The synergistic effect of $H_2O$ and DMF towards stable and 20% efficiency inverted perovskite solar cells

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High quality thick 500 nm $CH_3NH_3PbI_3$ perovskite absorber with the horizontal grain size up to 3 $\mu$m and the lateral size equal to the film thickness was prepared by the synergistic effect of $H_2O$ additive and DMF vapor treatment. The inverted (p-i-n) cell based on this high-quality thick perovskite film achieves a high power conversion efficiency of 20.1%. The cell shows no current hysteresis and stable in the inert and ambient atmospheres. $H_2O$ helps MAI to penetrate into the thick PbI2 to form thick film with pure MAPbI3 phase and produce bigger gains by slow down the perovskite crystallization rate. It can also cooperate with DMF to control the dissolving of perovskite grains during DMF vapor post treatment. As a result, large multi-crystalline perovskite grains without observable hole and crease are formed when DMF and $H_2O$ were removed in the following heating. The synergistic effect of $H_2O$ and DMF was evidenced by SEM images and GIWXRD patterns taken simultaneously. This synergistic strategy for preparing high-quality, thick perovskite film was extended to fabricate large-area MAPbI3 film for the mini-module with the active area of 11.25 cm2 to realize the efficiency of more than 15%.

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