ATOMIC RESOLUTION AFM AT LOW TEMPERATURES USING THE QPLUS SENSOR

M. Maier
Omicron NanoTechnology GmbH, Limburger Str. 75, D-65232 Taunusstein, Germany
Phone: +49 6128 987 297, Fax: +49 6128 987 33 297
Email address corresponding author: m.maier@omicron.de

Over many years, low temperature STM has been established as an advanced imaging and spectroscopy tool in various scientific fields such as inelastic tunnelling spectroscopy (IETS) on single molecules or manipulation on the atomic scale. However, the creation and investigation of nano-structures on insulating surfaces gains more and more interest an thus push AFM as an alternative and complementary imaging technique. Ideally, the used AFM probe should simultaneously or alternatively work in STM and STS modes and not compromise on performance. Based on a proven LT STM platform, we have integrated a QPlus [1,2] sensor for atomic resolution AFM while maintaining ease of use and level of STM performance. Especially at low temperatures and related spatial constraints, this self-sensing AFM technique is an ideal alternative to cantilever based optical detection.

The QPlus sensor [1,2] employs a quartz tuning fork for force detection in non-contact AFM operation mode. One prong of the tuning fork is fixed while the SPM probe tip is mounted to the second prong. It thus acts as a quartz lever transforming it's oscillation into an electrical signal as a result of the piezo-electric effect. The feedback signal is based on frequency shift originating from tip-sample force interaction.

A dedicated pre-amplification technique ensures distance control based on the pure vibrational signal. Perfect separation of the tunnelling current is important when working on conducting samples, since tunnelling at the oscillation reversal point of the lever can easily dominate the feedback signal. In addition, extremely low signals require the first amplification stage to be very close to the sensor, i.e. to be compatible with low temperatures.

Measurements on Si(111) 7x7 show that tunnelling current and vibrational signal are clearly separated. We have been using wet-chemically etched tungsten tips, which allow the sensor to be simultaneously or alternatively operated in STM mode. In addition, benchmark measurements on NaCl with a typical corrugation of approx. 10pm prove that resolution on insulation samples is competitive to best cantilever based AFM results.

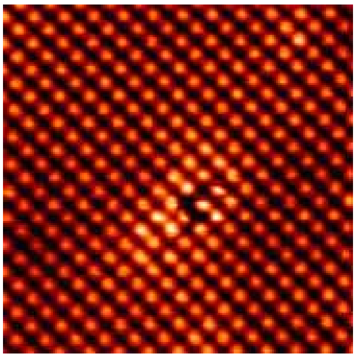

Image: Atomic resolution on NaCl(100) using QPlus force detection (no filtering applied). Lattice constant 5.65 Å (fcc), typical corrugation 10pm. Imaging parameters: scan range 6 x 6 nm^2, df = -2Hz, $f_{res} \approx 25230$Hz, Q = 36671, oscillation amplitude $\approx 1.5nm_{pp}$.

[1] Franz J. Giessibl, Appl. Phys. Lett. **73**, 3956 (1998)
[2] Franz J. Giessibl, Appl. Phys. Lett. **76**, 1470 (1998)