Doctoral position
2018-2019

Thesis supervisor

Name: Olivier PLUCHERY

Location:
4 place Jussieu, 75005 Paris
Tour 2 étage 4ème
Couloir 22-12, Bureau 403

Group: Physico-chimie et dynamique des surfaces

E-mail: olivier.pluchery@insp.jussieu.fr

Tel: +33 (0)1 44 27 94 10

Group website: http://www.insp.jussieu.fr/-Olivier-Pluchery

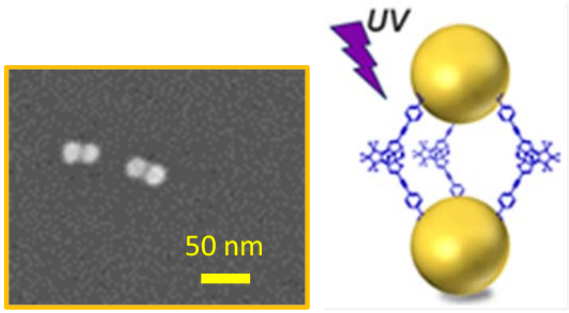
Thesis title

Electrically connected gold nanoparticles for molecular switches

This PhD work is proposed in the framework of a successful international funding granted by the ANR (Agence Nationale de la Recherche) and the DFG (Deutsche Forschung Gemeinschaft, Germany).The project name is PlasmoChrom.

Gold nanoparticle act as ideal nano-objects for storing electric charges, controlling accurately their flow and design ultra-compact devices for nanoelectronics. However a major challenge is to electrically connect such nanoparticles to electrodes and this is where molecules can play a decisive role. During a PhD thesis completed on Oct. 2018, we have studied a nanoparticle-molecule architecture and highlighted the relationship between the molecular self-organization and the electronic properties. Special advances were made in understanding electric and electrostatic properties of gold nanoparticles induced by molecular functionalization.

The present PhD proposal aims at fabricating more elaborate molecular connections based on molecular switches (diarylethene molecules, abbreviated DAE). DAEs can be switched OFF or ON by illuminating them with UV or visible light, respectively. By synthesizing dimers of gold nanoparticles, connected by DAEs molecules, we will fabricate the elemental *building block* of an electric switch controlled by light (see Fig). The nanoparticles will also serve as plasmonic antenna for increasing the switching rate. These nanoparticle dimers will be assembled by a tailored chemistry, which is presently under testing (see figure).



Assembly of gold nanoparticle dimers, connected with switching molecules (Electronic Microscope images and scheme). Switching from conductive to insulating states of the molecules is triggered by light and will be measured with a conductive AFM.

The PhD work will largely consist on experimental work based on atomic force microscopy (AFM), and

more specifically of a new mode of conducting AFM. Gaining a deep understanding of the electronic processes at the nanoscale is also one aim of this PhD work. These experiments will be coupled to a new hypermicroscopy technique for monitoring the optical spectra of the nanoparticle dimers. Several national and international collaborations have been started on this topic: with chemist (synthesis of DAE molecules), with theoreticians (DFT calculations for clarifying the molecular organization) and physicists (conductance measurement of single DAE molecules). The PhD student will be encouraged to take an active part in these collaborations.

Former work on these topic:

[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.

Sources of funding available : PhD funded by an international the ANR proposal PlasmoChrom, with a monthly salary of **2135 €/month**.

Application : send a **CV** with a **motivation letter**
before Mau 31st, 2019 to olivier.pluchery@insp.jussieu.fr

Unité mixte de recherche 7588 – CNRS / Sorbonne Université
Campus Jussieu – Tours 22 et 23 – Case courrier 840
4 place Jussieu – 75252 Paris Cedex 5 – France
Tél. : +33 (0)1 44 27 63 72 – Fax : +33 (0)1 44 27 46 09 – www.insp.upmc.fr