Lab project / internship M1 PPN (1,5 months : 13/05-21/06)

2023-2024

Title of the project:
Characterization of perovskite nanorods as local directional light nanosources

Supervisor(s): Erik DUJARDIN & Aymeric LERAY

Laboratory / Department / Team : ICB / Photonique / PRISM

Collaborations: Univ. Panjab, Inde

Summary:

The coupling of a nanosized light source with a plasmonic or dielectric structure is one of the challenges of nanophotonic integration. Although several methods have shown the ability to place an emitting nanoparticle (quantum dot, nanodiamond) with a precision of around 50 nm, none controls its orientation or that of the emission dipole moment. For example, an NV center in a nanodiamond is oriented relatively to the crystalline matrix but the spheroidal morphology of nanodiamonds obtained by explosion, grinding or CVD growth does not make it possible to correlate the orientation of the emission to that of the nanodiamond. This results in effective but sub-optimal coupling with plasmonic or photonic structure modes.[1]

$CsPbX_3$-type perovskites (X=Cl, Br, I) in the form of crystalline nanoplatelets or nanocubes show a correlation of the orientation of the faces with that of the emission dipole.[2] A similar family of perovskites, $CsPb_{1-x}Yb_xI_3$ and Ln^{3+}:$CsPbBr_3$, whose luminescence properties can be modulated by doping (Yb_x or Ln^{3+}) are being produced by a collaborator (Dr. J. Sharma, Univ. Panjab, India) and the morphology is adjusted to nanorods by tuning the synthesis conditions (Figs. 1ab).[3] These rods may carry an emitting dipole with a fixed orientation relative to the macroscopic facets and the doping allows tune the emission spectrum in the visible to near-IR, which is suitable for coupling to plasmonic resonators.

The intership will consist in characterizing, in solution, the absorption/emission of perovskite samples using spectrofluorimetry (Fig. 1a) to determine the best excitation/detection configuration of individual nanorods. Nanorods will then be deposited on transparent substrates and characterized by electron microscopy (Fig. 1b), fluorescence microscopy. The orientation of the emitting dipole with respect to the nanorod morphology will be explored using a technique established in the lab (Fig. 1c).[4] If time allows, the same protocol will be followed for perovskite nanorods deposited in the close vicinity of 2D plasmonic resonators.[1,5-7] Time-resolved fluorescence microscopy will be carried out to evidence the coupling of the nanoemitter with the plasmon modes.

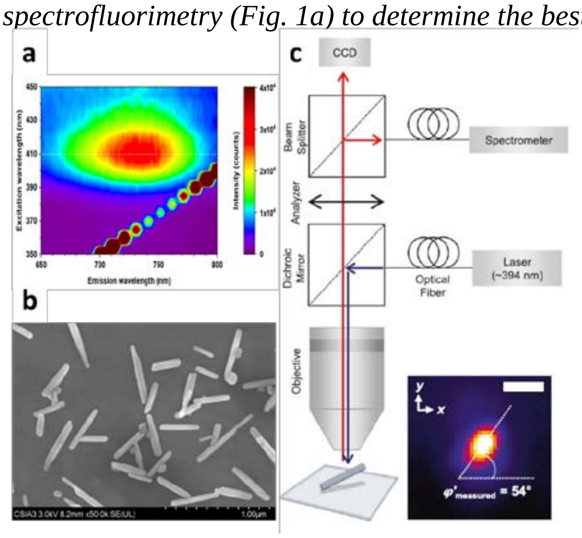

Figure 1: (a) 2D plot of the emission spectrum as a function of excitation wavelength for $CsPbI_3$ nanorods. **(b)** SEM image of $CsPb_{1-x}Yb_xI_3$ (x-3%). **(c)** Optical set-up for determining the orientation of the emission dipole moment with respect to the nanorod morphology.[4]

[1] U. Kumar, et al. *NanoScale*, **2020**, 12, 13414. [2] M.J. Jurow et al., Nano Lett. **2019**, 19, 2489. [3] J. Sharma et al, Opt. Mater., 2023, 141, 113937. [4] J. Kim et al., *Nat. Comm.*, **2021**, 12,1943. [5] A. Coste et al. PRB, **2020**, 101, 075406. [6] U. Kumar et al. *ACS Nano*, **2021**, 15, 13351. [7] F. Dell'Ova et al., ACS Photon., **2024**, 10.1021/acsphotonics.3c01624.

Type of project (theory / experiment): EXPERIMENTAL

Required skills: Strong taste for experimental sample preparation and optical set-up development. Knowledge in optical spectroscopy, data processing and analysis. Ability to communicate (oral and written reports). Self-motivation and hard working for demanding and precise experiments. Proactive team player.