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Supplementary Information

SnO_x-Brookite TiO_2 Bilayer Electron Collector for Hysteresis-less High Efficiency Plastic Perovskite Solar Cells Fabricated at Low Process Temperature

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Experimental details

A SnO_x hole-blocking layer was formed on the surface of an ITO-PEN films (Peccell Technologies, Inc.) by spin-coating 1-buthanol solution of 0.1 M $SnCl_2{\cdot}2H_2O$ and dried at 150 °C for 1 h. A binder-free brookite slurry (TiO_2 3.5wt% in ethylene glycol monopropyl ether), which was prepared by solvent replacement of brookite aqueous sol. (PECC-B01, Peccell Technologies, Inc, particle size 10–20 nm), was spin-coated and dried for further 3 h. For planar-structured cells, $SnCl_2{\cdot}2H_2O$ solution was dried for 4 h without deposition of brookite.

After UV-ozone treatment for 5 min, a mixed solution of CH_3NH_3I (2.7 M) and $PbCl_2$ (0.9 M) in *N*,*N*-dimethylformamide were spin-coated on the substrate at 2000 rpm for 30 s and annealed at 105 ^oC for 90 min in dry air to form perovskite $CH_3NH_3PbI_{3-x}Cl_x$ layer. A 0.12 M 2,2',7,7'-tetrakis-(*N*,*N*-di-4-methoxyphenylamino)-9,9'-spirobifluorene (spiro-OMeTAD) solution in cholorobenzene containing 0.034 M bis(trifluoromethane) sulfonamide lithium salt and 0.098 M 4-*tert*-butylpyridine was spin-coated at 4000 rpm for 30 s and aged overnight in dry air. Finally, Au was vapor-deposited on the top of spiro-OMeTAD as a counter electrode. The device size with ITO-PEN substrate was 1.2 cm × 1.2 cm on which three cells were fabricated by depositing Au counter electrode (3.2 mm × 8.0 mm). Photovoltaic characteristics of all the devices were measured with a black mask (aperture area of 0.09 cm^2, thickness of 400 μm) with a Keithley 2400 source meter under 1 sun illumination in ambient air at room temperature. Peccell Technologies PEC-L01 solar simulator (AM 1.5 G, 100 mW cm^{-2}) was employed with a reference crystalline Si cell (BS-520, calibrated and certified by Bunkou Keiki) for correction of incident intensity. Photocurrent density-voltage curves were measured with scan speed and dwell time of 0.125 V s^{-1} and 0.05 s, respectively. The IPCE action spectra of device were measured in ambient air at room temperature on Peccell Technologies, PEC-S20 action spectrum measurement setup. For characterization, an UV spectrophotometer (UV-1800, SHIMADZU), an X-ray diffractometer (D8 Discover, Brucker) with CuKα radiation source, ~~and~~ a scanning electron microscope (SU8000, HITACHI) and an atomic force microscope (SPM-9500J3, SHIMADZU) were employed. Photoelectron yield spectroscopy system (BIP-KV201, Bunkou Keiki) was employed to measure work function of materials.

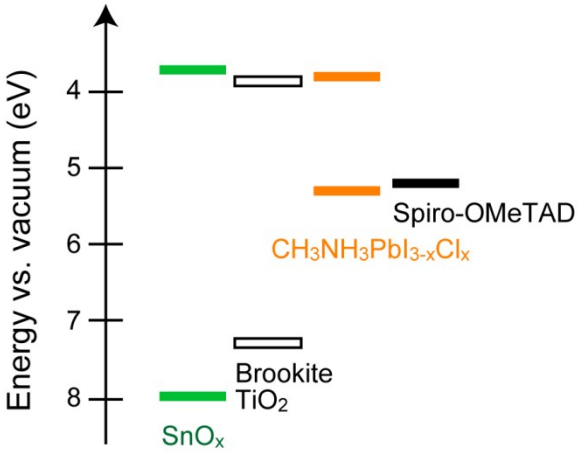

Figure S1. Energy levels of the materials used in this study. Values of $CH_3NH_3PbI_{3-x}Cl_x$ and spiro-OMeTAD are obtained from literature.[1]

References

1. J. T.-W. Wang, J. M. Ball, E. M. Barea, A. Abate, J. A. Alexander-Webber, J. Huang, M. Saliba, I. Mora-Sero, J. Bisquert, H. J. Snaith and R. J. Nicholas, *Nano Lett.*, 2014, **14**, 724–730.