Supplementary Information

A PCBM-assisted low temperature process to fabricate high efficiency semitransparent perovskite solar cells

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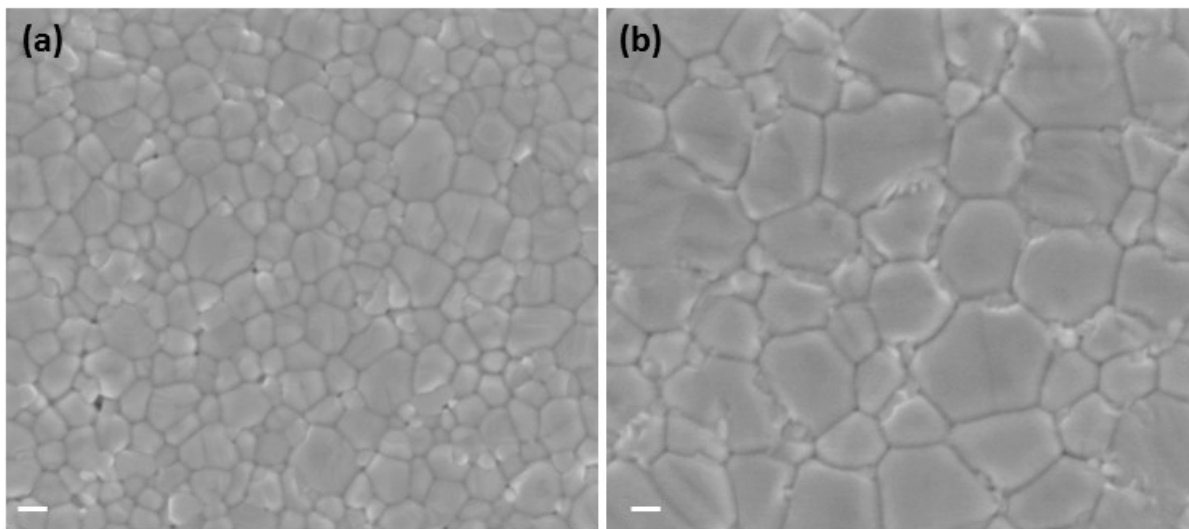
Jayan.Thomas@ucf.edu).

Fig. S1 SEM images of the surface morphology of the CH3NH3PbI3 films prepared by (a) conventional growth method and (b) CB assisted growth method. Scale bar: 200nm.
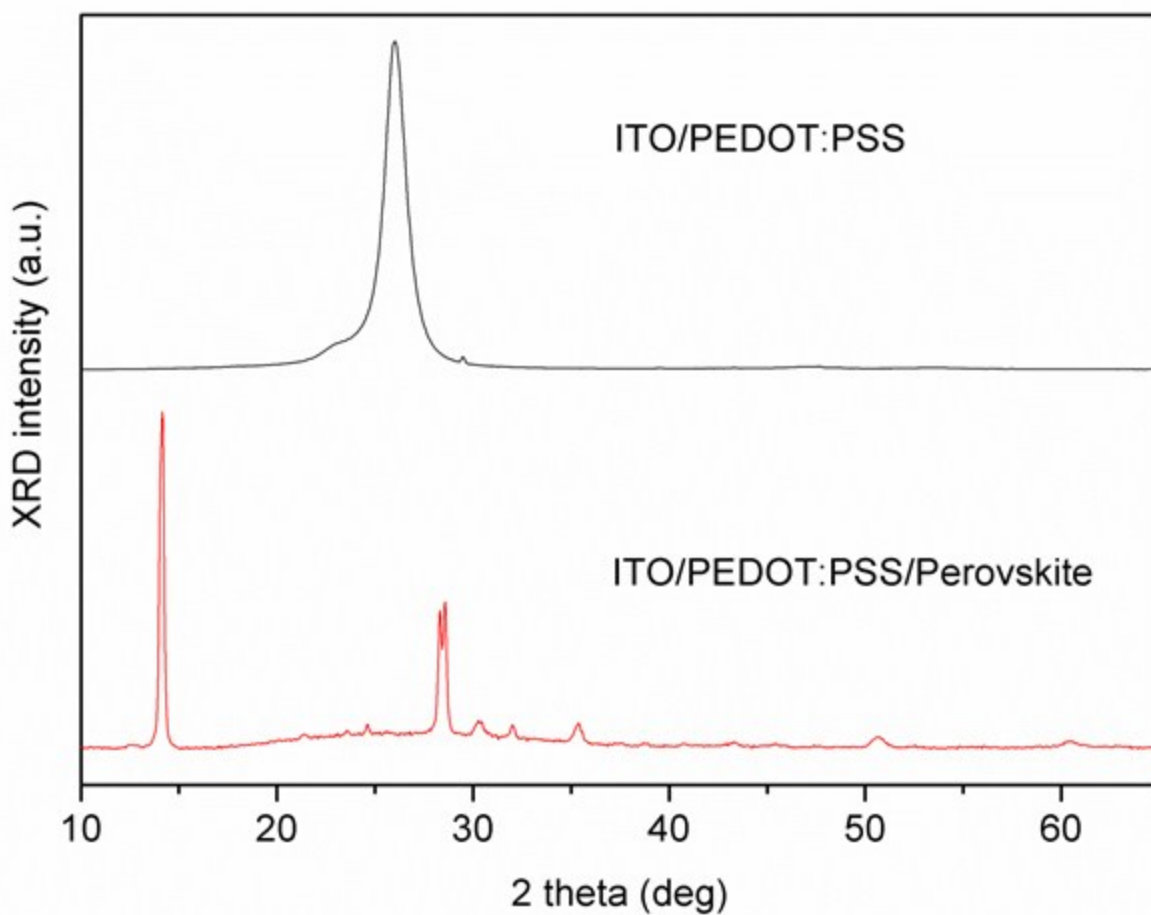
Fig. S2 XRD pattern of the perovskite crystals grown on PEDOT:PSS/ITO (red line), with blank sample of the PEDOT:PSS coated ITO substrate for comparison (black line).
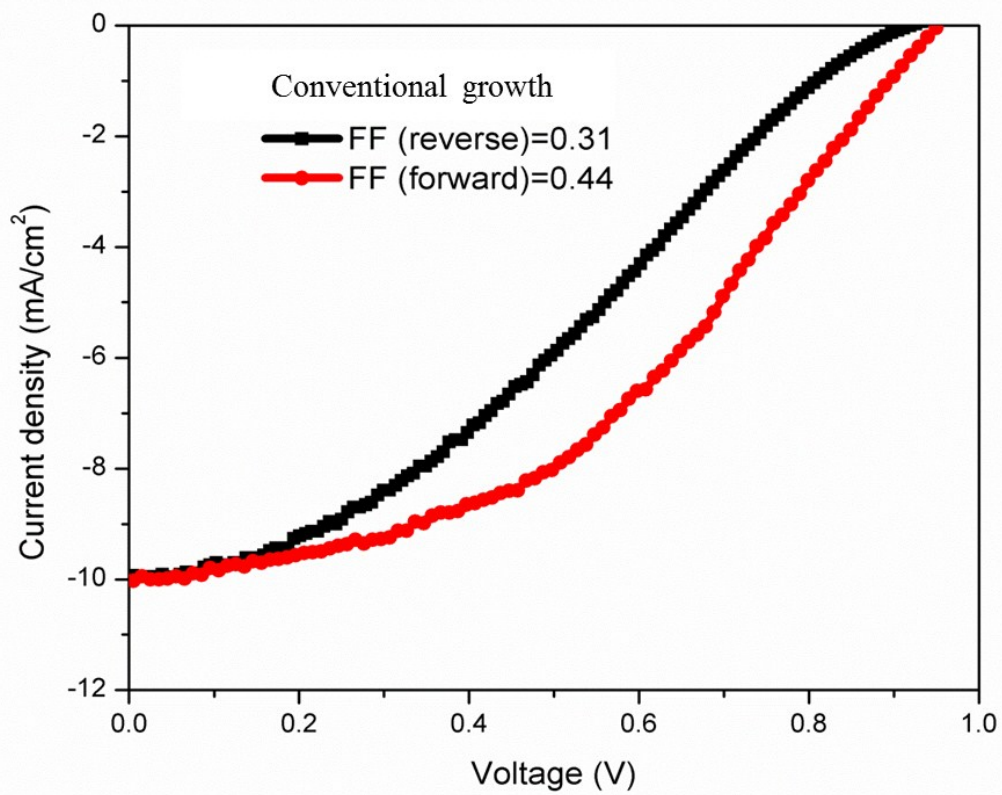
Fig. S3 J-V curve of conventional growth device with large hysteresis.

Table S1 Summary of opaque PSC performances with 100nm thick Au electrode.

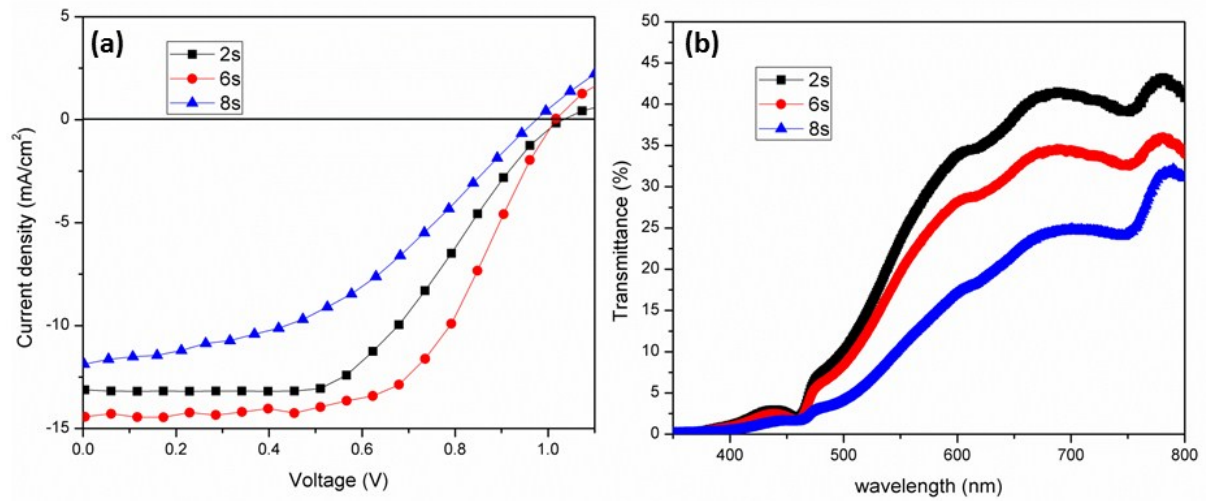| Cell	V_{oc} (V)	J_{sc} (mA cm-2)	FF (%)	PCE (%)
Conventional growth	0.930	14.98	55.14	7.68
CB-assisted growth	0.958	16.46	61.86	9.75
PCBM-assisted growth	1.017	17.82	70.12	12.71

Fig. S4 (a) Current-Voltage characteristics and (b) Transmittance spectra of complete perovskite solar cells prepared by adding PCBM solution at different delay times (2s, 6s, 8s) from the start of the spin-coating process.

Table S2 Device parameters for solar cells using perovskite films prepared by adding PCBM solution at different delay times (2s, 6s, 8s) from the start of the spin-coating process.

Cell	V_{oc} (V)	J_{sc} (mA cm-2)	FF (%)	PCE (%)
PCBM drop at 2s	1.031	12.82	53.94	7.13
PCBM drop at 6s	1.017	14.33	60.44	8.81
PCBM drop at 8s	0.976	11.87	42.64	5.0

In order to demonstrate the benefits of high V_{oc} perovskite solar cells, we connected two devices in series to efficiently power a red-light emitting diode (LED; operating voltage-1.7V). Figure S5 shows the lighting of LED, before (5a) and after (5b) connecting the perovskite solar cell. This is to demonstrate that high V_{oc} PSCs require fewer devices compared with low V_{oc} solar cells[1] to illuminate LED.
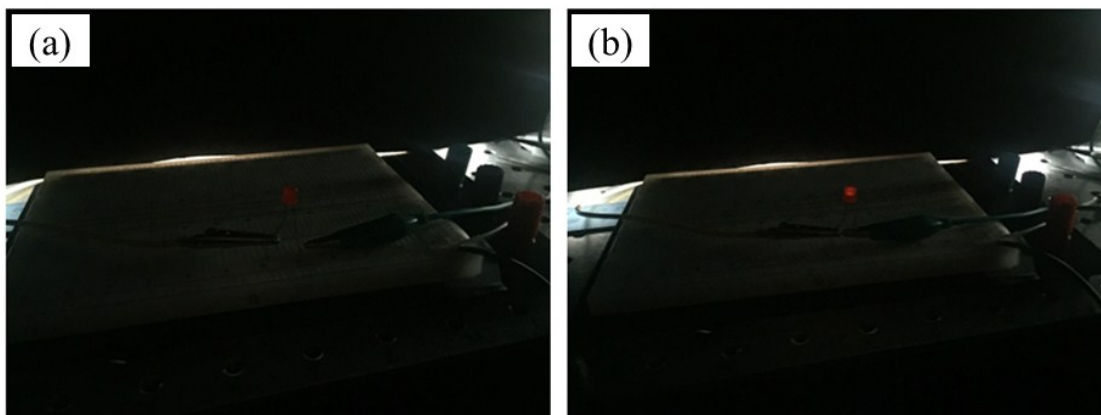

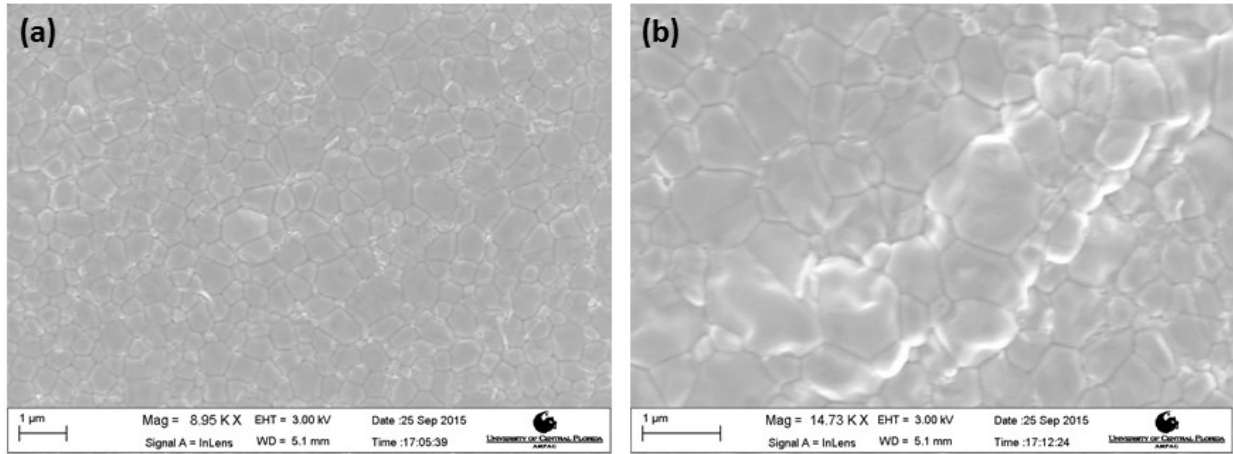**Fig. S5** It shows the red LED light before (5a) and after (5b) connecting the perovskite solar cell.

Fig. S6 SEM images of the surface morphology of the CH$_3$NH$_3$PbI$_3$ films prepared by PCBM solution at different delay times from the start of the spin-coating process: (a) 6s; (b) 8s.
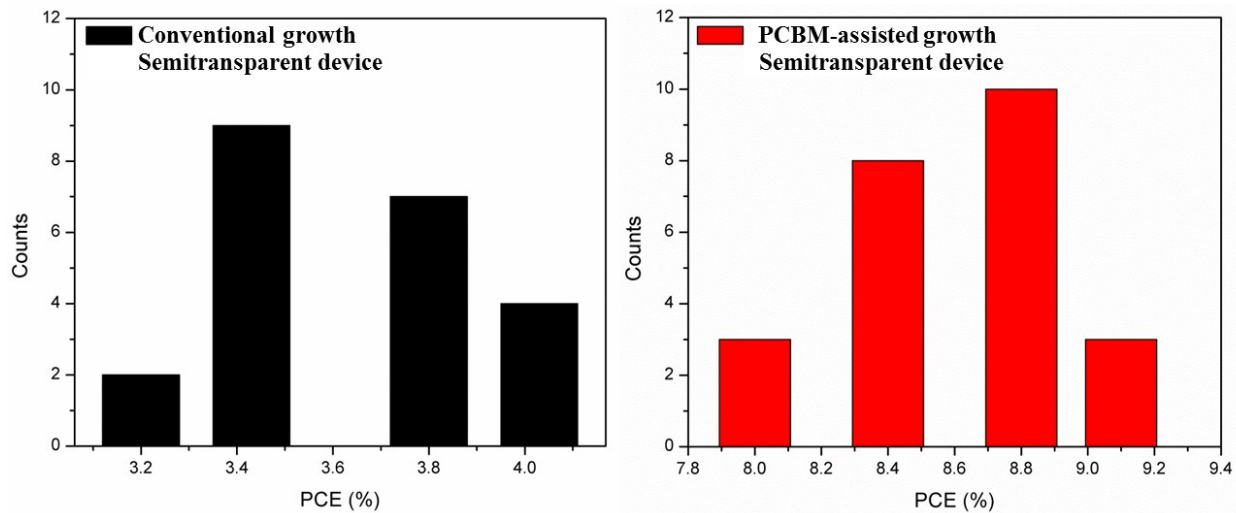
Fig. S7 Deviation of average power conversion efficiency of more than 20 conventional growth and PCBM assisted growth semitransparent devices

Reference:

1 S. Pan, Z. Yang, P. Chen, J. Deng, H. Li and H. Peng, *Angewandte Chemie International Edition*, 2014, **53**, 6110-6114.