Electronic Supplementary Information

Vapour-based processing of hole-conductor-free $CH_3NH_3PbI_3$ perovskite/C_{60} fullerene planar solar cells

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Experimental Procedure

Synthesis and Solar Cells Fabrication

CH_3NH_3I (or *MA*I) was prepared using the approach described in the literature [3]. Typically, 18 mL methylamine (40% in water, Sinopharm, China) and 30 mL of hydroiodic acid (45 wt% in water, Sinopharm, China) were mixed and reacted at 0 ˚C for 2 h while stirring. After rotary evaporation, the CH_3NH_3I powders was collected and washed three times and dried in a vacuum oven.

To prepare the *MA*PbI_3 thin film on a patterned indium tin oxide (ITO) coated glass substrates, the substrates were placed above the vapour sources with the ITO side facing down and 100 mg PbI_2 (Aladdin, China) was placed in a tungsten crucible. The distance between the crucible and the substrates was fixed at 20 cm. Once the pressure in the chamber was pumped down to below 5×10^{-3} Torr, the crucible was heated using a current of ~45 A for 15 min to obtain a PbI_2 thin film on the ITO-coated glass substrates. Subsequently, 40 mg of the *MA*I was placed in another tungsten crucible and evaporated (~38 A, 15 min) to convert the PbI_2 into *MA*PbI_3 film *in situ*. The as-deposited film was then taken out and annealing at 100 ˚C for 30 min in the air. To complete the *MA*PbI_3-C_{60} bilayer solar cell, 10 nm C_{60} layer and 50 nm Ag layer were successively evaporated onto the as-prepared *MA*PbI_3 film.

Characterization

X-ray diffraction (XRD) patterns from the PbI_2 and the *MA*bI_3 films were obtained using a microdiffractometer (D8-Advance, Bruker, Karlsruhe, Germany) with Cu K_α radiation (λ=1.5406 Å) at 0.02˚ per step under operation condition of 30 kV and 40 mA. The structural analysis was conducted using the Topas 4.2 program. A scanning electron microscope (SEM; S-4800, Hitachi, Japan) was used to investigate the cross-sectional structure of the whole solar cell, and the surface morphologies of the PbI_2 and the *MA*bI_3 films. The optical absorbance spectra of the *MA*PbI_3 perovskite film were measured using a UV-*vis*/NIR spectrophotometer (U-4100,

Hitachi, Japan).

Solar Cells Testing

The *J-V* responses of the solar cells (unmasked) were measured using an analyzer (2400 Series Sourcemeter, Keithley, Cleveland, OH) under simulated AM 1.5G sunlight at 100 mW/cm^2 irradiation (Oriel Sol3A Class AAA Solar Simulator, Newport Corp., Irvine, CA). The exact light intensity was calibrated using the Newport Calibrated Reference Cell and Meter with KG3 window (Model 91150-KG3, Newport Corp., Irvine, CA). The active area of the solar cells was typically 0.09 cm^2, which is defined by the overlapping area of the ITO-coated glass and the Ag electrodes. There might be some overestimatation of PCE due to the edge effects. [1, 2]

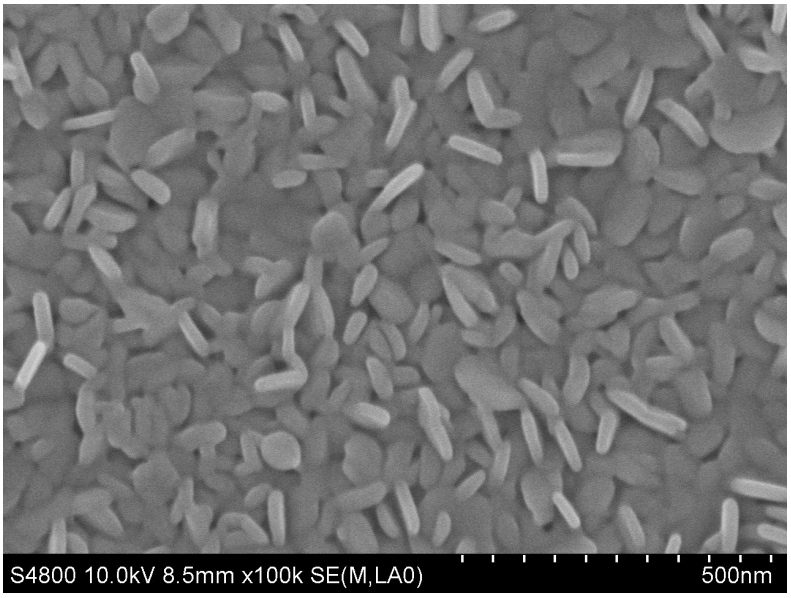

Figure S1. High-magnification SEM image (top view) of the vapor-deposited PbI_2 film.

Table S1. Performance parameter results from the testing of ten different *MA*PbI_3 perovskite/C_{60} fullerene solar cells.

	Voc	Jsc	FF	Efficiency
1	0.85	12.11	0.48	4.95
2	0.77	13.94	0.47	5.1
3	0.7	14.31	0.47	4.69
4	0.74	14.09	0.45	4.63
5	0.87	12.5	0.44	4.78
6	0.81	11.06	0.46	4.13
7	0.79	13.65	0.48	5.24
8	0.82	12.95	0.47	5.03
9	0.78	13.94	0.47	5.1
10	0.8	13.61	0.5	5.44

References

1 H. S. Kim, I. Mora-Sero, V. Gonzalez-Pedro, F. Fabregat-Santiago, E. J. Juarez-Perez, N.-G. Park and J. Bisquert, *Nature Comm.* 2013, 4, 2242.

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