Single charge electronics with gold nanoparticles, organic monolayers and semiconductor substrates

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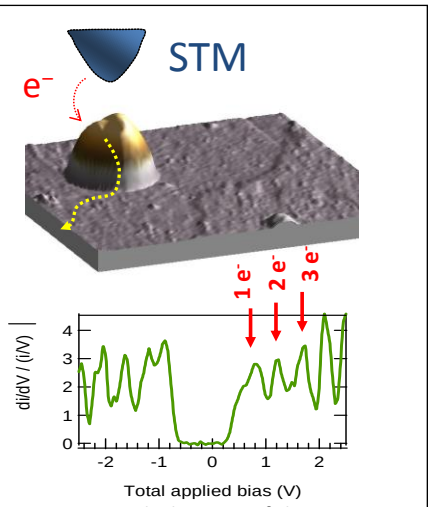
Nanoparticles can be used as ultimate electrical materials for storing electrons or controlling their flow for the next generation nano-electronic devices. These particles are the core element of assemblies where the electrical current is reduced to the smallest possible since electrons are controlled one by one by using the Coulomb blockade phenomenon.



Investigation with the STM of the transport properties of gold nanoparticles chemically attached to an organic mononlayer on silicon. Coulomb blockade is detected with transfer of single electrons.

We prepared colloidal gold nanoparticles of 6 nm and grafted them on a grafted organic monolayer (GOM) on silicon. GOM are highly ordered monolayers prepared by hydrosilylation of alkene molecules and subsequently modified with an amine group so that gold nanoparticles can be firmly immobilized on top of the layer. A wide range of characterization methods were used to assess the preparation: AFM, STM, Scanning Tunnel Spectroscopy (STS), High Resolution-TEM, XPS, FTIR and UV-visible spectroscopy [1, 2].

We will discuss several electrical properties at a single electron level. By placing an STM tip above a nanoparticle, Coulomb blockade allows controlling the number of electrons simultaneously injected in the nanoparticle [1]. Using the conductive tip of KPFM, we were also able to reveal the spontaneous charging behavior of the gold nanoparticles [3]. This opens the way for new kinds of single electron memories or single electron transistors.

[1] Caillard L , Sattayaporn S, Lamic-Humblot A -F, Casale S, Campbell P, Chabal Y J, and Pluchery O, **Controlling the reproducibility of Coulomb blockade phenomena for gold nanoparticles on an organic monolayer/silicon system ;** Nanotechnology **2015** (26) 065301

[2] Pluchery, O.; Caillard, L.; Benbalagh, R.; Gallet, J.-J.; Bournel, F.; Zhang, Y.; Lamic-Humblot, A. F.; Salmeron, M.; Chabal, Y. J.; Rochet, F., Static and Dynamic Electronic Characterization of Organic Monolayers Grafted on a Silicon Surface. *Phys. Chem. Chem. Phys.* **2016,** 18, 3675 - 3684.

[3] Zhang Y , Pluchery O, Caillard L, Lamic-Humblot A-F, Casale S, Chabal YJ, Salmeron M **Sensing the Charge State of Single Gold Nanoparticles via Work Function Measurements***Nano Letters* Nano Lett **2015** (15) 51