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Master thesis proposal

Institut des Nanosciences de Paris
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Title: Emission of single colloidal nanocrystals confined in a plasmonic nano-antenna

Keywords: fluorescence, nanocrystal, plasmonics, strong coupling, chemical synthesis

Scientific description:

In the framework of the ANR Strong Coupling of non Linear Multiexcitonic Emission to plasmons, and the planned joint PhD between INSP and LPEM, we propose an internship between both labs.

During the internship, the student will start developing bright optical nanosources by coupling nanoemitters to plasmonic antennas. This will improve their fluorescence characteristics such as emission rate or directivity. The final objective is to achieve the regime of strong coupling regime between the emitter and the confined field excited inside the antenna. Thanks to a high confinement and excitation, the emitters should gain specific original quantum properties.

Nanometric semi-conductor colloidal nanocrystals (quantum dots) are excellent stable and bright photon sources. In particular, their optical properties can be finely tuned by the effect of quantum confinement: the smaller the nanocrystals, the higher the bandgap energy. In addition, designing more complex heterostructures, such as core/shell or core/multishell systems, enables controlling the localization of their charge carriers in the core or the shell and their resultant optical properties. The student will first synthesize CdSe/CdS core/shell and CdS/CdSe/CdS "quantum shell" nanocrystals. He will then study the influence of the structure of the different layers on the optical properties, at the ensemble level in solution and at the level of single emitters by optical fluorescence microscopy.

Patch plasmonic nanoantennas consist of a thin dielectric medium sandwiched between a thick gold layer and gold patch. In the preceding years we have developed several protocols in order to locate single nanocrystals inside antenna.

During the internship, the student will fabricate antennas and study by confocal optical microscopy the fluorescence of the emitter confined in the patch antenna. Some numerical simulations of the antennas could be considered.

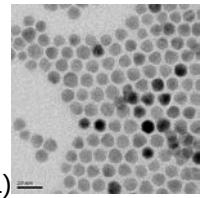
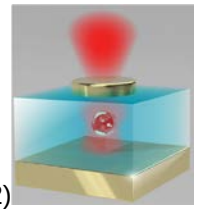
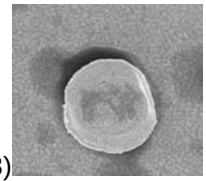
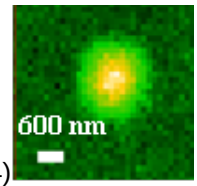
1)  2)  3)  4) 

Figure: 1) TEM images of CdSe/CdS nanocrystals 2) patch antenna 3) SEM image of patch antenna 4) emission pattern of patch antenna

Techniques/methods in use: colloidal synthesis, optical microscopy, optical lithography

Internship supervisors:

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Internship location: INSP, campus Jussieu, Tour 32-22, 5ème et LPEM, ESPCI, 10 rue Vauquelin

Possibility for a Doctoral thesis: Y (will be financed by ANR CoLiMe)