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Electronic Supplementary Information

Ordered macroporous $CH_3NH_3PbI_3$ perovskite semitransparent film for high-performance solar cells

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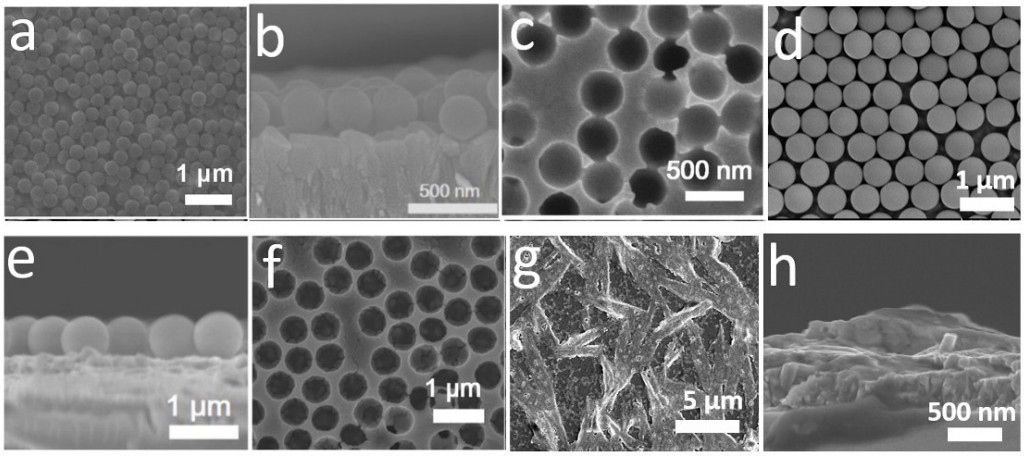

Fig. S1. (a) The top-view and (b) the cross-section SEM images of 200 nm PS monolayer. (c) The top-view SEM image for 200 nm perovskite film. (d) The top-view and (e) the cross-section SEM

images of 600 nm PS monolayer. (f) The top-view SEM images for 600 nm perovskite film. (g) The top-view and (h) the cross-section SEM images of island perovskite layer.

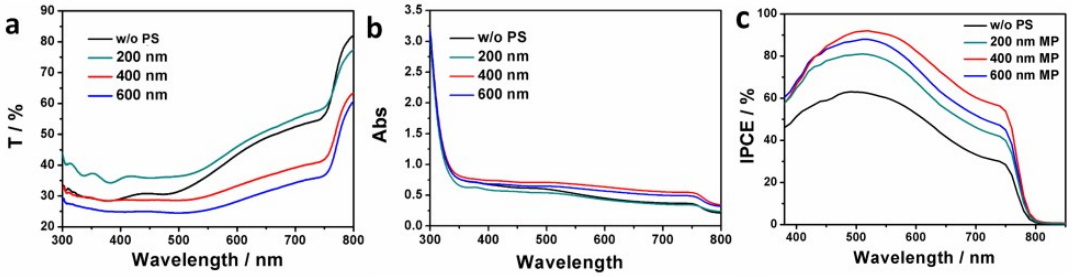

Fig. S2. (a) Transmittance spectra of MP perovskite with various pore sizes excluded the effect on FTO/TiO_2 substrate. (b) The absorption spectra of MP perovskite with various pore sizes deposited on FTO/TiO_2 substrate. (c) The IPCE spectra of MP perovskite with various pore sizes and island-like perovskite solar devices.

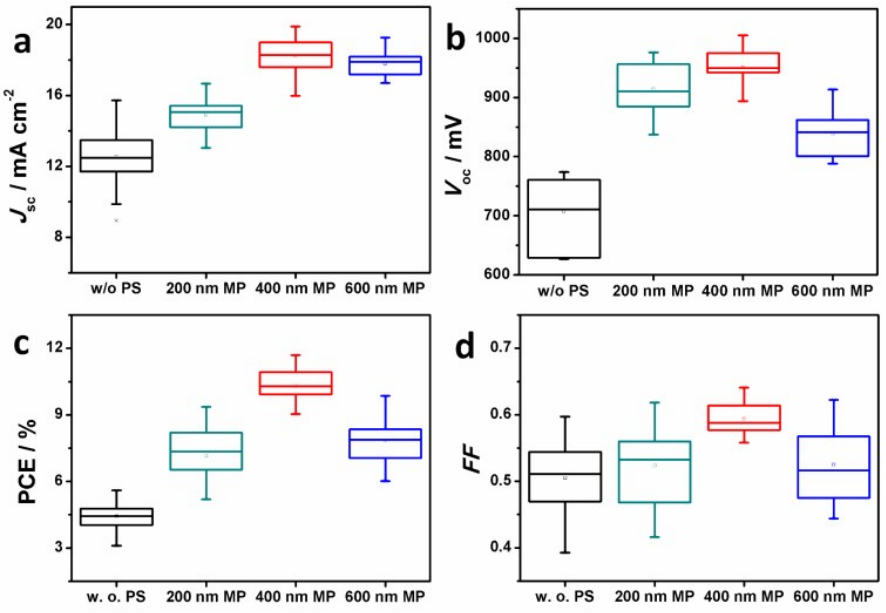

Fig. S3. The box-chart images of photovoltaic parameters for 20 devices based on MP perovskite films with various pore sizes and island-like perovskite film.

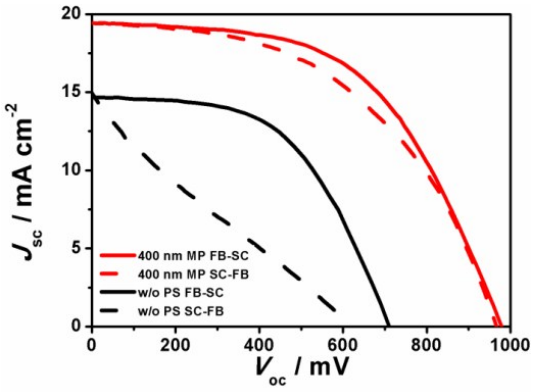

Fig. S4. The *J-V* curves performed from forward bias to short circuit (FB-SC, solid line) and from short circuit to forward bias (SC-FB, dashed line) for the typical PSC devices based on 400 nm MP and island-like perovskites.

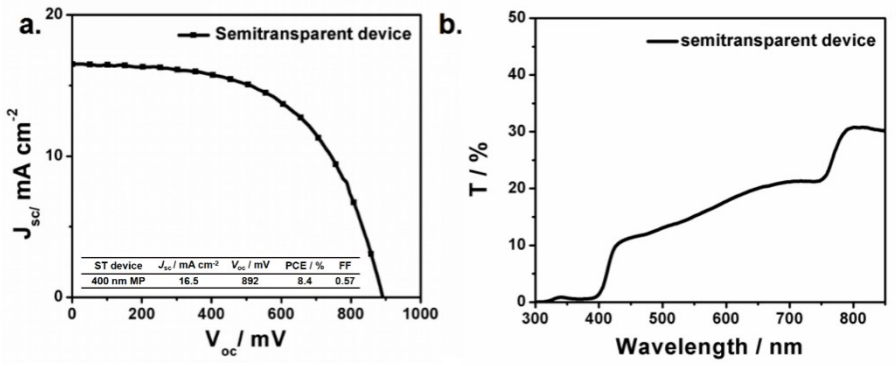

Fig. S5. (a) The *J-V* curves of semitransparent perovskite solar cells based on 400 nm MP perovskite and ~20 nm Au cathode. (b) Transmittance spectra of the whole device.

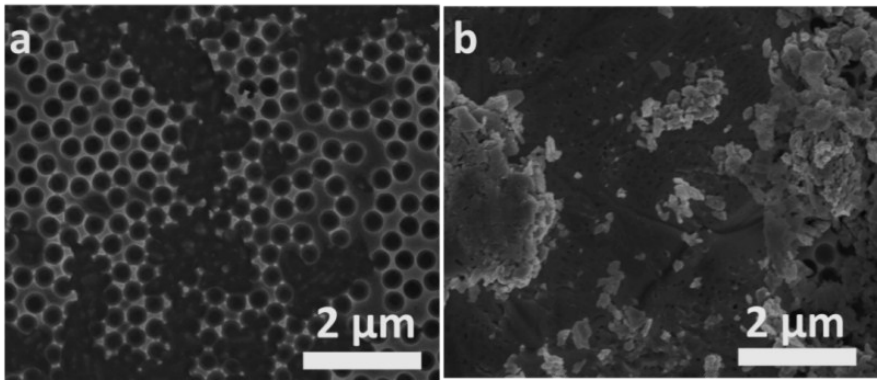

Fig. S6. The top-view of 400 nm MP perovskite film with 0.4 M precursor (a) and 0.8 M precursor (b).

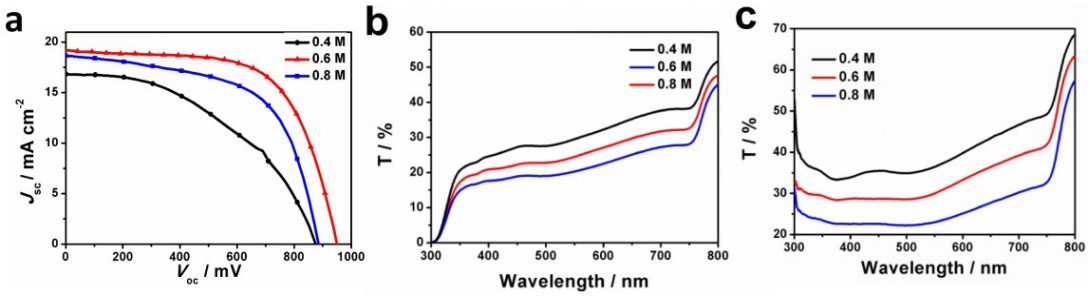

Fig. S7. (a) The *J-V* curves of typical 400 nm MP perovskite solar cells with various precursor concentrations measured under AM 1.5 G one sun (100 mWcm^{-2}) illumination. (b) Transmittance spectra of MP perovskite with various precursor concentrations deposited on FTO/TiO_2 substrate. (c) Transmittance spectra of MP perovskite with various precursor concentrations excluded the effect on FTO/TiO_2 substrate.

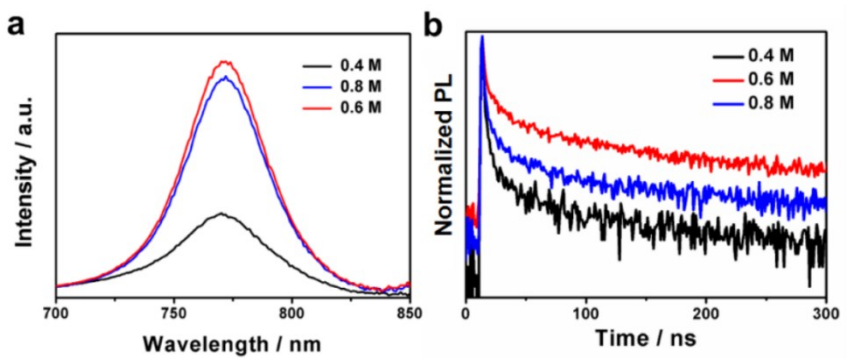

Fig. S8. (a) Steady-state photoluminescence (PL) (excitation at 406.2 nm) and (b) Time-resolved photoluminescence (TRPL) spectra (excitation at 406.2 nm and emission at 760 nm) of 400 nm MP perovskite films with various precursor concentrations.

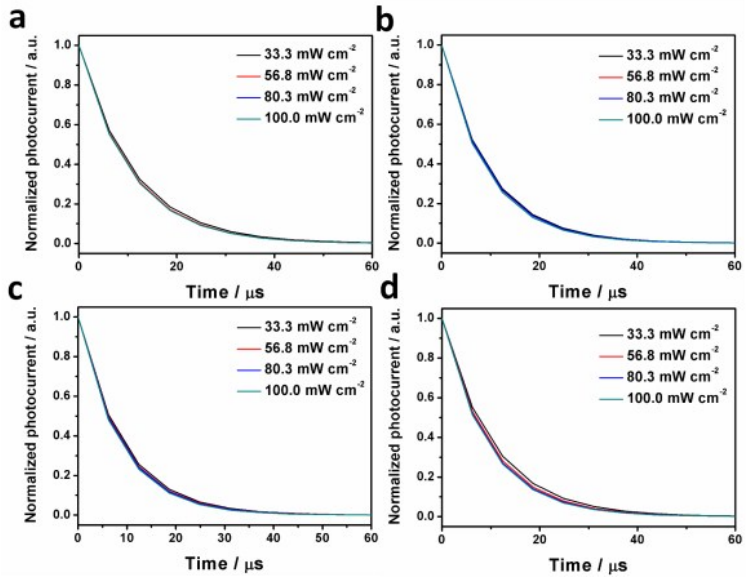

Fig. S9. The single exponential fitted transient photocurrent decay curves of island-like (a), 200 nm MP (b), 400 nm MP (c) and 600 nm (d) MP perovskite solar devices.

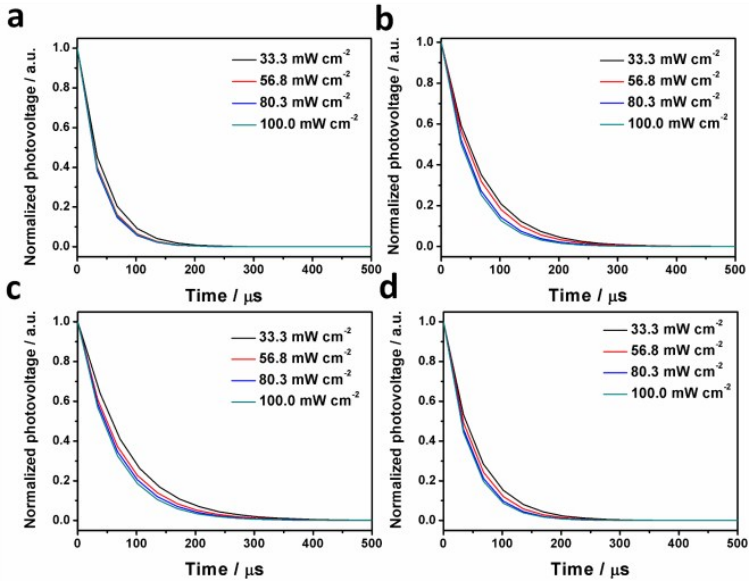

Fig. S10. The single exponential fitted transient photovoltage decay of island-like (a), 200 nm MP (b), 400 nm MP (c) and 600 nm (d) MP perovskite solar devices.

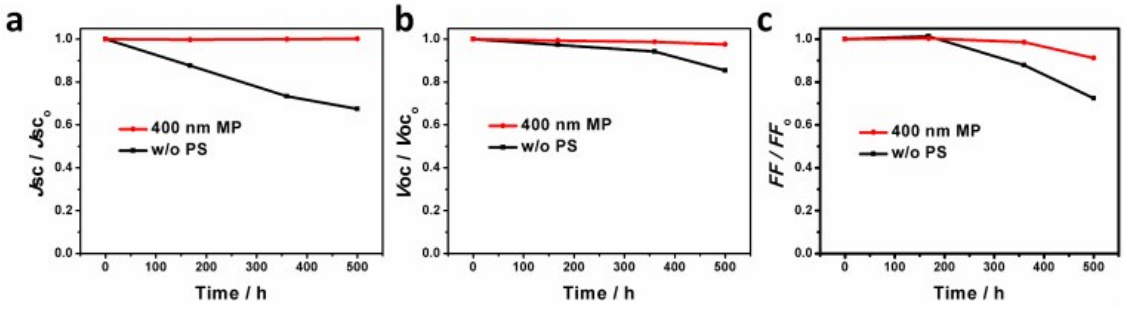

Fig. S11. The variations of J_{sc}, V_{oc} and *FF* for devices based on 400 nm MP perovskite and island-like perovskite during 500 h aging in ambient dry air.

Table S1. The max PCE and average values of photovoltaic parameters which extracted from measuring current density-voltage curves at simulated one sun illumination for precursor concentrations of 0.4 M and 0.8 M (100 mW cm^{-2}, AM 1.5 G).

		J_{sc}/mA cm^{-2}	V_{oc}/mV	PCE/%	FF
0.4 M	Max	16.1	759	6.5	0.53
	Average	16.7	793	4.9	0.37
0.8 M	Max	18.6	885	9.8	0.60
	Average	17.9	859	7.2	0.47

Table S2. The fitted charge transport lifetimes and charge carrier lifetimes of MP perovskite solar devices with different sizes and island-like perovskite cell (w/o PS) under different incident light intensity.

	Time/μs	33.3 mW cm^{-2}	56.8 mW cm^{-2}	80.3 mW cm^{-2}	100.0 mW cm^{-2}
w/o. PS	$\tau_{charge-carrier}$	42.8	37.4	36.6	35.7
	τ_{trans}	11.1	10.6	10.4	10.0
200 nmMP	$\tau_{charge-carrier}$	64.9	59.45	52.3	49.4
	τ_{trans}	10.0	9.4	9.1	8.8
400 nm MP	$\tau_{charge-carrier}$	75.9	70.1	63.9	60.3
	τ_{trans}	9.1	8.9	8.7	8.5
600 nm MP	$\tau_{charge-carrier}$	53.9	47.7	43.7	41.0
	τ_{trans}	10.4	9.8	9.5	9.3

Table S3 The fitted R_{HTM} and R_{rec} of MP perovskite solar devices with different sizes and island-like perovskite cell (w/o PS) according to the Nyquist plots.

	R_{HTM}/Ω cm^2	R_{rec} /Ωcm^2
w/o PS	32.21	76.89
200 nm MP	31.17	132.4
400 nm MP	27.64	172.2
600 nm MP	31.46	112.3