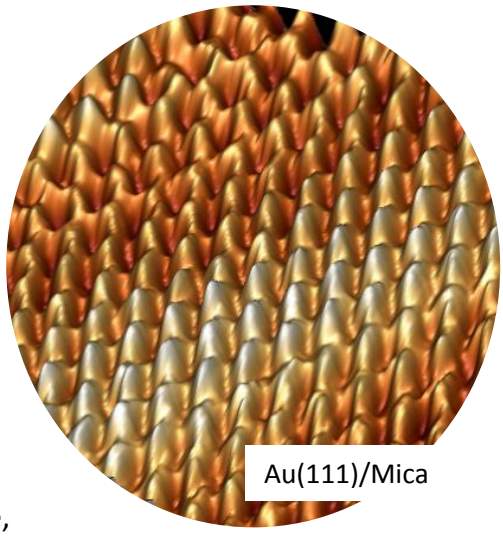
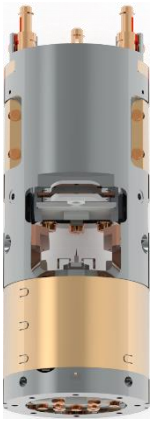
TRIBUS-Ultra SPM

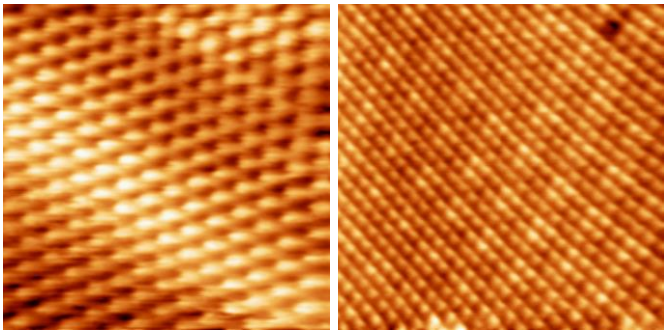
Evaluation of TRIBUS-Ultra SPM for operation at Low Temperatures and in High Magnetic Fields

TECHNICAL / APPLICATION NOTE


Au(111)/Mica

In cooperation with the group of Dr. Steffen Wirth from the Max-Planck-Institute for Chemical Physics of Solids (MPI for CPfS, Dresden, Germany) the Tribus-Ultra SPM head was successfully evaluated for operation in UHV, high magnetic fields and temperatures in the sub-Kelvin range. The group at the MPI for CPfS studies the electronic and magnetic structure, transport properties and the morphology of strongly correlated electron systems, in particular heavy fermion metals like $YbRh_2Si_2$ or $CeCoIn_5$. Some of the physical effects (like superconductivity or Kondo effect) and properties like the surface topography are studied by STM & Scanning Tunneling Spectroscopy as a function of temperature and applied magnetic field. The samples are often very small with lateral sizes of only a fraction of a square mm. Therefore, the STM head needs to be compatible with low temperatures and high magnetic fields and needs to be equipped with a 3D coarse navigation for sample/tip to enable a controlled positioning of the tip on these small samples.


TRIBUS-Ultra SPM head

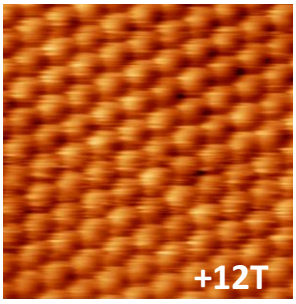

STM measurements: left) Au(111)/Mica @ T=670mK, U_{gap}=110mV, I_T=1.12nA; right) NbSe2 @ T=360mK, U_{gap}=130mV, I_T=0.8nA

The TRIBUS-Ultra was installed in a ^{3}He- Cryogenic STM UHV system with a base temperature of about 300mK and a superconducting magnet for vertical fields of maximum B=±12T. The SPM head is mechanically decoupled from the cryogenic system via spring suspension and thermally linked to the ^{3}He pot of the cryostat insert.

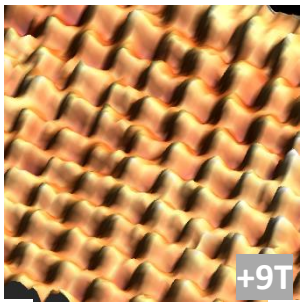
Measurements: Andreas Bettac, SIGMA Surface Science GmbH and Steffen Wirth, MPI for CPfS

Demonstration of compatibility with high magnetic fields

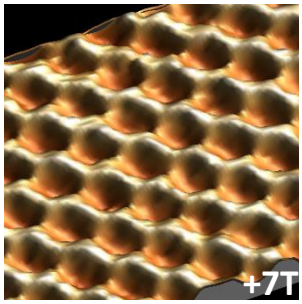
Because of its small atomic corrugation of only a few pm, a Au(111) sample was used as a reference to demonstrate the high stability of the TRIBUS STM head at low temperatures and in high magnetic fields. Over the full range from **B= -12T** to **B=+12T** atomic resolution on Au(111) has been achieved without any readjustment of the SPM system.



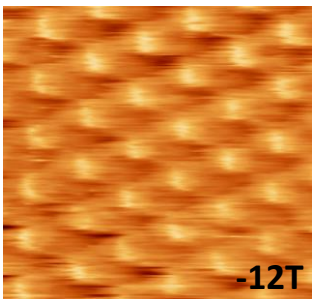
B=+12T, T=679mK
(U_{gap}=150mV, I_T=1.22nA)



B=+9T, T=589mK
(U_{gap}=120mV, I_T=0.72nA



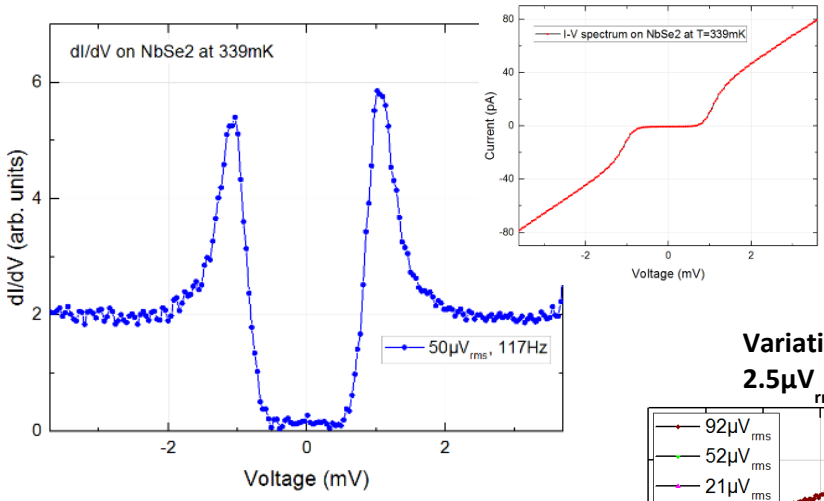
B=+7T, T=589mK
(U_{gap}=70mV, I_T=1.08nA)

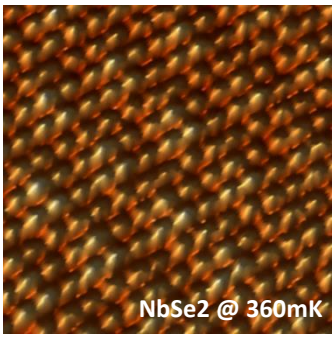


B=-12T, T=585mK
(U_{gap}=90mV, I_T=2.84nA)

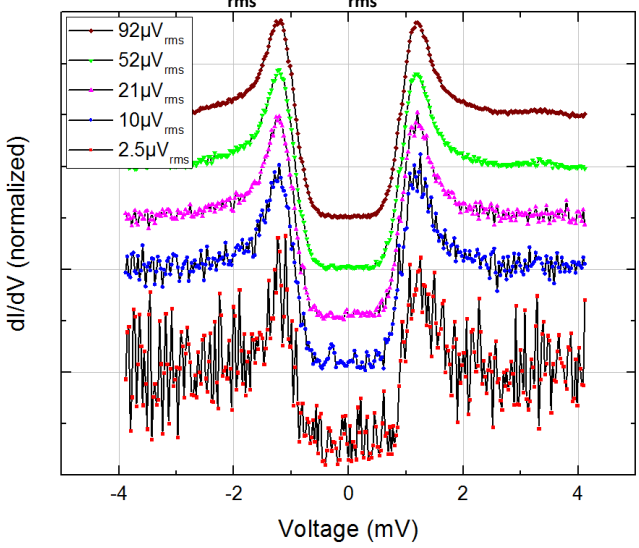
Tunneling spectroscopy

In addition to the integration of the TRIBUS SPM, the instrument setup was improved for optimum tunneling spectroscopy resolution. For evaluation of Tunneling Spectroscopy performance, a superconducting $NbSe_2$ sample was used.





Variation of Voltage modulation:
2.5μV$_{rms}$ – 92μV$_{rms}$ (470-500mK)



Every spectrum is a single spectrum (i.e. not averaged over several spectra) clearly showing the superconducting energy gap (200 points/spectrum; 117Hz; settling parameters: 7mV, 220pA). The amplitude of the modulation voltage can be reduced to far below 100μV_{rms} to ensure that the energy resolution is mainly dominated by the STM temperature and not by the modulation voltage.

Measurements: Andreas Bettac, SIGMA Surface Science GmbH and Steffen Wirth, MPI for CPfS