O 34 Rastersondentechniken II

Zeit: Montag 10:45–13:00 Raum: TU EB407

O 34.1 Mo 10:45 TU EB407

Investigation of the statistics of stick-slip friction on graphite — •Lars Jansen[1,2], André Schirmeisen[1,2], and Harald Fuchs[1,2] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster — [2]CeNTech, Center for Nanotechnology, Gievenbecker Weg 11, 48149 Münster

The stick-slip mechanism is believed to be one fundamental process of atomic friction. It is described by the Tomlinson model for zero temperature [1]. In this model a tip jumps between two equilibrium positions of a surface potential. The lateral forces, inducing the jump are called jump heights. For finite temperatures these jump heights follow a statistical distribution due to thermal excitation [2]. We measured stick-slip friction on the atomic scale with an AFM and we will introduce a new analysis method to extract the statistical information i.e. the corresponding jump height histograms from the experimental data, acquired with a Si-tip on a vacuum cleaved HOPG surface under ultra high vacuum conditions. These histograms are in good quantitative agreement with the theoretical model [3]. From the histograms we can extract quantitative values for the effective energy barrier. We find that the energy barrier depends strongly on the exact position of the tip within the surface potential. As a result of this the theoretical model has to be expanded to two dimensions. Furthermore we can confirm that the histogram shape depends sensitively on the measurement parameters like scan speed and normal load, as predicted by the theory. [1] Tomlinson, Phil. Mag. 7 (1929), [2] Gnecco et al., PRL 84 (2000), [3] Sang et al., PRL. 84 (2001)

O 34.2 Mo 11:00 TU EB407

Interface dependent frictional forces: Study of amorphous and crystalline nanoparticles by dynamic scanning force microscopy — •Claudia Ritter[1], Udo D. Schwarz[2], Markus Heyde[1,3], and Klaus Rademann[1] — [1]Humboldt-Universität zu Berlin, Institute of Chemistry, Brook-Taylor-Str. 2, D-12489 Berlin, Germany — [2]Department of Mechanical Engineering, Yale University, P.O. Box 208284, New Haven, CT 06520-8284, USA — [3]Fritz-Haber-Institute of the Max-Planck-Society, Faradayweg 4-6, D-14195 Berlin, Germany

The fundamentals of friction, in particular, the interplay between friction, adhesion, true contact area and crystalline structure at the interface, are still insufficiently understood. In this investigation, antimony nanoparticles grown on HOPG and MoS2 were used as a model system to investigate the contact area dependence of frictional forces. The morphology of the nanoparticles was characterized by Scanning Force Microscopy (SFM) and Electron Microscopy (SEM, TEM). Thus, both the interface structure and the real contact area were accurately determined. The TEM study revealed a size dependent amorphous-polycrystalline phase transition. Controlled translation of the particles was induced by the action of the oscillating tip in dynamic mode SFM. During manipulation, the power dissipated due to tip-sample interactions was recorded. Particles with contact areas below 10000nm2 were much easier to move compared to their larger counterparts. We suggest that structural lubricity might be the reason for the low dissipation in the small amorphous particles, while elastic multistabilities might dominate energy dissipation in the larger polycrystalline particles.

O 34.3 Mo 11:15 TU EB407

Adhesion force measurements for well-defined probe - sample geometries — •Bert Stegemann, Henrik Backhaus, Heinz Kloss, and Erich Santner — Bundesanstalt für Materialforschung, BAM - VIII.1 Tribologie und Verschleißschutz, Unter den Eichen 44-46, D-12205 Berlin

Adhesion is of fundamental importance for the tribological behavior, e.g., in nanomechanical devices. A promising approach to determine interfacial adhesion at sub-micron scale is to measure pull-off forces with an atomic force microscope (AFM). As adhesion depends on numerous factors, such as contact area, environment and dynamics, there is still a lack of reliable quantitative data. Here, we report on a systematic analysis of AFM pull-off forces for well-defined systems under ultrahigh vacuum conditions. Interaction geometry is controlled by means of colloid AFM probes, i.e., microspheres attached at the end of bare AFM cantilevers. Clean sample surfaces of a wide range of single crystal metals and compound materials were prepared by subsequent Ar ion sputtering and annealing as affirmed by surface analytical techniques. The influence of experimental parameters, like applied load, contact time and contact area on the pull-off forces is discussed. The results obtained are compared with predictions from theoretical models and correlated with macroscopic mechanical properties of the materials.

O 34.4 Mo 11:30 TU EB407

Nanoindentation with Atomically Defined Tips — •Andre Schirmeisen[1] und Graham Cross[2] — [1]Center for Nanotechnology (CeNTech), University of Münster, Wilhelm-Klemm-Str.10, 48149 Münster — [2]SFI Trinity Nanoscience Bldg, Trinity College, Dublin 2, Ireland

An atomically defined tungsten asperity of 3 nm radius was fabricated and imaged by field ion microscopy and brought into contact with a Au(111) terrace in ultra-high vacuum conditions. The mechanical evolution of the asperity contact under cyclic indentation testing was monitored by a simultaneous load-displacement and electrical current-displacement measurement. Adhesive forces of 10 nN consistent with short range chemical bonding were measured. Compressive loads of up to 100 nN under displacements of 1.5 nm, equivalent to 5 atomic gold layers, were recorded. Load displacement curves of the pristine surface showed multiple pop-in events during loading, which indicate the creation of nanoscale dislocations in the sample material. More interestingly, during unloading, we found correlated pop-out events, which indicate the occurrence of complete self-healing of the induced dislocation. The energy dissipated during those reversable dislocation creation and healing events can be directly measured in our experiments. These values are in good agreement with recent molecular dynamics simulations of incipient plasticity in asperity contacts.

O 34.5 Mo 11:45 TU EB407

Atomic transfer and single-adatom contacts — •Laurent Limot[1], Jörg Kröger[1], Richard Berndt[1], Aran Garcia-Lekue[2], and Werner A. Hofer[2] — [1]Institut für Experimentelle und Angewandte Physik,Christian-Albrechts-UniversitÄat zu Kiel, D-24098 Kiel, Germany — [2]Surface Science Research Centre, University of Liverpool, Liverpool L69 3BX, United Kingdom

How do mechanical and transport properties change as matter is sized down to the atomic scale? Proximity probes like the Scanning Tunneling Microscope (STM), metal break junctions and related techniques, together with computational methods for simulating tip-sample interactions with atomic detail, have enabled to address this question by investigating atomic-size contacts to the surface. We employed a low temperature STM to investigate the point contact of the tunnel tip when approached towards Ag(111) and Cu(111) surfaces. On these metallic surfaces, a sharp jump-to-contact, random in nature, is observed in the conductance. Images acquired after point contact show that the tip-apex atom is transferred to the surface, suggesting that a one-atom contact is formed during the approach. In sharp contrast, the conductance over single silver and copper adatoms exhibits a smooth and reproducible transition from tunneling to contact regime. Numerical simulations indicate that this is a consequence of the increased stiffness of the adatom-contact.

O 34.6 Mo 12:00 TU EB407

Nanomechanical tuning of an optical near-field interaction resonance — •Thomas Taubner[1], Fritz Keilmann[2], and Rainer Hillenbrand[1] — [1]Nano-Photonics Group, Max-Planck Institut für Biochemie, 82152 Martinsried — [2]Abt. Molekulare Strukturbiologie, Max-Planck Institut für Biochemie, 82152 Martinsried

We use a scattering-type near-field optical microscope (s-SNOM) to experimentally demonstrate the controlled shift of a near-field optical polaritonic resonance. Therefore we study both amplitude and phase of light scattered from a metallic s-SNOM's tip probing a flat SiC sample, at mid-infrared frequencies where surface phonon polaritons resonantly enhance the tip-sample near-field interaction [1]. Especially, we concentrate on effects of varying the gap width between tip and the sample. We find that a decreasing distance causes a red-shift of the resonance, accompanied by strong optical phase changes [2]. Both effects can be explained by theory that treats the system as a point dipole (tip) interacting with its image dipole (sample), in electrostatic approximation.

Tuning the polaritonic resonance of a nanosystem by adjusting nanometric distances could be applied to control confinement and transport of light in nanoassemblies [2].

[1] R. Hillenbrand, T. Taubner and F. Keilmann, Nature **418**, 159 (2002)

[2] T.Taubner, F.Keilmann and R. Hillenbrand, Nano Letters **4**, 1669 (2004)

O 34.7 Mo 12:15 TU EB407

Crystallinity Mapping of SiC-surfaces by Infrared Near-field Microscopy — •Andreas Huber, Nenad Ocelić und Rainer Hillenbrand — NanoPhotonics Group, Max-Planck-Istitut f. Biochemie, Martinsried

We exploit phonon-enhanced near-field interaction [1] in an infrared scattering-type scanning near-field optical microscope (s-SNOM) for mapping the structural properties of SiC crystals at nanoscale resolution.

Imaging is done by a s-SNOM in which the probing tip of an AFM is illuminated by infrared light (λ = 9-11 μm). Along with the topography the backscattered light is recorded, thereby measuring the complex-valued optical near-field signal originating from the tip-sample near-field interaction. The scattered light exhibits a phonon-polariton resonance close to the LO-frequency in a polar material. The magnitude and spectral position of this resonance is extremely sensitive to the sample's local dielectric function ϵ. Thus this resonance acts as an optical fingerprint of the materials properties. This is experimentally confirmed by s-SNOM imaging of lattice damage in a 6H-SiC crystal induced by focused ion beam implantation (FIB)[2]. The sensitivty of this method is confirmed by differentiating 4H - and 6H - SiC polytypes at nanoscale resolution.

Altogether, spatial monitoring of the local phonon-resonance in s-SNOM could be a useful tool to characterise SiC.

[1] R.Hillenbrand, T.Taubner, F.Keilmann, Nature 418, 159-162 (2002).

[2] N.Ocelic, R.Hillenbrand, Nature Materials 3, 606-609 (2004)

O 34.8 Mo 12:30 TU EB407

Laterally resolved electrical characterization of ultrathin oxides — •Herbert Wormeester, Marko Sturm, Andrey Zinine, Radko Bankras, Jisk Holleman, Jurriaan Schmitz, and Bene Poelsema — MESA+ Institute for Nanotechnology, Universiteit Twente, Enschede, The Netherlands

A non-contact AFM with a conducting tip was used to image both the topography and electrical properties of a 2.5 nm thick aluminumoxide film on Si(001). These films were grown with Atomic Layer Deposition (ALD). Large protrusions are observed on the surface, whose contrast depends on the applied bias voltage. They are the result of an electrostatic interaction between tip and a fixed charge. A quantitative understanding of these features is only feasible if not only the image charge in the tip is evaluated, but also the image of the tip in the silicon is taken into account. The Contact Potential Difference (CPD) of the surface was evaluated with and without the use of lock-in technique (1f signal). The similarities and differences of these measurements will be discussed. A 60 mV change in CPD over the surface was found to correlate with the topography. The local variation of the capacitance (2f signal) was found to negatively correlate with the topography, i.e. a larger height correlates to a lower capacitance. On a siliconoxide film with similar thickness and roughness, a lower variation of the capacitance was found to be uncorrelated with the roughness. These seemingly conflicting results can be attributed consistently to different growth modes of the oxide films.

O 34.9 Mo 12:45 TU EB407

SNOM-Untersuchungen zur Beeinflussung der Plasmonenausbreitung durch strukturierte dielektrische Deckschichten — •Stefan Griesing, Andreas Englisch und Uwe Hartmann — Fachrichtung Experimentalphysik, Universität des Saarlandes, Im Stadtwald, 66123 Saarbrücken

Oberflächenplasmonen zeichnen sich durch zweidimensionale Ausbreitung an der Grenzschicht Metall/Dielektrikum aus. Im roten Spektralbereich ist die Propagationslänge maximal, und der Betrag der Tangentialkomponente des Wellenvektors (ktan) ist von derselben Größenordnung wie der des Wellenvektors im Dielektrikum. Untersuchungen wurden am System Silber/PMMA durchgeführt. Durch strukturieren mittels Elektronenstrahllithografie wurden im Dielektrikum Gebiete mit unterschiedlichem ktan erzeugt. Über die Änderung der Schichtdicke des PMMA zwischen 30 nm und 250 nm konnte der Wellenvektor im Vergleich zum System Silber/Luft bis zu einem Faktor 1,40 vergrössert werden. Zur Plasmonenanregung diente eine Kretschmann-Raether-Konfiguration. Mit dem SNOM ließ sich die Plasmonenfahne bis zu 100 Mikrometer entfernt vom einkoppelnden Laserspot detektieren. Es wurde das Verhalten der Plasmonen beim Auftreffen auf PMMA-Strukturen studiert. Der einfachste Fall des geradlinigen Übergangs von Gebieten mit PMMA-Deckschicht zu Gebieten ohne PMMA-Deckschicht zeigte eine winkelabhängige Ablenkung des Plasmonenstrahls in der Ebene, was durch ein Brechungsgesetz analog zur klassischen Optik beschrieben werden kann. Weiterhin wurde das Verhalten beim Auftreffen auf aus der klassischen Optik bekannte Elemente wie Linsen, Gitter und Prismen untersucht.