O 34: Methods: Scanning probe techniques IV

Time: Tuesday 15:00–16:15 Location: H32

O 34.1 Tue 15:00 H32

Temperature Performance and Concept of an Ultra High Vacuum Compatible Dilution Refrigerator System for Scanning Tunneling Microscopy Applications — •Maximilian Assig[1], Fabian Zinser[1], Vladimir Shvarts[2], Zuyu Zhao[2], Christian R. Ast[1], and Klaus Kern[1] — [1]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany — [2]JANIS research company, USA

The investigation of novel physical phenomena implies the design and the construction of new setups and measurement techniques, which can break through instrumental limitations and open new areas in measurement accuracy. Scanning Tunneling Microscopy (STM) is a technique for probing the electronic structure of single adsorbed atoms and nanostructures at surfaces with atomic resolution. This contribution deals with the concept and performance of an ultra high vacuum (UHV) compatible dilution refrigerator (DR) system which is specially adapted for STM measurements in high magnetic field of 14 T perpendicular and 0.5 T parallel to the sample surface. We will give an overview of the temperature calibration in combination with base temperature and cooling power characterisation of our DR system. First tests of the STM head attached to the DR show heating at the tip and the sample due to the motion of the piezo in the scanning process. In idle conditions it was possible to reach a base temperature of 14mK at tip and sample. In addition, we will present further milestones in the project realisation.

O 34.2 Tue 15:15 H32

Design of a combined Scanning Tunneling / Atomic Force Microscope working at low temperatures — •Matthias Emmrich, Anja Merkel, and Franz J. Giessibl — University of Regensburg, Faculty of Experimental and Applied Physics, Universitätsstrasse 31, D-93053 Regensburg, Germany

It is well-known that Scanning Probe Microscopes (SPMs) can yield atomic resolution of surfaces in real space. Custom-built low-noise SPMs can push this envelope and yield chemical information [Sugimoto et al, Nature (2007)], sub atomic resolution [Hembacher et al, Science (2004)], spin contrast [Kaiser et al, Nature (2007)] and submolecular resolution [Gross et al, Science (2009)]. While many commercial microscopes are available, home-built microscopes do not need to sacrifice signal to noise ratio (SNR) in order to accommodate a wide variety of users.

Our goal is a microscope with a vibrational noise level well below 1 pm when operating at liquid He temperatures. Low temperatures reduce thermal motion and increase SNR. More importantly, however, is a stable tip-sample junction.

The current status and preliminary results of this new instrument will be presented.

O 34.3 Tue 15:30 H32

A sub-Kelvin scanning tunneling microscope with high energy resolution and high stability — •Lei Zhang and Wulf Wulfhekel — Physikalisches Institut, Karlsruhe Institut of Technology, Germany

We designed a new scanning tunneling microscope (STM) working at sub-Kelvin temperatures in ultra-high vacuum (UHV) in oder to study the magnetic properties on the nanoscale. Detecting excitations of single atoms and molecules, a high energy resolution instrument is needed. To achieve this, the set-up is operated at low temperatures and with high stability. A base temperature of 930 mK at the STM head is achieved using Joule-Thomson expansion of Helium-4, which can be reduced to approx. 400 mK when using Helium-3. Test experiments with a superconducting tip show a high energy resolution of 300 μeV when performing scanning tunneling spectroscopy (STS). The vertical stability of the tunnel junction is below 1pm (peak to peak) and the electric noise floor of tunneling current is about 6 fm/$\sqrt{Hz}$. The spatial drift is below 10 pm/h. Atomic resolution with a setpoint of 0.5 pA and 1 mV was achieved on Au (111). The set-up allow in-situ preparation of tip and samples under UHV condition. The fast cooling down of the samples (4h) guarantees high sample throughput.

O 34.4 Tue 15:45 H32

Quantum Point Contact Microscopy of a Noble Metal Surface — •Yong-hui Zhang[1], Peter Wahl[1], Jakob Bork[1,2], and Klaus Kern[1,3] — [1]Max-Planck-Institut für Festkörperforschung; Heisenbergstr. 1; 70569 Stuttgart — [2]Institut for Fysik og Nanoteknologi, and Interdisciplinary Nanoscience Center (iNANO), Aalborg Universitet, Denmark — [3]Institut de Physique des Nanostructures, Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland

Scanning tunneling microscopy is usually performed in the tunneling regime, with a tunneling junction conductance far below one conductance quantum ($G_0 = \frac{2e^2}{h} = 77.5\mu S$). Here, we present imaging of the noble metal (111) surfaces in point contact ($G \sim 1G_0$) by low-temperature STM. The point contact images routinely provide atomic resolution of the substrate. Details of point contact imaging are discussed exemplarily for Cu(111). Specifically, the threefold symmetric hollow sites of the hexagonal surface lattice are resolved. From an analysis of point contact images, the dynamics of the atomic contact is studied. A clear transition is found at a critical conductance G_c (e.g. $G_c \sim 0.5G_0$, G_c varies with STM tips) between two regimes. We propose a geometrical model to interpret point contact images below the critical conductance G_c which accounts for vertical relaxations. While the model works very well for conductances smaller than G_c, it clearly fails in the point contact regime at conductances above G_c. We discuss this finding in terms of relaxations of the tip-sample geometry.

O 34.5 Tue 16:00 H32

A calibration device for Scanning Thermal Microscopy based on the 3-ω-method — •Uli F. Wischnath, Adrian Czicholewski, and Achim Kittel — Energy and semiconductor research, Dept. of Physics, Univ. Oldenburg, 26111 Oldenburg

Near-field Scanning Thermal Microscopy (NSThM) measures the heating or cooling of a probe tip by a sample for distances of up to some nm [1]. The tip temperature has to be linked to theoretically calculated values of the heat flow for comparison with the theory of thermal near-field radiation.

We have constructed a calibration device for this purpose, consisting of a 4 μm thick glass fiber of about 5 mm length bridging two banks. The banks and the fiber are evaporated with a 80 nm thin metal film forming the heat source for the 3ω-method. The glass fiber has to be considered for the thermal properties while it merely serves as a passive support concerning the electrical properties. The thermal resistances for such composites are determined with the 3ω method to be of the order of 10^6 K/W. This value would not be accessible with a metal wire of sufficient mechanical stability.

A NSThM brought into tunneling distance forms an additional heat sink. The alteration of the 3ω signal is then used to quantify the heat flow corresponding to the thermovoltages.

[1] U. F. Wischnath, J. Welker, M. Munzel, and A. Kittel, Rev. Sci. Instrum.79, 073708, 2008.