

Supporting Information

High efficiency bulk heterojunction perovskite solar cell fabricated from one-step solution process using single solvent: synthesis and characterization of material and film formation mechanism

Chun-Yu Chang^{a†}, Chieh-Ping Wang^{a†}, Rathinam Raja^b, Leeyih Wang^b, Cheng-Si Tsao^{a,c}, and Wei-Fang Su^{a*}

¹ Department of Materials Science and Engineering, National Taiwan University, Taipei 10617, Taiwan

² Center of Condensed Matter Science, National Taiwan University, Taipei 10617, Taiwan

³ Institute of Nuclear Energy Research, Taoyuan 32546, Taiwan

† These authors contributed equally to this work.

*Corresponding author; E-mail: suwf@ntu.edu.tw

Table S1 Electron mobility of PC₆₁BM, 3F-PC₆₁BM and 5F-PC₆₁BM measured by SCLC model.

Sample	Electron mobility x 10 ⁻⁴ (cm ² V ⁻¹ s ⁻¹)
PC ₆₁ BM	4.16 ± 0.52
3F-PC ₆₁ BM	5.61 ± 0.41
5F-PC ₆₁ BM	2.29 ± 0.53

Table S2 Energy levels and band gap of PC₆₁BM, 3F-PC₆₁BM, 5F-PC₆₁BM.

Material	LUMO (eV)	HOMO (eV)	E _g (eV)
PC ₆₁ BM	-4.0	-5.8	1.8
3F-PC ₆₁ BM	-4.2	-6.0	1.8
5F-PC ₆₁ BM	-4.2	-6.0	1.8

Table S3 Device performance of BHJ perovskite solar cells made from different concentration of 3F-PC₆₁BM.

wt % of 3F-PC ₆₁ BM in active layer	V _{oc} (V)	J _{sc} (mA/cm ²)	FF (%)	PCE (%)
0	1.01	19.96	71.10	14.12 (13.36±0.64)
0.05	0.99	19.66	73.54	14.35 (13.28±0.83)
0.1	1.00	21.78	73.34	16.17 (14.93±0.71)
0.3	0.97	19.73	70.45	13.58 (13.83±0.44)
0.5	0.95	19.14	69.04	12.67 (11.66±0.90)

Table S4 Device performance of BHJ perovskite solar cells made from different concentration of 5F-PC₆₁BM.

wt % of 5F-PC ₆₁ BM in active layer	V _{oc} (V)	J _{sc} (mA/cm ²)	FF (%)	PCE (%)
0	1.01	19.96	71.10	14.12 (13.36±0.64)
0.05	0.93	17.75	75.13	12.39 (11.54±0.54)
0.1	0.87	14.99	65.71	8.65 (7.66±1.02)
0.3	0.85	14.85	45.91	5.82 (4.86±0.26)
0.5	0.77	15.44	35.94	4.30 (3.54±0.80)

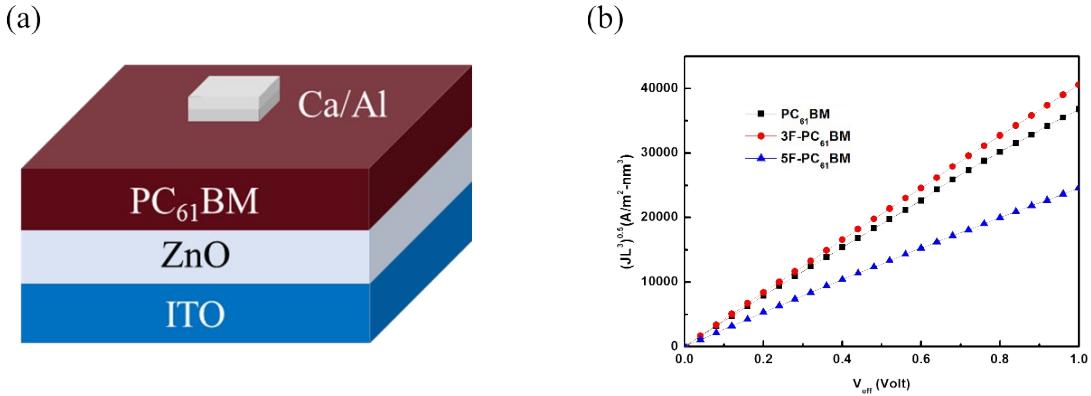


Fig. S1 (a) Cell architecture for SCLC model to measure electron mobility. (b) Current density-effective voltage curves of PC₆₁BM, 3F-PC₆₁BM and 5F-PC₆₁BM film.

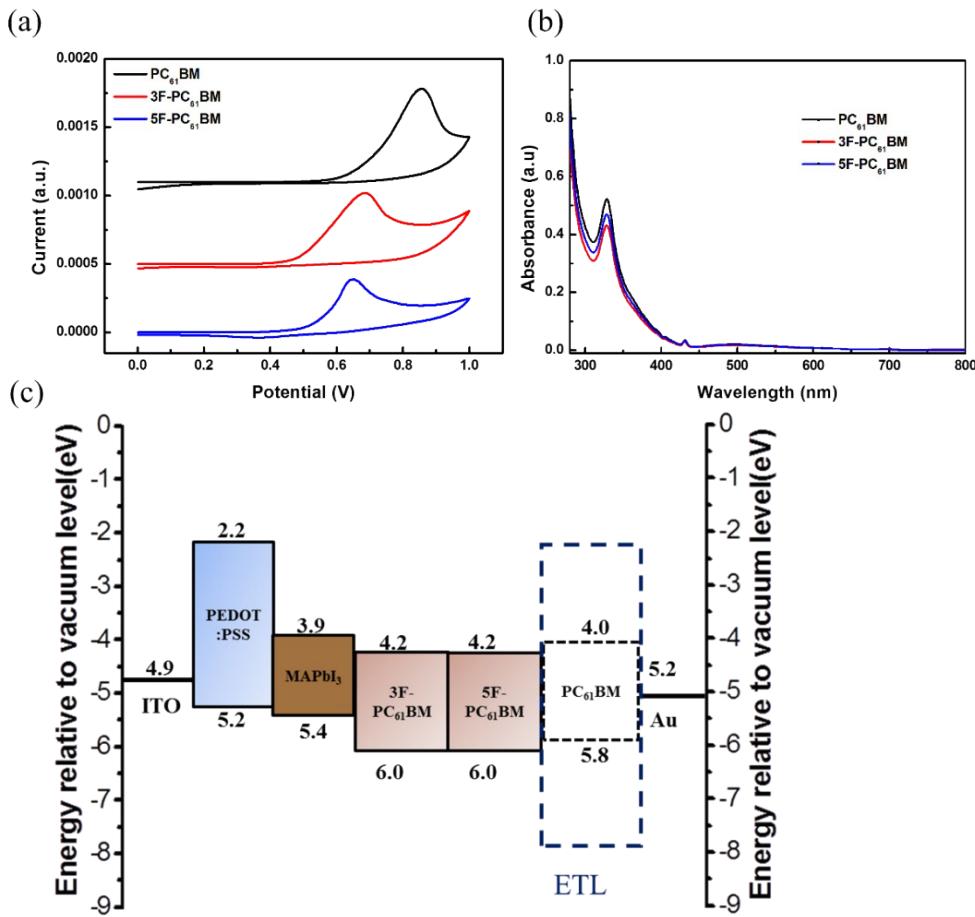


Fig. S2 (a) Cyclic-voltammograms of PC₆₁BM, 3F-PC₆₁BM and 5F-PC₆₁BM. (b) UV-vis absorption spectra of PC₆₁BM, 3F-PC₆₁BM and 5F-PC₆₁BM. (c) Energy band diagram of p-i-n planar BHJ perovskite solar cell.

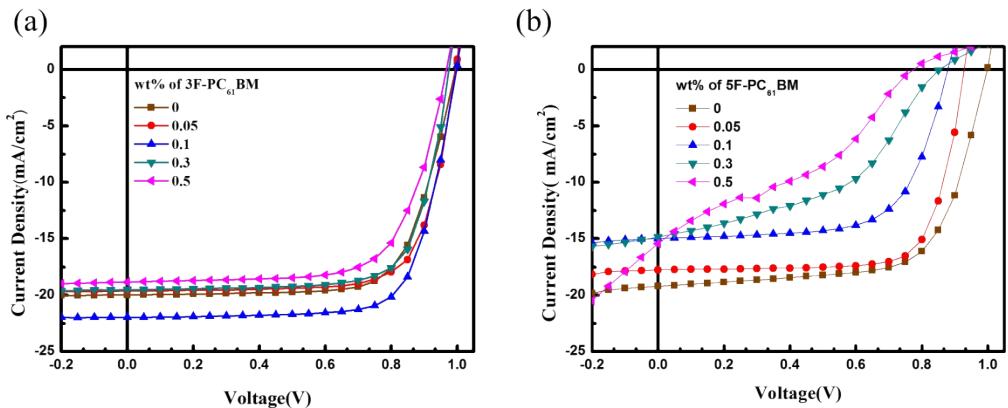


Fig. S3 Current density-voltage curves of (a) 3F-PC₆₁BM:perovskite BHJ devices and (b) 5F-PC₆₁BM:perovskite BHJ devices.

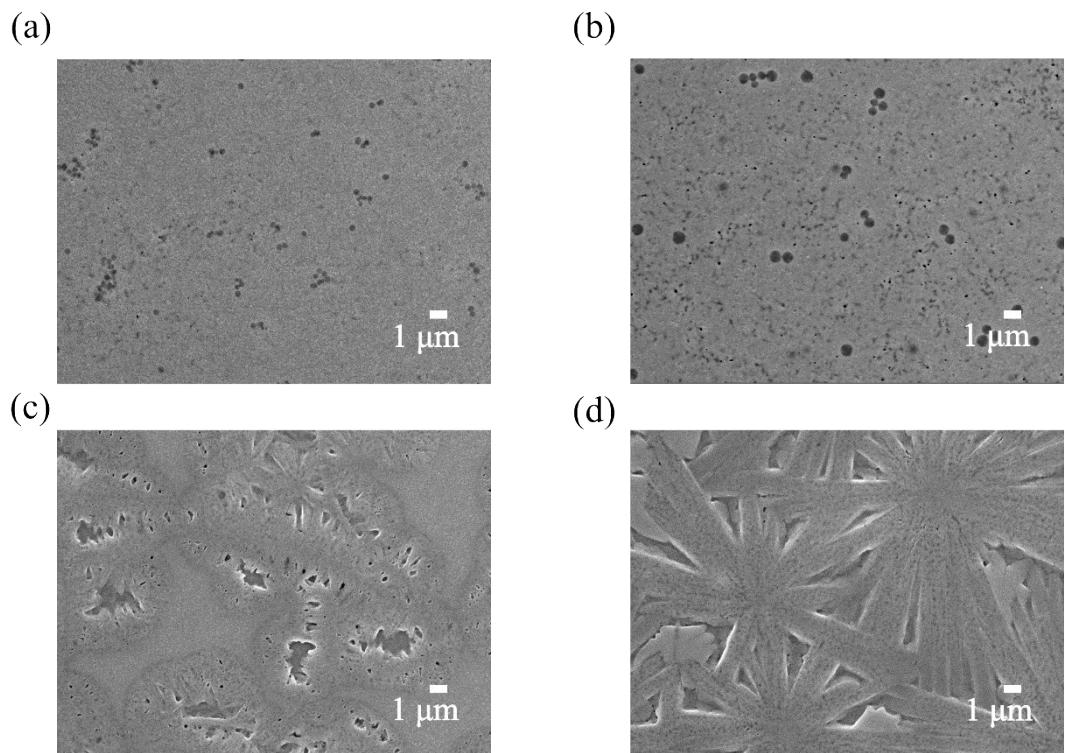


Fig. S4 SEM images of BHJ peovskite films blended with (a) 0.3 wt% 3F-PC₆₁BM (b) 0.5 wt% 3F-PC₆₁BM (c) 0.3 wt% 5F-PC₆₁BM (d) 0.5 wt% 5F-PC₆₁BM.

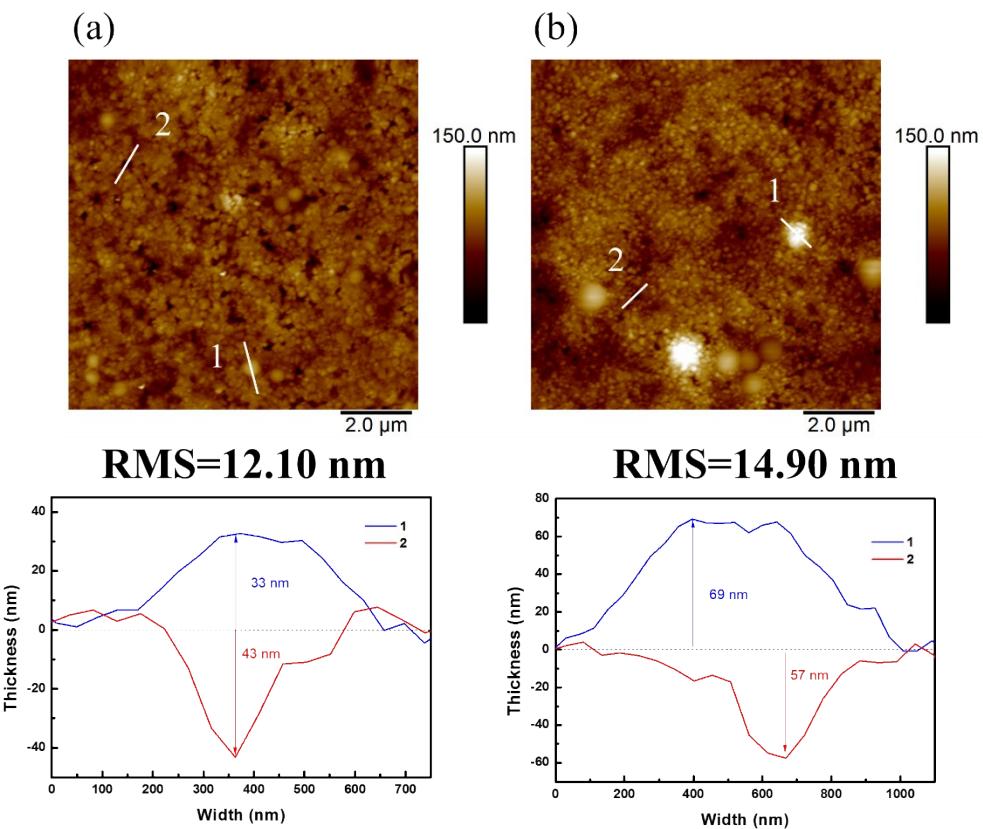


Fig. S5 AFM surface height images and depth information of BHJ perovskite films made from different concentration of 3F-PC₆₁BM: (a) 0.3 wt% (b) 0.5 wt%.

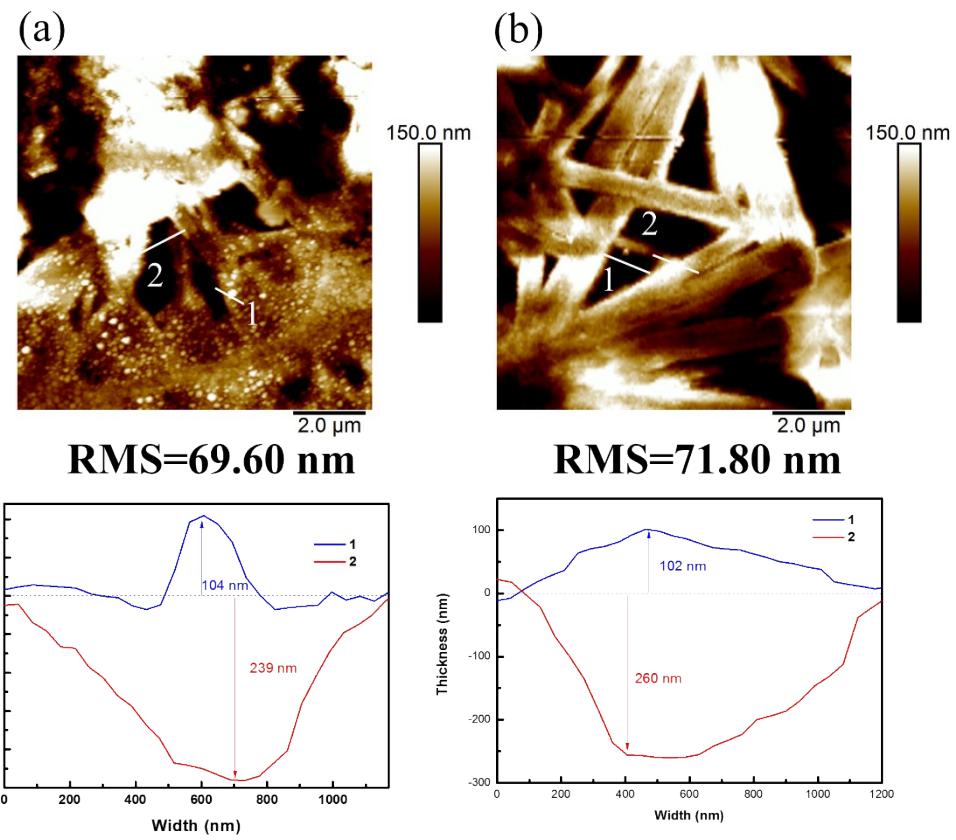


Fig. S6 AFM surface height images and depth information of BHJ perovskite films made from different concentration of 5F-PC₆₁BM: (a) 0.3 wt% (b) 0.5 wt%.