What is the role played by defects in opto-electronic properties of hybrid perovskites ?

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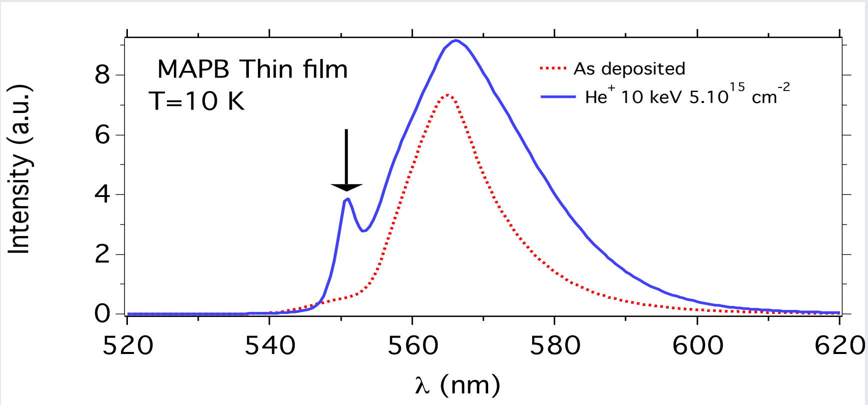
Defects are usually seen as imperfections in materials that could significantly degrade their performance. However, defects could be extremely useful since they could be exploited to generate innovative materials and devices. Defect engineering is applied to hybrid organic-inorganic perovskites (HOP) with 3D and 2D structures, with strong light emitting properties. HOP materials have become one of the most promising low-cost alternatives to traditional semiconductors in the field of photovoltaics and light emitting devices. The objective is to use ion irradiation as a tool for the introduction of point defects in a controlled manner. Both strain and defects energy levels will modify the electronic and light emitting properties of the materials. We want to study how these properties are modified in order to get knowledge about the role that defects might play in these materials where "self-healing" mechanisms were proposed.



Photoluminescence measured at 10 K of a thin film of $(CH_3NH_3)PbBr_3$ before (dashed) and after Helium ion irradiation at an energy of 10 keV and a fluence of 5.10^{15} cm^{-2} (continuous line). The excitation is a continuous Argon laser at 488 nm.

We use Helium ion irradiation in the range 10-30 keV as a tool for the introduction of point defects in a controlled way. At low fluences, mainly point defects are created that introduce energy levels and modify the electronic and light emitting properties of the materials. Contrary to usual semiconductors, like crystalline silicon for instance, where irradiation defects act as recombination centers for the electron-hole pairs and quench very efficiently the luminescence, we observe here an enhancement of the optical emission at low temperature as shown in Figure 1 for a thin polycrystalline film of $(CH_3NH_3)PbBr_3$. We can deduce from this observation that irradiation defects act as active optical centers, essentially in the low-temperature orthorhombic phase as seen in the dependence of the total photoluminescence yield. Another effect of the ion irradiation directly observable is the emission through new excitonic processes, as indicated by the arrow in Fig.1 showing a new feature at 550 nm after Helium ion irradiation. The temperature dependence of the spectra is under analysis and evidences light amplification after ion irradiation at low temperature. These behaviours are very intriguing and need further studies for a better understanding of the specificity of defects and their impact over opto-electronic properties in HOP materials.

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