Understanding the Formation and Evolution of Interdiffusion Grown Organolead Halide Perovskite Thin Films by Thermal Annealing

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BACKGROUND

1.Solar energy is a reliable, renewable and clean resource in contrast to conventional fossil fuels, and thin film photovoltage (PV) devices, providing features like low cost, light weight, easy fabrication, are promising for solar energy harvesting. As the third generation solar cell, thin film soalr cell attraches great amout of attention.

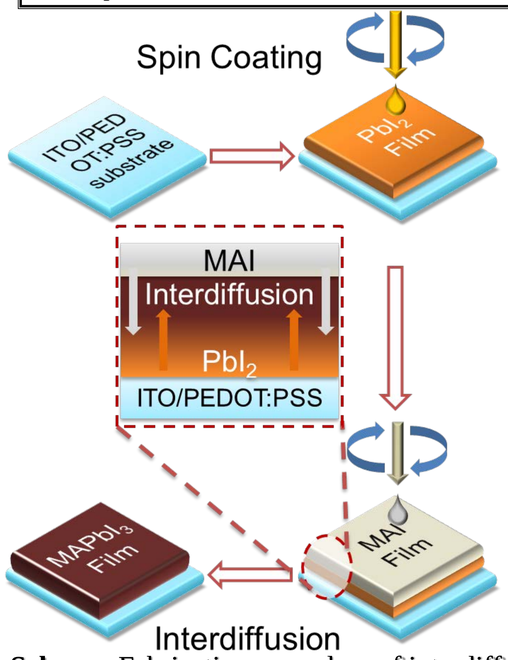
2. organolead halide perovskites are emerging as an new generation of photovoltaic materials since they are inexpensive, nature-abundant and solution processable. Efficiency above 15% was achieved by perovskite-based device.

PURPOSE AND HYPOTHESIS

In order to industrialize the thin film solar cell, the fabrication cost need to be reduced, and one effective way to reduce the cost of PV devices is to increase their efficiencies.

Thermal annealing is most broadly applied in both organic and inorganic thin film solar cells.

Applying thermal annealing on interdiffusion grown perovskite layer to (1) driving the interdiffusion of PbI_2 and MAI precursor for the formation of the perovskite, (2) induce the recrystallization and grain growth in the formed perovskite films



Scheme. Fabrication procedure of interdiffusion grown perovskite film

OPTICAL AND CRYSTALLINE PROPERTY

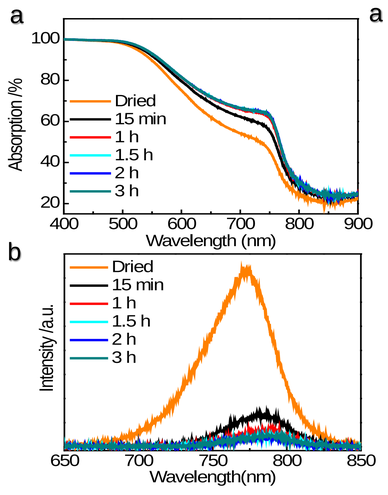


Figure 1. Single path absorption (a) and time-integrated PL spectra (b) of $MAPbI_3$ perovskite film dried at 75 °C for 10 min and annealed at 105 °C for varied time

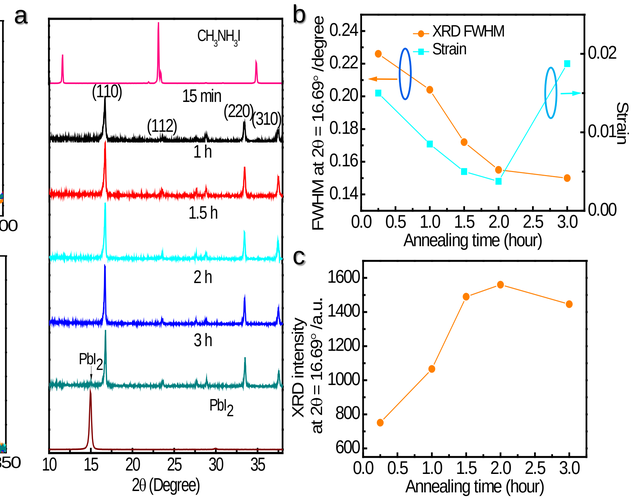


Figure 2. XRD patterns (a) of $MAPbI_3$ perovskite film annealed at 105 °C for varied duration, the annealing time shown on the patterns; (b) film's strain and FWHM of (110) plane's diffraction peak evolves with increased annealing time; (c) the variation of XRD peak intensity at $2\theta = 16.69°$ with increased annealing duration

CONCLUSION

1. The thermal annealing at 105 °C quickly drives the formation of phase-pure perovskite in a short time of 15 min, and followed annealing up to two hours continuously increases perovskite crystallinity and grain size without interrupting the film continuity or coverage.
2. Increased annealing time at relatively low temperature (105 °C) overall improves device performance by increasing J_{SC} and *FF*. The highest PCE of 13.4% was achieved when perovskite absorber layer was treated by 2 h thermal annealing at 105 °C.

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FILM MORPHOLOGY

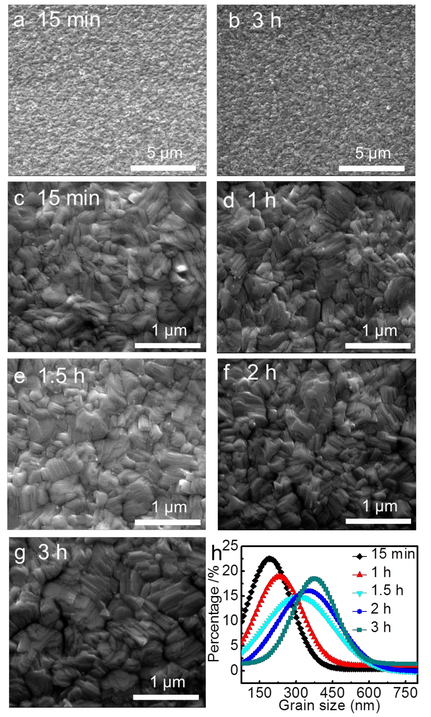
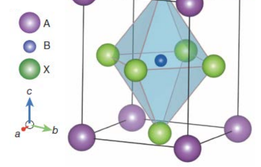


Figure 3. SEM images (a-b) showing the overall surface morphology of $MAPbI_3$ perovksite film annealed at 105 °C for 15 min and 3 h, respectively; SEM images (c-g) illustrating the details of $MAPbI_3$ crystals in the films with different annealing duration; annealing time shown on the images; grain size distribution (h) of the films with varied annealing time, measured from SEM images.

Grain size increases with annealing time



DEVICE PERFORMANCE

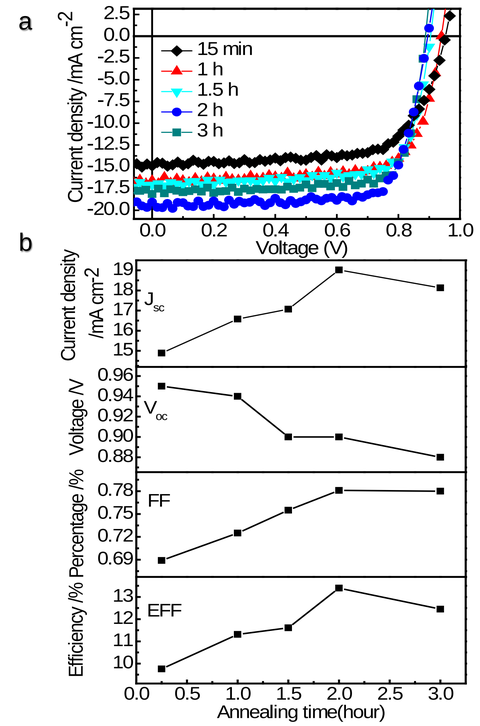


Figure 5. Performance of the $MAPbI_3$ perovskite device made by using 105 °C annealing for different time: (a) Current density-voltage (J-V) characterization performed under simulated AM 1.5G irradiation (100 mW/cm²), the annealing time displayed in the figure; (b) variation on device performance parameters, J_{SC}, V_{OC}, FF and PCE, with increased annealing duration, extracted from J-V curve.