Control of the spontaneous emission from silicon nanocrystals coupled to optical localized modes

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The use of silicon nanocrystals (SiNC) in optoelectronic devices has risen during the last decade thanks to the discovery of photoluminescence in porous silicon in 1991 [1]. Nevertheless, SiNCs exhibit a low quantum yield, which prevent from currently using them in optoelectronic devices. This problem can be overcome by coupling SiNCs to confined optical modes supported by localized surface plasmons (LSP) or dielectric microcavities. Indeed, both those two systems can modify emitters' photoluminescence by changing the optical local density of states and/or increasing the local excitation field. Numerous studies have been realized with different emitters, but the studies of SiNC coupled to LSP or to microcavities are scarce.

Concerning the coupling to microcavities, different studies have showed the possibility to couple SiNC to planar microcavities [2]. We stay here under the regime of weak coupling. Other studies show the possibility to use the microcavities as probed for analyzing the intrinsic properties of SiNCs. In the field of plasmonics, pionner studies realized by Biteen and coworkers [3,4] have showed the possibility to increase the SiNCs' luminescence performances when coupled to LSPs.

In this work, we present the results of coupling analysis between SiNCs and microcavity optical confined modes or LSP modes. We first present few results of intrinsic physical properties of our SiNCs. The results of coupling with planar microvavities show then a clear Purcell effect. Finally, we describe a study where LSPs resonances of gold nanodisks (GNDs) are coupled to SiNCs [5] and preliminary results concerning the coupling of both the absorption and emission wavelengths of SiNCs to gold nanorods. In both cases, the use of an original fabrication method gives us the control all the geometrical parameters that modify the SiNCs – LSPs coupling. In the first case, GNDs with different sizes are used and located at different distances to the SiNCs. We then evaluate the maximum quantum yield enhancement for the sample with the optimized geometry.

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