MI 4: Scanning Probe Microscopy

Time: Tuesday 11:15–12:00 Location: MER 02

MI 4.1 Tue 11:15 MER 02

Towards the measurement of atomic-scale forces associated with a superconducting transition — •Angelo Peronio and Franz J. Giessibl — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstraße 31, D-93053 Regensburg, Germany

The superconducting phase transition alters the electron energy spectrum of a metal, opening up a gap in the density of electronic states around the Fermi energy. The width of this is gap few meV at most, reflecting the strength of the interaction that binds the electrons in superconducting Cooper pairs. This modification of the electronic spectrum, albeit slight, is sufficient to reduce the friction of a niobium surface by a factor of 3 across the superconducting transition temperature [1].

Driven by this evidence, we will present an attempt to detect atomic-scale forces associated with the superconducting transition. In particular, we investigated a well-defined test system with a qPlus AFM sensor [2] equipped with a niobium tip, in order to map the interaction potential between the tip apex and the sample.

References:
[1] Kisiel et al., Nat. Mater. 10 (2011) 119
http://dx.doi.org/10.1038/nmat2936
[2] Giessibl, Appl. Phys. Lett. 73 (1998) 3956
http://dx.doi.org/10.1063/1.122948

MI 4.2 Tue 11:30 MER 02

Ultrasound plus Heterodyne Detection enables SubSurface sensitivity in an AFM — •Gerard J. Verbiest[1] and Marcel J. Rost[2] — [1]JARA- FIT and II. Institute of Physics, RWTH Aachen University, 52074 Aachen, Germany — [2]Kamerlingh Onnes Laboratory, Leiden University, P.O. Box 9504, 2300 RA Leiden, The Netherlands

Similar to the sonar of a submarine, it is possible to reach subsurface sensitivity with an AFM: it has been demonstrated that 20 nm small nanoparticles can be resolved, even if they are buried 500 nm deep in a sample. To enable this, Heterodyne Force Microscopy uses two ultrasonic signals in the order of a few MHz, which are sent through the cantilever and the sample, respectively. To detect the sample vibration, the ultrasonic frequencies are chosen slightly different to generate a low-frequency heterodyne force via the nonlinear interaction between the cantilever's tip and the sample. It is this heterodyne signal that contains the subsurface information. However, how this signal is exactly generated is not known.

We developed a general analytical model [1] to quantitatively explain the generation of the heterodyne signal. Standard textbook equations fail in this case, as they are all based on second order approximations. We confirm our results with both an experiment [2] and a full numerical calculation [3] on the example of Heterodyne Force Microscopy.

[1] G.J. Verbiest, and M.J. Rost, Nature Physics submitted
[2] G.J. Verbiest et al., Nanotechnology 24, 365701 (2013)
[3] G.J. Verbiest et al., Ultramicroscopy 135, 113 (2013)

MI 4.3 Tue 11:45 MER 02

Quantum-Emitter Fluorescence Lifetime Imaging Using a Single NV Center — •Andreas W. Schell[1], Philip Engel[1], Julia F. M. Werra[2], Christian Wolff[3], Kurt Busch[2,3], and Oliver Besnon[1] — [1]Humboldt-Universität zu Berlin, Institut für Physik, AG Nanooptik, D-12489 Berlin, Germany — [2]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik & Photonik, D-12 D-12489 Berlin, Germany — [3]Max-Born-Institut, D-12 D-12489 Berlin, Germany

Knowledge about the local density of optical states (LDOS) is a key requirement for understanding and engineering the coupling of emitters to photonic and plasmonic structures. One way to gain this knowledge is to use atomic force microscope nanomanipulation techniques to control the coupling of a single nitrogen vacancy (NV) center in nanodiamond to the structures of interest and use its varying decay rate as a measure for the LDOS [1].

Here, we will show a more sophisticated approach which uses an NV centers as a scanning probe. With a nanodiamond containing a single NV center glued to the tip of an atomic force microscope the LDOS is mapped out in a very controlled way in all three dimensions, giving insight into the local behavior of the coupling [2]. By comparison with three-dimensional ab-initio simulation this enables for quantitative understanding of local electromagnetic effects on the nanoscale.

[1] A. W. Schell et. al., Optics Express 19, 8, 7914 (2011).
[2] A. W. Schell et. al., submitted (2013).