Critical role of point defects on Hybrid organic inorganic perovskites

Ph.D. – Application before May 4th (proposal n°61) :

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Hybrid organic-inorganic perovskites (HOP) have become one of the most promising low-cost alternatives to traditional semiconductors in the field of photovoltaics and light emitting devices. It combines both attractive features of organic and inorganic materials within a single composite, for instance with stronger excitonic properties and brighter luminescence than inorganic semiconductors together with high mobilities. Since 2012, the structure of the type $(CH_3NH_3)PbI_3$ (3D perovskites) have led to the very fast emergence of a new class of solar cells, as after less than 3 years of research effort it has led to a conversion efficiency above 20 %. However, a number of issues related to structural, thermal and UV stability, as well as moisture sensitivity have to be solved and a better knowledge of the electronic properties of such materials is obviously a prerequisite for their use and optimization in opto-electronic devices.

The objective of the project will be **to study the influence of point defects introduced by ion irradiation in HOP materials** with the implanter IRMA at CSNSM. For instance, when using Helium ion irradiation at moderate energy (5 keV-100 keV) and over a range of fluences 10^{11}-10^{16} cm^{-2}, we will have the possibility to tune the defect concentration in the irradiated samples. **Helium ion irradiation will introduce strain in the crystallographic structure and induce changes in the electronic properties. We will address the problem of radiation hardness : why is this material so tolerant to defects ?** The samples will be grown in polycrystalline (thin films) as well as monocrystalline types in collaboration with Pr. E. Deleporte in Laboratoire Aimé Cotton (Orsay).
We will study more specifically **the influence of defects on the luminescence properties**. HOPs present strong optical emission coming essentially from bound excitons on impurities or defect levels. The CSNSM is equipped with an optical spectrometer for low temperature and time-resolved photoluminescence studies. We will study the fundamental mechanisms of light emission in HOP and the central role that surface or volume defects might play. These mechanisms will be studied together with the structural phase transitions occuring in these materials as a function of temperature.
We will work on the relationship between the structural, electronic and optical properties. The novelty of the approach proposed here, using ion irradiation for materials' modification, makes the attractivity of this proposal in one of the hottest topics in materials science today.

Experimental Techniques : Ion irradiation, Optical spectroscopy : low T and time-resolved photoluminescence, X-ray diffraction