The Atomic Eye

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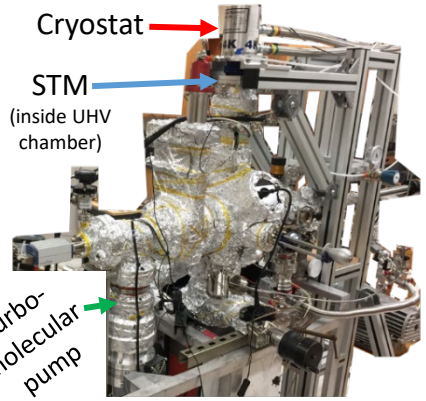
I. The Research Machine.



A custom built cryogenic scanning tunneling microscope (STM) housed inside an ultra-high vacuum (UHV) chamber.

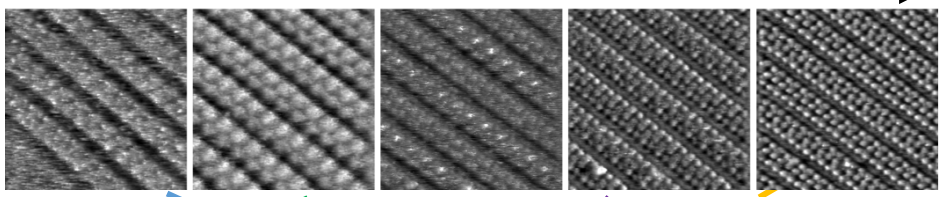
II. How does it works?

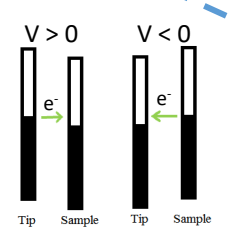
1. The cryostat brings the working environment to 10K.
2. The UHV chamber in conjunction with a turbomolecular pump create a vacuum of 5×10^{-10} mbar.
3. The principle operation of STM – an atomically sharp, one-atom metallic tip, is brought within a few angstroms of a conductor (sample). A bias voltage is applied to the sample/tip – Fermi levels shift as a result of quantum tunneling. Electrons tunnel from one surface to the other of lower potential.

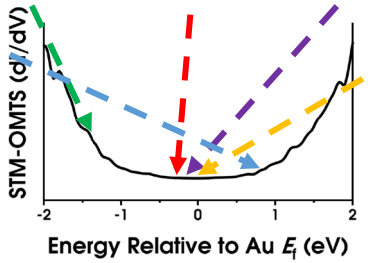
III. What does it ALL mean? – You are capturing a surface image at a specific energy level!

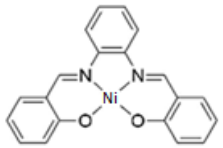
Here we see a self-assembled monolayer (SAM) of Ni(Salophen) molecule deposited on top of a Au(111) surface.

Image Acquisition Sequence









Ni(Salophen)

IV. A LOT of different experiments can be done!!!

Single-molecule investigation of dimethyl disulfide.

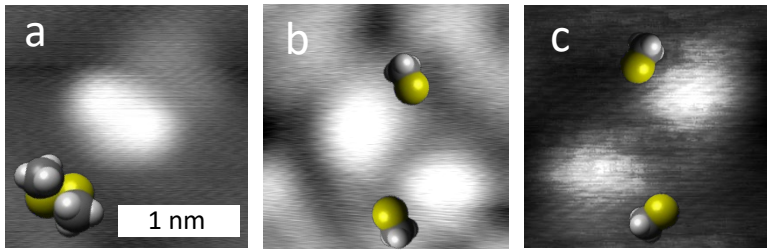


Figure 4. (a) STM image of single-molecule dimethyl disulfide (DMDS). (b) STM-tip induced dissociation of DMDS into two methyl sulfide radicals. (c) Photodissociation of DMDS into two methyl sulfide radicals using UV photons. All images have accompany chemical model as insets.

Comparing vacuum STM to solution measured values Ni(Salophen) molecule.

Yi C. Zhang, et. Al. J. Phys. Chem. Letter. 2019, 10, 13, 3525-3530

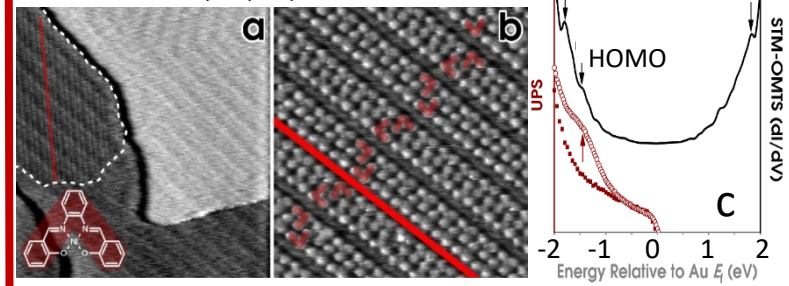


Figure 3. (a) Ni(Salophen) SAM on Au(111) the white dashed line depicts a partial monolayer. The inset is shows the chemical structure shaped as a red chevron (^). (b) A closer view of the SAM the molecule (represented by ^) orient themselves in alternating direction between each row. (c) Single-molecule STM-dI/dV spectra shown in black and ensemble ultraviolet photoelectron spectroscopy (UPS) of Ni(salophen) O line vs bare Au(111) ■ line. Cyclic voltammetry reveals the first Reduction level is at -1.38 eV vs. saturated calomel electrode (SCE).

Co-existence of different SAMs on the same substrate.

Yi C. Zhang & David Y. Lee. Langmuir 2018, 34, 44, 1337-13394

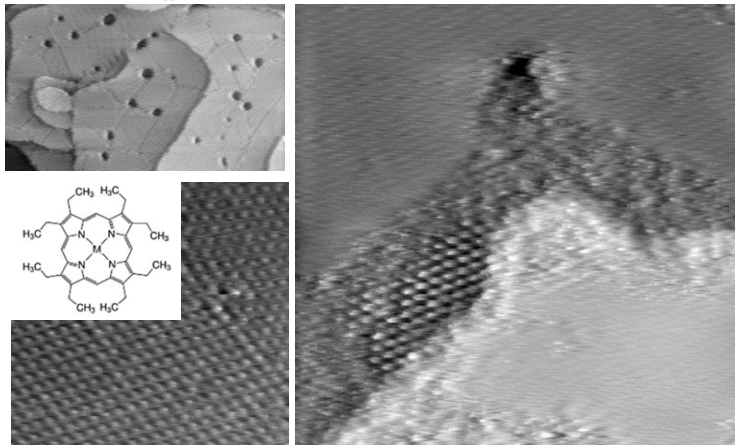


Figure 2. (a) STM image of octanethiol SAM & chemical structure. (b) STM image of Nickle octaethyl porphrine (NiOEP) SAM & chemical structure. (c) Simultaneous existence of an octanethiol and NiOEP SAM on a Au(111) surface.

Doping surfaces with radicals.

Colin Harthcock, Abdolreza Jahanbekam, Yi C. Zhang, David Y. Lee. J. Phys. Chem. C 2017, 121, 36, 20051-20056

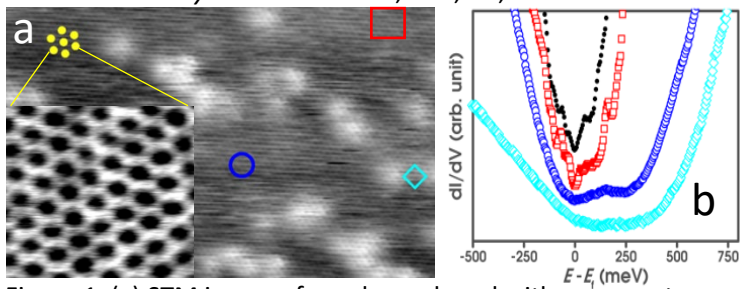


Figure 1. (a) STM image of graphene doped with oxygen-atoms. The inset is a clean graphene lattice. (b) Orbital mediated tunneling spectra (dI/dV) as a function of bias voltage. The black line "V – shaped" is pristine graphene but the band opens/widens at various locations denoted by □, O and ◇.