Supporting Information

Improvement in printable mesoscopic perovskite solar cells via thinner spacer layer

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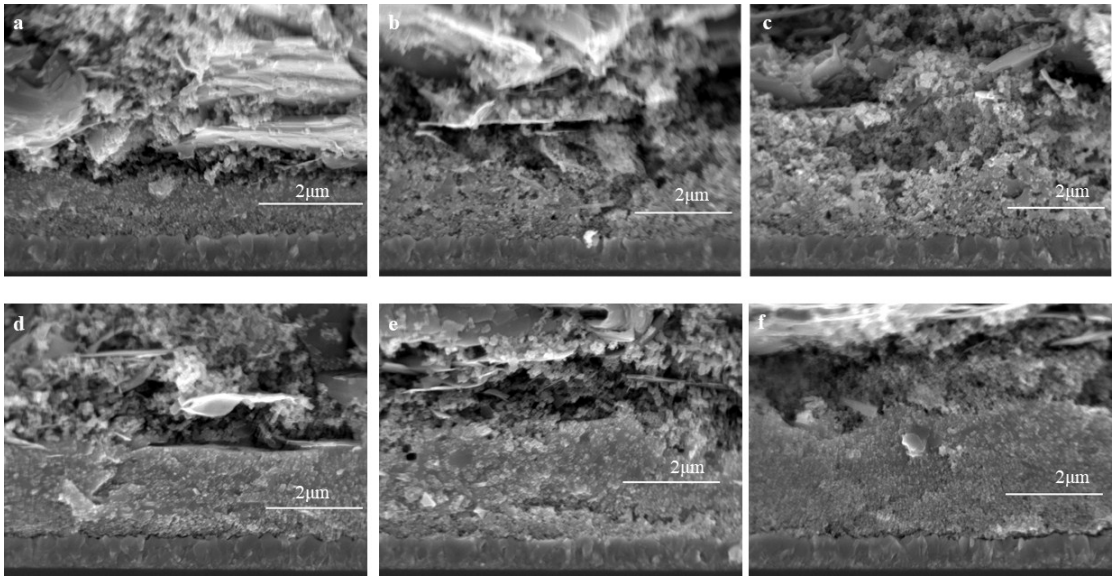

Figure S1. The cross-section SEM of devices with different thickness of mp-ZrO_2 layer. 2 μl (a,b,c) and 3 μl (d,e,f) of perovskite precursor solution were filled into devices with 1.2 μm (a,d), 2 μm (b,e) and 3 μm (c,f) mp-ZrO_2 layers.

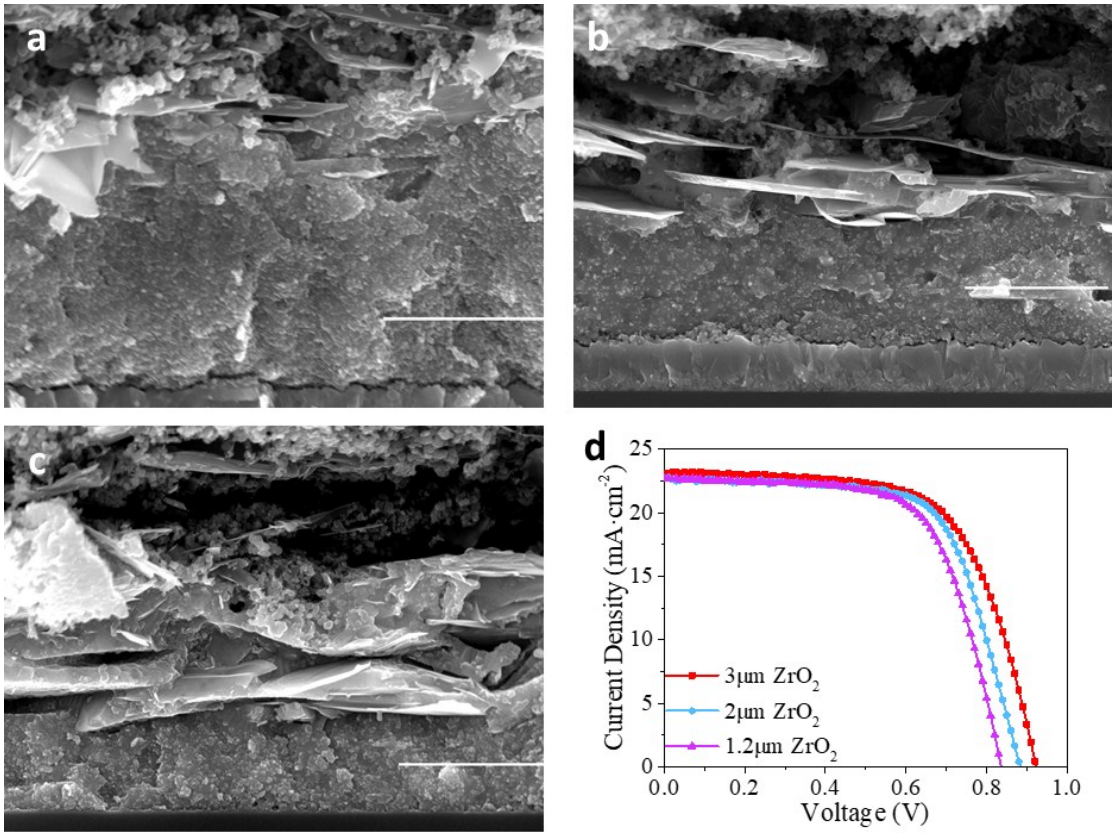

Figure S2. Cross-section SEM images and performance of devices. The thickness of ZrO_2 layer in devices are 3 μm (a), 2 μm (b), and 1.2 μm (c). (d) The J-V curve of three types of devices with three different ZrO_2.

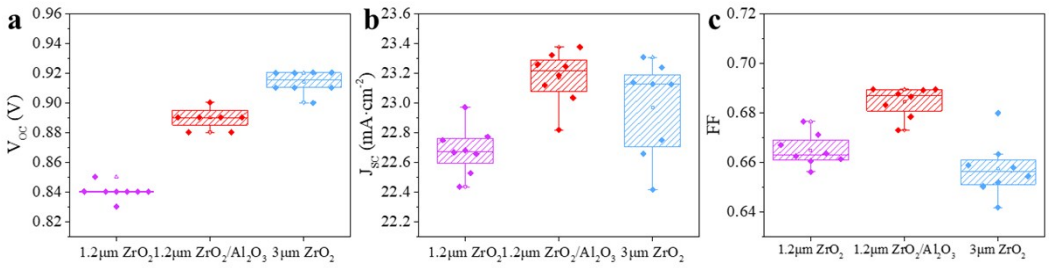

Figure S3. The parameters of devices based on different thickness of ZrO_2. (a) V_{OC}, (b) J_{SC}, (c) FF. For each kind of devices, eight devices are tested and all devices are fabricated in the same batch.

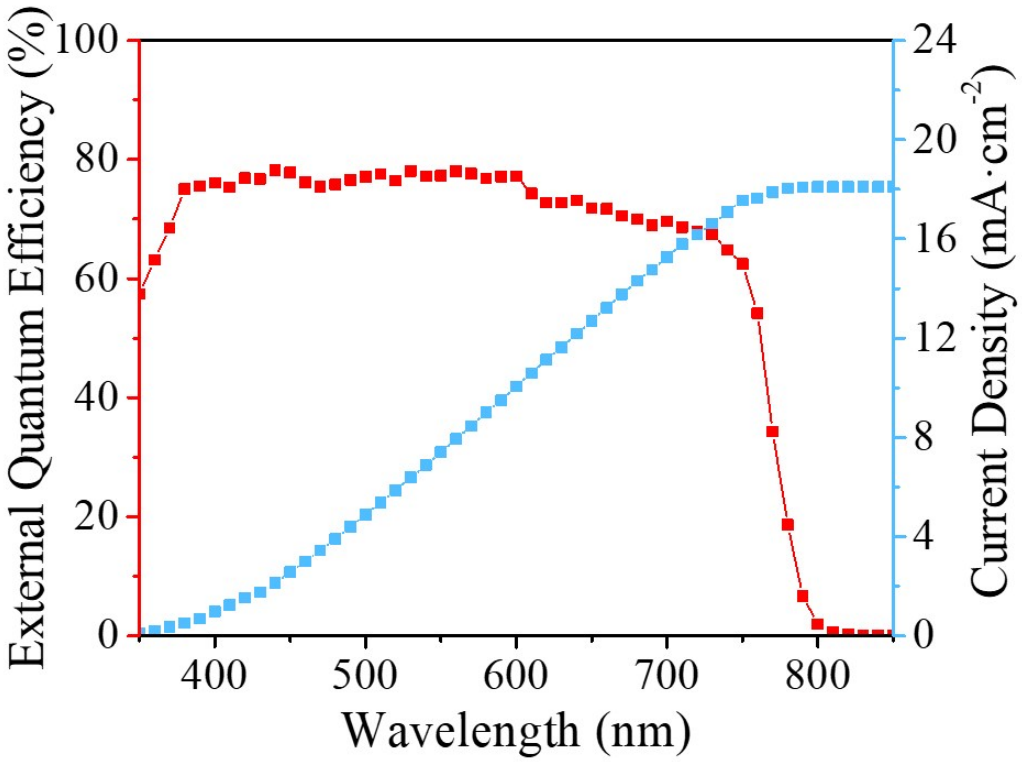

Figure S4. The IPCE spectrum and integrated photocurrent of the champion device.

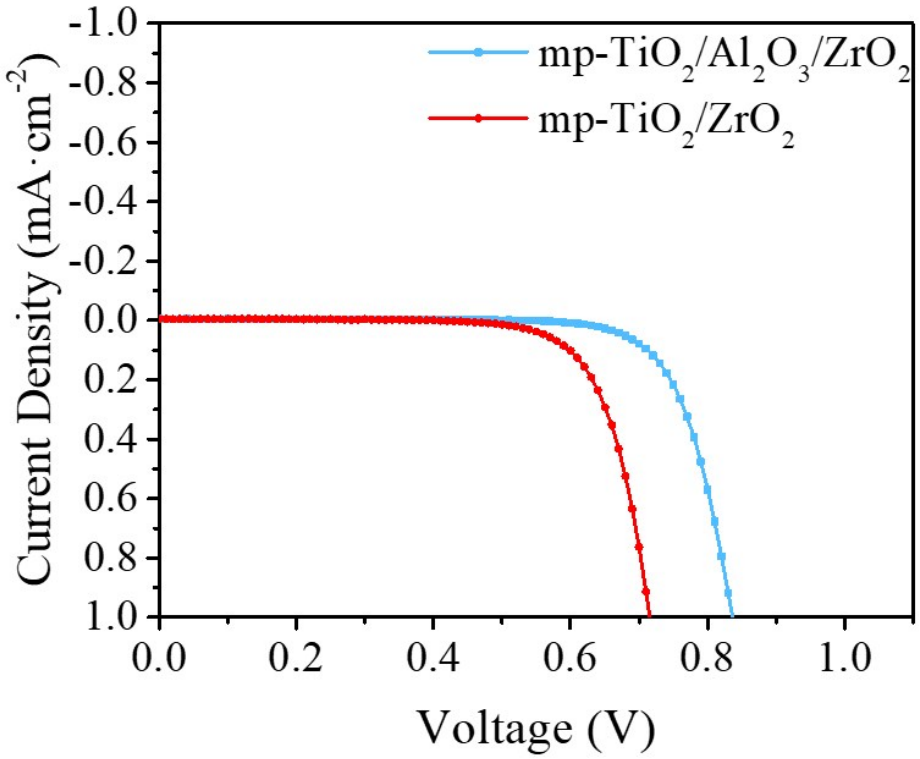

Figure S5. The dark current density of devices, the sweep rate was 100mV·s^{-1}

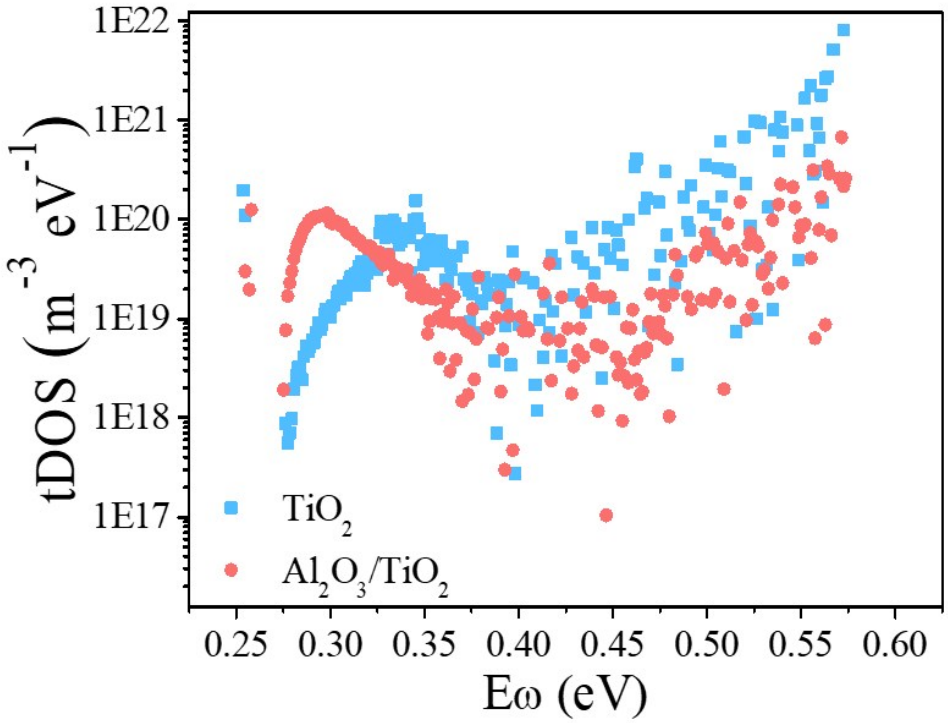

Figure S6. The result of TAS test of mp-TiO_2 and mp-TiO_2/Al_2O_3 films.

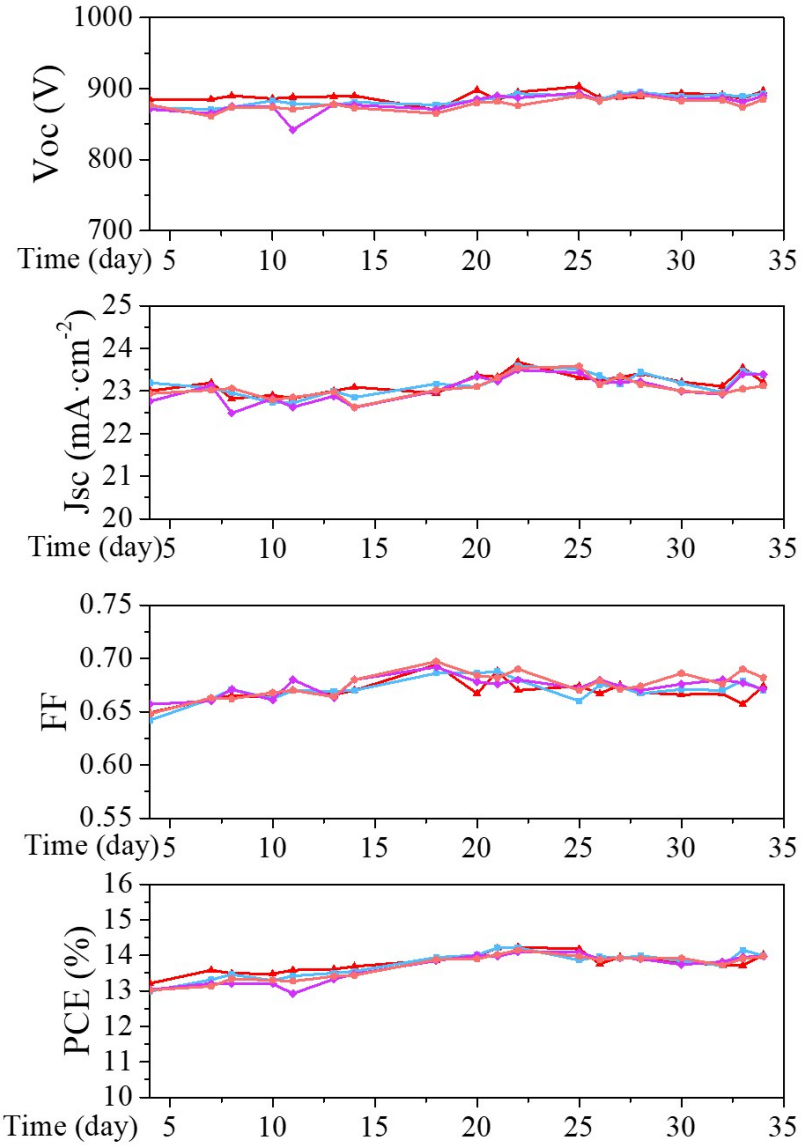

Figure S7. The stability of devices. (a) V_{OC}, (b) J_{SC}, (c) FF, (d) PCE of four devices within a period of time. The devices were stored in the humidity chamber without encapsulation. (RH~60%, Temperature~25 ^{o}C)

Peak	Position BE(eV)	FWHM (eV)	Raw Area (cps eV)	RSF	Atomic Mass	Atomic Conc %	Mass Conc %
Ti 2p	458.678	1.043	74324.6	2.001	47.878	39.71	72.29
C 1s	285.078	1.315	14869.5	0.278	12.011	59.97	27.39
Al 2p	73.828	0.317	50.0	0.193	26.982	0.31	0.32

Table S1. The XPS result of the mp-TiO_2/Al_2O_3 film deposited on the FTO substrate.