Colloidal architectures for plasmonics

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Abstract

We present several colloidal architectures able to generate plasmonics effects, leading to the observation of new resonance modes and possibly to surface enhanced fluorescence.

In a fist approach [1], we present a nanofabrication method which combines bottom-up and top-down techniques to realize nanosized curved Fabry–Pérot cavities. These cavities are made of a hexagonal closed packed monolayer of silica particles enclosed between flat and curved metallic mirrors. They exhibit geometric cavity modes such as those found in gold shell colloids. These modes manifest as dips in the reflection spectra which shift as a function of the diameter of the used nanoparticles. An excellent agreement is found between experiment and theory which allows us to properly interpret our data. In particular, owing to FDTD simulations, we could discriminate between dipolar and quadripolar resonances which result from the coupling of cavity modes and plasmonic collective modes. The strong exaltations observed in the vicinity of the front gold curved mirror are of particular interest: potential emitters could be inserted by functionalization at these positions and benefit of the maximum field. This feature could prove very important for applications as nanoscale light sources, sensors, or lasers.

In a second approach [2], owing to the competition between the radiative and nonradiative decay channels occurring in plasmonic assemblies, we show how to conceive a long pass emission filter and actually design it. We report the synthesis of gold@silica nanoparticles grafted with dye molecules. The control of the thickness of the silica shell allows us to tune the distance between the metal core and the dye molecules. Assemblies of small number (1 to 7) of these core-shell (CS) particles, considered as multimers, have also been produced for the first time. We show that the shaping of the emission spectra of the multimers is drastically enhanced by comparison with the corresponding monomers. We also show a strong enhancement of the decay rates at the LSP resonance, dominated by the non-radiative energy tranfer from the active medium to the metal. The decay rates decrease as the detuning between the long wavelength emission and the LSP resonance increases

In a third approach [3], We numerically investigate end experimentally demonstrate the influence of the interaction of localized and propagating surface plasmon polaritons on the resonances exhibited by metallic structures. The structure under investigation is an hexagonal close packed array of gold core – silica shell nanoparticles (NPs) sandwiched either between two gold films or in contact with a single gold film. We show that sandwiching the NP array between two gold films significantly enhances the amplitude of specific resonances as compared to the same NP array in contact with a single gold film. The robustness of the optical properties exhibited by the sandwiched structure against disorder makes it an ideal candidate for further investigations. In particular, this structure might be able to promote a broadband enhancement of the decay rates of emitters embedded in.

References

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