Hybrid Systems for Tunable NanoPhotonics

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Metal nanoparticles exhibit optical properties which differ remarkably from those from bulk materials, one of them being the localized surface plasmon resonance. This phenomenon becomes apparent when an external electromagnetic field incident on a metal nanoparticle induces electron cloud delocalization. Net charge difference on the nanoparticle surface acts as restoring force, producing in the simplest case dipolar oscillation. Optical response is originated from the strong absorption of the metal nanoparticles when the frequency of the electromagnetic field becomes resonant with the coherent electron motion. One of the most challenging problems concerning the photonics of nanoparticles is the possibility of modulating those optical properties through external inputs. In this context, merging of metal-nanoparticle and smart-soft-polymer technologies to make hybrid systems leads to very successful results. In this talk, a set of hybrid nanoparticle systems are first presented, pointing out their main single-particle properties and applications to enhance Raman Spectroscopy. Short-range couplings of metal nanoparticles display intense optical fields concentrated at the interparticle gap, and broad spectral tenability is achieved by simply varying this gap at nanoscale precision. 2D particle arrays have been successfully built through the control of electrostatic and interfacial forces. However, they are dramatically sensitive to the deposition conditions and to the presence of contamination. A simple alternative to those methods bases on the use of tunable mechanical spacers located in between the particles. In this context, smart polymers are excellent candidates to fix those distances, being the particle gap set by the swelling state. We show hybrid Au@PNiPAM core-shell nanoparticles ensembles, thus taking advantage of the intrinsic PNiPAM-polymer temperature-controlled swelling. The thermo-responsive nature of the PNiPAM shells allows high precision and continuous interparticle-gap tuning. Imaging analysis allows accessing the spatial and angular 2D structures. Simple plasma etching removes the polymer, thus releasing the Au cores from the spacer. It results non-invasive to the Au cores and preserves the stability of the 2D Au arrays. Finally, the fabrication of tunable nanovoid photonic surfaces using hybrid particles as template is tacked.

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