O 12: Scanning Probe Techniques: Method Development I

Time: Monday 15:00–17:00 Location: GER 37

O 12.1 Mon 15:00 GER 37

Performance boundaries of piezoelectric friction-inertia walkers due to the choice of contact materials — •Felix Huber, Susanne Baumann, and Sebastian Loth — University of Stuttgart, Institute for Functional Matter and Quantum Technologies, Stuttgart, Germany

High precision positioners are an important tool to realize and automate cutting edge experiments. Piezoelectric friction-inertia walkers enable high accuracy movement on the millimeter scale with nanometer resolution, which makes them essential to realize scanning probe microscopes. The working principle of these nanopositioners makes use of the friction-inertia principle [1]. Therefore, the choice of materials for the contact surfaces defines the performance limits and the reproducibility of stepwise motion. We use optical interferometry to determine the key performance parameters of a linear piezoelectric friction-inertia walker and test combinations of metallic and ceramic contact surface materials to improve the capabilities and reliability of high precision positioner devices.

[1] Z.M. Zhang et al. (2012) Int J Adv Manuf Technol 62, 669-685

O 12.2 Mon 15:15 GER 37

Surface tension measurement of microdroplets using AFM — •Pranav Sudersan[1], Mohammad Hormozi[2], Maren Müller[1], Shuai Li[1], Hans-Jürgen Butt[1], and Michael Kappl[1] — [1]Max Planck Institute for Polymer Research, Mainz, Germany — [2]Technical University of Darmstadt, Darmstadt, Germany

Surface tension is a physical property which is central to our understanding of wetting phenomena. One could easily measure liquid surface tension using commercially available tensiometers. However, these tensiometers are designed for bulk liquid volumes of the order of millilitres. In order to perform similar measurements on extremely small sample volumes in the range of femtoliters, Atomic Force Microscopy (AFM) is a promising tool. It was previously reported that by fabricating a special 'nanoneedle' shaped cantilever probe, a Wilhelmy-like experiment can be performed with an AFM. In our study, we carried out measurements on microscopic droplets with the AFM, but instead using standard pyramidal cantilever tips. The AFM tips were coated with a hydrophilic polymer brush, which reduced its contact angle hysteresis. Numerical simulations of a liquid drop interacting with a pyramidal geometry were used to calculate surface tension from the experimentally measured force. Our method eliminates the need for specially fabricated 'nanoneedle' tips, thus reducing complexity and cost of measurement, making it more suitable for widespread application.

O 12.3 Mon 15:30 GER 37

Modification of Fluid-FM Cantilevers for Studying Local Electrochemistry at Solid | Liquid Interfaces — •Matin Karimnia[1] and Timo Jacob[1,2,3] — [1]Institute of Electrochemistry, Ulm University, Ulm, Germany — [2]Helmholtz-Institute-Ulm (HIU), Ulm, Germany — [3]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Local electrochemical measurements at the solid | liquid interface are of particular interest to gain deeper insights into the structure-activity relationship for electrochemical systems. Atomic force microscopy (AFM), can be effectively used for *in situ* monitoring of electrochemical processes, including adsorption, and metal deposition[1−4]. For a better resolution of local phenomena, in this work, we present the use of Fluid-FM. Here the cantilever has a hollow microfluidic channel, allowing for probing electrochemical processes in the vicinity of the tip. This can be achieved by modifying the Fluid-FM cantilever to serve as a counter electrode in the electrochemical cell formed by the tip and the investigated substrate. The feasibility of the approach is demonstrated using a Au surface in contact with a diluted H_2SO_4 electrolyte. The influence of parameters such as the ratio between the surface area of the working electrode and counter electrode, as well as the volume of the electrolyte on the electrochemical performance is discussed.

[1] Seo, Yongho, *et al. Rep.Prog.Phys.* **71** (2007): 016101. [2] Oorschot, Ralph, *et al. Techn. Instrum.* **2** (2015): 1-11. [3] Zampardi, Giorgia, *et al. RSC Adv.* **5** (2015): 31166-31171. [4] Ossola, Dario, *et al. Phys. Rev. Let.* **115** (2015): 238103.

O 12.4 Mon 15:45 GER 37

Analysis of DNA-origami-based calibration standard for AFM using artificial intelligence — •Ziba Akbarian[1,2], Tim Johannes Seifert[1], Birka Lalkens[2], Ingo Busch[3], Harald Bosse[3], and Uta Schlickum[1,2] — [1]Technische Universität Braunschweig, Braunschweig, Germany — [2]Laboratory for Emerging Nanometrology (LENA), Braunschweig, Germany — [3]Physikalisch Technische Bundesanstalt, Braunschweig, Germany

In this investigation, we focus on a nanoscale-standard reference system for calibrating atomic force microscopes utilizing DNA origami. To introduce measurable protrusions on the DNA origami nanostructure, markers at well-defined positions have been attached. To analyze the nanostructures as accurately as possible, we propose the use of artificial intelligence (AI) based image analysis techniques. Commonly, evaluation of the obtained data from atomic force microscopes is performed manually and includes preparatory steps to visualize images before analysis. As a result, the data analysis process requires a lot of time and always introduces not-avoidable errors. We present an AI-based measurement procedure using the YOLOv5 object detection and a semantic segmentation network trained on synthetic data to crop origami structures and pixelwise locate markers, respectively. This way, we can achieve a relative calibration accuracy in the range of 1% with an automatic data evaluation tool.

O 12.5 Mon 16:00 GER 37

Interplay between magnetic and electrostatic forces when imaging complex current carrying stripline geometries with Magnetic Force Microscopy — Denis Goman, Dhavalkumar Mungpara, and •Alexander Schwarz — Institute of Nanostructure and Solid State Physics, University of Hamburg, Jungiusstr. 11, 20355 Hamburg

Current carrying strip-lines have been oftentimes used to calibrate the sensitivity of magnetic tips to perform quantitative magnetic force microscopy, because for this system the Oersted field can be calculated analytically. In these investigations possible electrostatic contribution to the measured signal have been usually ignored.

Our research focuses on more complex strip-line arrangements with meander and spiral geometries, which are part of a magnetometer. Current dependent magnetic force microscopy (MFM) images clearly show that the measured signal possesses a large electrostatic contribution, which, in a peculiar fashion, depends on the tip location. We find that electrostatic contributions stem from three sources: (i) the contact potential difference between strip-line and substrate material, (ii) the potential drop along the strip-line and (iii) an edge effect related to the finite size of the tip apex. This knowledge helps to disentangle magnetostatic and electrostatic contributions even for rather complex strip-line geometries.

This work has been conducted as part of the OXiNEMS project, which has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement No. 828784.

O 12.6 Mon 16:15 GER 37

Influence of Surfaces Charges and Trap States in KPFM Measurements of Doping Concentration — •Thilo Glatzel, Urs Gysin, and Ernst Meyer — University of Basel, Department of Physics, Klingelbergstr. 82, 4056 Basel, Switzerland

Kelvin Probe Force Microscopy is a scanning probe method for imaging the surface potential by atomic force microscopy. The surface potential is one of the most important surface properties and is correlated to e.g. the work function, surface dipoles, localized surface charges, and structural properties. It gives detailed information on the electrical properties and can be combined with optical and electrical excitation mechanisms providing additional properties like surface band bending and charge carrier mobilities. We will introduce the main concept and will briefly describe the major methods of operation. Based on the analysis of a Si super-junction device structures dopant profiling and the concept of surface photovoltage measurements will be introduced. The influence of local charge accumulation and trap states on these devices will be presented and the effect on the measured contact potential values will be discussed.

O 12.7 Mon 16:30 GER 37

Development of SNOM combining plasmonic picocavities with noncontact AFM — •Akitoshi Shiotari[1], Jun Nishida[2], Adnan Hammud[1], Martin Wolf[1], Takashi Kumagai[2], and Melanie Müller[1] — [1]Fritz-Haber Institute of the Max-Planck Society, Berlin, Germany — [2]Institute for Molecular Science, Okazaki, Japan

Scattering-type scanning near-field optical microscopy (s-SNOM) is a powerful tool to visualize the nanoscale optical response of sample surfaces. However, the resolution of conventional s-SNOM is usually limited by thermal instabilities of the tip-apex structure and the weak light intensities scattered from small volumes. On the other hand, it has been shown recently that light can be confined to the atomic scale using plasmonic picocavities. Here we demonstrate the development of plasmonic s-SNOM based on noncontact atomic force microscopy (nc-AFM) under the low-temperature and ultrahigh-vacuum conditions. A quartz tuning fork sensor with a Ag tip sharpened by focused ion beam milling enables precise control of the subnanometer tip-sample gap under illumination with visible laser light. The extremely high field enhancement and localization of light in the picocavity enhances the scattered light intensity and allows to image the optical response of samples at 1 nm resolution. The combination of ncAFM with plasmonic picocavities has high potential for atomic resolution optical imaging of various materials, including insulators.

O 12.8 Mon 16:45 GER 37

Polarization-sensitive scanning near-field optical microscopy — •Felix G. Kaps[1,2], Susanne C. Kehr[1,2], and Lukas M. Eng[1,2] — [1]Technische Universität Dresden, Germany — [2]Würzburg-Dresden Cluster of Excellence - EXE 2147 (ct.qmat), Dresden, Germany

Scanning near-field optical microscopy (SNOM) enables nanoscopic optical surface characterization at visible, infrared, and THz wavelengths [1], with applications to various research fields e.g. 2D materials, semiconductors, and in biology [2]. Here, typically the pure out-of-plane field components are considered. For resonant samples however, near-field excitation of all vectorial components becomes possible [3], enabling the full polarization analysis at the nanometer length scale.

In the work presented here, we examine the polarization-dependent near-field response of both non-resonantly (Au) and resonantly (SiC) excited samples at around 10.6 μm. By varying the incident linear polarization direction from s- to p-polarization, we are able to capture differently scattered near-field contributions, showing up in characteristic lobe-shaped polarization signatures. These results are confirmed by theoretical simulations, where we combine the analytic dipole model [5] and the Jones matrix formalism. Comparing the experiment with our simulations, we are able to disentangle the near-field‘s vectorial contributions via spectral and polarization analysis.

[1] T. Nörenberg etal., *ACS Nano*, **article ASAP** (2022)
[2] T.V.A.G. de Olivera et al., *Adv. Mater.* **33**, 2005777 (2021).
[3] H. Aminpour et al., *Opt. Express* **28**, 32316 (2020)