



Kolloquium des
Zentrums für Materialforschung (LaMa)

Scanning Probe Microscopy

Freitag, 17. November 2017

Hörsaal C 5a, neue Chemie, Heinrich-Buff-Ring 19

- 14:15 Uhr** *Prof Dr. Ernst Meyer*
Departement Physik, Universität Basel, Schweiz
Superlubricity on the Nanometer Scale
- 15:15 Uhr** Break with Coffee and Cake
- 15:45 Uhr** *Prof. Dr. Karina Morgenstern*
Physikalische Chemie I, Ruhr-Universität Bochum
**Real-space investigation of microsolvation and its
influence on reactions**

Gäste sind herzlich willkommen!

Die Dozenten des Zentrums für Materialforschung

Kontakt

Dr. Thomas Leichtweiß
Zentrum für Materialforschung (LaMa) - Justus-Liebig-Universität Gießen
Heinrich-Buff-Ring 16 - 35392 Gießen - Tel.: +49-641-99 33601
<https://www.uni-giessen.de/lama> zfm@materialwiss.uni-giessen.de

Superlubricity on the Nanometer Scale

Ernst Meyer

Department of Physics, University of Basel, Switzerland

A number of experiments have demonstrated that superlubricity on the nanometer scale is possible. By reducing the normal loading of nanoscale contacts, it is observed that the energy barriers are reduced and below a defined threshold smooth sliding is found. This transition is described by a parameter, which compares the energy barrier to the stored elastic energy. An extension of this concept is to use oscillations in the direction normal to the contact, which leads to oscillations of the energy barrier and a transition to smooth sliding. Since the small contact reacts rather quickly, oscillations up to several MHz were found to be suitable for this type of experiment. Remarkably, the normal oscillations can be induced by small bias voltage modulations, which allows us to control the sliding conditions. Turning on and off the AC voltage leads to the transitions from stick slip to smooth sliding [1].

Another way to observe the extraordinary conditions of superlubricity is to change the commensurability of the contact, also called structural lubricity [2]. A recent example are the motion of graphene nano-ribbons (GNR) across the Au(111) surface [3]. In this case, the ribbons follow a preferred [-101] direction, where small frictional forces of the order of some pico-Newtons are observed. The forces are nearly independent of the length of the ribbon and the force per atom is decreasing for longer ribbons. Comparison with molecular dynamics simulations show that the contacts are incommensurate and that the remaining tiny forces are related to atoms at the border of the ribbons in contact with the surface. Superlubricity of nanoribbons seems to be a robust concept which can be extended to hundreds of nanometers. Theoretically, a breakdown of superlubricity is only expected for very long ribbons, where the elastic deformations become so large that commensurate areas occur, which leads to an increase of friction. An important aspect of this type of structural lubricity is the large elastic modulus of graphene, which leads to a very rigid behavior of the ribbon, keeping its atomic lattice constant and maintaining incommensurate conditions under shear. A second important pre-requisite is the absence of adsorbates at the interface. "Contaminated" contacts have the tendency to adapt a configuration in registry with the substrate, which leads to an increase of friction and loss of superlubric conditions.

Keywords: Friction force microscopy, Nanoscale superlubricity

References:

[1] A. Socoliuc, E. Gnecco, S. Maier, O. Pfeiffer, A. Baratoff, R. Bennewitz and E. Meyer, Atomic-scale control of friction by actuation of nanometer-sized contacts, *Science*, 313, 207-210 (2006).

[2] M. Diewiebel, G. S. Verhoeven, N. Pradeep, J.W.M. Frenken, J.A. Heimberg and Henny W. Zandbergen, Superlubricity of graphite, *Phys. Rev. Lett.* 92, 126101 (2004).

[3] S. Kawai, A. Benassi, E. Gnecco, H. Söde, R. Pawlak, X. Feng, K. Müllen, D. Passerone, C. A. Pignedoli, P. Ruffieux, R. Fasel, E. Meyer, Superlubricity of graphene nanoribbons on gold surfaces, *Science*, 351, (6276), (2016), 957.

Real-space investigation of microsolvation and its influence on reactions

Karina Morgenstern

Physikalische Chemie I, Ruhr-Universität Bochum

Solvation science aims at using the solvent to enhance and steer reactivity. However, there is little to no experimental evidence of the exact structure of solvents around molecules and thus very little is known about the solvent-solute interaction on a microscopic level. We use low-temperature scanning tunneling microscopy and ps-laser illumination to shed light on the interaction of individual water molecules with each other, with other molecules and how this influences the reactivity of photo-induced reactions. The systems discussed in this talk are benzene and azobenzene derivatives as prototypes for polar and bistable molecules, respectively.