

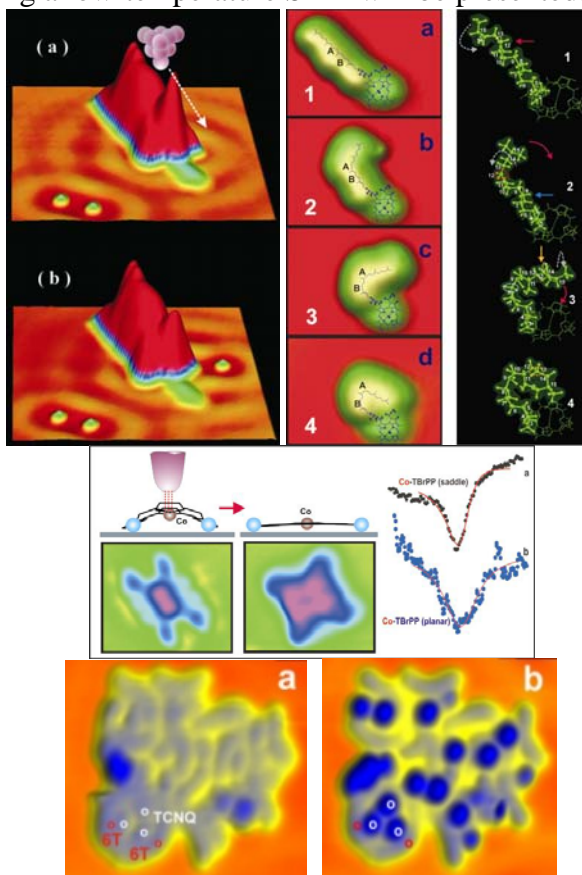
# STM Atom/Molecule Manipulation: Realizing Single Molecule Switches and Devices

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Scanning tunneling microscope (STM) manipulation of single atoms and molecules on surfaces have enabled construction of novel quantum structures on an atom-by-atom basis and demonstration of single molecule devices on a one molecule at-a-time basis. STM is not only an instrument used to 'see' individual atoms by means of imaging, but also a tool used to 'touch' and 'take' atoms/molecules or to 'hear' their vibration by manipulations. Therefore, STM can be considered as the 'eyes', 'hands' and 'ears' of the scientists connecting our macroscopic world to the exciting atomic and nanoscopic world. In our research projects, we combine STM manipulation schemes with a variety of tunneling spectroscopy measurements to investigate properties specific to the type of atoms/molecules. These innovative experiments are tailored to address several critical issues covering both fundamental understanding of atom manipulation mechanisms, and realization of monomolecular switches and devices. In this talk, our recent results of single atom/molecule manipulations using a low-temperature STM will be presented.

The atomic scale interaction is a fundamental subject of materials. Just by approaching the STM tip over a silver cluster on a Ag(111) surface, the binding of the top cluster atom is greatly reduced due to the perturbation of the tip. By tuning tip-cluster interactions, individual atoms from the silver cluster could be repeatedly and reproducibly extracted on an atom-by-atom basis (Fig. 1) [3]. This process involves extraction of individual atoms and a subsequent manipulation of atoms on the rough terrain of a 3-D cluster surface.

One of the visions of nanotechnology is the development of nanoscale electronic and mechanical devices using individual molecules or molecular components [1,2]. A monomolecular switch can be operated by changing either the conformation or electronic state of a molecule between two or more levels. By injecting tunneling electrons into a molecule, rotation or conformation changes can be performed with a single bond precision. Three types of single molecule switches; a Kondo switch and manipulation of Kondo resonance [4], a multi-step chlorophyll-a switch [5], and a molecular charge transfer switch will be presented.



**Figures:** Atom extraction and chlorophyll-a switch (top), Kondo switch (middle) and charge transfer switch (bottom).

- [1] S.-W. Hla, *J. Vac. Sci. Technol. B* **23**, 1351 (2005).
- [2] S.-W. Hla, *Nature Nanotech* **2**, 82-84 (2007).
- [3] Deshpande, H. Yildirim, A. Kara, D. P. Acharya, J. Vaughn, T. S. Rahman, and S.-W. Hla, *Phys. Rev. Lett.* **98**, 028304 (2007).
- [4] V. Iancu, A. Deshpande, S.-W. Hla, *Nano Lett.* **6**, 820-823 (2006).
- [5] V. Iancu, and S.-W. Hla, *PNAS* **103**, 13718 (2006).
- [6] F. Jäckel, U.G.E. Perera, V. Iancu, K.-F. Braun, N. Koch, J.P. Rabe, and S.-W. Hla, *Phys. Rev. Lett.* **100**, 126102 (2008).