Solvent Engineering to Improve the Performance of Planar Organic-Inorganic Hybrid Perovskite Solar Cells

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Summary

Hybrid organic-inorganic perovskite solar cells are an emerging field of scientific research, which currently manage to capture much attention in the area of photovoltaics and optoelectronics. However, there are still many scientific challenges which confront the inordinate promise of this technology. Methylammonium lead halide perovskites are among the most widely used compositions in photovoltaic devices, which are mostly deposited from low volatile solvents, for example N,N-dimethylformamide. Such solvents dry slowly inducing the formation of relatively large perovskite crystallites that causing surface roughness in the film and lead to pin hole defects between the crystallites. In this contribution, we show $MAPbI_{3-x}Cl_x$ perovskite solar cells (PSCs) processed in ambient air from precursor solution containing acetylacetone (AA) as a solvent additive. Atomic force microscopy (AFM) topographic imaging reveals that the addition of AA into the $MAPbI_{3-x}Cl_x$ precursor solution enhances the crystallite growth with improved smoothness and compactness of the crystal grains. PSCs with AA additive display enhanced photovoltaic properties, i.e. open-circuit voltage (V_{oc}), short-circuit current density (J_{sc}), and power conversion efficiency (PCE). The best PSCs show an average V_{oc} of about 1.02 V, J_{sc} of around 20 mA/cm^2, fill factor (FF) of ～76 %, and PCE of ～15.5 %. Electrochemical impedance spectroscopic (EIS) and intensity modulated photovoltage spectroscopy (IMVS) investigations show that the addition of AA results in improved charge carrier dynamics in the bulk and across interfaces of the devices. PSCs display reduced charge carrier transport resistance (R_{tr}), increased recombination resistance (R_{rec}), and elongated charge carrier life-time

characteristics at a given photon intensity. Moreover, $MAPbI_{3-x}Cl_x$ films prepared with AA additive exhibit stronger photoluminescence compared to the pristine $MAPbI_{3-x}Cl_x$ films. This appear to confirm that AA solvent additive plays a vital role to reduce the trap states across the film, which boosts the enhancement of radiative recombination pathways. We believe that this additive is highly a practical and viable option to fabricate and optimize large area, thin film perovskite solar cells in ambient environment.