Supporting Information

Bulk-heterojunction pushes photoresponse of perovskite solar cells to 970 nm

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Synthesis and characterization

PDPP3T was synthesized using reported method.[1] Absorption spectra of films were recorded on a Shimadzu UV-1800 spectrophotometer. The thicknesses of films were measured using a Tencor D-120 profilometer.

Solar cell fabrication and characterization

Patterned ITO glass with a sheet resistance of 15 Ω sq^{-1} was cleaned by ultrasonics in detergent, deionized water, acetone, isopropanol sequentially and then treated with UV-ozone for 10 min. A 30 nm thick PEDOT layer was formed on ITO glass by spin coating an aqueous dispersion (PEDOT:PSS, Clevios™ P VP AI 4083) onto ITO glass (4000 rpm for 30 s). PEDOT substrates were dried at 150 °C for 10 min, and then transferred into a N_2 glovebox. For BHJ cells, a PDPP3T:$PC_{61}BM$ blend solution (10~24 mg/mL in chlorobenzene with 4 vol% DIO) was spin coated onto PEDOT at 1200 rpm for 60s. For perovskite cells, the precursor solution (10~19 wt%) was spin coated onto PEDOT at 3000 rpm for 60 s and heated at 100 °C for 30 s. Then $PC_{61}BM$ solution (20 mg/mL in chlorobenzene) was spin coated onto $CH_3NH_3PbI_3$

layer at 1500 rpm for 30 s. For the integrated solar cells, a PDPP3T:$PC_{61}BM$ blend solution (10~24 mg/mL in chlorobenzene with 4 vol% DIO) was spin coated onto $CH_3NH_3PbI_3$ layer at 1200 rpm for 60s. Finally Ca (10 nm) and Al (100 nm) was deposited onto $PC_{61}BM$ layer or the blend layer through a shadow mask in vacuo (10^{-4} Pa). The effective area for the cells is 4 mm^2. *J-V* curves were measured using a computerized Keithley 2420 SourceMeter. Device characterization was performed in air using a solar simulator (Newport 91159A, AM 1.5G, 100 mW/cm^2). The illumination intensity was determined using a monocrystalline silicon cell (Oriel 91150, 2×2 cm) calibrated by NREL. EQE spectra were measured using a QE-R3011 system (Enli Technology).

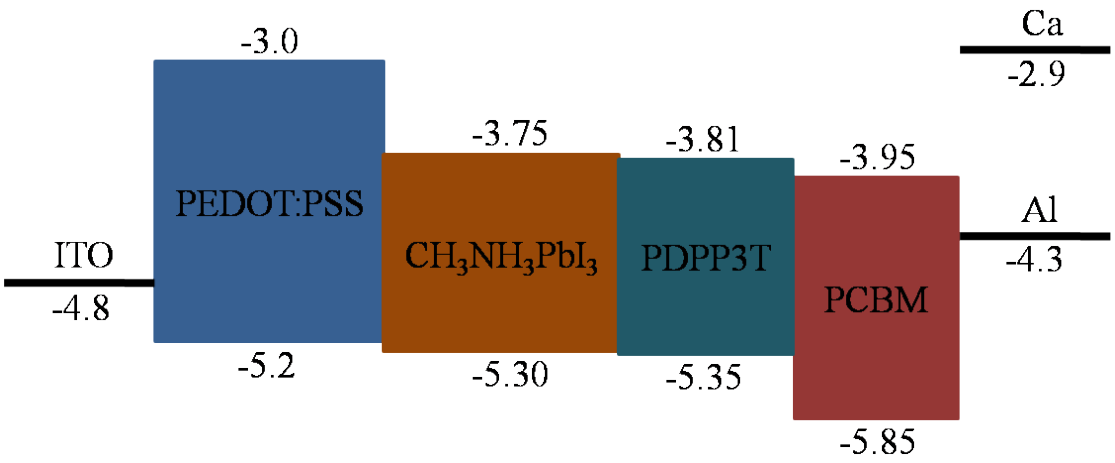

Fig. S1 The energy level diagram for the integrated cells.[2,3]

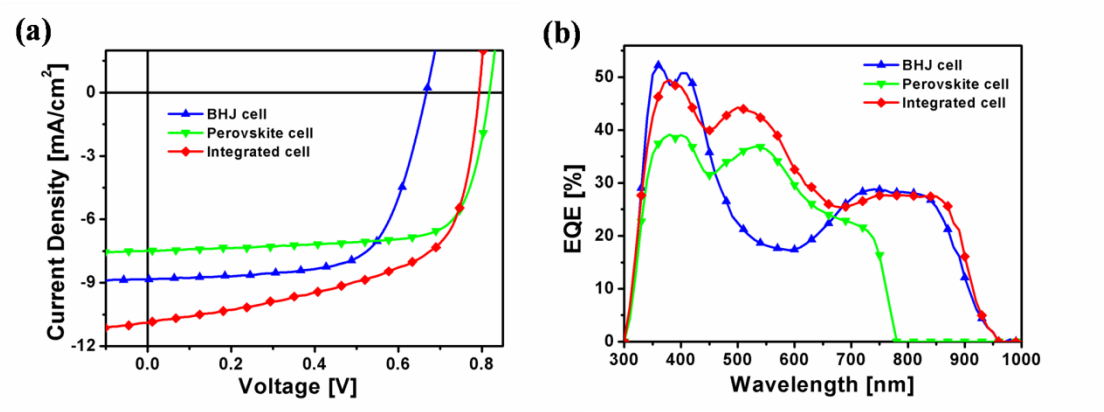

Fig. S2 *J-V* curves (a) and EQE spectra (b) for BHJ cells, perovskite cells and the integrated cells. The thicknesses for $CH_3NH_3PbI_3$ layer and PDPP3T:$PC_{61}BM$ (1:2) layer are 70 nm and 130 nm, respectively.

Table S1 Performance data for BHJ cells, perovskite cells and the integrated cells.

Cell type	V_{oc} [V]	J_{sc} [mA/cm^2]	Cal. J_{sc} [mA/cm^2]	FF [%]	PCE [%]
BHJ cell	0.67	8.82	8.76	67.07	3.96
Perovskite cell	0.82	7.49	7.42	74.08	4.55
Integrated cell	0.79	10.86	10.89	59.26	5.08

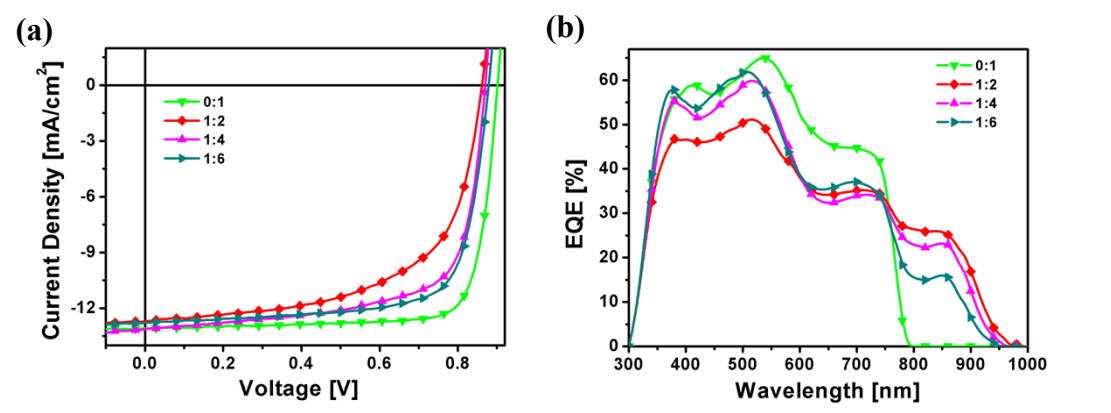

Fig. S3 *J-V* curves (a) and EQE spectra (b) for the integrated solar cells with different PDPP3T:$PC_{61}BM$ ratio.

Table S2 Performance data for the integrated solar cells[a] with different D/A ratio.

PDPP3T:$PC_{61}B$M	V_{oc} [V]	J_{sc} [mA/cm^2]	Cal. J_{sc} [mA/cm^2]	FF [%]	PCE [%]
0:1[b]	0.90	13.09	12.78	80.33	9.46
1:2[c]	0.86	12.67	12.55	60.84	6.63
1:4[c]	0.87	13.12	12.91	69.37	7.92
1:6[c]	0.88	12.78	12.62	73.72	8.29

[a] thickness for perovskite layer: 150 nm
[b] thickness for $PC_{61}BM$ layer: 80 nm
[c] thickness for blend layer: 130 nm

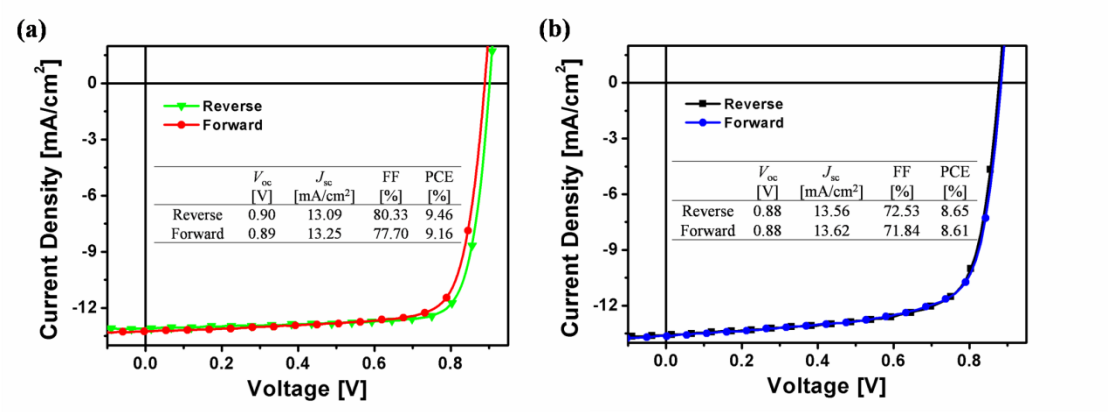

Fig. S4 (a) *J–V* curves for a perovskite solar cell (ITO/PEDOT/150nm $CH_3NH_3PbI_3$/80nm $PC_{61}BM$/Ca/Al) under forward (from short circuit to open circuit) and reverse (from open circuit to short circuit) scans with bias step of 0.013 V and scan rate of 0.13 V s^{-1}. (b) *J–V* curves for an integrated solar cell (ITO/PEDOT/150nm $CH_3NH_3PbI_3$/80nm PDPP3T:$PC_{61}BM$ (1:4)/Ca/Al) under the same measurement conditions.

References

[1] K. H. Hendriks, G. H. L. Heintges, V. S. Gevaerts, M. M. Wienk and R. A. J. Janssen, *Angew. Chem. Int. Ed.,* 2013, **52**, 8341.

[2] P. Docampo, J. M. Ball, M. Darwich, G. E. Eperon and H. J. Snaith, *Nat. Commun.*, 2013, **4**, 2761.

[3] J. W. Jung, F. Liu, T. P. Russell and W. H. Jo, *Energy Environ. Sci.*, 2013, **6**, 3301.