Optical signatures of the photo-induced transformation of $MAPbI_3$ thin films

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Hybrid organic-inorganic perovskites such as methylammonium lead iodide ($MAPbI_3$) hold great promise for photovoltaic applications with power conversion efficiencies already exceeding 26%. Despite the unprecedented advantages of these materials in photovoltaics and optoelectronics they exhibit a range of complex phenomena under light illumination that remain poorly understood.

In this study, we investigate the light-induced changes in the photoluminescence (PL) characteristics of $MAPbI_3$ thin films. Utilizing a combination of experimental techniques including photoluminescence spectroscopy, spatially resolved cathodoluminescence (CL) imaging, and theoretical calculations, we explore the dynamic behavior of PL intensity under light illumination. We reveal that short-term light exposure induces a more homogeneous distribution of emitting and quenching sites in the $MAPbI_3$ thin films, while prolonged illumination leads to PL quenching (Fig. 1). Our findings suggest that these light-induced transformations can be explained within a bistable amphoteric native defect model. Furthermore, we analyze the influence of various factors such as different atmospheres, temperatures, excitation power, film thicknesses, and grain sizes on the observed PL fluctuations. Our study provides valuable insights into the fundamental mechanisms governing the light-induced changes in the optical properties of $MAPbI_3$ thin films, which have significant implications for their applications in optoelectronic devices.

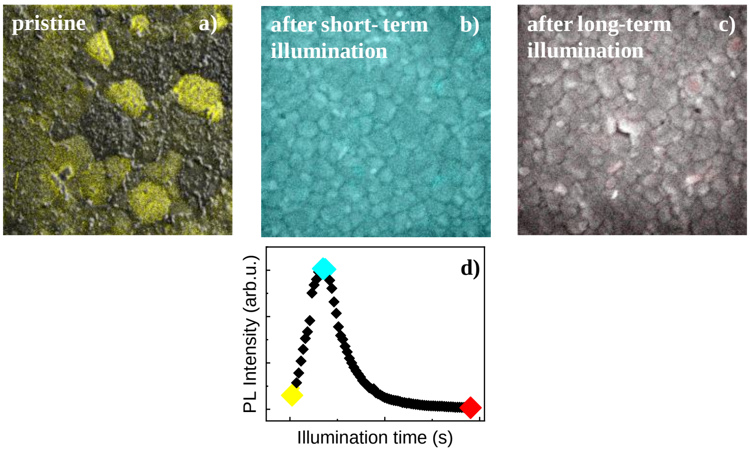

Fig. 1 Correlated scanning electron microscopy images and false-color panchromatic CL maps of a) a pristine 93 nm thick $MAPbI_3$ film, b) after short-term light illumination, c) after long-term light illumination, and d) fluctuations of PL intensity over time under continuous light illumination.