Optical and chemical study of two-dimensional lead iodide perovskite stability to ambient conditions

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Abstract

Two-dimensional (2D) halide perovskites hold a great promise for electronics and optoelectronics applications due to the structural diversity, high absorption and photoluminescence, and tunable bandgap. Especially, they are one of the most promising studied material for photovoltaics. However critical issue is their low stability to the ambient environment conditions. In this work, we have investigated their degradation processes upon external factors such as oxygen, humidity, light, heat and photo-induced degradation. We applied combination of optical (micro-photoluminescence, micro-Raman spectroscopy) and chemical (X-ray photoemission spectroscopy) characterization techniques. We demonstrate that 2D perovskites easy degrade upon heat and laser illumination in atmospheric conditions. Surprisingly, we have found a different aging chemical processes after the crystal exposition to long periods (up to 1 year) in atmospheric conditions with and without presence of external light (see Figure 1). Crystals exposed to light aged into morphology with penetrated micro-holes and their photoluminescence is degraded. On the other hand, crystals exposed to dark show wire-like morphology maintaining photoluminescence. The degradation processes finally results in removal of organic part from the crystal and formation of lead and iodine vacancies, which are probably related to side non-radiative recombination mechanisms responsible for the photoluminescence degradation. These vacancies are associated with the crystal decomposition into PbI_2, metallic Pb, and Pb oxides. Presented work is beneficial for development of long-term stable perovskite devices with an enhanced optical performance.

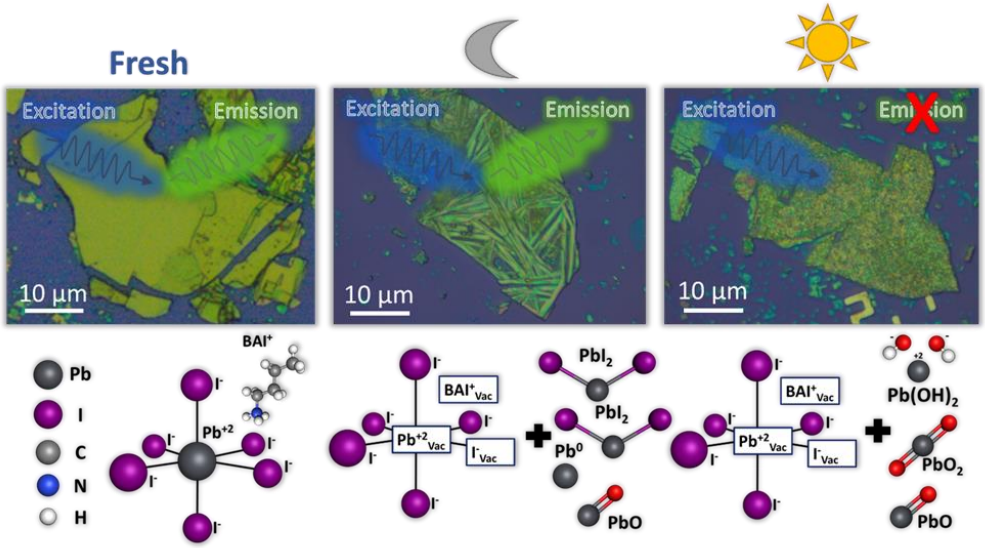

Figure 1: Degradation processes in 2D perovskites.