Inhomogeneities in lead halide perovskite absorbers revealed by quantitative Photoluminescence Imaging

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The exceptionally high optoelectronic properties of hybrid organic-inorganic perovskites have led to more than 25% power conversion efficiency (PCE) [NREL]. However, long-term stability and deterioration of the bulk and interface properties due to ionic motion are still of great concern. Therefore, dedicated passivation strategies that block ionic motion are of high importance [1].

Herein, we analyze the optoelectronic properties of state-of-the-art $(FAPbI_3)_{0.97}(MAPbBr_3)_{0.03}$ perovskite absorbers with different organic buffer layers. Full devices with and without the additional buffer layer result in PCE of 24% and 22.7%, respectively. We employ time-resolved hyperspectral calibrated photoluminescence imaging to quantify the losses in external quantum efficiency (PLQY) and minority carrier lifetime for the different perovskite absorbers with and without the buffer layer. We compare the results to measurements on full devices.

Measurements on large areas show that all absorbers exhibit variations in the PL peak position by approximately 0.03 eV. Histograms of the minority carrier lifetime show variations by approximately 40ns for samples without the buffer and approximately 150ns for samples with the buffer layer. Similar variations are also observed in Quasi-Fermi level splitting. The sample with a buffer layer has an average lifetime higher than that of the sample with no buffer. Furthermore, we find a correlation of PLQY with thickness variations of the mesoporous TiO2. In addition, on specific locations, we find much longer lifetimes, which we attribute to changes in the absorber composition, corroborated by energy dispersive X-Ray analysis performed on the same spot.

The full device of the sample with buffer layer shows a high V_{oc} of 1.195V, FF of 79.1%, and longer average minority carrier lifetime as compared to a device without buffer layer which has Voc of 1.15V and FF of 77.6%. Our analysis shows that inhomogeneities are present in all the absorbers and devices and they contribute substantially to the current limitations of state-of-the-art perovskite devices.

References:

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