O 40: Methods: Scanning probe techniques I

Time: Wednesday 15:00–17:30 Location: SCH A316

O 40.1 Wed 15:00 SCH A316

Detection of charges using scanning force microscopy in contact mode* — •Florian Johann, Akos Hoffmann, and Elisabeth Soergel — Institute of Physics, University of Bonn, Wegelerstr. 8, 53115 Bonn, Germany

Electrostatic force microscopy is the standard technique to detect surface charges using a scanning force microscope (SFM). Therefore the SFM is operated in non-contact mode with an alternating voltage applied to the tip. The electrostatic interaction between the tip and the charges to be measured lead to oscillations of the cantilever that can be read-out using a lock-in amplifier. Now, operating the SFM in contact-mode results in the same electrostatic interaction between tip and surface charges. However, in this case, the tip can not move freely due to its being in contact with the sample surface. To still allow for charge detection in contact-mode, e.g. a deformation of the sample surface underneath the tip caused by the electrostatic forces must occur. To reveal the limits of charge detection in contact-mode SFM we performed a detailed analysis of the relevant parameters such as cantilever stiffness, tip load, and elastic properties of the sample.

*Financial support from the Deutsche Telekom AG is gratefully acknowledged.

O 40.2 Wed 15:15 SCH A316

Investigation of isolated single molecules on an insulating substrate — •Knud Lämmle[1], Alexander Schwarz[1], Marc Prosenc[2], and Roland Wiesendanger[1] — [1]Universität Hamburg - Institut für Angewandte Physik, Jungiusstrasse 11a, 20355 Hamburg — [2]Universität Hamburg - Department Chemie, Martin-Luther-King Platz 6, 20146 Hamburg

To tailor new molecular based devices, it is important to understand the characteristic features of their building blocks, i.e., the properties of individual molecules. Here, we utilized non-contact atomic force microscopy (NC-AFM) to study isolated Co-Salen molecules on NaCl(001). On this large band-gap insulator hybridization effects, which strongly alter the properties of molecules if adsorbed on metallic surfaces, are eliminated.

Immobilization of the rather small molecule is achieved by evaporating them *in situ* onto a 20 K cold substrate and by performing subsequent measurements at 8.2 K. NC-AFM images acquired on wide terraces reveal randomly distributed isolated banana-shaped objects with long and short axis of about 1.5 and 0.6 nm, respectively. By comparison with the known structure of the molecule, they can be identified as individual molecules adsorbed in a planar configuration. Surprisingly, the bananas appear asymmetric, i.e., the 60 pm high maximum is considerably shifted away from the center. Details of the orientation with respect to the underlying substrate as well as the exact adsorption site will be discussed by evaluating images, were isolated molecules and atomic resolution on the substrate are visible simultaneously.

O 40.3 Wed 15:30 SCH A316

High Resolution 3D-Force-Field-Spectroscopy on Fe/W(001) — •Rene Schmidt, Cesar Lazo, Uwe Kaiser, Alexander Schwarz, Stefan Heinze, and Roland Wiesendanger — Institut für Angewandte Physik, Universität Hamburg

Three-dimensional force fields with atomic resolution have been measured by atomic force microscopy in the non-contact regime (NC-AFM) in ultrahigh vacuum and at low temperatures. Force spectroscopy allows a site specific determination of the distance dependence of tip and sample interaction potential and force on the investigated system. Here, we study a purely metallic system, i.e., the iron monolayer epitaxially grown on a W(001) substrate with a metallic tip.

The high resolution data consists of 128×128 curves on a 2 nm×2 nm surface area. The curves were recorded in a distance range of 270 pm close to the surface with Δz-steps of 10 pm. Additionally, one single curve was recorded up to a distance of 20 nm to determine the long-range tip-sample forces. The resulting total force at each lattice site can be separated into long- and short-range contributions. The experimentally obtained short-range forces are compared quantitatively with first principles calculations based on density functional theory.

O 40.4 Wed 15:45 SCH A316

3D-Force-Spectroscopy and -Dissipation Data of an Organic-Inorganic Interface: PTCDA on Ag(111) — •Daniel-Alexander Braun, Gernot Langewisch, Harald Fuchs, and Andre Schirmeisen — CeNTech (Center for Nanotechnology) & Institute of Physics, University of Münster, Germany

Organic semiconductors have attracted intensive research over the last years. Especially the adsorption of π-conjugated organic molecules on metal substrates in view of potential applications in organic and molecular electronics gained a lot of interest. One of the most studied molecules is 3,4,9,10-perylenetetracarboxylic-dianhydride (PTCDA) and it has been investigated on a wide range of substrates.

Noncontact atomic force microscopy (ncAFM) experiments with PTCDA adsorbed on Cu(111) revealed, that the intramolecular contrast of PTCDA-molecules depends strongly on the local adsorption environment [1]. Here we present experimental ncAFM results of 3-dimensional force and dissipation spectroscopy experiments of PTCDA adsorbed on Ag(111) with submolecular resolution. The dissipation is understood as a hysteresis of forces between approach and retraction of the tip and is caused by bistabilities in the potential energy surface of the tip-sample system. Therefore the dissipation signal can reveal information about the mechanical properties of individual molecules.

[1] B. Such, D. Weiner, A. Schirmeisen and H. Fuchs Applied Physics Letters 89 (2006), 093104

O 40.5 Wed 16:00 SCH A316

Static and Sliding Friction of Nanoparticles — •Dirk Dietzel, Michael Feldmann, and André Schirmeisen — Institute of Physics and Center for Nanotechnology, University of Münster, Germany

We present a new approach for identifying static and sliding friction during atomic force microscopy (AFM) manipulation of nanoparticles [1]. In this approach the AFM-tip is centered on top of an antimony nanoparticle, which is weakly bound to a graphite surface. Depending on the normal load of the cantilever two scan modes are then possible: At low normal forces the tip will scan on top of the particle, whereas higher normal forces can lead to a movement of the particle simultaneously with the tip. We measure the lateral force during this transition, which allows us to extract values for static as well as sliding friction. We find that the static friction is reproducible during several subsequent manipulation events of the same nanoparticle. Once the particle is moving, further increase of the normal force might also make load dependent friction measurements possible.

O 40.6 Wed 16:15 SCH A316

A low-temperature high resolution scanning tunneling microscope with a three-dimensional magnetic vector field operating in ultra-high vacuum — •Marco Pratzer, Torge Mashoff, and Markus Morgenstern — II. Institute of Physics B, Otto-Blumenthal-Straße, RWTH Aachen and JARA-FIT, 52074 Aachen

Scanning tunneling microscopy and spectroscopy at low temperatures lead to a detailed microscopic understanding of electronic interactions. The combination of a low-temperature spin-polarized STM with a rotatable magnetic vector field, in addition, allows to determine the full map of magnetic anisotropies for individual nano-entities. Moreover, complex noncollinear spin structures of nanoclusters could be mapped by appropriately aligning the relative magnetization axis of probe and sample with the help of the external fields.

We present a low-temperature ultra-high vacuum scanning tunneling microscope setup with a combination of a superconducting solenoid coil and two split-pair magnets, providing a rotatable magnetic field of 500 mT applicable in all spatial directions. An absolute field maximum of B=7 T (3 T) can be applied perpendicular (parallel) to the sample surface. The instrument is operated at a temperature of 5 K. Topographic and spectroscopic measurements on tungsten carbide and indium antimonide revealed a z-noise of 600 fm_{pp} even in magnetic field. The energy resolution is, at least, below 6.5 meV. In addition the microscope is equipped with a tip exchange mechanism and a lateral sample positioning stage.

O 40.7 Wed 16:30 SCH A316

Intrinsic and extrinsic corrugation of monolayer graphene deposited on SiO_2 — •Viktor Geringer[1], Marcus Liebmann[1], Tim Echtermeyer[2], Sven Runte[1], Matthias Schmidt[1], Reinhard Rückamp[1], Max Lemme[2], and Markus Morgenstern[1] —

[1]II. Physikalisches Institut, RWTH Aachen and JARA-FIT, Otto-Blumenthal-Straße, 52074 Aachen — [2]Advanced Microelectronic Center Aachen (AMICA), Otto-Blumenthal-Straße 25, 52074 Aachen

Using scanning tunneling microscopy (STM) in ultra high vacuum and atomic force microscopy, we investigate the corrugation of graphene flakes deposited by exfoliation on a Si/SiO_2 surface. While the corrugation on SiO_2 is long-range with a correlation length of about 25 nm, some of the graphene monolayers exhibit an additional corrugation with a preferential wave length of about 15 nm. A detailed analysis shows that the long range corrugation of the substrate is also visible on graphene, but with a reduced amplitude, leading to the conclusion that the graphene is partly freely suspended between hills of the substrate. Thus, the intrinsic rippling observed previously on artificially suspended graphene can exist as well, if graphene is deposited on SiO_2 [1].

[1] J. C. Meyer, A. K. Geim, M. I. Katsnelson, K. S. Novoselov, T. J. Booth, and S. Roth, Nature 446, 60 (2007).

O 40.8 Wed 16:45 SCH A316

Cross-sectional Scanning Tunneling Microscopy across a Metal-Semiconductor Interface - Structural and Electronic Properties on the Atomic Scale — Lars Winking, Martin Wenderoth, •Tim Ifflländer, Thomas Druga, and Rainer G. Ulbrich — IV. Physikalisches Institut, Georg-August-Universität Göttingen

Understanding the formation of Schottky barriers has been a major theme of surface science for more than half a century. However, the various mechanisms that determine the barrier height are still subject to discussion. To a large part this is due to the lack of appropriate experimental techniques with atomic resolution and the difficulties associated with preparing well-defined epitaxial interfaces.

We report scanning tunnelling spectroscopy (STS) across a cleaved epitaxial GaAs(110)/Fe interface. It provides information on the structural as well as the electronic properties of the heterointerface on the atomic scale. Furthermore, in combination with 3D simulations of the tip induced band bending we are able to quantify both the local Schottky barrier height and the influence of single dopant atoms on the electrostatic potential landscape representing the space charge layer in the semiconductor. Our experimental data are discussed in the context of existing theoretical models for Schottky barrier formation, like the advanced unified defect model or the metal-induced gap states model.

This work was supported by the SFB 602 TP A7.

O 40.9 Wed 17:00 SCH A316

Plasmon enhanced luminescence from fullerene molecules using a scanning tunneling microscope — •Frédéric Rossel, Marina Pivetta, François Patthey, and Wolf-Dieter Schneider — Ecole Polytechnique Fédérale de Lausanne (EPFL), Institut de Physique des Nanostructures, CH-1015 Lausanne, Switzerland

Luminescence from supported C_{60} and C_{70} molecules induced by tunneling electrons in a scanning tunneling microscope (STM) has been observed. The fullerene nanocrystals were electronically decoupled from the Au(111) substrate by an ultrathin NaCl film. Intramolecular fluorescence and phosphorescence associated with the transitions between the lowest electronic excited state and the ground state of C_{70} molecules were identified, demonstrating the capability of this technique for chemical recognition on the nanometre scale. Moreover we show that the molecular luminescence is selectively enhanced in the STM tip-sample gap by localized surface plasmons excited in an inelastic electron tunneling process.

We acknowledge financial support of the Swiss National Science Foundation.

O 40.10 Wed 17:15 SCH A316

Manipulating surface diffusion ability of single molecules by scanning tunneling microscopy — Dingyong Zhong[1,2], Jörn-Holger Franke[1], •Tobias Blömker[3], Gerhard Erker[3], Harald Fuchs[1,2], and Lifeng Chi[1] — [1]Physikalisches Institut, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany & Center for Nanotechnology (CeNTech), Universität Münster, Heisenbergstr. 11 , 48149 Münster, Germany — [2]Institut für Nanotechnologie, Forschungszentrum Karlsruhe, 76021 Karlsruhe, Germany — [3]Organisch-Chemisches Institut, Universität Münster, Corresstr. 40, 48149 Münster, Germany

The bonding of single diferrocene [Fc(CH2)14Fc, Fc = ferrocenyl] molecules on a metal surface can be enhanced by partial decomposition of Fc groups induced by the tunneling current in scanning tunneling microscopy. Although the isolated intact molecule is mobile on the terrace of Cu(110) at 78 K, the modified molecule is immobilized on the terrace. Calculations based on density functional theory indicate that the hollow site of the Cu(110) surface is the energetically favorable adsorption site for both ferrocene and the Fe-cyclopentadienyl complex, but the latter one possesses a much higher binding energy with the substrate.