2019-2020

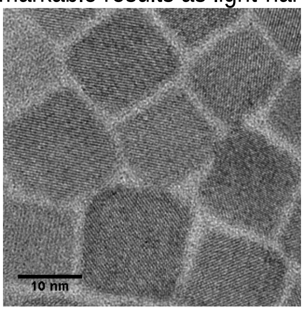
Master thesis proposal

Campus Pierre et Marie Curie
Tower 23 – 3rd floor – 23-22
Director: Massimiliano Marangolo

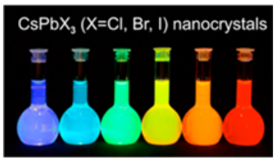
Title: **Perovskite nanocrystals for optoelectronics**

Keywords: excitons, quantum confinement, single nanocrystal, organic/hybrid perovskites, micro-luminescence, electronic band-structure, emission properties.

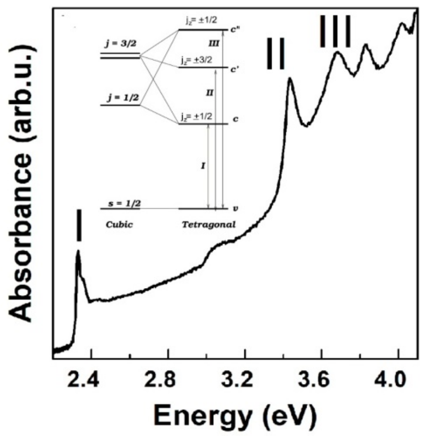
Scientific description: Colloidal perovskite semiconductor nanocrystals (NCs,~2-20 nm large) are systems where quantum confinement effect induces size-tunable emission wavelengths, discrete "atomic like" energy spectra and enhances the probability of emission or absorption of photons. They are being intensively studied as future optoelectronic materials. Some of them are already used as the new generation of phosphors in industrial applications and integrated in displays [1]. They have many advantages. Aside from having outstanding physical properties, for example their bright emission properties, they are produced with low-cost chemicals methods, can be obtained as dispersed objects in films of transparent matrices and eventually easily incorporated into various devices. Some of them, hybrid organic perovskites NCs, are promising systems for photovoltaics due to their remarkable results as light-harvesting materials for low cost solar cells.



MET of cubic nanocrystals



Solutions of a class of nanocrystals with a different size



Absorption and band-structure

Before using such NCs in devices it is crucial to have a deep knowledge of the fundamental mechanisms that govern the emission of light (structure of emitting states, polarization states properties, source of quenching, etc.) [2,3] or the generation and transport of charges. This is particularly important if those NCs should be envisaged as elementary bricks not only in "ordinary" applications but also in advanced quantum applications, in particular as single photon emitters: for instance, all-inorganic perovskite NCs are indeed now considered as the most promising systems to be used as bright quantum sources with room temperature and high repetition rate working capability [4]. In this context the internship aims at addressing the highly controversial issue of perovskite NCs band-edge electronic structure through fine spectroscopic investigations.

The internship candidate will resort to optical spectroscopies (micro-photoluminescence, time resolved luminescence, magneto-luminescence) to investigate NCs that might be of different types: hybrid perovskite NCs ($APbX_3$, with A is an organic cation, X=Cl, Br, I) and a new class which emerged four years ago, namely caesium lead halide perovskites ($CsPbX_3$, X=Cl, Br, I) NCs. The NCs will be prepared under the form of nanocubes and/or nanoplatelets where excitons are strongly confined. As much as possible studies will be carried out at the *single* nanocrystal level in order to get rid off inhomogeneous effects. The confinement will be varied with the size, form and/or composition of the NCs synthetized at the laboratory itself (E. Lhuillier's group will provide the materials). The emission properties will be studied in thin film-matrices where the NCs will be sufficiently dispersed and addressed individually using the different micro-photoluminescence platforms available in the group. The proposed studies are clearly of fundamental nature and will mobilize state of the art experimental techniques.

[1] X. Zhao et al., ACS Photonics 5, 3866 (2018) ; [2] J. Ramade et al., Nanoscale 10, 6393 (2018) ; [3] R. Ben Aich et al., Phys. Rev. Applied 11, 034042 (2019) ; [4] F. Hu et al., ACS Nano 9, 12410 (2015).

Techniques/methods in use: Micro-photoluminescence, time-resolved and polarization-resolved luminescence, luminescence under magnetic field, low temperatures studies using cryogenic setup, absorption spectroscopy, spin-coating.

Applicant skills: Taste for experimental work, good knowledge of condensed matter and light-matter interaction.

Industrial partnership: No

Internship supervisors: Laurent LEGRAND, legrand@insp.jussieu.fr, Thierry BARISIEN, barisien@insp.jussieu.fr, 01 44 27 46 08, PHOCOS team.

Internship location: Campus Pierre et Marie Curie, T 22-32, room 219, 2d floor.

Possibility for a Doctoral thesis: Yes, Doctoral School 564 contract.