Internship offered in M2
2018-2019

Responsible for internship

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Ultra-sensitive plasmonic sensors of molecules

Nanoparticles of different metals (gold, silver, palladium, etc.) have particular optical properties, related to plasmon resonances, which are collective oscillations of the conduction electrons confined within the particles. For example, plasmon resonance for Au is in the visible optical range, and gives a red or purple color to Au particles instead of the usual yellow color. This resonance is very sensitive to the immediate environment of the particles and can be strongly affected when the particles interact with molecules or ions. Thanks to this very high sensitivity, gas or biological sensors based on nanoparticles of gold, gold-based alloys or other metals [1] are being developed. (see Fig. 1)

We have developed an original optical technique, the reflectance anisotropy spectroscopy, which allows us to achieve a higher sensitivity than conventional plasmonic sensors, making it possible to demonstrate the adsorption of very small quantities of molecules. We used it to study the reaction of hydrogen with gold nanoparticles [2] or to make a prototype hydrogen sensor [3]. For this purpose, specific samples with optical dichroism are prepared by evaporation of gold and / or palladium on a glass substrate (fig 2).

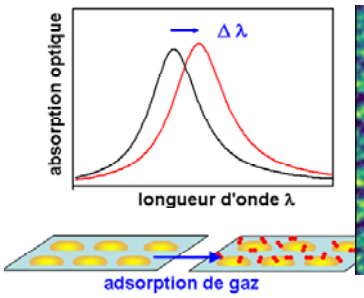

Fig.1. Shift of the plasmon resonance induced by the adsorption of molecules

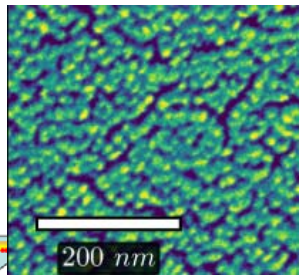

Fig.2. Scanning electron microscopy of gold nanoparticles

The aim of the internship is, initially, to extend these studies, which led to a PhD defended in October 2018 as well as to a patent. In a second step, the method will be adapted in aqueous medium. The plasmonic metal nanoparticles being covered by probe molecules, we will thus be able to study the presence, even in very small quantities, of the molecules to be detected in the solution. We will focus in particular on the detection of heavy metals (such as mercury) polluting the water.

1. Biosensing with plasmonic nanosensors, J.N. Anker et al, Nature Materials, 7, 442 (2008)

2. Mechanism of hydrogen adsorption on gold nanoparticles and charge transfer probed by anisotropic surface plasmon resonance, W. Watkins et Y. Borensztein, Phys. Chem. Chem. Phys. 19, 27397 (2017)

3. Ultrasensitive and fast single wavelength plasmonic hydrogen sensing with anisotropic nanostructured Pd films, W. Watkins et Y. Borensztein, Sensors and Actuators B: Chemical 273, 527 (2018)

Techniques involved : physico-chemical elaboration of samples, characterization by electron microscopy and atomic force microscopy, optical measurements, theoretical modeling.

Type of internship: experimental,
Paid internship: Yes
Can this internship be continued for a PhD? No