Electronic Supporting Information

Inverted Perovskite Solar Cells with Inserting Cross-linked Electron-Blocking Interlayer for Performance Enhancement

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General instrumentations

The thickness was measured by Tencor P-10 Surface Profiler. UV-vis spectra were measured using an UV-vis spectroscopy (Perkin-Elmer, Lambda 19). The XRD were collected on Rigaku Ultima IV X-ray diffractometer with Cu-Kα radiation. The SEM images were taken on Hitachi SU8010. Photoluminesence spectra were taken by Horiba-Jobin Yvon FluoroMax-3 with the excitation wavelength of 405 nm. The current-voltage (J-V) characteristics were measured under atmosphere using a Keithley 2400 source-measure unit and an AM 1.5G solar simulator (Oriel 94021A, 150 W from Newport). The illumination intensity of 100 mW/cm^2 irradiation was calibrated using a KG5-filtered NREL-traceable monocrystal Si reference cell to ensure the accurate light source intensity. The external quantum efficiency (EQE) was measured using a measurement system (model QE-R, from Enli Technology Co.). Light from a 150 W xenon lamp (Oriel, U.S.A.) was focused through a monochromator under testing. EQE (λ) as defined by EQE (λ) = 12400 (J_{sc}/λφ), φ is the incident radiative flux (mW/cm^2). J-V characteristics were measured in nitrogen filled glovebox and the device was encapsulated for EQE measurement in air.

XRD and PL quench

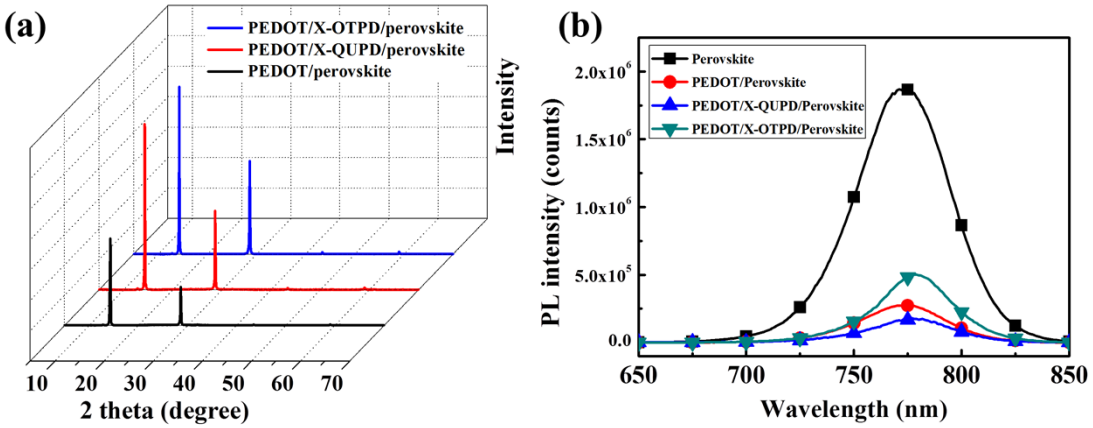

Fig S1. (a) XRD spectra of perovskite on glass/PEDOT:PSS and glass/PEDOT:PSS/ X-QUPD or X-OTPD. (b) PL quenching effect of perovskite on glass, glass/PEDOT:PSS and glass/PEDOT:PSS/ X-QUPD or X-OTPD.

SCLC

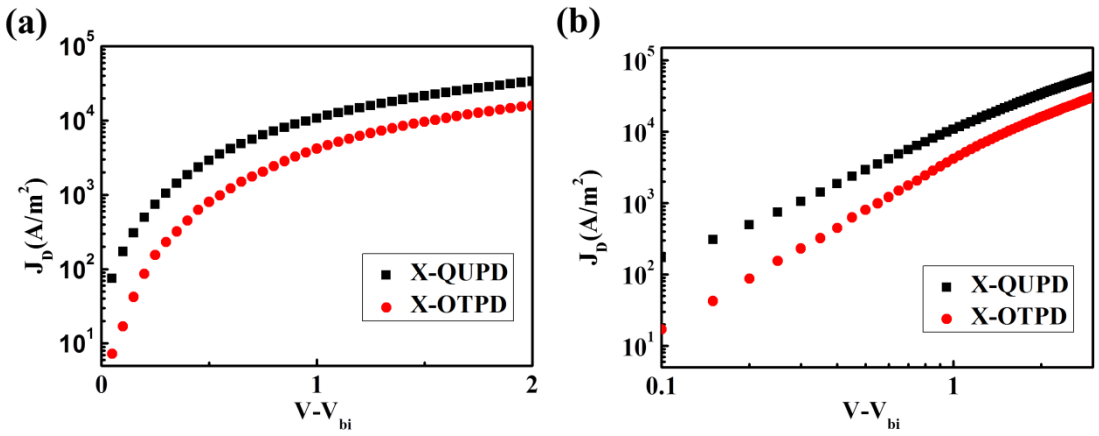

Fig S2. Current density versus bias voltage of the electron-only devices: (a) semi-log and (b) double-log.

J–V characteristics of invert type perovskite solar cells under various light intensities

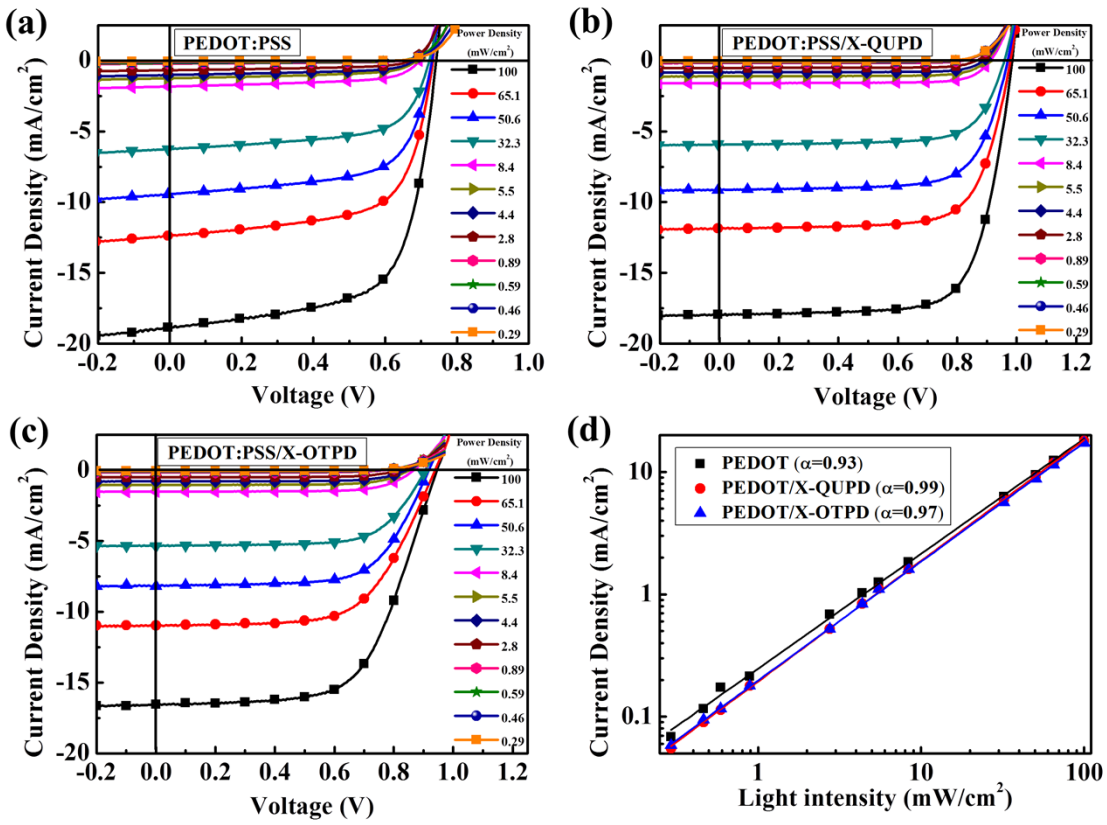

Fig. S3. J–V characteristics of invert type perovskite solar cells with (a) PEDOT:PSS, (b) PEDOT:PSS/X-QUPD, (c) PEDOT:PSS/X-OTPD under various light intensity ranging from 100 mW/cm^2 to 0.29 mW/cm^2. (d) log-log plot of current density versus irradiation light intensity.

Photovoltaic performance of the devices with various thickness of X-QUPD and X-OTPD as interlayer under AM 1.5G irradiation (100 mW/cm^2)

Table S1. Photovoltaic performance of the devices with various thickness of X-QUPD as interlayer under AM 1.5G irradiation (100 mW/cm^2).

X-QUPD	V_{oc} [V]	J_{sc} [mA/cm^2]	FF	PCE [%]	R_s [Ωcm^2]	R_{sh} [Ωcm^2]
2 nm	0.93	18.30	0.73	12.42	6.94	1876
4 nm	0.99	18.07	0.73	13.06	7.06	2096
7 nm	0.98	17.66	0.67	11.67	10.07	1497
10 nm	0.98	17.33	0.56	9.51	30.63	930
15 nm	0.98	16.81	0.46	7.58	53.02	252

Table S2. Photovoltaic performance of the devices with various thickness of X-OTPD as interlayer under AM 1.5G irradiation (100 mW/cm^2).

X-OTPD	V_{oc} [V]	J_{sc} [mA/cm^2]	FF	PCE [%]	R_s [Ωcm^2]	R_{sh} [Ωcm^2]
2 nm	0.91	17.68	0.65	10.46	9.66	991
4 nm	0.95	17.34	0.66	10.87	10.42	1590
6 nm	0.96	16.44	0.57	9.00	27.26	629
9 nm	0.96	15.56	0.48	7.17	33.49	312
11 nm	0.96	13.55	0.44	5.72	41.2	298