Scanning Tunneling Microscopy: In Touch With Atoms and Molecules

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As manmade devices become increasingly smaller, there is a strong need for understanding of matter and its interactions with the surrounding at the atomic and molecular level. Over 20 years after the visionary talk ”There is plenty of room at the bottom” in 1959 by Richard P. Feynman the scanning tunneling microscope (STM) was invented, soon followed by other scanning probe techniques.

By using low-temperature (LT) STM it is possible not only to visualize surfaces with atomic resolution [1], but also to manipulate individual building blocks of matter into different nanostructures [2]. The sharp tip of the microscope can be used to perform lateral and vertical manipulation of adsorbed species (Fig. 1(a)), and to form and break individual chemical bonds. By arranging the atoms or molecules in a controlled way one can synthesize different chemical substances or probe quantum phenomena. By using a magnetic tip STM can be made sensitive to the spins of the tunneling electrons [3]. Using spin-polarized (SP) STM allows resolving different magnetic structures at the atomic level, as well as imaging and even manipulating the spin direction of individual atoms. Finally, STM can be used to perform spectroscopy of single atoms and molecules on the surfaces studied [4] (Fig. 2(b)).

Building artificial atomic-scale structures, probing local quantum phenomena, studying properties of single atoms and molecules, inducing single molecule reactions and studying reaction mechanisms at a fundamental level makes STM one of the most important modern nanotechnological tools.

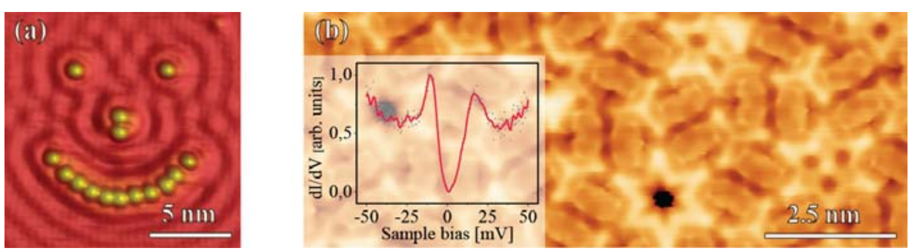

Figure 1: LT-STM image of (a) individually manipulated Cu adatoms on a Cu(111) surface and (b) pairs of $(BETS)_2GaCl_4$ molecules on Ag(111) surface showing spatial variation of the charge density with sub-molecular resolution. Measured LDOS with superconductive-like gap is shown in the inset.

References:

1. F. Besenbacher, *Reports on Progress in Physics* **1996**, 59(12), 1737-1802.
2. S.-W. Hla, *Journal of Vacuum Science & Technology B* **2005**, 23(4), 1351-1360.
3. D. Serrate et. al., *Nature Nanotechnology* **2010**, 5, 350–353.
4. T. Komeda, *Progress in Surface Science* 2005, 78(2), 41 – 85.