Supporting information for

Transparent Poly(3,4-ethylenedioxylenethiophene):Poly(styrene sulfonate) Cathode for Low Temperature Processed, Metal-Oxide Free Perovskite Solar Cells

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Fabrication of FTO/TiO_2-based PSCs

The conventional PSCs are based on the structure of FTO/TiO_2/perovskite/spiro-OMeTAD/Au. Firstly, a 20 nm thick TiO_2 compact layer (c-TiO_2) was coated on the cleaned FTO substrates by aerosol sprayed pyrolytic deposition of a titanium diisopropoxide bis(acetylacetonate) solution. The FTO/TiO_2 substrates were treated by UV-ozone for 20 min and transferred into a glove box. After that, a $CH_3NH_3PbI_3$ perovskite precursor solution (1:1 molar ratio 45 wt% in DMF) was directly spin-coated on the FTO/TiO_2 substrate at 5500 rpm in the N_2 atmosphere. During the spin-coating process, 150 μL chlorobenzene (CB) was quickly added to the surface of the substrate after a specific delay time of 6 s to form flat pin-hole free perovskite films. The hole transport material (HTM) was prepared by dissolving 75 mg ml^{-1} spiro-OMeTAD, 28 μl tert-butylpyridine, and 18 μl of bis(trifluoromethane) sulfonamide lithium salt solution (520 mg in 1 ml acetonitrile) in 1 ml CB. Then, the HTM solution was spin-coated onto the perovskite films at 4000 rpm for 30 s. Finally, 100 nm thick Au anodes were deposited on the devices, under a vacuum pressure of 10^{-4} Pa.

Fabrication of ITO/PEDOT:PSS-based PSCs

The inverted PSCs had the structure of ITO/PEDOT:PSS/perovskite/PCBM/bathocuproine (BCP)/Ag. Firstly, a 40 nm PEDOT:PSS (Clevios P VP AI 4083) layer was spin-coated onto the pre-cleaned ITO glasses. Then, the PEDOT:PSS layer was baked at 140 °C for 10 min in air. After that, the same $CH_3NH_3PbI_3$ perovskite precursor solution was spin-coated on the PEDOT:PSS layer at 5500 rpm, in the N_2 atmosphere. Similarly, during the spin-coating process, 150 μL CB was quickly dropped on the surface of the substrate after a delay time of 6 s to form flat pin-hole free perovskite films. Then, PCBM (Nano-C) in the CB

solution was spin-coated onto the perovskite films at 1000 rpm for 30 s. BCP (Sigma-Aldrich) in the 2-propanol solution was spin-coated onto the PCBM layers at 4500 rpm for 30 s. Finally, 100 nm thick Ag anodes were thermally evaporated on the devices, in the vacuum pressure of 10^{-4} Pa.

Table S1. Summary of photovoltaic parameters of the PSCs using the PEDOT:PSS/PEI cathode.

Scan	J_{sc} (mA cm^{-2})	V_{oc} (V)	FF (%)	PCE (%)
Forward	17.88	0.95	73.1	12.42
Reverse	17.95	0.95	73.6	12.55

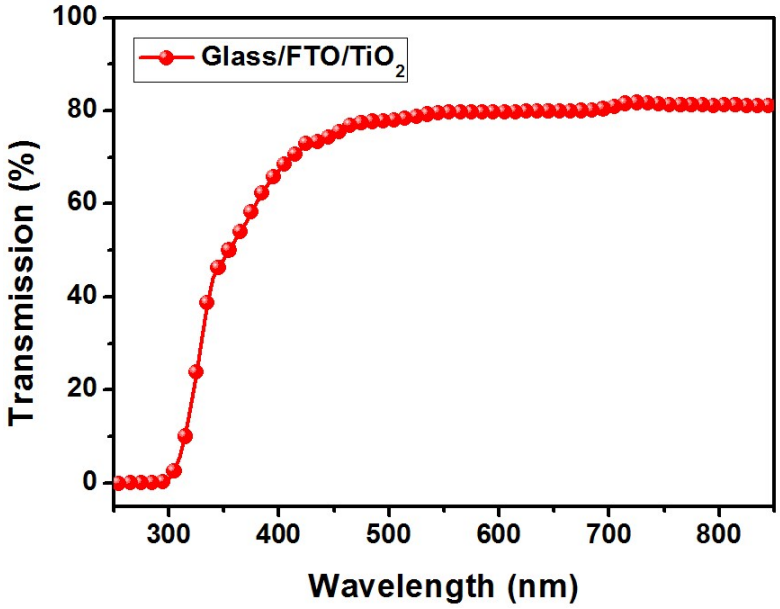

Fig. S1. Transmittance spectrum for the glass/FTO/TiO_2 substrate.

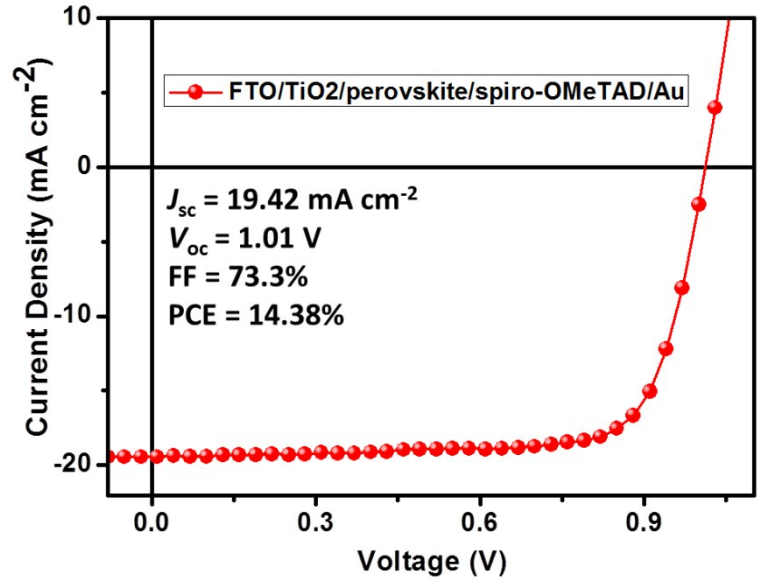

Fig. S2. *J–V* characteristics of the conventional PSC based on the FTO/TiO_2 substrate under the AM1.5 100 mW cm^{-2} illumination.

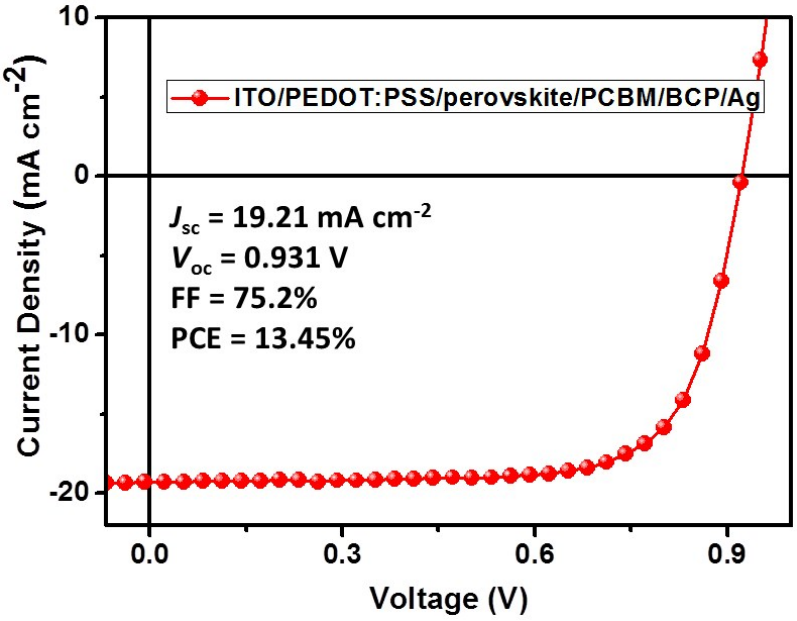

Fig. S3. *J–V* characteristics of the inverted PSC based on the ITO/PEDOT:PSS substrate under the AM1.5 100 mW cm^{-2} illumination.

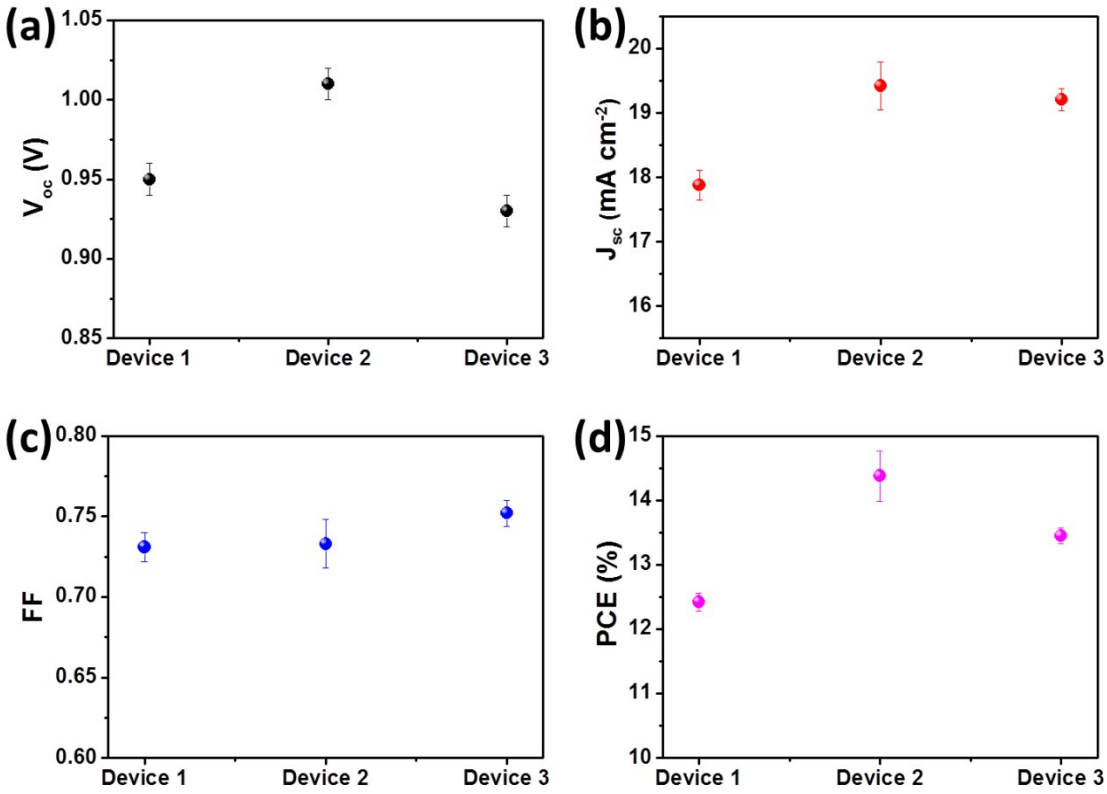

Fig. S4. Median values and standard deviations of (a) V_{oc}, (b) J_{sc}, (c) FF, and (d) PCE of 22 PSCs. Device 1, 2, and 3 stand for PSCs fabricated on substrates of PEDOT:PSS/PEI, FTO/TiO_2, and ITO/PEDOT:PSS, respectively.

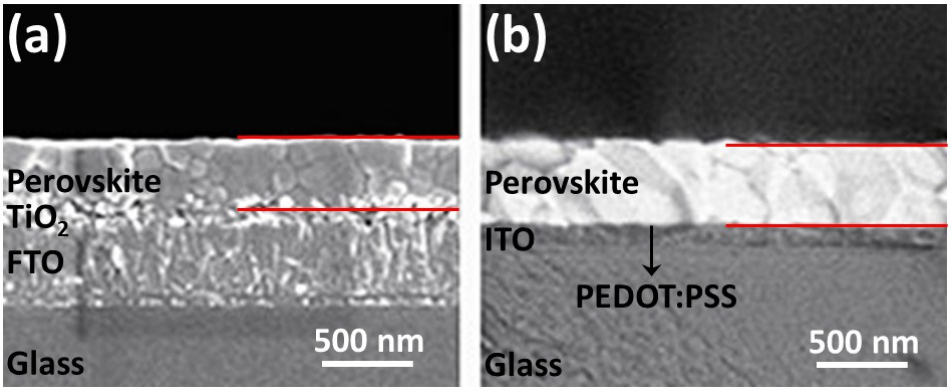

Fig. S5. Cross-sectional SEM images of (a) perovskite on FTO/TiO_2 substrate, and (b) perovskite on ITO/PEDOT:PSS substrate.

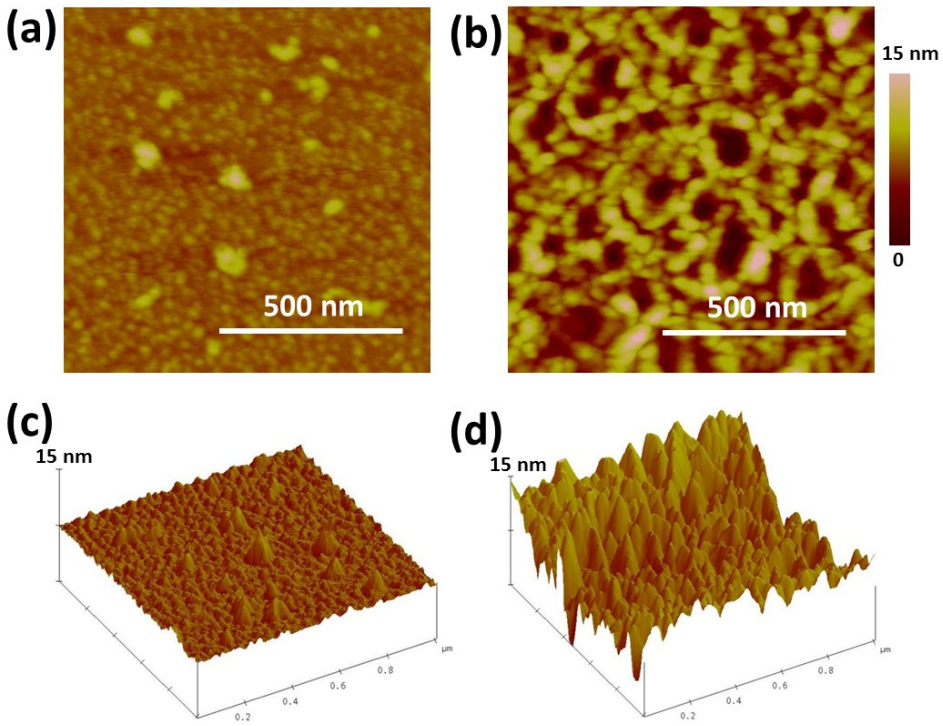

Fig. S6. (a-b) Height and (c-d) 3D AFM images of glass and PET substrates used in this work: (a) and (c) for glass; (b) and (d) for PET.

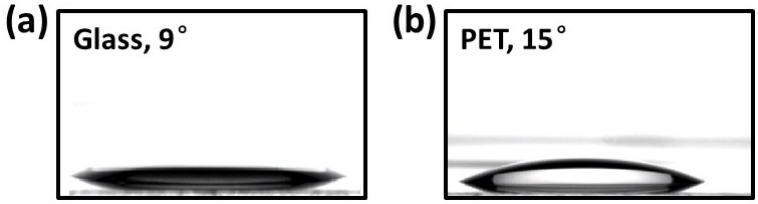

Fig. S7. Contact angel measurements on (a) glass substrate, and (b) PET substrate.