O 16: Scanning probe methods I

Time: Monday 15:00–17:00 Location: WIL C307

O 16.1 Mon 15:00 WIL C307

Deconvolution of the local density of states from z-V spectroscopy and its application to Nb(110) — •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 in order to analyze the local density of states (LDOS) of a sample. However, in contrast to I-V spectroscopy [1], numerical methods are lacking to remove effects of the tunnelling barrier from the measurement and to deconvolve the LDOS of tip and sample. Here we introduce an adopted method from [1] to achieve a deconvolution of the LDOS from z-V measurements. We first demonstrate the deconvolution method using numerical data. Secondly, we apply this method to experimental data obtained on Nb(110) at low temperature and compare the results with the differential barrier height $\left(\frac{d^2I}{dVdz}/\frac{dI}{dV}\right)^2$ [2]. We show that the differential barrier is much more sensitive to changes in the DOS than the commonly used (integral) barrier height $\left(\frac{dI}{dz}/I\right)^2$.

[1] B. Koslowski, H. Pfeifer, P. Ziemann, PRB 80, 165419 (2009).
[2] B. Koslowski et al. PRB 75, 035421 (2007).

O 16.2 Mon 15:15 WIL C307

Ultracompact nanopositioner for scanning probe microscopy — •Bert Voigtländer, Vasily Cherepanov, and Peter Coenen — Peter Grünberg Institut (PGI-3), Forschungszentrum Jülich, 52425 Jülich, Germany, and JARA-Fundamentals of Future Information Technology

The coarse positioning unit consumes most space in a scanning probe microscope. Here we present a new type of ultra compact nano-drive which has diameter less than 2.5 mm and length smaller than 10 mm and can serve as an STM coarse positioning device. Alternating movements of springs move a tube which holds the STM tip or AFM sensor. Due to the operation principle we name it Koala-drive. The travel is limited only by the tube length used, which can be several cm long. The new operating principle provides a smooth travel and avoids shaking which is intrinsically present for nanopositioners based on inertial motion with saw tooth driving signals. No high slew rate of the driving electronics is required. Adding a piezo tube for xyz scanning integrates a complete STM inside a 4 mm outer diameter piezo tube. The use of the Koala-drive makes the scanning probe microscopy design ultra compact and leads accordingly to an high mechanical stability. The drive is UHV and magnetic field compatible. The smooth operation minimizes also the power dissipation which can be a problem of inertial drives when operated at cryogenic temperatures. Furthermore, we use the Koala-drive to design a multi tip STM where four independent STM units are integrated on a diameter of 50 mm. We present examples of the performance of STM's designed using the Koala-drive.

O 16.3 Mon 15:30 WIL C307

Imaging atomic-scale magnetic structures by means of lateral atom manipulation with an STM tip — •Boris Wolter[1], Yasuo Yoshida[1], André Kubetzka[1], Kirsten von Bergmann[1], Saw-Wai Hla[2], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, University of Hamburg, Jungiusstr. 11, 20355 Hamburg — [2]Nanoscale & Quantum Phenomena Institute, Ohio University, Athens, Ohio 45701

While spin-polarized STM and lateral atom manipulation with an STM tip are known to be powerful experimental techniques that have been employed to great extent, there are not many studies regarding the combination of these two methods[1].

Stroscio *et al.* have shown the use of lateral atom manipulation for enhanced imaging of the Cu(111) surface[2]. We apply this approach to SP-STM as an innovative magnetic imaging technique, observing increased magnetic contrast and atomic resolution of the substrate at the same time. To improve our understanding of this process, we combine Monte Carlo simulations for a classical Heisenberg spin system and lateral atom manipulation[3] with a model for SP-STM imaging[4]. By evaluating and comparing the results, we expect to gain insight into the dynamics involved in the manipulation imaging with magnetic atoms.

1. D. Serrate *et al.*, Nature Nano. 5, 350-353 (2010)
2. J. Stroscio *et al.*, Science 8, 306, 5694, 242-247 (2004)
3. A. Kühnle *et al.*, Surf. Sci. 449, 15 (2001)
4. S. Heinze, Appl. Phys. A 85, 407-414 (2006)

O 16.4 Mon 15:45 WIL C307

Low noise transimpedance amplifyer for STM applications — •Wulf Wulfhekel and Roland Jehle — Physikalisches Institut, Karksruher Institut für Technologie, Wolfgang Gaede Str. 1, 76131 Karlsruhe

Transimpedance amplifiers, or short IV-converters, are used in scanning tunneling microscopes to amplify the small tunneling currents before processing in the feed back loop and thus largely determine the performance of the instrument. While modern operational amplifiers (OPAs) offer extremely low current input noises ($\approx$1 fA/$\sqrt{Hz}$), the feed back resistor in IV-converters limits their performance due to thermal or Johnson-Nyquist noise when operated at room temperature. At an amplification of 10^9V/A the latter corresponds to 4.2 fA/$\sqrt{Hz}$ setting the theoretical noise limit of IV-converters. We present a careful analysis of the different noise sources, i.e. noise of the feed back resistor as well as input current noise, shot noise of the input bias current and input voltage noise of the OPA and present a new approach to IV-converters that beats the noise limit given by the feedback resistor using a sophisticated feed back mechanism. Further, internal capacitances of the circuit are compensated to minimize gain peaking. Finally, we compare the performance (noise and band widths) of the home build IV-converter with commercial products.

O 16.5 Mon 16:00 WIL C307

Miniature active damping stage for Scanning Probe Applications in Ultra High Vacuum — •Maximilian Assig[1], Alexandra Ast[2], Andreas Koch[1], Wolfgang Stiepany[1], Carola Strasser[1], Klaus Kern[1], and Christian R. Ast[1] — [1]Max-Planck-Institut für Festkörperforschung, Stuttgart — [2]Institut für Technische und Numerische Mechanik der Universität Stuttgart

Scanning Probe experiments demand a low vibration level to keep the distance between tip and sample constant. Small changes in the spacing between probe and sample result in enormous variations of the measured signal no matter if it is the tunneling current in Scanning Tunneling Microscopy (STM) or atomic forces and phase shift in Atomic Force Microscopy (AFM) measurements. We present a six-degree of freedom active damping technique based on a Stewart platform (Hexapod) which is to operate in Ultra High Vacuum (UHV)[1]. We outline the main working principle and show the effect of the internal damping on Scanning Tunneling Microscopy measurements of a Si(111) 7x7 surface at Room Temperature.

[1] D. Stewart, Proc. Instn. Mech. Engrs, **180**, 371, 1965

O 16.6 Mon 16:15 WIL C307

Magnetic Exchange Force Spectroscopy on antiferromagnetic Fe/W(001) — •Rene Schmidt[1], Cesar Lazo[2], Alexander Schwarz[1], Stefan Heinze[2], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, University of Hamburg — [2]Institute of Theoretical Physics and Astrophysics, University of Kiel

With the invention of magnetic exchange force microscopy (MExFM)[1] a new powerful tool to investigate atomic scale magnetic structures on all kinds of surfaces became available. Recently, we were able to resolve the antiferromagnetic structure of the Fe monolayer on W(001)[2]. Here, we demonstrate that it is possible to directly measure the distance dependence of the magnetic exchange interaction across a vacuum gap by applying a spectroscopic mode, i.e. magnetic exchange force spectroscopy (MExFS). Experimentally acquired data are compared with first-principles calculations accounting for magnetically different tips composed of Cr, Fe or mixtures of both. While sign and magnitude of the magnetic exchange energy are well reproduced, the majority of tips exhibit a stronger distance dependence than predicted for simple pyramidal tips and a more sudden onset of the interaction. More complex tip models will be discussed, which can explain this behavior.

[1] U.Kaiser *et al.*, Nature **446**, 522 (2007)
[2] R. Schmidt *et al.*, Nano Lett. **9**, 200 (2009)

O 16.7 Mon 16:30 WIL C307

4-Tip LT-STM with High Resolution SEM — •Bastian Schnitzler[1], Frank Matthes[1], Daniel E. Bürgler[1], Claus M. Schneider[1], Bernd Günther[2], and Markus Maier[2] — [1]Peter Grünberg Institute (PGI-6), FZ Jülich — [2]Omicron Nanotechnology GmbH

A new type of in-situ 4-tip scanning tunneling microscope will be presented featuring low temperatures less than 5 K, four independent tips for scanning and conductance measurements as well as a high resolution scanning electron microscope (SEM) and a super conducting coil providing a magnetic field of 25 mT.

The LT-Nanoprobe system has been developed in a collaboration between Omicron and the Peter Grünberg Institute. It is designed to provide excellent STM-qualities in scanning and spectroscopy, while being compact to be cooled down to LHE temperature. Further applications regarding (4-Point) conductance measurements of nanostructures benefit of a SEM resolution down to 20 nm to locate and contact nanostructures like quantum wires and Nanotubes.

System design and features will be discussed and first measurements will be presented.

O 16.8 Mon 16:45 WIL C307

Low Temperature Scanning Tunneling Spectroscopy on high quality Nb(110) films — •Matthias Stocker, Holger Pfeifer, Berndt Koslowski, and Paul Ziemann — Institut für Festkörperphysik, Universität Ulm, D-89069 Ulm, Germany

High quality Nb(110) films were prepared by evaporation onto (0001)oriented sapphire substrates at 850°C and analyzed in situ by Low Temperature Scanning Tunneling Spectroscopy (LT-STS). In this way, the superconducting gap in the quasi-particle density of states (DOS) of Nb(110) is investigated. The incomplete opening of this gap at 5.3 K can be attributed to the somewhat higher tip temperature of $\sim$ 7 K. Significant structures in the I-V data positioned symmetrically around zero energy and matching nicely known phonon energies of Nb indicate strong coupling behavior of this superconductor. These results suggest attempting an evaluation of the corresponding Eliashberg function, α^2 F(ω).