

## O 75: Nanotribology II

Time: Thursday 15:00–17:00

Location: H36

O 75.1 Thu 15:00 H36

**Atomic Friction on Electrode Surfaces** — ●NIKOLAY PODGAYNNY and HELMUT BALTRUSCHAT — University of Bonn, D-53117 Bonn, Germany

Friction under ambient conditions often involves wet surfaces, and thus electrochemical interfaces. Yet, measurements of friction at an atomic scale under electrochemical conditions are scarce. For HOPG, a change of friction forces at steps edges was observed with a change of potential. We recently started to measure friction by AFM and the influence of potential, Cu UPD on Au(111) and other parameters thereupon. We will present friction measurements performed on Au(111) single crystal electrodes and the effect of potential thereupon. Friction increases upon adsorption of anions (sulphate). An increase of friction is also observed at step edges. Here, a careful analysis is necessary to separate geometric effects from true changes of friction. The range of a normal force necessary to observe stick-slip resolution depends on the type of ionic adsorbates and tip radius. Atomic resolution is easily observed if sulfate anions are adsorbed on the gold or copper submonolayer surface. However, with the type of cantilever we used, it was not possible to observe stick-slip resolution on a monolayer of Cu on Au(111) and on Cu bulk deposits. In contrast to Coulomb's friction law the tip scan rate has an influence on the friction force, however, only when sulfate is adsorbed on the clean Au surface. Such effects were found and explained with conditions when atomic stick-slip occurs.

O 75.2 Thu 15:15 H36

**Frictional changes upon modification of single crystal electrodes with anions** — ●FLORIAN HAUSEN and ROLAND BENNEWITZ — INM - Leibniz Institute for New Materials, Campus D2 2, 66123 Saarbrücken

Considering that most tribological processes occur at a solid - liquid interface, friction measurements under electrochemical conditions are scarce. Compared to similar experiments in ultra high vacuum the surfaces are as clean and well defined. A unique tool offered by electrochemical methods is the possibility to alter the surface structure and to deposit various adsorbates by changing the applied potential at the working electrode.

We present friction force measurements on Au(111) and Au(100) single crystal electrodes performed by means of atomic force microscopy (AFM). The influence of a surface modification with anions is explored by using electrolytes containing sulphate. With adsorbing sulphate to the surface a strong increase of the friction force compared to the bare gold substrate is found. Furthermore we observe a strong correlation between friction forces and the anion structure. Complementary studies were done by using perchlorate, which is isoelectronic to sulphate but shows a different electrochemical behaviour. Additionally the effect of chloride on friction and wear due to the enhanced mobility of the surface atoms in the presence of chloride will be discussed.

O 75.3 Thu 15:30 H36

**Friction Induced Deformation of Microstructured Rubber Surfaces** — ●KATRIN BRÖRMANN and ROLAND BENNEWITZ — INM - Leibniz-Institut für Neue Materialien, Saarbrücken

In an attempt to bridge the gap between macroscopic and microscopic friction measurements, R. Bennewitz et al. [1] introduced a method to analyse friction by means of optical diffraction. In the experiment, a microstructured sample is dragged over a glass surface, resulting in a deformation of the sample due to friction. While sliding, a diffraction pattern of the surface structure is recorded and the strain across the contact, i.e. the average distance between the asperities, is extracted. Simultaneously, the force in normal and lateral direction is measured. PDMS samples with different periodically structured surfaces were used, representing a simple model of multi-asperity contacts.

In a second experiment, the deformation of the sample was observed in real space using an optical microscope. The movement and deformation of the surface structure was tracked and the local trajectories of specific sites on the patterned surface were recorded.

Results of both experiments indicate three phases in the deformation process: first shearing, then the transition from static to kinetic friction and last stick-slip motion. Furthermore, a 2D Poisson's ratio of the structure can be determined. Details on the phases will be presented and briefly compared to a recent theoretical model.

[1] R. Bennewitz et al., *J. Phys.: Condens. Matter* **20** (2008) 015004

O 75.4 Thu 15:45 H36

**Friction Force Microscopy on a Layer Compound with Organic Surfaces** — ●GREGOR FESSLER<sup>1</sup>, IWAN ZIMMERMANN<sup>2</sup>, THILO GLATZEL<sup>1</sup>, SASCHA KOCH<sup>1</sup>, PASCAL STEINER<sup>1</sup>, ENRICO GNECCO<sup>1</sup>, TONY KEENE<sup>2</sup>, SHI-XIA LIU<sup>2</sup>, SILVIO DECURTINS<sup>2</sup>, and ERNST MEYER<sup>1</sup> — <sup>1</sup>Dept. of Physics, University of Basel — <sup>2</sup>Dept. of Chemistry and Biochemistry, University of Bern

We investigated the surface structure of a layer compound crystal formed by a stack of copper oxalate layers sandwiched between stereoregular organic cations. Friction force microscopy in ultra-high vacuum on the (001) surface revealed a friction contrast between different molecular rows along the [100] direction. High resolution measurements were possible without any preparation of the sample in ultra-high vacuum. Excellent agreement with the experimental results is obtained with numeric simulations reproducing the scan process based on the phenomenological Prandtl-Tomlinson model in 2D.

O 75.5 Thu 16:00 H36

**Frictional properties of a mesoscopic contact with engineered surface roughness** — ●JOHANNES SONDHAUSS<sup>1,2</sup>, HARALD FUCHS<sup>1,2</sup>, and ANDRÉ SCHIRMEISEN<sup>1,2</sup> — <sup>1</sup>Institute of Physics, University of Münster, Münster, Germany — <sup>2</sup>Center for Nanotechnology (CeNTech), University of Münster, Münster, Germany

Friction force microscopy (FFM) is a standard tool to perform friction experiments on the nanoscale. However, with a conventional tip used in FFM, only contact areas of a few nm<sup>2</sup> are realizable. To get access to friction experiments with larger contact geometries typical for, e.g., MEMS, new concepts to prepare mesoscale tip-sample contacts are necessary. In this work, we used a focused ion beam (FIB) to engineer both sliding partners, i.e. tip and sample. Cantilever with spherical apexes with diameters of 5 and 16 μm were fabricated by attaching a titanium microparticle to the modified tips. To investigate the influence of interface roughness of the contact, a silicon surface was patterned with arrays of grooves with a lattice periodicity ranging from 1 to 9 μm and a depth of 26 nm. The average friction coefficient was determined systematically for the two tips as a function of the lattice periodicity of the sample grooves. For both tips the maximum friction force was found where the geometry of the spherical tip and the lattice are commensurate. These findings highlight the importance of surface structure on tribological properties of mesoscale contacts.

O 75.6 Thu 16:15 H36

**Oxygen-induced degradation of carbynoid structures on carbon surfaces: a DFT study** — ●GIANPIETRO MORAS<sup>1,2</sup>, LARS PASTEWKA<sup>1</sup>, PETER GUMBSCH<sup>1,2</sup>, and MICHAEL MOSELER<sup>1,3</sup> — <sup>1</sup>Fraunhofer Institut für Werkstoffmechanik, Freiburg (Germany) — <sup>2</sup>Universität Karlsruhe, Institut für Zuverlässigkeit von Bauteilen und Systemen, Karlsruhe (Germany) — <sup>3</sup>Albert-Ludwigs Universität Freiburg, Physikalisches Institut, Freiburg (Germany)

Carbynoid structures - sp-bonded carbon chains - have recently gained in importance in materials science as they have been reported to form during the growth of diamond-like carbon and nanostructured carbon films, as well as during diamond polishing. The interaction of these structures with air is crucial to the final structure of the deposited or polished surfaces. In particular, oxygen was found to cause the degradation of carbynoid structures. This may play an important role in the wear mechanism of the diamond polishing.

Here we present a DFT study of the oxidation mechanisms of carbynoid structures. Due to the lack of reference experimental studies specifically devoted to the oxidation mechanisms of supported carbon chains, the accuracy of our simulations is assessed by studying the oxidation of small cationic carbon cluster in the gas phase, for which detailed experimental data exist. This allows us to gain insight into unclear oxidation mechanisms of cyclic cationic carbon clusters. Moreover, the extension of our simulation approach to supported linear carbon clusters yields possible mechanisms for the oxygen-induced degradation of such structures.

O 75.7 Thu 16:30 H36

**Scaling laws in superlubric sliding of metallic nanoparticles** —

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If an interface between two incommensurate surfaces is atomically clean, a state of virtually frictionless sliding is anticipated, often referred to as 'superlubricity'. Theory predicts that the lattice mismatch at the interface causes a decrease of shear stress with increasing contact area, ultimately leading to vanishing friction. Analyzing the contact area dependence of superlubric friction should therefore confirm the concept of superlubricity. To measure the interfacial friction we have manipulated metallic nanoparticles of different size on atomically flat surfaces by contact mode atomic force microscopy techniques. An optimized experimental setup allowed us to quantify friction of nanoparticles which previously appeared to be sliding frictionless[1]. As theoretically expected, interfacial friction showed a nonlinear contact area dependence with a shear stress decreasing with contact area. This confirms the superlubric sliding of the nanoparticles under investigation. [1]Dietzel et al., Phys. Rev. Lett. 101, 125505 (2008).

O 75.8 Thu 16:45 H36

**Ultra-thin films as wear resistive coatings** — •TASSILO KAULE<sup>1</sup>, SASCHA PIHAN<sup>1</sup>, SEBASTIAN G. J. EMMERLING<sup>1</sup>, YI ZHANG<sup>1</sup>, RE-

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Here we report on developing and characterizing ultra-thin polymer films with certain mechanical and chemical properties. The films were deposited via plasma-polymerisation from the monomers hexamethyldisiloxane or norbornene. The variation of the reaction conditions, e.g. plasma power, reaction time, pulse modes and additional gases allow adjusting mechanical and interface properties like hardness or hydrophilicity. We discuss the feasibility of such ultra-thin films as mechanical protection layers for softer polymers such as polystyrene. In particular, we optimized the ultra-thin films for the use as a protection layer for storage media as used for thermomechanical probe based storage. The mechanical stability of the layered medium was tested with scanning force microscopy tribology tests [1], the thickness of the films were measured by profilometry and X-ray reflectivity measurements. Furthermore contact angle studies were performed to characterize the film surface. We found that film thicknesses < 10 nm can be used as suitable wear resistant protection layers for polystyrene but still allow thermomechanical read and write operations.

[1] R. Berger et al., Langmuir, 23, 3150 - 3156 (2007)