O 19: Poster Monday: Scanning Probe Techniques 1

Time: Monday 18:00–20:00 Location: P4

O 19.1 Mon 18:00 P4

Quantifying Force and Energy in Single-Molecule Metalation — Karl Rothe[1], •Nicolas Néel[1], Marie-Laure Bocquet[2], and Jörg Kröger[1] — [1]Institut für Physik, Technische Universität Ilmenau, D-98693 Ilmenau, Germany — [2]PASTEUR, Département de Chimie, École Normale Supérieure, PSL University, Sorbonne Université, CNRS, 75005 Paris, France

An atomic force microscope is used to determine the attractive interaction at the verge of adding a Ag atom from the probe to a single free-base phthalocyanine molecule adsorbed on Ag(111). The experimentally extracted energy for the spontaneous atom transfer can be compared to the energy profile determined by density functional theory using the nudged-elastic-band method at a defined probe-sample distance.

O 19.2 Mon 18:00 P4

Live demodulation of pseudo-heterodyne SNOM at kHz repetition rates — •Philipp Schwendke[1], Samuel Palato[1], Nicolai Grosse[2], and Julia Stähler[1] — [1]PC dept., FHI of the MPG and HU Berlin — [2]ELAB, FHI of the MPG

Scanning near-field optical microscopy (SNOM) allows the spectroscopic investigation of functional surfaces with spatial resolution beyond the diffraction limit. For the observation of electron dynamics on a femtosecond and nanometre scale, common setups rely on high repetition rate laser systems in order to avoid the Nyquist limit, imposed by signal modulation through the tapping AFM tip. Phase-domain sampling schemes allow sample rates below the Nyquist frequency, permitting the use of kHz-class optical amplifiers for tunable wavelengths down to the UV and femtosecond time resolution. We introduce quadrature demodulation for a robust and fast signal demodulation, while also simplifying the experimental setup.

Here, we illustrate and evaluate different methods for signal modulation and data analysis, with the aim of increasing the signal to noise ratio while maintaining high spatial resolution. The near-field contribution is identified through retraction curves, while noise and overall performance is evaluated on real-space images of a Si test sample, showing a significant signal contrast at high harmonic orders of tapping modulation. The presented methods are straightforward to combine with established optical methods, paving the way towards time-resolved SNOM and nano-spectroscopy.

O 19.3 Mon 18:00 P4

Designing a Scanning Probe Microscope to quantify electron correlations in novel 2D materials — •Nikhil Seeja Sivakumar, Henning von Allwörden, Daniel Wegner, Alexander Ako Khajetoorians, and Nadine Hauptmann — Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands

Quantum phases in a single or few layers of van der Waal materials often exhibit novel types of charge and spin orders that are driven by electron correlations. To understand the role of electron-electron interactions, it is required to quantify the interplay between the geometric structure, charges and spins at the atomic scale. Scanning tunneling microscopy (STM) and its accompanying magnetic mode, spin polarized STM, are powerful techniques to study the geometric, electronic and magnetic structure, but their application is limited to metallic or semiconducting quantum phases. Here, we present the design and setup of a home-built scanning probe microscopy setup working at 1K based on a JT-stage with 4He, operating in a 3T out-of-plane magnetic field. The setup will combine STM with non-contact Atomic Force Microscopy, Kelvin Probe Force Microscopy, and Magnetic Exchange Force Microscopy to independently study the geometric, electronic and magnetic structure in insulating quantum phases of 2D materials, as well as at phase transitions to conducting phases. A gating stage will allow to study 2D materials in a device geometry.

O 19.4 Mon 18:00 P4

Nanoscale capacitance and dielectric permittivity measurements — •Pascal Rohrbeck[1], Lukas Drago Cavar[1,2], Peter Reichel[2], and Stefan A. L. Weber[1,2] — [1]Max Planck Institute for polymer research, Department physics at interfaces, Ackermannweg 10, 55128 Mainz, Germany — [2]Johannes Gutenberg University, Department of Physics, Staudingerweg 10, 55128 Mainz, Germany

The knowledge of capacitance and dielectric properties in the nanoscale is important to understand the basic physics of semiconductor materials, such as solar cells or battery materials.[1]

In this work, we demonstrate quantitative capacitance and dielectric constant measurements of individual nanostructures using an Atomic Force Microscope (AFM). The new Heterodyne Scanning Capacitance Microscopy (H-SCM) method is based on frequency mixing of two alternating current (AC)-voltages with frequencies in the MHz range. This new method enables quantitative measurements of tip-sample capacitance and local dielectric permittivity with the lateral resolution of the AFM. We can show that the H-SCM reduces the effect of stray capacitance and thereby yields superior lateral resolution.

References:

[1] Fumagalli, L.; Ferrari, G.; Sampietro, M.; Gomila, G. Applied Physics Letters 2007, 91(24), 236243110. doi:10.1063/1.2821119

O 19.5 Mon 18:00 P4

Sphere Probes for Scanning Thermal Microscopy — •Sophie Rodehutskors, Fridolin Geesmann, Philipp Thurau, and Achim Kittel — Insitut für Physik, Carl-von-Ossietzky Universität Oldenburg

Scanning thermal microscopes based on STM and AFM have been used for years to observe near-field mediated heat transfer. Using custom-built coaxial thermocouple tips in an STM setup, spatially highly resolved heat transfer measurements are possible [1]. The total heat transfer between a spherically approximated tip and a sample is expected to depend on the square of the tip's radius [2]. By attaching a 20 μm borosilicate sphere to such a coaxial thermocouple sensor, heat flux sensitivity is further increased in distance-dependence measurements of the heat transfer between a cooled sample and a tip at room temperature for different materials. These sensors can be used for highly resolved radiative heat transfer measurements as well as for heat conduction measurements through self-assembled monolayers of organic molecules.

[1] K. Kloppstech et al., Nat. Commun., 8, 14475 (2017)
[2] E. Rousseau et al., Nat. Photonics 3.9, 514-517 (2009)

O 19.6 Mon 18:00 P4

A New Sensor Concept for Scanning Thermal Microscopy — •Marvin Glittenberg, Philipp Wiesener, and Achim Kittel — Institut für Physik, Carl von Ossietzky Universität Oldenburg

Near-field mediated heat transfer (NFMHT) between two surfaces separated by a vacuum gap has become a widely investigated topic in the past decades. To measure this phenomenon, we are using a self-developed near-field scanning thermal microscope (NSThM) based on an STM. It is equipped with self-made thermocouple tips consisting of a platinum wire molten into a borosilicate glass capillary which is then coated with gold. Since the gold layer can also be used as a tunneling electrode, we were able to measure the thermoelectric voltage and the tunneling current between the tip and sample simultaneously. However, the voltage drop due to the tunneling current interfered with the thermo voltage, making break junction experiments investigating heat and electrical conduction uninterpretable. In a new design of the tips for the NSThM, the thermocouple is covered first by an insulating silicon dioxide film and finally by a second gold film, which then acts as a tunneling electrode separate from the thermocouple and eliminates crosstalk. These tips are called PASA-tips due to the sequence of materials (platinum-gold-silicon dioxide-gold). Some example measurements of radiative heat transfer and heat conduction with these tips are shown to illustrate their capabilities.

O 19.7 Mon 18:00 P4

Implementation of a SPPX Setup and investigation of the delay-time modulation induced intensity modulation — •Marlo Teichmann, Georg Traeger, and Martin Wenderoth — V. Physical Institute, University of Göttingen, 37077, Göttingen, Germany

Shaken-pulse-pair-excited STM (SPPX-STM) successfully combines optical pump-probe techniques with STM to obtain high temporal and spatial resolution [1]. SPPX-STM achieves this by introducing a modulation of the delay time between pump- and probe pulses. The modulation of the delay time instead of the intensity leads to a constant thermal load and hence minimizes thermal effects. However, recent studies have shown that higher harmonics of this modulation causes additional undesirable signals in time resolved measurements [2].

In this study, we implemented a SPPX setup with two semiconductor lasers. These lasers can be triggered electronically which allows for delay times below 1ns between pump- and probe pulse. We implemented two different pump probe schemes to suppress the additional signals, caused by the SPPX-Method. By choosing an improved modulation scheme, we show that it is possible to suppress the contribution of the higher harmonic signals by more than one order of magnitude.

[1] Kloth et al. Rev. Sci. Instrum. 87 (2016)
[2] Takeuchi et al. 2019 Jpn. J. Appl. Phys. 58 SIIA12

O 19.8 Mon 18:00 P4

Grating Coupled Illumination with Image Recognition for Scanning Tunneling Microcopy under Highly Stable and Truly Localized Optical Excitation — •Georg A. Traeger[1], Marlo H. Teichmann[1], Benjamin Schröder[1,2], and Martin Wenderoth[1] — [1]IV. Physikalisches Institut, Georg-August-Universität Göttingen, Germany — [2]Max Planck Institute of Multidisciplinary Sciences, Göttingen, Germany

We present a versatile approach for a highly stable and localized optical excitation in a scanning tunneling microscopy (STM). Optical gratings on STM tips allow to excite a surface plasmon polariton (SPP), which travels to the tunneling junction and results in a highly confined optical excitation. Unfortunately, this technique comes with the drawback, that a much larger thermal load compared to the conventional direct illumination of the tunnel gap is introduced to the tip. This necessitates a high stability of the laser setup both in terms of long-term power stability and pointing[1]. The latter is limited by the mechanical decoupling of the STM from the environment, leading to independent movement of the microscope and the laser focus. We utilize an auto focus approach based on a CCD camera, which is aligned with the optical pathway of a fs-laser to achieve a active coupling between the laser and the STM. Studying ultrafast photo-currents in tunneling junctions we find that the new setup allows for STM operation under higly localized and background free illumination with a lateral resolution better than 2nm. [1] Kloth et al., Rev. Sci. Instrum. 87, (2016).

O 19.9 Mon 18:00 P4

Shot-noise measurements of single-atom Josephson junctions — •Verena Caspari, Idan Tamir, Christian Lotze, and Katharina J. Franke — Fachbereich Physik, Freie Universität Berlin, 14195 Berlin, Germany

Current passing through small constrictions fluctuates due to the discreteness of charge. Measuring this so-called shot noise in atomic-scale superconducting junctions can provide valuable information, from the quanta of charge transferred in multiple Andreev reflections to the correlations between the transmitted electrons in such processes. Here, we use a local shot-noise measurement apparatus, operating at low temperatures, to investigate shot noise in single-atom Pb-Pb junctions. We observe charge doubling inside the superconducting gap and an unexpected deviation from the thermal limit at zero bias voltage.

O 19.10 Mon 18:00 P4

Surface science with haptic feedback — •Maximilian Koall[1], Denis Heitkamp[2], Jaccomo Lorenz[2], Philipp Lensing[2], and Philipp Rahe[1] — [1]Universität Osnabrück, Barbarastraße 7, 49076 Osnabrück, Germany — [2]Hochschule Osnabrück, Albrechtstraße 30, 49076 Osnabrück, Germany

Modern scanning probe microscopy requires intuitive 3D tip positioning and direct access to 3D physical data for interpretation. Still, it is common practice to rely on time-consuming 2D control protocols with only very few approaches involving 3D virtual reality methods [1].

Here, we employ a haptic device for moving the tip at the microscopic scale by hand. An immediate feedback from the measurement signals that reflect the interaction of the tip with the sample is provided, allowing for a quick and intuitive exploration of conductivity landscapes and force fields at surfaces as well as for atom manipulation and tip preparation procedures.

We present the *offline* implementation for recorded data of the well-studied system PTCDA/Ag(111) in a virtual environment (Unity) for improved intuitive understanding of the physical properties. Furthermore, we discuss the approach to interface this system with the scan controller for *online* experiments. The 3D Systems Touch X is used to provide tip control and haptic feedback. The physical observable (tunneling current, frequency shift, damping, force or others) at the tip position in the recorded data is translated into haptic feedback.

[1] Leinen, P.; Green, M. F. B.; Esat, T.; Wagner, C.; Tautz, F. S.; Temirov, R. Beilenstein J. Nanotechnol. 2015, 6, 2148