2018 NanoScientific Forum Europe

Scanning Probe Microscopy (SPM)

NSFE 2018

10-12 October, 2018
TU Bergakademie Freiberg, Germany

Sponsored by Park Systems, TU Bergakademie Freiberg & NANOscientific Magazine

Program Overview

Wednesday, October 10

Time	Room	Event
9:00-10:30	Alte Mensa	Registration Meet and Greet Snack
10:30-10:45		Welcome
10:45-12:55		Invited Talks I / Nanomechanics & Electrical Characterization
13:00-14:00		*Lunch*
14.00-14:40		Contributed Talks I
14:45-15:25		*Nanobubbles* Session I
15:25-15:40		*Coffee Break*
16.00-17:00	Alte Mensa/ MVTAT	Hands-on-Session I
17:00		*Wrap-up / Transfer*
18:00-21:30		Fusing Science & People - Conference Dinner

Thursday, October 11

9:00-11:25		Invited Talks II / SPM Methodology
10:25-10:45		*Coffee Break*
11:30-12:10		Invited Talks III/ / SPM & Biological Applications
12:15-13:15		*Lunch*
13:15-14:15		Contributed Talks II
14:20-14:40		*Nanobubbles* Session II
14:40-15:00		*Coffee Break*
15:20-16:20	Alte Mensa/ MVTAT	Hands-on-Session II
16:20		*Wrap Up / Transfer*
17:00-18:30		terra mineralia Tour
18:30-20:30		Discovering Natural Treasures - terra mineralia Party

Friday, October 12

9:00-11:05		Invited Talks IV/ SPM & Nanostructuring
10:25-10:35		*Coffee Break*
11:05-11:45		*Nanobubbles* Session III
12:00-12:30	Alte Mensa/ MVTAT	Hands-on-Session III
12:45		Closing Remarks

Wednesday, October 10

Time	Room	Speaker	Title
10:45-12:55		Invited Talks I	Nanomechanics & Electrical Characterization
10:45		Michael Kappl, MPI for Polymer Research, Germany	From elasticity to capillarity in soft materials indentation
11:30		Tobias Cramer, University of Bologna, Italy	Atomic Force Microscopies to study Electronic Properties and Strain in Thin Films for Flexible Electronics
12:15		Cristiano Albonetti, CRN - ISMN, Italy	The Growth of Organic Ultra-thin Films on Silicon Oxides with Variable Vacancy States: a Scanning Force Microscopy Approach
13:00		*1:00 h*	*Lunch*
14:00-14:40		Contributed Talks I	
14:00		Kevin-Peter Gradwohl, Montanuniversität Leoben, Austria	Investigation of twin boundaries in CdZnTe for X-ray detector applications
14:20		Daniel Wesner, University of Siegen, Germany	Probing Surface Nanobubbles with Combined Fluorescence Lifetime Imaging and Atomic Force Microscopy
14.45-15:25		*Nanobubbles* Session I	
14:45		Urs Peuker, TU Bergakademie Freiberg, Germany	Detection of Hydrophobic Interactions on Rough Surfaces via Atomic Force Microscopy: from Measurement to Modelling
15:05		Paul Knüpfer, TU Bergakademie Freiberg, Germany	Evaluation of CP-AFM Force-Distance Curves: Limitations, Challenges and Possibilities
15:25		*20 min.*	*Coffee break*

Time	System	Location	Topic
16.00-17:00		Hands-on-Session I	
	XE-7	Alte Mensa	Non-contact vs. Tapping Mode
	NX10	Alte Mensa	Nanomechanical imaging (PinPoint) / FC
	XE-100	MVTAT	Liquid environment
	NX10	Alte Mensa	Piezoelectric Force Microscopy
			Kelvin Probe Force Microscopy
17:00			*Wrap-up / Transfer*
18:00			Fusing Science & People - Conference Dinner

Thursday, October 11

Time	Room	Speaker	Title
9:00-11:25		Invited Talks II	AFM Methodology
9:00		Lukas Eng, Technical University Dresden, Germany	Chemical Sensitivity for Scanning Probe Microscopy
9:45		Kristof Paredis, imec, Leuven, Belgium	Scanning Probe Microscopy for Future Semiconductor Devices
10:25		*20 min.*	*Coffee break*
10:45		Sang-il Park, Park Systems, S. Korea	The Latest Innovations in Atomic Force Microscopy and Its Related Techniques
11:30-12:10		Invited Talks III	SPM & Biological Applications
11:30		Francesco S. Ruggeri, University of Cambridge, UK	Revisiting the Early Aggregation of Amyloids by AFM Single Molecule Statistical Analysis
12:15		*1:00 h*	*Lunch*
13:15-13:55		Contributed Talks II	
13:15		Jiangtao Zhou, EPFL, Switzerland	Configurational identification of Hierarchically Twisted Amyloid Fibrils
13:35		Simonetta Croci, University of Parma, Italy	Cell Cytoskeleton: a Unconventional Target for Protons
13:55		Fabio Perissinotto, Elettra Sincrotrone Trieste, Italy	Atomic force microscopy to elucidate biological processes using model membrane systems: from signaling proteins to extracellular vesicles interactions
14:20-14.40		*Nanobubbles* Session II	
14:20		Lisa Ditscherlein, TU Bergakademie Freiberg, Germany	Approaches for the Detection of Nanobubbles on Technical Rough Surfaces via Atomic Force Microscopy (AFM) and Contribution of AFM Results to Engineering Processes
14:40		*20 min.*	*Coffee break*

Time	System	Location	Topic
15.20-16.20		Hands-on-Session II	
	XE-7	Alte Mensa	Non-contact vs. Tapping Mode
	NX10	Alte Mensa	Nanomechanical imaging (PinPoint) / FC
	XE-100	MVTAT	Liquid environment
	NX10	Alte Mensa	Piezoelectric Force Microscopy
			Kelvin Probe Force Microscopy
16:20			*Wrap-up / Transfer*
17:00			*terra mineralia* Tour
18:30			*Discovering Natural Treasures* - terra mineralia Party

Friday, October 12

Time	Room	Speaker	Title
9:00-11:05		Invited Talks IV	SPM & Nanostructuring
9:00		Steven de Feyter, KU Leuven, Belgium	"Controlling" Molecules on Surfaces: from DNA Dynamics to 2D Materials- Getting Close with SPM
9:45		Rigoberto Advincula, Case Western Reserve University, US	Nanostructured Films: Templated and Patterned Interfaces
10:25		*10 min.*	*Coffee break*
10:35		Christian Teichert, Montanuniversität Leoben, Austria	AFM based investigation and manipulation of organic nanocrystals on 2D materials
11:05-11:45		*Nanobubbles* Session III	
11:05		Edgar Schach, Helmholtz Institute Freiberg for Resource Technology, Germany	Investigation of Nano-Bubbles on Langmuir-Layers
11:25		Bent Babel, Helmholtz Institute Freiberg for Resource Technology, Germany	Characterizing Mineral Wettabilities on a Microscale by Colloidal Probe Atomic Force Microscopy

Time	System	Location	Topic
12:00-12:30		Hands-on-Session III	
	XE-7	Alte Mensa	Non-contact vs. Tapping Mode
	NX10	Alte Mensa	Nanomechanical imaging (PinPoint) / FC
	XE-100	MVTAT	Liquid environment
	NX10	Alte Mensa	Piezoelectric Force Microscopy
			Kelvin Probe Force Microscopy
12:45			Closing Remarks

From elasticity to capillarity in soft materials indentation

Dr. Michael Kappl
Max Planck Institute for Polymer Research, Ackermannweg 10 D-55128 Mainz , Germany

Wednesday, October 10, 10:45

For soft materials with Young's moduli below 100 kPa, quantifying mechanical and interfacial properties by small scale indentation is challenging because in addition to adhesion and elasticity, surface tension plays a critical role. Until now, microscale contact of very soft materials has only been studied by static experiments under zero external loading. Here we introduce a combination of the AFM colloidal probe technique and confocal microscopy to characterize the force-indentation and force-contact radius relationships during microindentation of soft silicones. We confirm that the widespread Johnson-Kendall-Roberts theory must be extended to predict the mechanical contact for soft materials. Typically, a liquid component is found within very soft materials like PDMS or hydrogels. With a simple analytical model, we illustrate that accounting for this liquid surface tension can capture the contact behavior. Our results highlight the importance of considering liquid components that are often associated with soft materials, during small scale mechanical contact.

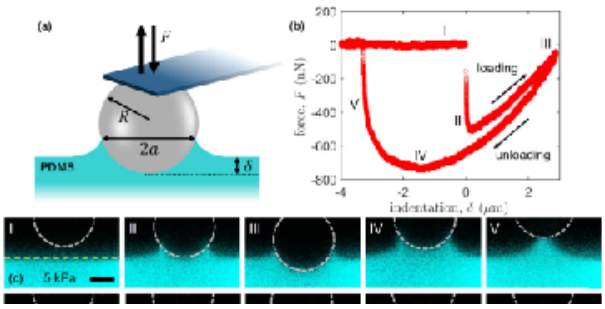


Figure 1: Measuring force, indentation, and contact geometry during indentation of soft solid surfaces. (a) Schematic of a colloidal probe in contact with a soft solid surface. The relevant parameters of force F, contact radius a, indentation δ, and the particle radius R are labeled. (b) A representative force-indentation curve measured by atomic force microscopy indentation on PDMS with E_{bulk} = 5 kPa and a maximum indentation depth δ ≈ 2.8 µm. (c) Corresponding cross-sectional images obtained by confocal microscopy of the labeled points on the force-indentation curve in part (b). The green dashed line represents the interface between solid and air, which is determined by measuring reflection at the surface. The gray circle represents the spherical probe as a guide to the eye. (d) Confocal images of indentation on PDMS with E_{bulk} = 400 kPa, illustrating the clear difference in contact deformation. Note that image III in (d) is not the maximum indentation but rather the same force as in (c) during retraction for comparison. The particle radius here is R = 6.5 µm. Scale bars: 5 µm.

Atomic Force Microscopies to study Electronic Properties and Strain in Thin Films for Flexible Electronics

Dr. Tobias Cramer
Dep. of Physics and Astronomy, University of Bologna, Viale Berti Pichat 6/2, Italy

Wednesday, October 10, 11:30

Flexible, large area electronics relies on materials and devices that combine electrical functionality with resistance to mechanical deformation. In order to address the full range of possible flexible electronics applications such as sensors, actuators or bioelectronic interfaces, a fast range of electronic materials ranging from conductors and semi-conductors to photoconductors, piezoelectrics or electrochemical interfaces has to be considered. Atomic Force Microscopy and its various derivatives allow to study the morphologies and electronic properties of such materials while they are subjected to mechanical strain. The resulting information provides crucial insight on how strain and electronic properties are

entangled at the nanoscale. In this tutorial presentation we will give an overview of the AFM techniques that we employ in the context of flexible electronics in our laboratory.(1, 2). In particular two techniques will be detailed: First, Kelvin Probe Microscopy used to study defect formation in organic semiconductors under strain. Second, AFM in liquid under electrochemical control to observe actuation and strain effects in conducting polymer interfaces.

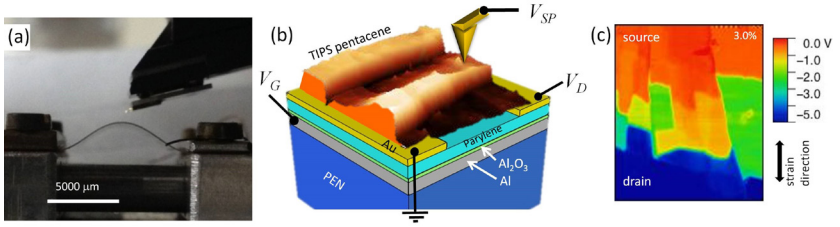


Figure: (a) Photograph of sample and AFM probe hand, (b) scheme showing the sample structure and applied potentials during SKPM, (c) SKPM potential map of transistor channel during 3.0% tensile strain. Abrupt changes in surface potential show local defects reducing charge carrier transport.

[1] S. Lai et al., Morphology Influence on the Mechanical Stress Response in Bendable Organic Field-Effect Transistors with Solution-Processed Semiconductors. Adv. Electron. Mater. 1700271, 1–9 (2017).
[2] T. Cramer et al., Direct imaging of defect formation in strained organic flexible electronics by Scanning Kelvin Probe Microscopy. Sci. Rep. 6, 38203 (2016).

The Growth of Organic Ultra-thin Films on Silicon Oxides with Variable Vacancy States: a Scanning Force Microscopy Approach

Dr. Cristiano Albonetti
Consiglio Nazionale delle Ricerche - Istituto per lo Studio dei Materiali Nanostrutturati (CNR-ISMN) via P. Gobetti 101, 40129 Bologna, Italy

Wednesday, October 10, 12:15

The master equation ruling the growth of organic films was proved by using the activation energy and the substrate temperature [1]. Ultra-thin films of sexithiophene (6T) were grown on Si/SiOx (native) substrates with increasing resistivity ρ from 0.0015 to 1000 Ω·cm. As shown by topographic images, organic films are composed of 6T islands (i.e. sub-monolayer regime) whose morphology is influenced by ρ. Surface coverage, shape, fractal dimension and height were used to probe the film growth mode. In particular, the fractal dimension Df [2] hints a Volmer-Weber growth mode for the highest ρ which evolves into a Stranski-Krastanov one for the lowest ρ. The Df evolution is non-monotonic, showing a maximum for mean resistivity (1-10Ω·cm) where the film follows the layer-by-layer growth mode (Frank-van der Merwe). By means of ρ, the substrate surface energy (i.e. the molecular diffusion energy Ed) has been systematically varied for describing the master equation together with the activation energy EN. These results are correlated to the decreasing of SiOx vacancy states for increasing ρ [3], underlying also the key role of electrostatic interactions in the nuclei formation.

[1] F. Dinelli et al. J. Phys. Chem. B 110, 258 (2006)
[2] F. Valle et al. Micron 100, 60 (2017)
[3] W.B. Ying et al. Appl. Surf. Sci. 181, 1 (2001)

Chemical Sensitivity for Scanning Probe Microscopy

Prof. Dr. Lukas Eng
Institute of Applied Physics, Experimental Physics / Photophysics, Hermann-Krone-Bau, Raum 91a, Nöthnitzer Straße 61, 01187 Dresden, Germanz

Thursday, October 11, 9:00

Material identification by chemically fingerprinting molecules and solids down to the 1-nm length scale is an ever-lasting dream and wish of the Scanning-Probe-Microscopy (SPM) community. Ultimately, this requests the careful analysis of the sample band structure and density-of states, through probing electronic or optical transitions between energy levels.
Both Scanning-Tunneling-Microscopy/Spectroscopy (STM/STS) [1] and Kelvin-Probe-Force Microscopy (KPFM) [2] are well suited SPM techniques to investigate the local electronic properties of materials. This allows to quantify surface reactivity and dangling-bond structure through local transport or electrostatic measurements down to the < 0.5 nm lateral resolution. In fact, this becomes very relevant for instance when inspecting modern-type 2D layered materials (as is graphene) allowing to deduce the degree of sp2-to-sp3 hybridization through quantum-capacitance inspections [3].
Moreover, optical near-field techniques based on scattering-type Scanning-Force-Microscopy (SFM) methodologies offer a manifold of different excitation energies to probe the local electronic and vibrational energy levels of the nanoscale sample system by optical means, and hence to deduce the relevant chemical identification. We have severely pushed this development of such techniques by combining standard non-contact SFM with optical excitation at vis, IR, NIR or THz wavelengths, with the result not only to indeed achieve the needed chemical fingerprinting [4,5], but equally to push the optical resolution limit by orders of magnitude below the diffraction limit: our (world) record measures ~ ג / 6000.
I will introduce into the methodology of all these chemically sensitive SPM techniques, and discuss their suitability upon relevant result and measurements obtained from different sample systems.

[1] J. Repp et al., Phys. Rev. Lett. 94 (2005) 026803.
[2] U. Zerweck et al., Phys. Rev. B 71 (2005) 125424.
[3] T. Wagner et al., Appl. Phys. Lett. 103 (2013) 023102.
[4] T. Firkala et al., Minerals 8 (2018) 118.
[5] J. Döring et al., Appl. Phys. Lett. 105 (2014) 053109.

Scanning Probe Microscopy for Future Semiconductor Devices

Kristof Paredis
imec, Remisebosweg 1, 3001 Leuven, Belgium

Thursday, October 11, 9:45

In this talk, the focus will be on scanning probe microscopy developments and results targeting future semiconductor devices and materials. A first example will cover Fast Fourier transform Scanning spreading resistance microscopy, a newly developed extension of SSRM for improved carrier profiling in devices. It allows to significantly increase the sensitivity and eliminate the impact of parasitic resistances. Secondly, the application of SPM for 2D materials in the context of imec is shown. For instance, with the help of conductive AFM and lateral force microscopy, we show that the electrical impact of grain boundaries is not confined to a single layer but extends across multiple layers. Thirdly, we will go in detail on theory and application of scalpel-SPM for obtaining 3D information with SPM, examples on Si, oxides and magnetic materials will be shown.

The Latest Innovations in Atomic Force Microscopy and Its Related Techniques

Dr. Sang-il Park
Park Systems Corp., KANC 4F, Gwanggyo-ro 109, Suwon 16229, Korea

Thursday, October 11, 10:45

Behind the bright scientific minds and their breakthrough discoveries are the scientific tools that enable them. To discover, one needs to visualize, measure and characterize the samples under investigation. As science moves into nanoscale world of research and development, Atomic Force Microscope (AFM) has been widely used as it provides various physical property information in nanometer scale resolution, not only in air but also in liquid and vacuum. However, conventional AFM suffers from measurement accuracy and operational complexity. In this talk, I would like to present the new, advanced AFM that has a separated x-y scanner from the z scanner, provides true non-contact mode, and renders automatic parameter setting capability. The new AFM not only provides quantitative data with high reproducibility, but it also operates as simple to use as a point and shoot digital camera. The new AFM PinPoint mode can precisely measure mechanical properties and electrical properties with controlled contact force at each measurement points. The nanopipette based Scanning Ion Conductance Microscopy (SICM) enables advanced Scanning Electrochemical Microscopy (SECM), Scanning Electrochemical Cell Microscopy (SECCM), as well as in situ live cell nano-microscopy. These new innovative advances in AFM will certainly help scientist around the world attain their coveted scientific breakthroughs.

Revisiting the Early Aggregation of Amyloids by AFM Single Molecule Statistical Analysis

Dr. Francesco Simone Ruggeri
Centre for Misfolding Diseases & Darwin College, University of Cambridge, United Kingdom

Thursday, October 11, 11:30

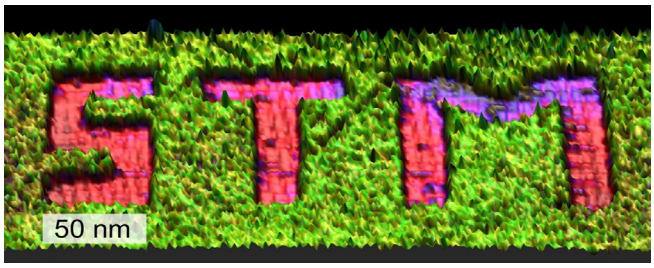
Today, more than 40 million people worldwide are affected by neurodegenerative disorders. These diseases are associated at the molecular level with the aggregation of protein into insoluble fibrils, termed amyloids. In particular, the formation and spreading in the brain of amyloid aggregates, formed from the presynaptic protein α-synuclein, play central roles in the pathogenesis of Parkinson's disease [1]. Increasing evidence suggests that the intermediate aggregates, rather than the final fibrillar products, are implicated in toxicity in vivo. However, the investigation of the interconversion of proteins into amyloid represents a formidable experimental challenge because of their nanoscale and heterogeneous nature [1-3]. Here, we use high-resolution Atomic Force Microscopy to investigate α-synuclein early oligomerization events at the single monomer scale with angstroms resolution [4].
For the first time, we identify on pathway elongated monomeric aggregates possessing sub-nanometer diameter, which we termed single strand protofilaments. We demonstrate that these new species form from the direct interaction and assembly of unfolded monomeric α-synuclein polypeptide chains. The single molecule scale identification and biophysical characterisation of the intermediate aggregates of amyloids provides forming during amyloid formation is fundamental to unravel their stability and to gain biophysical insights into their potential toxicity and role in pathology onset.

[1] Ruggeri et al., Current Pharmacological Design, 2016.
[2] Ruggeri et al., Angewandte, 2015.
[3] Ruggeri et al., Nature Communications, 2015.
[4] Ruggeri, Scientific Reports, 2016

"Controlling" Molecules on Surfaces: from DNA Dynamics to 2D Materials- Getting Close with SPM

Prof. Steven de Feyter
Department of Chemistry, Division of Molecular Imaging and Photonics, KU Leuven, Celestijnenlaan 200F, B-3001 Leuven, Belgium

Friday, October 12, 9:00



Combined STM imaging and STM nanolithography of functionalized 2D materials

The importance of scanning probe microscopy techniques to bring insight into a broad range of (bio) chemical and physical processes cannot be overestimated. In this contribution, our activities in apparently different worlds will be highlighted, ranging from DNA dynamics to the molecular functionalization of 2D materials, using advanced interface specific methods such as scanning tunnelling microscopy (STM) and atomic force microscopy (AFM), combining imaging, spectroscopy, and SPM based nanolithography.

Nanostructured Films: Templated and Patterned Interfaces

Prof. Rigoberto Advincula
Department of Macromolecular Science and Engineering , Case Western Reserve University, 2100 Adelbert Road, Cleveland, Ohio 44106, US

Friday, October 12, 9:45

Stimuli responsive polymers capable of eliciting response based on applied fields such as electrochemical, temperature, etc results in interesting properties from common functionality. Nanostructuring polymer brushes, molecularly imprinted polymer films, nanopatterned electropymerization, and other surface chemistries have been demonstrated effectively by the Advincula Research Group. Patterning and templating can be designed hierarchically to mimic bio inspired systems. Key to our effect characterization or reporting new phenomenon is AFM which can also be used as a patterning or writing tool.

AFM based investigation and manipulation of organic nanocrystals on 2D materials

Prof. Christian Teichert
Institute of Physics, Montanuniversität Leoben, Franz Josef Str. 18, 8700 Leoben, Austria

Friday, October 12, 10:35

Crystalline films of small conjugated molecules offer attractive potential for fabricating organic solar cells, organic light emitting diodes (LEDs), and organic field effect transistors (OFETs) on flexible substrates. Here, the novel two-dimensional (2D) van der Waals materials like conducting graphene (Gr), insulating ultrathin hexagonal boron nitride (hBN) or semiconducting transition metal dichalcogenides come into play. For the rod-like oligophenylene molecule parahexaphenyl (6P), atomic-force microscopy (AFM) reveals the formation of µm long crystalline nanoneedles - oriented close to the substrate's zigzag direction on exfoliated Gr [1] and hBN [2] as well as on chemical vapor deposited MoS2.
For the oligoacene derivate dihydrotetraazaheptacene (DHTA7), crystalline needles grow +/- 9° off the armchair direction of these substrates. For DHTA7 needle networks on hBN (acting as gate dielectric) for charge trapping and light-assisted charge spreading along the nanoneedles is observed using conductive AFM (C-AFM) and photo-assisted electrostatic force microscopy (EFM). We found that the organic nanocrystals are not conductive in the dark, while visible light - linearly polarized perpendicular to the long axis of the nanowires - allows spreading of the charges across the network for tens of micrometers.
Based on previous experiments of AFM based cutting of Gr [3], it will be demonstrated that by AFM based lateral manipulation of short segments - cut out of these needles - friction anisotropy with preferential sliding directions on the 2D materials can be probed. These directions originate from the complex epitaxial relation between the organic nanocrystals and the 2D substrates.

Work has been done in collaboration with A. Matković, J. Genser, G. Lin, A. Vukušić, M. Kratzer (University of Leoben), B. Vasić, I. Stanković, R. Gajić (University of Belgrade), B. Kollmann, D. Lüftner, P. Puschnig (University of Graz), Z. Shen, O. Siri, and C. Becker (Aix Marseille Université) and has been supported by Austrian Science Fund (FWF) through project I 1788-N20 and by Austrian Academic Exchange Services through the project SRB 09/2016.

[1] M. Kratzer, C. Teichert, Nanotechnology 27, 292001 (2016).
[2] A. Matković, et al., Sci. Rep. 6, 38519 (2016).
[3] B. Vasić, et al., Nanotechnology 24, 015303 (2013).

Investigation of twin boundaries in CdZnTe for X-ray detector applications

Kevin-Peter Gradwohl
Institute of Physics, Montanuniversität Leoben, Franz Josef Str. 18, 8700 Leoben, Austria

Wednesday, October 10; 14:00

Due to the good efficiency and high energy-resolution, $Cd_{0.9}Zn_{0.1}Te$ (CZT) is one of the most suitable materials for room temperature X- and gamma-ray detectors[1]. However structural inhomogeneities such as Te inclusions, dislocations, and grain boundaries diminish the device performance and need to be studied thoroughly[2-4]. A CZT bicrystal was cut from an ingot grown by a modified vertical Bridgman method[5]. The two CZT grains are separated by twin boundaries which are decorated by Te inclusions as shown in Figure 1a). Morphological sample characterization by atomic force microscopy revealed at least two crystallographically different twinning systems (see Figure 1b). Electron backscattering diffraction (EBSD) and infrared imaging confirmed that the main twinning system is the well-known coherent Σ=3, {111}-{111} system. There are steps in the twin plane which can only be described by addition of the lateral {112}-{112} twinning[6]. Morphological considerations of the bicrystal suggest even a third type of grain boundary.

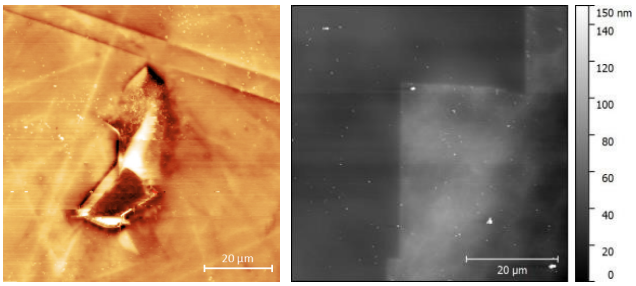


Figure 1. (a) Contact potential difference (CPD) map of a Te inclusion in CZT located at a {111}-{111} twin boundary measured by Kelvin Probe Force Microscopy, (b) AFM height image showing steps in the twin boundary of CZT consisting of {111}-{111} and {112}-{112} twins.

[1] Szeles C., CdZnTe and CdTe materials for X-ray and gamma ray radiation detector applications. Physica status solidi (b) 2004, 241.3: 783-790.
[2] He Y., Jie W., Xu Y., Wang Y., Zhou Y., Liu H. Wang T., Zha G., Dislocation-mediated coupling mechanism between the microstructural defects and Te inclusions in CdZnTe single crystals. Scripta Materialia 2014, 82:17-20.
[3] Xu Y., He Y., Wang T., Guo R., Jie W., Sellin P.J., Veale M., Investigation of Te inclusion induced glides and the corresponding dislocations in CdZnTe crystal. CrystEngComm 2014, 14: 417-420.
[4] Bolotnikov A.E., Camarda G.S., Carini G.A., Cui Y., Li L., James R.B., Cumulative effects of Te precipitates in CdZnTe radiation detectors. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 2007, 571.3: 687-698.
[5] Li G., Zhang X., Hua H. Jie W., A modified vertical Bridgman method for growth of high-quality Cd 1– x Zn x Te crystals. Journal of Electronic materials 2005, 34.9: 1215-1224.
[6] Durose K., Russel G.J., Twinning in CdTe. Journal of crystal growth 1990, 101.1-4: 246-250.

Probing Surface Nanobubbles with Combined Fluorescence Lifetime Imaging and Atomic Force Microscopy

Dr. Daniel Wesner
Chemistry and Biology, University of Siegen, Adolf-Reichwein Str. 2, 57068 Siegen, Germany

Wednesday, October 10; 14:20

The nucleation of surface nanobubbles in water dependent on the surface treatment and modification has been addressed by a new combination of fluorescence lifetime imaging microscopy (FLIM) and atomic force microscopy (AFM). Rhodamine 6G (Rh6G)-labeled surface nanobubbles nucleated by the ethanol–water exchange were studied on differently cleaned and treated glass surfaces by combined AFM-FLIM.

While the AFM data confirmed earlier reports on surface nanobubble nucleation, size, and apparent contact angles in dependence of the underlying substrate, the colocalization of these elevated features with highly fluorescent features observed in confocal intensity images added new information. PDMS and lubricants from needles of syringes have been added representing contaminations that might occur in measurements and showing a similar shape in AFM images as surface nanobubbles. All these structures accumulate Rh6G from solution leading to bright fluorescence. Nanobubbles could be distinguished from both contaminants by analyzing the characteristic contributions to the excited state lifetime of Rh6G in decay curves obtained from time-correlated single photon counting (TCSPC) experiments. The characteristic short-lived (~660 ps) component could be associated with an emission at the gas–water interface. Its colocalization with nanobubble-like features in the AFM height images provides evidence for the observation of gas-filled surface nanobubbles.

Configurational identification of Hierarchically Twisted Amyloid Fibrils

Jiangtao Zhou
Laboratory of the Physics of Living Matter, EPFL SB IPHYS LPMV, BSP 408 (Cubotron UNIL), Rte de la Sorge, CH-1015 Lausanne, Switzerland

Thursday, October 11, 13:15

Protein folding is of great significance in realizing organic functions and activities of living organisms. However, uncontrolled misfolding can result in amyloid fibrillogenesis which is associated with many amyloidosis and neurodegenerative disorders, such as Alzheimer's diseases. Intensive studies recently have enriched our knowledge on protein aggregation, but fibril polymorphism and related fibril-fibril interaction have not been fully understood.
Atomic force microscopy (AFM), as a powerful tool for studying biological systems, allows not only depiction on the profile of individual aggregate, but also provides a full picture of numerous aggregates which enables the study on general behaviors and aggregation mechanism of protein assembly. However, for amyloid fibrils with only a few nanometer in diameter, AFM convolution effect is the main barrier to access the fibril differences so that plenty discoveries by AFM are strongly limited. Nevertheless, AFM potential was not fully exploited. In this work, we took the advantage of high-sensitive AFM Z-detector with Ångström-level vertical resolution (2 Å) and low noise (0.2 Å) to statistically study on the profile of hierarchically twisted fibrils. By comparing statistical data in vertical direction, we are able to distinguish different classes of fibrils and further identify their configurations. Moreover, these results are capable of promoting our understanding on protein aggregation mechanisms and contribution of fibril-fibril interactions such as steric zipper effect and adhesion effect, that results in fibril polymorphism.

Cell Cytoskeleton: a Unconventional Target for Protons

Prof. ass. Simonetta Croci
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Thursday, October 11, 13:35

Attempting to describe the biological effects of ionizing radiations (IRs) radioscientists mostly looked for genomic DNA damages because of their structural and functional aspects. In fact, a large number of DNA damages and related repairing mechanisms are the subjects of assays aimed at validating the effectiveness of these reparation mechanisms. The goal of this work is to validate an assay capable of quantifying the damages born to whole cell cytoskeleton as target of protons, in the same way it's usually done for DNA. The irradiation experiments were performed with Hs 578Bst cells - non-cancer, non-immortalized, human breast epithelial cell line. Hs 578Bst cells might be compared to a healthy tissue neighbouring the breast cancer resected area. The cell line was irradiated with protons (total delivered dose 8Gy) at the Proton Therapy Centre of Trento (Italy). The day before the irradiation experiments, Hs 578Bst cells were seeded at the concentration of 8000cell/ml and after irradiations the plasmatic membrane was removed by means of mild denaturation. The purpose was to preserve cytoskeleton proteins as much as possible. After the plasmatic membrane denaturation, Hs 578Bst cells were fixed using a biological cabinet airflow to reduce chemical hazard. Finally, cells were scanned with atomic force microscopy (AFM) (non-contact mode and ambient conditions) and the image collection analyzed. The effects on the cytoskeleton of the irradiated Hs 578Bst cell structure were established and showed an appreciable loss of thin fibre networks embedded into the bigger fibre networks, forming the whole cytoskeleton structure. In spite of that Hs 578Bst cells did not show any remarkable irradiation induced morphological modification. Furthermore, no increase of mortality, beside the physiological rate, was registered. The study main purpose was selected because the cytoskeleton of Hs 578Bst cell line can be included on the list of IRs biological targets in the same way DNA was included years before. The next step will be the quantification of the cytoskeleton damages using a parameter able to quantify the loss of directionality. The cytoskeleton quantification damages were assessed by a designated linearity index starting from Hough Transform (HT). Although the parameter definition is still ongoing, because of the complexity of the cytoskeletal patterns from AFM images, several trials were accomplished. Once a fibre patterns was defined \"thresholds\" were used to eliminate artefacts or structures that are too small to be considered as intact. The second step was the selection of the fibres long enough for the interruption detection. Finally, the evaluation of the amount and the length of the fibres was possible. The isolation of the relevant structures, the application of certain constraints as well as the thresholds, were justified by the considerations of a strictly biological nature. Even though it is still not possible to quantify the cytoskeleton damages provoked by protons the obtained data lead to think the linearity parameter is suitable for assessing the irradiation damages of the cell cytoskeleton.

Atomic force microscopy to elucidate biological processes using model membrane systems: from signalling proteins to extracellular vesicles interactions

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Thursday, October 11, 13:55

Atomic force microscopy (AFM) is a powerful tool to study surface topography as well as molecular events of biological membranes. The high complexity and dynamics of cellular membranes led to the development of artificial model membrane systems that mimic the lipid and protein organization of cellular membranes.

The application of AFM to these systems allows measurements of the interaction of molecules with membrane at the nanoscale under physiological conditions. In this framework, we developed an AFM- and model membrane-based approach to study two biologicaland pathological events. We focused on artificial membranes that mimic lipid rafts, functional
microdomains of cell membrane that act as signaling platforms and are involved in several membrane processes.
First, we investigated the iron-mediated interaction of Alpha synuclein, the main protein of Parkinson's disease (PD), with artificial lipid bilayers that simulate a lipid raft organization. The key hallmark of the pathology is the aberrant misfolding and aggregation of this presynaptic protein which culminates in the formation of amyloid fibrils. We demonstrated the ability of iron to induce aggregation of the protein and a functional change of its binding to the membrane that might be associated with the disease.
Second, we studied the interaction of Extracellular vesicles (EVs) with model membranes of same lipid composition. EVs are small cell-derived vesicles ensuring transport of molecules between cells and throughout the body. Their small size and biological and physical functions make them optimal candidates for therapeutic agents in immune therapy, vaccination, regenerative medicine, and drug delivery. The characterization of biophysical and biochemical properties of EVs is crucial for the understanding of their interaction with recipient cells. AFM measurements indicate a strong interaction of EVs with artificial vesicles mimicking lipid rafts pointing out the importance of rafts-like structure in the uptake processes.

POSTERS

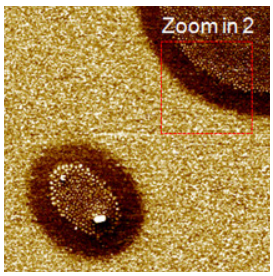
Characterization of the surface forces of pyrite in an acidic electrolyte
Christine Klinger, Physikalische Chemie, TU Bergakademie Freiberg, Germany

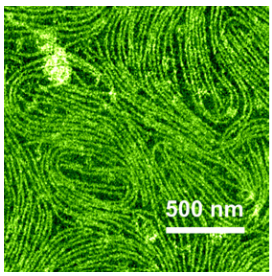
Investigation of structural inhomogenities and photoresponse of CdZnTe and doped ZnTe crystals on the nanometer scale
Kevin-Peter Gradwohl, Montanuniversität Leoben, Austria

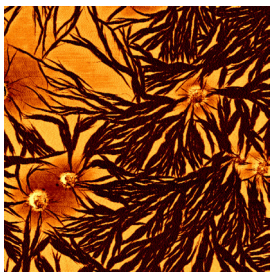
Magnetic structure dependence on plate thickness on Mn1.4PtSn
Belén Elizabeth Zúñiga Céspedes, Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

Studying mechanical properties and their changes by PinPoint™ nanomechanical mapping in air and liquid
Mina Hong, Park Systems, Suwon, South Korea

SmartScan Automatized atomic force microscopy for simple point-and-click imaging, producing expert level quality AFM images at high speed
Sang Joon Cho, Park Systems, Santa Clara, US







Detection of Hydrophobic Interactions on Rough Surfaces via Atomic Force Microscopy: from Measurement to Modelling

Prof. Urs A. Peuker
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Wednesday, October 10; 14:45

The investigation of hydrophobic interactions is in the scope of research for many years: En-gineering processes like agglomeration [1], filtration [2] and especially flotation [3] are highly influenced by hydrophobic forces and knowledge about their appearance and magnitude is of essential interest. Israelachvili and Pashley focused on hydrophobic interactions in 1982 [4]. Since then, it becomes clear that hydrophobic forces consist of a short-ranged and a long ranged part, whereby they have a totally different nature: short-ranged interactions are caused by a structuring of water molecules and, in most cases, the long-ranged part occurs from small cap-shaped bubbles. Such nanobubbles lead to capillary forces that increase adhesive interactions significantly [5].
In connection with the Collaborative Research Center 920 "Multi-Functional Filters for Metal Melt Filtration – A Contribution towards Zero Defect Materials" and the SPP 2045 "MehrDim-Part", the Institute of Mechanical Engineering and Mineral Processing has examined hydro-phobic interactions via atomic force microscopy for several years. We investigate particle-particle- and particle-plate interactions in water-based model systems under variation of mate-rial properties and develop adhesion force models for highly rough surfaces. By recording a large number of force distance curves (>1000) onto the samples, force distributions can be generated instead of a single value (e.g. average force) to get statistically valid results [6, 7]. If snap-ins are recorded during approach, the total force distribution can be split up in different distributions, which reflect the interaction mechanism. Here a distinction in VAN DER WAALS-, short-ranged hydrophobic and capillary forces caused by nanobubbles becomes possible [8].
This presentation gives an overview of the past and present work on hydrophobic interactions at the institute. Topics are the AFM data acquisition (XE-100, Park Systems), analysis and evaluation of the data and the subsequent development of an adhesion force model [9].

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Approaches for the Detection of Nanobubbles on Technical Rough Surfaces via Atomic Force Microscopy (AFM) and Contribution of AFM Results to Engineering Processes

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Thursday, October 11, 14:20

The investigation of nanobubbles via atomic force microscopy is a more than 15 years exist-ing branch of research [1]. Since this time, many investigations on nanobubble generation [2, 3], their size dimensions [4] and stability [5] were done and influencing AFM parameters on the scanning results were examined [6, 7]. Interestingly, in nearly all published work nanobub-bles are studied on smooth surfaces with roughness below 3 nm, like silanized mica or silicon wafers, polystyrene or HOPG. It is obvious that with the results of these studies a fundamen-tal understanding of nanobubble behaviour can be achieved. However, the main drawback of investigations on very smooth surfaces is the sometimes poor comparability with real engi-neering processes due to overarching mechanisms that are not detectable by applying ideal systems. For example, nanobubbles on smooth surfaces are cap-shaped with a circular inter-face onto the sample surface because it is energetically most favourable. On rough surfaces, their shape is less circular due to pinning effects.
In this study we detect and examine nanobubbles on technically rough surfaces (rms > 0.2 µm) and we will show the influence of the presence of nanobubbles on filtration experiments, on the particle adhesion respectively. Different nanobubble generation methods (spontaneous generation, tempera-ture gradient, ethanol-water exchange) are tested in a wa-ter-based model system for both AFM and filtration experiments.
The AFM studies are subdivided in two parts: forces spectroscopy and topographical scan-ning. With the combination of two different concepts of topological scanning the identification of nanobubbles on the rough surface becomes possible. By using the colloidal probe tech-nique [8, 9] adhesion forces between a rough particle and the rough sample are quantified. 2D mapping of adhesive forces pro-vides statistically valid results; force distributions give uncom-pressed information about the samples and impacts like wetting or roughness properties. Ad-hesion forces increase with a higher amount of nanobubbles, because of capillary bridging. Compared to smoother substrates, adhesion increases on rough surfaces due to this fact. Finally, we compare AFM results with filtration experiments in the mod-el system and under real conditions.

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Evaluation of CP-AFM Force-Distance Curves: Limitations, Challenges and Possibilities

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Wednesday, October 10; 15:05

The atomic force microscope is a mighty instrument in engineering or scientific work for characterization of state and behavior of materials at nanoscopic length scales. One of a variety of measuring methods is the colloidal probe atomic force microscopy (CP-AFM), which is particularly relevant in particle technology. A particle (permitted diameter 5-50 µm) is glued onto a tipless cantilever, which acts as probe for force measurements. This measuring setup allows force measurement between the colloidal particle and arbitrary surfaces or rather interfaces in the range of 10 pN – 30 µN in relation to their separation.
The shape and trend of the resulting force-distance curves indicates physicochemical properties and behavior of the investigated material system. However, there can occur measurement artefacts due to various disturbances, which sometimes makes it difficult to obtain reliable data from this sensitive measuring device.
This is one of the reasons why in many cases several force curves are recorded which can be evaluated via statistical analysis. These curves, coming from force maps, can be quickly evaluated in a Matlab®-routine which processes the data, finds certain points of the force distance curves and even calculates energies. Due to this measuring and evaluation method, it is possible to measure interaction force distributions out of thousands of measuring points. This allows not only a determination of forces between hydrophobic surfaces, but also the distinction between contact events with and without nanobubbles. The distinction can be made by interpretation of the shape of the force curves.
For some applications (e.g. interactions with deformable microbubbles), the range of the z-scanner of 10 µm is not enough and the force measurement of larger distances is necessary. In these cases, it is possible to move the cantilever with the stepper motor and record the signal of the position sensitive photo detector (PSPD). Challenges are the calibration of this system in order to calculate the forces from the measured signal. This study gives an overview of these two data acquiring methods and deals especially with their limitations and possibilities.

Investigation of Nano-Bubbles on Langmuir-Layers

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Friday, October 12; 11:05

The wettability of mineral surfaces is the key property determining the behavior of a particle in a flotation separation process. Further, this property can be influenced by the adsorption of collectors, chemicals that mostly consist of a hydrophobic chain group, which is directed into the pulp phase and a functional polar head group that adsorbs on the mineral surface. The resulting hydrophobic interaction of the particle and an air bubble is still discussed in literature but more and more authors refer to nano-bubbles on the particle surface as a possible explanation of these interactions. Such bubbles were investigated in dependence of various parameters as e.g. surface hydrophobicity and surface roughness via AFM-technology. The Langmuir trough allows building up well-defined monolayers of surfactants. Further, these monolayers can be deposited by Langmuir-Blodgett technique on different substrates to render their surface behavior. Such layers were subject to many investigations that often included a visualization via AFM. The aim of the presented study is to establish such techniques at the Helmholtz-Institute for Resource Technology in Freiberg using model systems that are already well described. Further, the techniques should be applied to systems that are more relevant for the flotation process. Therefore, the layers will be deposited on thin sections of minerals. Subsequently the structure of the layers can be investigated in dependence of different environmental conditions as e.g. pH or electrolyte concentration. A hydrophobization of the mineral surface can be investigated by either adhesion force measurements or a visualization and measurement of nano-bubbles.

Characterizing Mineral Wettabilities on a Microscale by Colloidal Probe Atomic Force Microscopy

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Friday, October 12; 11:25

The wettabilities of particle systems play a crucial role for the separation efficiency of flotation processes. The characterization of wettabilities of finely intergrown ores is limited in the applicability of standard techniques like Hallimond tube tests and contact angle experiments or renders them impossible due to a lack of sufficient samples in terms of quality and quantity. We present the utilization of an atomic force microscope with a hydrophobic colloidal probe to characterize the wettabilities of individual mineral grains on a microscale. A sulfidic ore sample containing chalcopyrite, pyrite and quartz is investigated in an aqueous environment. Force mappings on the respective minerals are performed and allow a distinction between quartz, chalcopyrite and pyrite with the resulting force distributions. An additional focus of this paper lies on the heterogeneities within one mineral surface domain and the applicability of grain mappings.

Conference Venue & Acknowledgements

Conference Venue

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