GEMaC

Groupe d'Étude de la Matière Condensée

SPECTROSCOPY OF HYBRID PEROVSKITES

Hybrid perovskites have emerged in recent years as a new class of semiconductor and are very promising for optoelectronic applications. They can be synthesized in solution at low cost, while presenting excellent performances, comparable to the best inorganic semiconductors. In particular, the efficiencies of solar cells based on hybrid perovskites has increased dramatically and are now close to the efficiencies of cells based on monocrystalline silicon. However, the fundamental properties behind these performances are not yet fully understood. In addition, this family of material present a wide variety of structures, which is still explored. On the one hand, we are interested in the synthesis and functionalization of hybrid perovskites, at the interface of physics and chemistry. On the other hand, we are studying the fundamental photophysics of these materials, in the context of applications to photovoltaics and light emission.
In order to access the intrinsic properties, we focus on the study of single crystals, synthesized by the team of Emmanuelle Deleporte of the LUMIN laboratory. [Lédée 2017]

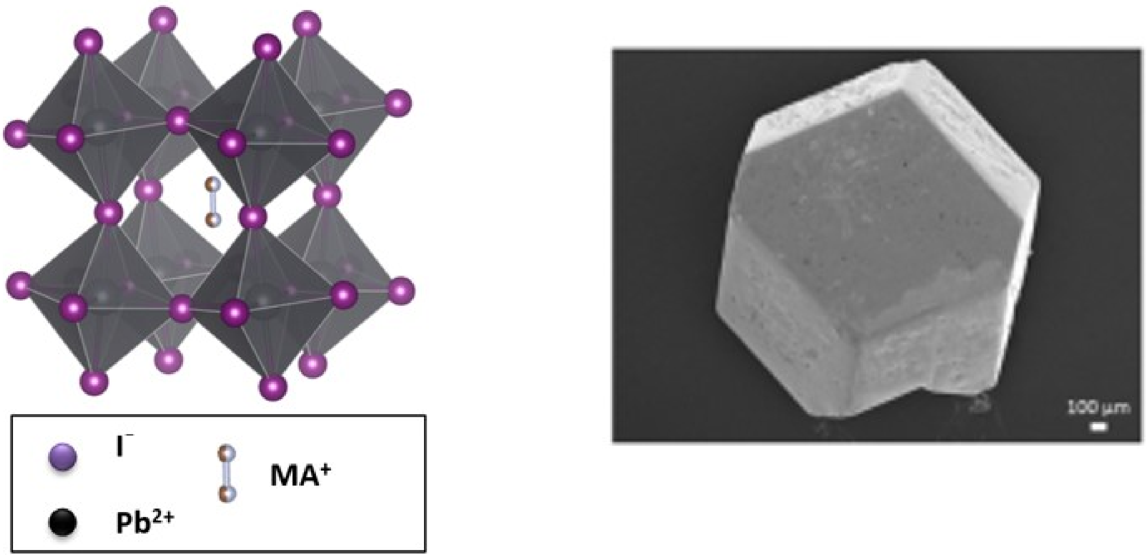

Figure : Schematic representation of the structure of CH3NH3PbI3 and scanning electron microscopy image of a single crystal.

Hybrid perovskites are direct gap semiconductors. A light excitation can produce free charges or excitons. The nature of the photoexcited species plays a crucial role for applications. The presence of free carriers promotes the separation of charges in the photovoltaic cells, while the presence of excitons fosters an efficient radiative recombination at low injection level and is desirable for the realization of light sources: light emitting diodes and lasers. We study the optical and excitonic properties of these materials using optical absorption spectroscopy and micro-photoluminescence in the steady state and resolved in time, as a function of temperature. We study the photophysics of 3D hybrid perovskites, which are at the origin of the high performance of perovskite solar cells. We have characterized the excitonic emission as well as the reabsorption phenomena in 3D perovskite single crystals. [Diab 2016] [Diab 2017] We are also interested in the recombination mechanisms in 2D layered hybrid perovskites, which present an electronic structure comparable to a multi-quantum well structure. [Delport 2019] In the context of emission, we are studying laser emission and light-matter coupling in Fabry-Perot type micro-cavities. [Bouteyre 2019]

[Diab 2016] "Narrow Linewidth Excitonic Emission in Organic–Inorganic Lead Iodide Perovskite Single Crystals", The Journal of Physical Chemistry Letters 7, 5093-5100.
[Lédée 2017] "Fast growth of monocrystalline thin films of 2D layered hybrid perovskite", CrystEngComm 19(19), 208-215.
[Diab 2017] "Impact of Reabsorption on the Emission Spectra and Recombination Dynamics of Hybrid Perovskite Single Crystals", The Journal of Physical Chemistry Letters, 2977-2983.

[Delport 2019] "Exciton-Exciton Annihilation in Two-Dimensional Halide Perovskites at Room Temperature", Journal of Physical Chemistry Letters 10(17), 5153-5159.
[Bouteyre 2019] "Room-Temperature Cavity Polaritons with 3D Hybrid Perovskite: Toward Large-Surface Polaritonic Devices", ACS Photonics 6(7), 1804-1811.

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