Processing at the Nanoscale/NANO 6
Room 302 - Session NS+NANO6+MC-WeM

Nanomechanical and Interface Measurements

Moderator: R.J. Hamers, University of Wisconsin, Madison

8:20am **NS+NANO6+MC-WeM1 Surface Acoustic Wave Investigation by UHV Scanning Tunneling Microscopy*, P.U. Voigt*, *S. Krauß, E. Chilla, R. Koch,* Paul-Drude-Institut für Festkörperelektronik, Germany

Recently we have shown that the scanning tunneling microscope can also be used to investigate surface acoustic waves (SAW) of 35 MHz by adding a high frequency sinusoidal signal to the dc tip voltage.@footnote 1@ Due to mixing with the SAW oscillation at the tunneling gap the tunneling current contains both amplitude and phase information of the SAW. Here we report on the first UHV compatible version of this technique including provisions for sample transfer and in situ surface preparation. Since both signal-to-noise ratio and spacial resolution are significantly enhanced, the acoustic oscillation of single atoms and monoatomic steps can be investigated. At present SAW frequencies up to 500 MHz have been successfully fed into the UHV system. @FootnoteText@ @footnote 1@ E. Chilla, W. Rohrbeck, H.-J. Fröhlich, R. Koch, K. H. Rieder, Appl. Phys. Lett.61, 3107 (1992) .

8:40am **NS+NANO6+MC-WeM2 Q-Control: Characterizing Highly Sensitive Surface Structures with the AFM*, B. Anczykowski,*** NanoAnalytics WWU Münster, Germany*; L.F. Chi, H. Fuchs,* Physikalisches Institut WWU Münster, Germany

When operating an atomic force microscope (AFM) in a dynamic mode the oscillation of the cantilever is influenced by non-linear interaction forces between the probing tip and the surface. In principle the instantaneous forces exerted on the sample while scanning the surface can be either repulsive or attractive. Experimental findings and corresponding computer simulations of the tapping mode show that by choosing appropriate system parameters the AFM can continuously be operated in the regime of net-attractive interaction forces. Thereby the risk of modifying the sample surface by the probing tip is minimized. However, in most cases the range in which the system parameters have to be adjusted is rather narrow and therefore a stable operation of the AFM in this interaction regime is difficult to achieve. With the help of the Q-Control module it is possible to reduce the damping of the dynamic system, i.e. to increase the effective quality factor of the oscillating cantilever and thereby to enlarge the regime of net-attractive interaction forces.@footnote 1@ This method allows to minimize the forces exerted by the probing tip on the sample surface. Therefore by applying Q-Control delicate and highly sensitive surfaces, such as ultrathin organic layers or DNA structures, can be characterized with high resolution. @FootnoteText@ @footnote 1@B. Anczykowski, J. P. Cleveland, D. Krüger, V. B. Elings, and H. Fuchs, Appl. Phys. A 66, S885 (1998).

9:00am **NS+NANO6+MC-WeM3 Traceability for Nanoscale Properties***, L.P. Howard,* ***J. Pratt,*** National Institute of Standards and Technology **INVITED**

The accuracy of nanoscale materials properties measurements ultimately depends upon the accurate determination of many SI units. When measurements are pushed into the nano-scale, many difficult circumstances arise due to what may be effectively described as a poor signal to noise ratio. This talk will highlight work involving the integration of interferometers into scanned-probe microscopes and work in traceable, sub-micronewton force measurements. Interferometry provides us the means to realize the meter. Several applications of sub-nanometer laser interferometry will be presented in the context of scanned-probe microscopes. Atomic lattice spacings have been measured using interferometers, and the expanding role of the atomic lattice in scanned-probe microscope metrology will be explored. Nanonewton force measurements are the subject of a new NIST project with the goal of improving traceability below the micronewton level. The unit of force is derived from the SI base units. Extending force measurement accuracy to the nanonewton level can require a combination of difficult dimensional, mass and electrical measurements. Our development of an electromagnetic balance capable of interfacing to scanned-probe instruments will be highlighted. With this new instrument (and a related electrostatic balance), we will explore the practical limits of using an electrical representation of the newton while attempting to extend our traceability chain back to a purely mechanical realization of force using mass and the earth's gravitational acceleration.

9:40am **NS+NANO6+MC-WeM5 Low Temperature Scanning Force Microscopy of the Si(111) 7x7 Surface and Site-specific Measurements of Tip-Sample Interaction Forces*, M.A. Lantz,*** *H.J. Hug, S. Martin, A. Abdurixit, A. Baratoff, R. Hoffmann, P. Kappenberger, P.J.A. van Schendel,* University of Basel, Switzerland*; Ch. Gerber,* IBM Research Division, Zuerich Research Laboratory*; H.-J. Guentherodt,* University of Basel, Switzerland

A low temperature scanning force microscope (SFM) operating in a dynamic mode in ultra high vacuum was used to study the Si(111)7x7 surface at 7.2K. Not only the twelve adatoms but also the six rest atoms of the unit cell are clearly resolved for the first time with SFM. In addition, the first measurements of the short-range chemical bonding forces above specific atomic sites are presented. The data is in good agreement with first-principles computations and indicates that the nearest atoms in the tip and sample relax significantly when the tip apex is within a few Å of the surface.@footnote 1@ New experiments with non-reactive tips reveal atomically resolved images with surprisingly different contrast from those obtained with a reactive tip. Careful analysis of frequency and damping versus distance curves clearly shows the obtained contrast does not result from the formation of a covalent bond, however atomic resolution is still obtained. This strongly suggests that true atomic resolution can be obtained with a new type of tip-sample interaction.The physical nature of this interaction mechanism will be discussed and compared to theoretical models.@FootnoteText@@footnote 1@Lantz et al., Phys. Rev. Lett 84, 2642 (2000).

10:00am **NS+NANO6+MC-WeM6 Simultaneous STM/nc-AFM Imaging and Force Spectroscopy of Si(100)-(2x1) Surface with Small Oscillation Amplitudes*, H.O. Ozer,*** *A. Oral,* Bilkent University, Turkey*; J.B. Pethica,* University of Oxford, UK

We have used a new, fiber interferometer based, high force resolution nc-AFM to image the Si(100)(2x1) surface with atomic resolution, using very small tip oscillation amplitudes down to 0.5 ?pp. The lever is dithered with the small oscillation amplitude at a frequency below resonance and the changes in the oscillation amplitude recorded simultaneously with force gradient and STM topography. With this method we can measure the force gradients quantitatively. Simultaneous images of Force gradient and STM topography have been recorded as a function of tunnel current and bias voltage. The effect of tunnel current and bias voltage on the force gradient contrast will be presented. We have also present force-distance curves between tip and Si(100) surface, measured with sub-Angstrom oscillation amplitudes.

10:20am **NS+NANO6+MC-WeM7 A Liquid Helium Temperature Ultrahigh Vacuum Dual-tip Scanning Tunneling Microscope*, H. Okamoto*,** *D. Chen,* Rowland Institute for Science

A dual-tip scanning tunneling microscope (D-STM) is a powerful instrument for investigating dissipative, diffusive, or ballistic transport phenomena of electrons in nanoscale structures.@footnote 1@ Here we present an ultrahigh vacuum compatible D-STM system working at liquid helium temperature for these new potential applications. Coarse positioning system consists of five rigid and compact inertial steppers, which has mechanical resonant frequency of ~900 Hz after integration. Each stepper has embedded capacitive position sensors with sub-micron resolution. An efficient new method, which we call tri-plane method, is used to navigate the two tips to proximity. The whole D-STM system is installed in a home-made vapor-cooled helium cryostat with a very low evaporation rate of 1.25 liter/day without liquid nitrogen radiation shield. @FootnoteText@ @footnote 1@Q. Niu et al., Phys. Rev. B 51 5502 (1995).

Author Index

Bold page numbers indicate presenter