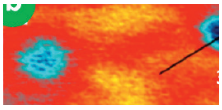

When gold nanoparticles turn into nano-memories...

A gold nanoparticle can be viewed as an infinitesimal point of contact that helps understanding how electrical currents behave at the nanoscale. When this nanoparticle is anchored to a surface, it behaves like a conductor, allowing electrons to go through. However, by attaching it via selected molecules, nanoparticles can retain electrical charges and turn into memories about ten nanometres in diameter. A member of INSP, in collaboration with American and Spanish researchers, revealed this mechanism with the tip of a Kelvin Probe Force Microscope (KPFM).

By depositing gold nanoparticles on a very specific silicon surface, called G.O.M. for Grafted Organic Monolayer, a tunnel contact is established with the silicon substrate (Fig 1-a). This way we have developed a surface whose molecules are terminated by an amine function that allows the immobilization of nanoparticles with a diameter of 7 nm (Fig 1-b). We have further analyzed this surface by KPFM.

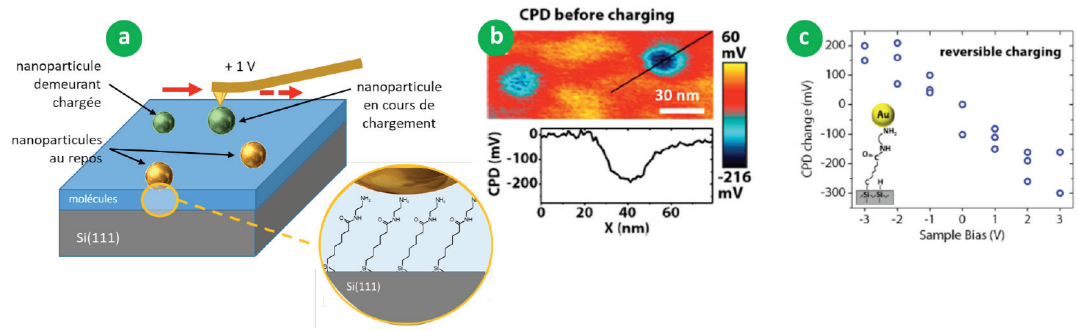

Figure 1

(a) Scheme of a G.O.M. (Grafted Organic Monolayer) surface on silicon and four gold nanoparticles. With the tip of a Kelvin Probe Force Microscope (KPFM) these nanoparticles can be charged and demonstrate a memory effect: the electrical charge remains at least 24 hours. (b) KPFM measurement of the surface contact potential (CPD) generated by a nanoparticle at rest. (c) Summary of CPD measurements for different charged states of nanoparticles.

Initially, all the nanoparticles are at rest and exhibit a surface potential of -180 mV (Fig. 1-b). By placing the tip of the KPFM on one nanoparticle and applying a bias of +1 V, electrons flow towards the nanoparticle. The remarkable phenomenon we have analyzed is that these electrons are not released when the AFM tip is withdrawn. The particle lies in a new metastable state where its surface potential stabilizes at -130 mV. The nanoparticle is able to store these electrons for more than 24 hours. If the tip is contacted again with the nanoparticle by reversing the potential (-1 V), the nanoparticle returns to its original rest state. We have repeated these manipulations with bias between -3 V and +3 V and have demonstrated completely reversible charge/discharge effects (Fig. 1-c). These nanoparticles behave like erasable memories. We have explained the origin of this memory effect using DFT theoretical calculations and showed that the charged metastable state was due to a reversible change in the conformation of the amine molecules.

By extrapolating these results, we can estimate that the information storage density of such a nanoparticle system would reach 100 GB/cm², which exceeds the best memories currently on the market. When will computer memories based on gold nanoparticles be available?

Reference

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