Internship offered in M2
2018-2019

Responsible for internship

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Internship topic: **Combining electronic and optical properties of single gold nanoparticles modified by photoactive molecules**

Gold nanoparticles are the ideal testbeds for interrogating electronics and optical properties when sizes are decreased to the nanoscale [1, 2]. In term of electronic property this is essential to assess the work function of nano-materials because it will allow using them for electronics devices such as "single electron transistors" or "single charge memories". In term of optical properties gold nanoparticles exhibit a pronounced absorption resonance due to the localized plasmon resonance (LSPR) which makes gold nanoparticle take a red color when they are in an aqueous solution [3].

Gold nanoparticles that will be studied have sizes ranging from 10 to 150 nm and they will be deposited on a conductive substrate. We want first to confirm that by covering the nanoparticle with an ordered layer of well-chosen molecules, the work function of these particles can be adjusted (see Figure 1). These measurements will be carried out with a state-of-the art Atomic Force Microscopy (AFM used in the KPFM configuration). A new optical setup is also being assembled (2018) and it will be possible to record the optical spectrum of a single nanoparticle (extinction or scattering).

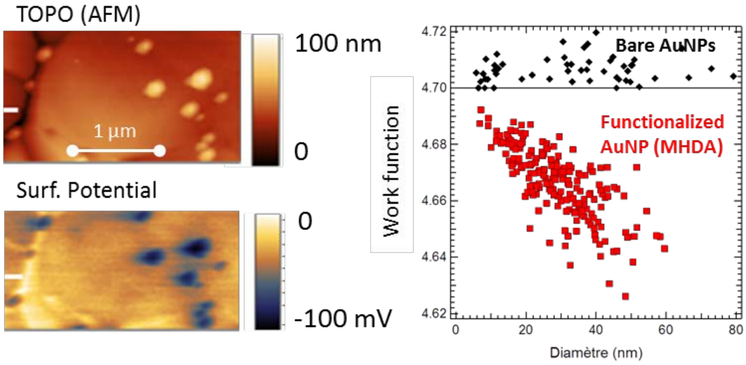

Fig. 1. Measure with a KPFM of the work function of AuNPs, when they are functionalized with the MHDA molecule (mercapto-hexadecyl-acid).

The aim of the internship is to conduct a precise comparison of the optical and electronic properties of gold nanoparticles. The challenge is to understand how to modulate the spectrum of nanoparticles (change their color) with an external parameter and relate this ability to their electronic properties. The final goal is to use photochromic molecules that can be switched between two different electronic states with an optical irradiation [4] (See Figure 2)

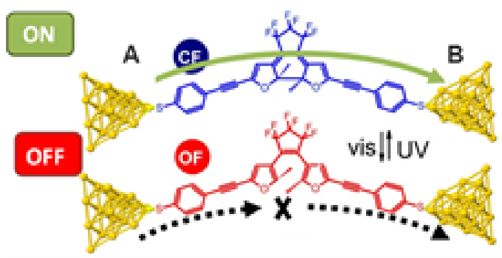

Fig. 2. Switchable molecule with its ON/OFF configurations. The switching is operated by visible (ON→OFF) or UV (OFF→ON) illumination. In the ON state, electrical current can be driven from A to B through the molecule.

<u>Former work on these topic:</u>

[1] Zhang, Y.; Pluchery, O.; Caillard, L.; Lamic-Humblot, A.-F.; Casale, S.; Chabal, Y. J.; Salmeron, M., *Sensing the Charge State of Single Gold Nanoparticles via Work Function Measurements*. *Nano Letters* 2015, 15, (1), 51-55.
[2] Pluchery, O.; Caillard, L.; Dollfus, P.; Chabal, Y. J., *Gold nanoparticles on functionalized silicon substrate under Coulomb blockade regime: an experimental and theoretical investigation*. J. Phys. Chem. B 2018, 122, (2), 897-903.
[3] Bossard-Giannesini, L.; Cruguel, H.; Lacaze, E.; Pluchery, O., Plasmonic properties of gold nanoparticles on silicon substrates: *Understanding Fano-like spectra observed in reflection*. *Applied Physics Letters* 2016, 109, (11), 111901.
[4] Snegir, S.; Khodko, A. A.; Sysoiev, D.; Lacaze, E.; Pluchery, O.; Huhn, T., *Optical Properties of Gold Nanoparticles Decorated with Furan-based Diarylethene Photochromic Molecules J. Photochem. Photobiol. A* 2017, 324, 78-84.

Techniques involved: Atomic Force Microscopy, Kelvin Probe Force Microscopy, UV-visible spectroscopy, nanoparticle deposition, chemical functionalization.

Type of internship: ~~theorical, experimental,~~ mixed
Paid internship: Yes
Can this internship be continued for a PhD? Yes
If yes, type of PhD funding envisaged is: funding from ANR or from Doctoral School ED 397