Nanoscale mapping of light absorption on functionalized metal nanoparticles with an atomic force microscope

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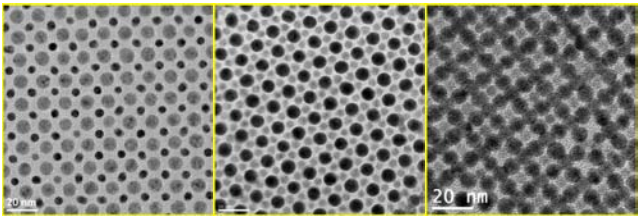
We recently developed a novel optoelectronic spectroscopy technique based on mechanical resonant response of highly sensitive atomic force microscope probes. The technique is able to explore optoelectronic effects on individual or on a finite number of functionalized nanoparticles on surfaces. The detection signal is therefore entirely based on force detection, which is revealed through frequency/phase shifts and generation of mechanical harmonics. The force sensibility of our AFM detection scheme goes down to attoNewtons range. This is largely enough to detect small changes in the radiation pressure generated by minute variations in photon number circulating between the AFM probe and a sample surface. Moreover, the same AFM detection probe is also used to reversibly tune the interparticle distance and organization, thus adjusting the interparticle coupling.



The goal in the present project is to experimentally and theoretically investigate the impact of the organic ligand shell (polycatenars, dendrons, etc) on the plasmonic response of individual and of a finite number of nanoparticles assembled in various geometries. Our calculations and first experimental results show a signal exceeding quantum and thermal fluctuations. Various electronic optoelectronic interactions between the various organic ligands and the metal nanoparticles can be studied in this way, with a resolution down to nanometer scale. The absorption signal in visible and near infrared regimes is relevant on the optoelectronic interactions. See references 3 and 4 for general reviews on cavity optomechanics and thermal effects on nano-mechanical oscillators, respectively.

The project therefore comprises experimental and theoretical phases. Notions in solid state physics, optics, electronic effects, and resonant mechanics, are needed. Knowledge of physics and chemistry of metal nanoparticles, semiconductor QDs, surface physics, and scanning probe techniques will be helpful.

1. A.D. Craciun PhD Thesis: AFM force spectroscopy of surfaces and supported plasmonic nanoparticles, UDS Strasbourg, mars (2017).

2. M. Aspelmeyer, T. J. Kippenberg, F. Marquardt, Cavity Optomechanics, Springer (2014) and references therein.

3. J. Gieseler, L. Novotny, and R. Quidant, Nature Physics 9, 806, (2013) and references therein.