Acoustic Vibrations of Nanoparticles: Mass Sensing and Interface Characterisation

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The investigation of metallic nanoparticles acoustic vibrations is at the interface between plasmonics, nano-thermics and nano-acoustics and can reveal crucial information at the nanoscale. Time-resolved optical measurements of these vibrations (1GHz-1THz) are possible taking advantage the high sensitivity of the surface plasmon resonance to shape and volume variations of the nanoobject [1]. In this kind of experiment, a first femtosecond laser pulse excites the nanoparticle: the energy is absorbed by the electron gas and redistributed to phonons and then the particle environment. During this relaxation process, acoustic vibrations are launched and modulate the optical response of the particles [1]. A second pulse, delayed, monitors the absorption variations that are due to the surface plasmon modulations induced by acoustic vibrations. We will present two sets of results using this technique to get information at the nanoscale on the particles and their environment.

The first one is a demonstration of the great sensitivity of gold bipyramid vibrations to a tiny silver deposition (cf. Figure). Investigation of the periods and amplitudes of the observed modes allowed us to estimate the sensitivity limit at 40 attograms of silver per particle [2]. These results show that the use of gold nanoparticles is an interesting path to develop nano-balances since they can perform a multi-criterion analysis (periods, amplitudes, several modes) rather than classical methods based on a single frequency monitoring.

The second one deals with results obtained on core-shell particles (gold-silica and silver-silica) and shows that acoustic vibration measurements permit the characterisation of the nature of the mechanical contact at the interface between core and shell; this information of major importance is non reachable with electronic microscopy imaging [3].

References

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