O 104: Poster Session VIII: Scanning probe techniques: Method development III

Time: Thursday 13:30–15:30 Location: P

O 104.1 Thu 13:30 P

Ultra-high vacuum millikelvin scanning tunnelling microscope with adiabatic demagnetisation refrigeration — •Taner Esat[1,2], Peter Coenen[1,2], Andrea Raccanelli[3,2], Vasily Cherepanov[1,2], Xiaosheng Yang[1,2], Peter Borgens[1,2], Stefan Tautz[1,2], and Ruslan Temirov[1,2,4] — [1]Peter Grünberg Institute (PGI-3), Forschungszentrum Jülich, Germany — [2]Jülich Aachen Research Alliance (JARA), Fundamentals of Future Information Technology — [3]Cryo-Lab, Peter Grünberg Institute (PGI-3), Forschungszentrum Jülich, Germany — [4]II. Physikalisches Institut, Universität zu Köln, Germany

We describe the design of an ultra-high vacuum scanning tunnelling microscope that operates at millikelvin temperatures and high magnetic fields of up to 8 Tesla. Employing adiabatic demagnetisation refrigeration technique instead of the traditionally used 3He dilution refrigeration, we have built a very modular setup with outstandingly high stability, allowing STM experiments in very well controlled variable temperature conditions down to 26 millikelvin. To demonstrate the microscope's performance, we show the temperature-dependent scanning tunnelling spectroscopy data acquired on a superconducting Al(100) surface and discuss the factors determining the effective electronic temperature of the STM junction.

O 104.2 Thu 13:30 P

The Quantum Corral - Bond to an artificial atom — •Fabian Stilp[1], Andreas Bereczuk[2], Julian Berwanger[1], Nadine Mundigl[1], Klaus Richter[2], and Franz J. Giessibl[1] — [1]Institute of Experimental and Applied Physics, University of Regensburg, 93053 Regensburg, Germany — [2]Institute of Theoretical Physics, University of Regensburg, 93053 Regensburg, Germany

In 1993 Crommie, Lutz and Eigler first created a quantum corral, an adatom structure that confines surface state electrons on metal surfaces, and investigated discrete energy states inside the corral using scanning tunneling microscopy (STM) [1]. We revisit the same corral, a ring of 48 iron atoms on a Cu(111) surface with a diameter of 14.26 nm, with atomic force microscopy (AFM) to investigate the bonding of this artificial atom to the front atom of the AFM-tip. The measured forces on the order of 100 femtonewtons reveal a covalent attraction to metal tips and Pauli repulsion to CO terminated tips. This is familiar to the interactions of these tips with natural atoms, so one would also expect repulsive interaction for closer distances between the front atom of the metal tip and the quantum corral. It is not possible to measure this repulsive force, because the tip is not stable for closer tip-sample distances, but one can place the front atom of the metal tip inside the corral and investigate the change of the corral states with STM. The response of the states to this additional adatom indicates the expected repulsive force.

[1] Crommie et al. Science 262, 218 (1993)

O 104.3 Thu 13:30 P

Optimising conditions for high resolution SPM at room temperature — •Timothy Brown, Phil Blowey, and Adam Sweetman — University of Leeds, Leeds, UK

Non-contact atomic force microscopy has yielded enormous progress in the established field of scanning probe microscopy (SPM), with its ability to characterise materials at the atomic scale, and study chemical structures of individual molecules. Long acquisition times are typically required for system stability, which is often accomplished by operating at cryogenic temperatures. However if high resolution characterisation of species at room temperature is required, thermal non-equilibrium between the tip and sample poses a limit on acquisition time. Atom tracking can counteract the effects of thermal drift between the tip and sample. Measuring the displacement, and subsequent compensation thereof, using a feedforward correction, can be used as a means to correct the drift, a technique pioneered by Abe. et. al (2007). The net drift is liable to change continuously due to the surroundings, thus diminishing the accuracy of the applied correction. We describe a protocol, similar to that of Rahe. et. al (2011), by which the temperature in a ultra-high vacuum scanning tunnelling / atomic force microscope is stabilised at room level using a tuned feedback circuit, such that atom tracking, can be continuously used in order to take scripted, dense 3D data sets, even at room temperature.

References:

1. Abe, M. et al. Applied Physics Letters. 90, 203103 (2007).
2. Rahe, P. et al. Review of Scientific Instruments 82, 063704 (2011).

O 104.4 Thu 13:30 P

Single Atom Electron Spin Resonance Spectroscopy at High Magnetic Fields — •Piotr Kot, Robert Drost, Maximilian Uhl, and Christian Ast — Max Planck Institute for Solid State Research, Stuttgart, DE

In the last several years electron spin resonance spectroscopy (ESR) and scanning tunneling microscopy (STM) have been combined, introducing a new technique for studying spin dynamics on the atomic scale. Here, we present a next-generation ESR-STM with operating frequencies between 60GHz and 90GHz, which allows us to probe larger Zeeman energies than what has been previously reported. The instrument operates at a base temperature of 300mK, much lower than typical Zeeman energies in the operational frequency range. Spin systems are therefore thermally initialised to their ground state. We envision to take advantage of this to maximise the ESR-STM signal and ultimately implement coherent control at the nanoscale.

O 104.5 Thu 13:30 P

Statistical analysis of AFM images of nanofiber mats by grey-scale resolved Hurst exponent distributions — •Tomasz Blachowicz[1], Krzysztof Domino[2], Michal Koruszowic[1], Jacek Grzybowski[3], and Andrea Ehrmann[4] — [1]Silesian University of Technology, Institute of Physics - Centre for Science and Education, Gliwice, Poland — [2]Polish Academy of Sciences, Institute of Theoretical and Applied Informatics, Gliwice, Poland — [3]Silesian University of Technology, Faculty of Automatic Control, Electronics and Computer Science, Gliwice, Poland — [4]Bielefeld University of Applied Sciences, Faculty of Engineering and Mathematics, Bielefeld, Germany

Two-dimensional periodic or random structures can be classified by diverse methods. Nevertheless, quantitative descriptions of such surfaces are still problematic. While the statistical analysis of periodic fibrous structures by Hurst exponent distributions was suggested some years ago [1], the quantitative analysis of atomic force microscopy (AFM) images of nanofiber mats was only recently described [2]. Here we present the influence of typical AFM image post-processing steps, such as polynomial background subtraction, aligning rows, deleting horizontal errors or sharpening, on the grey-scale-resolved Hurst exponent distribution. Our results show that while characteristic features of these false-color images may be shifted by grey-channel and Hurst exponent, they can still be used to identify AFM images and, in the next step, to quantitatively describe AFM image of nanofibrous surfaces.

[1] T. Blachowicz et al., Physica A 452, 167-177 (2016)
[2] T. Blachowicz et al., Tekstilec 63, 104-112 (2020)

O 104.6 Thu 13:30 P

Nonlinearities in force microscopy cantilever oscillations — •Lukas Böttcher[1], Dominique Schneider[1], Jens Starke[2], Ingo Barke[1], and Sylvia Speller[1] — [1]Institute of Physics, University of Rostock, 18059 Rostock — [2]Institute of Mathematics, University of Rostock, 18051 Rostock

In dynamic force microscopy nonlinearities of the nanoprobe-surface interaction at small separations lead to deformed and bistable resonance curves of the cantilever oscillation [1-4]. To understand and control instable imaging conditions we acquire distance dependent frequency sweeps of the amplitude in dynamic atomic force-microscopy and determine frequencies of instability. We address the behavior on hard versus soft surfaces.

[1] Gleyzes et al. (1991), Appl. Phys. Lett. 58 (25), S. 2989*2991
[2] Hölscher, Schwarz (2007), International Journal of Non-Linear Mechanics 42 (4), S. 608*625
[3] Raman, et al. (2009), In: Morita, Giessibl und Wiesendanger (Hg.): Noncontact Atomic Force Microscopy: Volume 2. Berlin, Heidelberg: Springer Berlin Heidelberg, S. 361*395
[4] Stark (2010), Materials Today 13 (9), S. 24*32