O 66: Nanotribology I

Time: Thursday 10:30–12:15 Location: H36

O 66.1 Thu 10:30 H36

Tuning mechanical properties of single silica capsules — •Doris Vollmer[1], Lijuan Zhang[1], Alfons van Blaaderen[2], Robert Graf[1], and Michael Kappl[1] — [1]Max Planck Institute for Polymer Research, Mainz, Germany — [2]Debye Institute for Nanomaterials Science, Utrecht University, Utrecht, The Netherlands

The shell's mechanical properties determine their stability and flow behavior. We investigated the mechanical properties of single silica shells by force-distance spectroscopy. The spherical capsules of different diameters (800 nm and 1.9 μm) and shell thickness (15 nm thickness 70 nm) were immobilized on a silicon substrate.

We probed the elastic response of the hollow particles by applying a point load, successively increasing the load until the shell broke. In agreement with the predictions of shell theory the deformation increases linearly with applied force for small deformations. For thicknesses larger than 20 nm the Young modulus is independent of shell thickness. However, it depends on the thermal history of the sample. It increases from 10 GPa for unheated shells to close to that of fused silica (80 GPa) after heating the hollow particles to 1100 °C. Heating transforms the large number of silanol groups into Si-Si bonds. This transformation leads to a compaction of the shells, which is reflected in a reduction of the diameter of the hollow particle as well as its shell thickness. Amazingly, tempering at 1100 °C induces smoothing of shells although the particles still remain spherical as shown by atomic-force-microscopy and scanning-electron-microscopy.

O 66.2 Thu 10:45 H36

Crystallographic Orientation Maps by Transverse Shear Microscopy (TSM) — •Quan Shen[1], Gregor Hlawacek[1], Markus Kratzer[1], Heinz-Georg Flesch[2], Thomas Potocar[2], Roland Resel[2], Adolf Winkler[2], and Christian Teichert[1] — [1]Institute of Physics, University of Leoben, 8700 Austria — [2]Institute of Solid State Physics, Graz University of Technology, 8010 Graz, Austria

For organic semiconductor devices (OTFTs, OLEDs and organic solar cells, etc.), the grain boundary and domain size of organic thin films have a strong effect on the final device performance [1]. In this work, we use transverse shear microscopy (TSM) to characterize crystallographic domains in a para-sexiphenyl (6P) polycrystalline thin layer [1] and a thiophene based self assembled monolayer (SAM). TSM is a special mode of conventional lateral force microscopy (LFM). The elastic anisotropy [2] in different crystallographic arrangements can be recognized by TSM sensitively. The generated TSM image can be considered as a Crystallographic Orientation Map to reveal information on shape, size, boundary and crystallographic orientation of domains in the molecular films.

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[1] G. Hlawacek, et al., Science, 2008, 321, 108-111.

[2] K. Puntambekar, et al., Adv. Funct. Mater. 2006, 16, 879-884.

O 66.3 Thu 11:00 H36

A miniature high vacuum microtribometer: from conception to calibration — Mikhail Kosinskiy[1], Yonghe Liu[2], Juergen A. Schaefer[1], and •Syed Imad-Uddin Ahmed[1] — [1]Institut für Physik and Institut für Mikro- und Nanotechnologien, TU Ilmenau, P.O. Box 100565, 98684 Ilmenau, Germany — [2]European Patent Office, Bayerstr. 115, München 80335, Germany

A newly developed microtribometer for evaluating the tribological performance of materials and coatings in vacuum and controllable atmospheres on the micro- and milli-Newton scale is presented. The microtribometer consists of a piezo driving table, an elastic force sensor and two laser interferometers to precisely detect normal and lateral deflections of the force sensor. The driving unit and the force sensor are located in the vacuum chamber, while the laser interferometers are installed outside. Force sensor deflections are measured with accuracy down to nanometers by focusing laser beams on small mirrors attached to the sensor. Various types of counterbodies can be attached to the sensor allowing examination of a wide variety of tribopairs. Results of friction tests of Si-Si tribopairs in ambient and vacuum conditions were performed using the UHV microtribometer and compared with measurements performed on a commercial microtribometer as well as with values published in literature using other types of tribometers.

O 66.4 Thu 11:15 H36

Wear-less floating contact imgaging of polymer surfaces — Armin Knoll, Hugo Rothuizen, Bernd Gotsmann, and •Urs Duerig — IBM Research GmbH - Zurich, Saeumerstrasse 4, 8803 Rueschlikon, Switzerland

An atomic force microscopy (AFM) technique is described combining two operating modes that previously were mutually exclusive: Gentle imaging of delicate surfaces requiring slow dynamic AFM techniques, and passive feedback contact mode AFM enabling ultra-fast imaging. A high frequency force modulation is used to excite resonant modes in the MHz range of a highly compliant cantilever force sensor with a spring constant of 0.1 N/m. The high order mode acts as a stiff system for modulating the tip-sample distance and a vibration amplitude of 1 nm is sufficient to overcome the adhesion interaction. The soft cantilever provides a force-controlled support for the vibrating tip enabling high-speed intermittent contact force microscopy without feedback control of the cantilever bending. Using this technique, we were able to image delicate polymer surfaces and to completely suppress the formation of ripple wear patterns that are commonly observed in contact AFM.

O 66.5 Thu 11:30 H36

Large-scale MD simulations of the contact and sliding of nanoscale metallic asperities — •Joël Peguiron[1] and Michael Moseler[1,2] — [1]Fraunhofer-Institut für Werkstoffmechanik IWM, Wöhlerstraße 11, 79108 Freiburg — [2]Physikalisches Institut, Albert-Ludwigs Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg

Molecular dynamics simulations of the tribology of nanoscale gold contacts are reported. Contact formation, sliding, and fracture between two asperities are investigated, bearing special interest on the mechanisms of material flow underlying these processes. In particular, the formation of long atomic chains, a known property of gold, is observed. The influence of the presence of a liquid lubricant is also explored. Large-scale simulations (hundreds of thousands atoms) are set up in order to make one step further, with respect to earlier works, towards connection with experiments from the literature.

O 66.6 Thu 11:45 H36

Friction on Graphene/SiC(0001) — •Christian Held and Roland Bennewitz — INM-Leibniz Institute for New Materials, 66123 Saarbrücken, Germany

Layers of graphene are grown on SiC(0001) samples by means of thermal decomposition in ultra-high vacuum [1]. The resulting structure consists of atomically flat terraces of SiC with a width of tens on nanometer, covered with single and bilayer patches of graphene. Single and bilayer coverage can be identified by Kelvin force microscopy. Strong friction contrast is observed across the surface structure when measured in situ by means of friction force microscopy. Friction on the SiC substrate is greatly reduced even by a single layer of graphene.

[1] K. V. Emtsev et al. , Nat. Mater. 2009, 8, 203.v

O 66.7 Thu 12:00 H36

Atomic stick-slip friction on a metal vs. a monolayer lubricant surface. — •Nitya Nand Gosvami, Philip Egberts, and Roland Bennewitz — INM-Leibniz Institut für Neue Materialien, Saarbrücken, Germany

We study friction at the atomic scale on a Au(111) surface with and without an alkanethiol self-assembled monolayer (SAM) coverage. The experiments were performed using an atomic force microscope (AFM), operated in ultra-high vacuum (UHV) conditions. On atomically flat terraces of Au(111), very low friction with clear atomic stick-slip instabilities was observed which did not vary with load in the low load regime. However, as the normal load was increased beyond a threshold, friction showed sharp rise with significant variation in magnitude and accompanied with irregular stick-slip events, indicating wear of the sur-

face. The striking observation of atomic stick-slip without dissipation can not be explained using existing classical models for single asperity friction. Our results also did not show agreement with a recently developed two-mass-two-spring model, which incorporates thermal effects. Alternate mechanisms for the observed friction behaviour are discussed.

We extended atomic scale friction studies to a SAM covered Au(111)surface. We found that the self-assembled molecules support atomic stick-slip friction where friction maps revealed the molecular superstructure of the SAM film. In several cases, frictional contrast down to single molecular level was achieved near the pull-off force.