Facile Fabrication of Planar Perovskite Solar Cells via One-Step Spin-Coating and Antisolvent Bath Methods

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Introduction

In recent years, most highly efficient perovskite solar cells (PSCs) were fabricated using complicated methods or expensive vacuum facilities such as glovebox with humidity less than 1%. Herein, we have successfully prepared planar PSCs via one-step spin-coating and antisolvent bath technique (OSABT) in ambient air with relative humidity greater than 30%. The OSABT led to the efficient extraction of the precursor solvent and induced rapid precipitation, crystallization of homogenous and ultra-smooth perovskite films.[1)] Solvent annealing (SA) was applied for grain growth to obtain better morphology.[2)] Planar perovskite solar cell based on the SA high-quality perovskite films showed power conversion efficiency (PCE) up to 16.74%. The thermally annealed (TA) device, which were used as control device delivered a PCE of 12.71%. This work shows good potential for mass production of PSCs in the future.

Results and Discussion

Planar PSCs were fabricated with the structure fluorine-doped tin oxide (FTO)/compact-TiO_2/$MAPbI_3$/spiro-OMeTAD/Au. Figure 1 presents the schematic procedure of OSABT. SEM micrographs depicting the morphologies of the TA and SA perovskite films are shown in Fig. 2. The resulting perovskite films are homogeneous and densely packed, confirming the advantages of OSABT. The mean grain sizes were estimated to be about 600 nm and 1µm for the TA and SA perovskite films, respectively. The current density–voltage (*J–V*) curves of forward and reverse scan of the best performance SA and TA PSCs are shown in Fig. 3a.

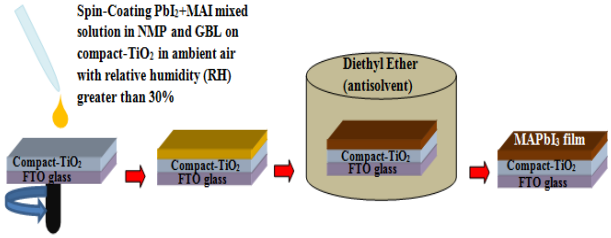

Figure 1. Schematics of one-step spin-coating and antisolvent bath technique progressing from left to right.

All the photovoltaic parameters of SA solar cell are superior to that of the TA solar cell. The short-circuit density (J_{sc}), open circuit voltage (V_{oc}), fill factor (FF), and PCE of 22.50 mA/cm^2, 0.869 V, 0.65, and 12.71% respectively, were obtained from the TA solar cell. While the SA solar cell achieved higher J_{sc} of 23.65 mA/cm^2, V_{oc} of 1.011 V, FF of 0.70 and PCE of 16.74 %. The values listed here are for the reverse scan measured under simulated one sun AM 1.5G (100 mW/cm^2) illumination.

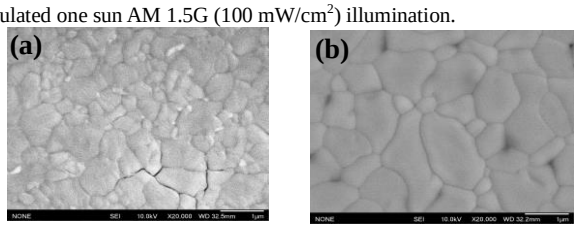

Figure 2. SEM images of the (a) thermal- annealed and (b) solvent-annealed perovskite films. The scale bars are 1 µm

The Ultraviolet-visible (UV-vis) absorbance spectra of TA and SA perovskite films were measured as shown in Fig. 3b. The increased absorbance over the entire UV-vis region for SA film should be due to improved morphology.

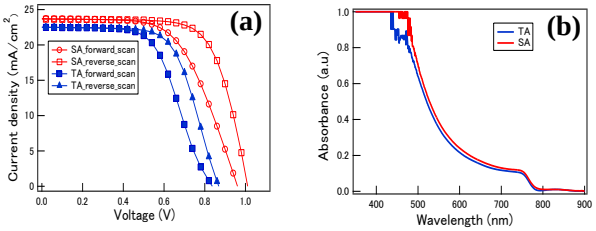

Figure 3. (a) *J-V* curves for TA and SA perovskite solar cells. (b) UV-vis absorbance spectra of TA and SA Perovskite films

References

1) Zhou Yuanyuan et. al., *J. Mater. Chem. A, 2015, 3, 8178-8184*

2) Zhengguo Xiao et. al., *Adv. Mater. 2014, 26, 6503-6509*

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