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S E M I N A R Semiconductor Physics & Nanotechnology

Fr, 20.7.2018, 8:30 – 15:00 Uhr, Lecture Hall of Physics

(8700 Leoben, Franz-Josef-Strasse 18, main building, 2nd floor, next to library)

Minisymposium on "Advanced Atomic Force Microscopy"

8.30 Get together

8.50 Opening, Prof. Christian Teichert, Montanuniversität Leoben, Austria

9.00 High-speed Atomic Force Microscopy: A tool for direct visualization of single-molecule dynamics, Prof. Takayuki Uchihashi, Nagoya University, Japan

10.00 Extending the functionality of high-speed Atomic Force Microscopy: In-line force measurements to study microtubules, Dr. Christian Ganser, Nagoya University, Japan

11.00 Break and networking

11.45 Amphibious Force Measurements: Probing and modelling local Forces in Air and Water using Atomic Force Microscopy, Dr. Sidney R. Cohen, Weizman Institute of Science, Rehovot, Israel

12.45 Study of the local redox processes on transition metal oxides surfaces using Kelvin Probe Force Microscopy, Prof. Franciszek Krok, Jagiellonian University, Krakow, Poland

14.00 Closing remarks and networking with refreshments

15.00 End of Minisymposium

Attendance is free of charge, however, registration until Juli 14th at physics@unileoben.ac.at is required.

Organization: Christian Teichert, Institute of Physics, Montanuniversität

For further questions, please contact the symposium secretary, Mrs. Heide Kirchberger (physics@unileoben.ac.at).

ABSTRACTS

High-speed Atomic Force Microscopy: A tool for direct visualization of single-molecule dynamics

Prof. Takayuki Uchihashi
Laboratory of Biomolecular Dynamics and Function, Department of Physics, Nagoya University, Japan

Atomic force microscopy (AFM) does not possess spatial resolution as high as conventional techniques but is very unique in its ability to visualize individual protein molecules under a physiological condition. One of the most coveted new functions of AFM is “fast recording” because it allows us to visualize dynamic processes of biological molecules at work. We have been improving the imaging speed of AFM over a decade and recently established high-speed AFM (HS-AFM) which can capture successive images of protein dynamics with a frame rate less than 1 fps[1)]. In this talk, I will first introduce key devices which enabled fast AFM imaging. Then I will discuss about potential of the HS-AFM for studying conformational dynamics and function mechanisms of proteins by demonstrating recent successful imaging[2-4)].

References:
1. T. Uchihashi *et al*, "Guide to video recording of structure dynamics and dynamic processes of proteins by high-speed atomic force microscopy", *Nat. Protoc.* **7**, 1193-1206 (2012).
2. T. Uchihashi and S. Scheuring, “Applications of high-speed atomic force microscopy to real-time visualization of dynamic biomolecular processes", *BBA Gen. Sub.* **1862**, 229-240 (2018).
3. M. Shibata *et al*, "Real-space and real-time dynamics of CRISPR-Cas9 visualized by high-speed atomic force microscopy", *Nat. Commun.* **8**, 1430 (2017).
4. T. Uchihashi *et al*, "Dynamic structural states of ClpB involved in its disaggregation function", *Nat. Commun.* **9**, 2147 (2018).

Extending the functionality of high-speed atomic force microscopy: In-line force measurements to study microtubules

Dr. Christian Ganser
Laboratory of Biomolecular Dynamics and Function, Department of Physics, Nagoya University, Japan

One big advantage of atomic force microscopy (AFM) is the ability to perform nanoscale manipulation and probe mechanical properties in addition to imaging. In conventional AFM, the time between scanning a region on a sample, do a force measurement, and scan the region again can take as long as several minutes. If the dynamic reaction of a sample to the deformation is to be studied, a faster approach is desirable. To do so, high-speed AFM (HS-AFM) was modified to perform force measurements within a single AFM scan (hence: in-line). The time between finishing a force curve and resuming the scan is about 80 ms. Using this method, it was possible to study the creation of defects in microtubules (MTs) – self-assembled biopolymer tubes consisting of the protein tubulin – and observe the MTs capability to recover from sustained damage. Further, all force curves can be recorded at high temporal resolution and quantitative information such as bond energies between tubulin dimers in the MT lattice could be determined.

Amphibious Force Measurements: Probing and modelling local Forces in Air and Water using Atomic Force Microscopy

Dr. Sidney R. Cohen

Weizmann Institute of Science, Rehovot, Israel

One of the attractive features of the scanning probe microscope (SPM) is that it can function well in varied environments, including ambient, vacuum, and fluid. In this talk, I will describe two different studies which highlight this versatility, while measuring forces at the nanoscale. One study examines wetting behavior of individual nanotubes by water and shows how the nanotube radius influences the wetting behavior [1]. The other study probes the elastic [2] and tribological [3] properties of a unique surface with tunable stiffness. Modelling and atomistic calculations are compared with experiments to derive a detailed microscopic picture.

1) Goldbart et al, Proc. Nat. Acad. Sci. 113, 13624-13629 (2016)
2) Gotlib-Vainshtein, et al, J. Phys. Chem. C. 117, 22232-22239 (2013)
3) Gotlib-Vainshtein, et al Beilstein Journal of Nanotechnology 5, 1005-1015 (2014)

Study of the local redox processes on transition metal oxides surfaces using Kelvin Probe Force Microscopy

Prof. Franciszek Krok

Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland

Reduction-oxidation (redox) processes involve all reactions where oxidation state of atoms changes. In the case of oxide materials, vast majority of structural, chemical and physical properties are governed by the oxygen concentration and, subsequently, cation oxidation state. The only way to determine the chemical composition of their surface at the scale of single nanometers is to use Kelvin Probe Force Microscopy (KPFM), where the surface potential is directly mapped.

In this talk, an overview of KPFM principles followed by details on AFM instrumentation will be presented. In particular, the frequency modulation method of the non-contact AFM (NC-AFM) used in ultra-high vacuum conditions will be explained in details. Then, applications of KPFM for nanometer-scale characterization of electronic properties of transition metal oxides surfaces (i.e. TiO_2(110) and $SrTiO_3$(100)) due to high-temperature (up to 1000^{o}C) annealing under reducing conditions and in situ oxidation will be discussed.