Tunable point contacts in dynamic atomic force/scanning tunneling microscopy

Franz J. Giessibl

Lehrstuhl für Experimentalphysik 6, Institut für Physik, Universität Augsburg, 86135 Augsburg, Germany

franz.giessibl@physik.uni-augsburg.de

In 1995 it was shown that dynamic atomic force microscopy (AFM) allows to obtain true atomic resolution by force microscopy in vacuum. In this technique, a cantilever with a stiffness of $k \approx 10\,\mathrm{N/m}$, supplied with a sharp tip at its end is vibrating with an amplitude of $A \approx 20\,\mathrm{nm}$. The forces between tip and sample cause a detectable frequency shift, which ultimately is used to image surfaces. Frequency modulation AFM is now a standard technique [1] and allows to image conducting and nonconducting samples with atomic resolution. Recently, the technique was improved by increasing the cantilever stiffness to $k \approx 2000\,\mathrm{N/m}$ and reducing the amplitude to $A \approx 1\,\mathrm{nm}$. Features within single atoms (orbitals) have been imaged [2] with this low-amplitude technique. The small amplitudes also allow two new types of experiments: i) lateral force imaging with true atomic resolution of conservative and dissipative interactions [3] and ii) dynamic scanning tunneling (STM) microscope experiments [4] where orbital contributions similar to the nano-bridge experiments by Scheer et al. [5] are measured. The tip-sample system in dynamic AFM/STM thus is a tunable nanocontact, allowing the study of currents, forces and dissipation between single atoms.

[1] *Noncontact Atomic Force Microscopy*, S. Morita, R. Wiesendanger, E. Meyer (Eds.), Springer Series in Nanoscience and Technology (Springer Berlin Heidelberg New York 2002).
[2] F. J. Giessibl, S. Hembacher, H. Bielefeldt, and J. Mannhart, Science **289**, 422 (2000); F. J. Giessibl, H. Bielefeldt, S. Hembacher, and J. Mannhart, Ann. Phys. (Leipzig) **10**, 887 (2001).
[3] F. J. Giessibl, M. Herz, and J. Mannhart, PNAS Early Edition August 27, 2002, 10.1073/pnas.18216059987 (2002).
[4] M. Herz et al., in preparation.
[5] E. Scheer et al., Nature **394**, 154 (1998).