal transducer, which probes the repulsive branch of the surface adsorption potential and transforms the force signal into variations of the junction conductance [3].

[1] L. Gross et al. Science 325, 1110 (2009). [2] R. Temirov et al. New J. Phys. 10, 053012 (2008) [3] C. Weiss et al. arXiv:cond-mat/0910.5825