Photoluminescence of defects in hybrid organic-inorganic perovskites

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Defects are usually seen as imperfections in materials that could significantly degrade their performance. However, at the nanoscale, defects could be extremely useful since they could be exploited to generate innovative and useful materials and devices. Defect engineering is applied here to hybrid organic-inorganic perovskites (HOP) with 3D structures. HOP materials have become one of the most promising low-cost alternatives to traditional semiconductors in the field of photovoltaics and light emitting devices. A better knowledge of the electronic properties of such materials is obviously a prerequisite for their use and optimization in opto-electronic devices. We use here 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 defects 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. We can deduce from this observation that irradiation defects act here as active optical centers, essentially in the low-temperature orthorhombic phase as seen in the dependence of the total photoluminescence integrated intensity. Another effect of the ion irradiation directly observable is the emission through new exciton processes as indicated by the arrow in Fig.1 showing a new feature at 550 nm after Helium ion irradiation of $(CH_3NH_3)PbBr_3$ polycrystalline thin films. The temperature dependence of the spectra evidences light amplification after ion irradiation at low temperature both with $(CH_3NH_3)PbI_3$ and $(CH_3NH_3)PbBr_3$. 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.

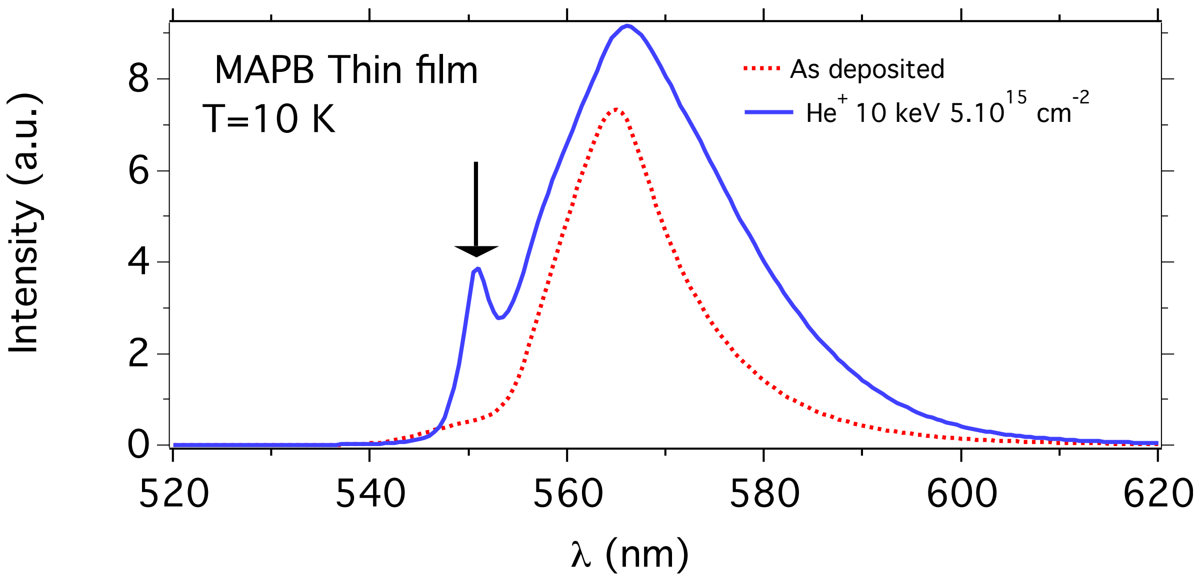

Fig. 1 : Photoluminescence measured at 10 K of a thin film of $(CH_3NH_3)PbBr_3$ before (dashed) and after Helium ion irradiation at an energy of 10 keV and a fluence of 5.10^{15} cm^{-2} (continuous line). The excitation is a continuous Argon laser at 488 nm.