O 33 Scanning probe techniques III

Time: Thursday 11:15–13:00 Room: PHY C213

O 33.1 Thu 11:15 PHY C213

Combined Frequency Modulated Atomic Force and Scanning Tunneling Microscope: Basic Concept, Experimental Design, Signal Electronics, Atomic Resolution — •Georg Simon, Markus Heyde, Hans-Peter Rust, and Hans-Joachim Freund — Fritz-Haber-Institute of the Max-Planck-Society, Faradayweg 4-6, D-14195 Berlin, Germany

A low temperature (5 Kelvin) ultra-high vacuum system has been supplemented with a new double tuning fork sensor for frequency modulated atomic force microscopy (FM-AFM) and scanning tunneling microscopy (STM) measurements [1]. Here the experimental set-up of the whole microscope will be presented, e.g. vacuum chamber, vibrational isolation, cryostat, microscope head, force sensor and signal electronics. The combined FM-AFM/STM set-up has been tested successfully. It shows atomic resolution in both modes. For detailed analysis and interpretation of surface structures, we benefit from the capability of our sensor to record FM-AFM and STM images as well as spectroscopic data at the same surface area. Atomically resolved images obtained on thin oxide films will be presented [2].

[1] M. Heyde, M. Kulawik, H.-P. Rust, H.-J. Freund, Rev. Sci. Instrum. 75, 2446 (2004).
[2] M. Heyde, M. Sterrer, H.-P. Rust, H.-J. Freund, Appl. Phys. Lett. 87, 083104 (2005).

O 33.2 Thu 11:30 PHY C213

Computing scanning tunneling spectroscopy by the layer-KKR real-space method — •Kamal K. Saha, Jürgen Henk, Arthur Ernst, and Patrick Bruno — Max-Planck-Institut für Mikrostrukturphysik, Halle/Saale, Germany

Often, the computation of scanning tunneling spectroscopy (STS) relies on severe approximations. For example in the Tersoff-Hamann model, the electronic structure of the STM tip is taken into account rather imprecisely. Or in a supercell approach, the periodicity may lead to artifacts.

In this contribution, a new approach to compute STS from first principles is proposed. Applying a self-consistent real-space multiple-scattering theory (here: spin-polarized relativistic layer-KKR) for the Green function of the tunnel junction, the abovementioned shortcomings can be avoided. The conductance is obtained within the Landauer-Büttiker theory.

After introducing key issues of the proposed approach, its application to the Co(0001) surface will be discussed, with a focus on the tunnel magnetoresistance due to spin-polarized surface states.

O 33.3 Thu 11:45 PHY C213

Calibration and optimization of scanning conditions in combined scanning thermal microscopy and scanning thermoelastic microscopy — •Dirk Dietzel[1], Sutharat Chotikaprakhan[2], Ralf Meckenstock[2], Detlef Spoddig[2], and Josef Pelzl[2] — [1]Physikalisches Institut, Universität Münster, 48149 Münster — [2]Experimentalphysik 3, Ruhr Universität Bochum, 44780 Bochum

In this contribution we will present a combined experimental set-up for the simultaneous detection of the thermal and thermoelastic signal of electrically heated semiconductor devices by scanning probe techniques. The simultaneously obtained signal profiles of the Scanning Thermal Microscope (SThM) and the Scanning Thermoelastic Microscope (SThEM) give information on the shape and position of heat sources, where the combination of the two detection schemes gives a more precise set of parameters describing the heat sources and the temperature distribution in the sample. Additionally, two new techniques related to SThEM are presented: 1) a simple and straightforward calibration technique for the modulated surface expansion by force distance spectroscopy measurements using a electrically heated tip and 2) the optimisation of the scanning conditions by performing SThEM measurements on the 2nd harmonic resonance frequency of the cantilever. Using this technique on a high power capacitor structure a significant increase of the sensitivity can be achieved, which allows faster scanning or the detection of smaller surface oscillations (e.g. from subsurface heat sources).

O 33.4 Thu 12:00 PHY C213

Development of an ultra-low cost scanning tunneling microscope for high-school education — •Grit Petschick[1], Holger Eisele[1], Robert Kastl[2], Kai Hodeck[1], Volkhard Nordmeier[2], and Mario Dähne[1] — [1]Technische Universität, Festerkörperphysik, Hardenbergstr. 36, 10623 Berlin — [2]Freie Universität, Didaktik der Physik

25 years ago we learned in school that atoms cannot be optically imaged. But nowadays, since the invention of the scanning tunneling microscope (STM) in the early 1980th it is possible to map surfaces on the atomic scale. Today, a various number of microscopic possibilities exist to image atoms, still none is as simple and trouble-free as the scanning tunneling microscope itself. As schools funds are strictly limited it is mostly not possible to equip them with commercial microscopes and thus to gain experince about the nano-world of atoms at the state of the art of modern physics in the 21st century.

We report on the development and construction of an ultra-low cost scanning tunneling mircoscope setup, which is designed especially for high-school education requirements. A special challenge was to comply with safety requirements, requiring a special design of the piezo-based coarse approximation. Yet, another requirement towards capability was the possibility to image actual solid surfaces at the atomic scale. The aim towards school application is to get pupils to independently prepare and analyse surfaces of graphite and mica.

O 33.5 Thu 12:15 PHY C213

Little Changes - big Effects! Molecular Self-Organization probed by STM. — •B. A. Hermann[1], L. J. Scherer[2], C. E. Housecroft[2], and E. C. Constable[2] — [1]Dept. of Physics / CeNS, LMU Munich and WMI, Walther-Meissner-Str. 8, 85748 Garching, Germany — [2]Dept. of Chemistry, Uni. of Basel, Spitalstrasse 51, 4056 Basel, Switzerland

Aromatic-rich Fréchet-type dendrons are ideally suited to visualisation by scanning tunnelling microscopy (STM) and guarantee excellent self-organization on graphite. Here, asymmetric dendritic wedge-functionalised terpyridine ligands, are studied in a careful comparison of highly resolved 2-D self-organized monolayers on graphite using scanning tunnelling microscopy (STM) and x-ray analysis of crystals of the same molecules. The (sometimes) near atomic resolution in conjunction with x-ray analysis of 3-D crystals allowed us to assign the observed molecular arrangements. The observed molecular pattern appears like being knitted row by row. As the octyl chains of the Fréchet-type dendrons, play a major role in the process of molecular organisation, we also synthesised compounds without the octyl chains but otherwise similar molecular structure. Omitting the octyl chains led to no longer opposing Fréchet wedges. Replacing additionally the inner oxygen atom by a sulphur atom and thus changing an inner bond angle caused completely different symmetric properties in the observed self-organized monolayers. Deposition of dendritic wedge-functionalised terpyridine ligands on HOPG resulted in the formation of well-defined monolayers exhibiting different arrangements depending on small changes in the studied molecules.

O 33.6 Thu 12:30 PHY C213

High-ordered arrays of single molecular magnets on Cu(111) — •Lucia Vitali[1], M.Alexander Schneider[1], Mario Ruben[2], Adriano Mosca conte[3], Stefano Fabris[3], Stefano Baroni[3], and Klaus Kern[1] — [1]Max-Panck-Institute for solid state research Stuttgart — [2]Institute of Nanotechnology Karlsruhe — [3]INFM CNR DEMOCRITOS National Simulation Center Trieste

Molecular magnets are promising candidates for the realization of molecule-based information storage media within the nanometer regime. So far, the difficulty of forming ordered structures on surfaces prevented their application. Here we report on the formation of long-range ordered layers of a recently discovered class of single-molecular-magnets (SMMs), called lanthanide double-deckers, on the Cu(111) surface. These, consisting of a single lanthanide ion located between two phthalocyanine units, act as isolated magnetic domains exhibiting a magnetization hysteresis below a characteristic blocking temperature of 40K[1]. The highly-ordered hexagonal networks have been imaged and analyzed in situ by Scanning Tunneling Microscopy and Spectroscopy at 6K. The direct comparison of the spectroscopic results with density-functional-theory calculations of the molecule in the gas phase suggests that the molecules are not affected by the deposition and contact to the metallic substrate.

[1] N. Ishikawa et al., J. Am. Chem. Soc. 125, 8694 (2003)

O 33.7 Thu 12:45 PHY C213

Quantitative Dynamic Mode Force Spectroscopy on a Type-II Superconductor Using a Magnetic Tip: Meissner Force, Magnetostatic Tip-Vortex Interaction and Lateral Dragging Force
— •Alexander Schwarz[1], Ung Hwan Pi[1], Marcus Liebmann[2], Zheong Gu Khim[3], Dong Ho Kim[4], and Roland Wiesendanger[1] — [1]University of Hamburg, IAP, Jungiusstr. 11, 20355 Hamburg — [2]Present Address: RWTH Aachen, Department of Physics, 52056 Aachen — [3]School of Physics, SNU, Seoul 151-742, South Korea — [4]Dept. of Physics, Yeungnam University, Kyungsan, South Korea

In the mixed phase of type II superconductors quantized flux can penetrate the specimen in the form of vortices with a normal conducting core. Using magnetic tips, such samples can be investigated by magnetic force microscopy. We used the frequency modulation technique to study the glass-like flux solid state of a $Bi_2Sr_2CaCu_2O_{8+\delta}$ single crystal in the low flux density regime, where neighboring vortices do not overlap. To quantify the distance dependence of the relevant tip-sample interactions, force spectroscopy has been utilized. On top of a vortex, the maximum attraction 18 nm above the surface was determined to be about 5.4 pN. Far away from vortices the Meissner repulsion of about 4.0 pN between the magnetic tip and the superconducting phase dominates the interaction. By taking several force spectroscopy curves across a vortex, the lateral dragging force exerted by a scanning tip on a vortex could be determined to be about 1.5 pN [1]. These results agree well with theoretical predictions.

[1] U. H. Pi *et al.*, Appl. Phys. Lett. **85**, 5307 (2004).