

Supporting Information for

## **Polyethylenimine as a dual functional additive for electron transporting layer in efficient solution processed planar heterojunction perovskite solar cells**

Sujuan Dong<sup>1,2</sup>, Yangyang Wan<sup>1,2</sup>, Yaling Wang<sup>1,2</sup>, Yin Yang<sup>1,2</sup>, Yahui Wang<sup>1,2</sup>, Xinyu Zhang,<sup>1,2</sup> Huanqi Cao<sup>1,2</sup>, Wenjing Qin<sup>1,2</sup>, Liying Yang<sup>1,2\*</sup>, Cong Yao<sup>3\*</sup>, Ziyi Ge<sup>4\*</sup>, Shougen Yin<sup>1,2\*</sup>

1 Key Laboratory of Display Materials and Photoelectric Devices, Education Ministry of China, School of Materials Science and Engineering, Tianjin University of Technology, Tianjin 300384, China

2 Tianjin Key Laboratory for Photoelectric Materials and Devices, Tianjin University of Technology, Tianjin 300384, China

3 China Electronics Technology Group Corporation No.18th Research Institute, Tianjin 300384, China

4 Ningbo Institute of Materials Technology & Engineering, Chinese Academy of Sciences, Ningbo 315201, China

Email: liyingyang@tjut.edu.cn; sgyin@tjut.edu.cn; geziyi@nimte.ac.cn and huobingyao@vip.qq.com

**Keywords:** Perovskite solar cells; Doping; Interface engineering;

Polyethylenimine; Trap states

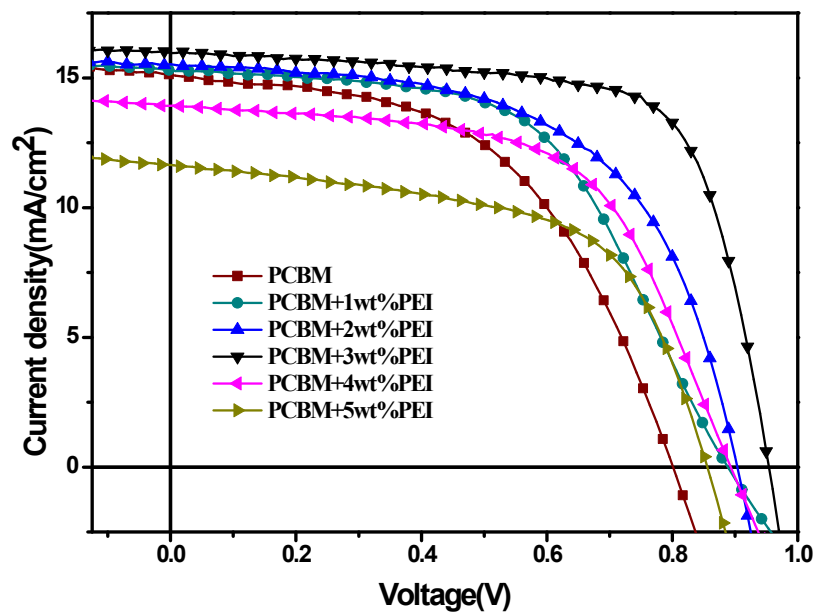


Fig.S1 J-V curves for the planar perovskite solar cells (ITO/PEDOT: PSS/perovskite /PCBM or PCBM+PEI/Al) with different PEI doping concentration and without doping.

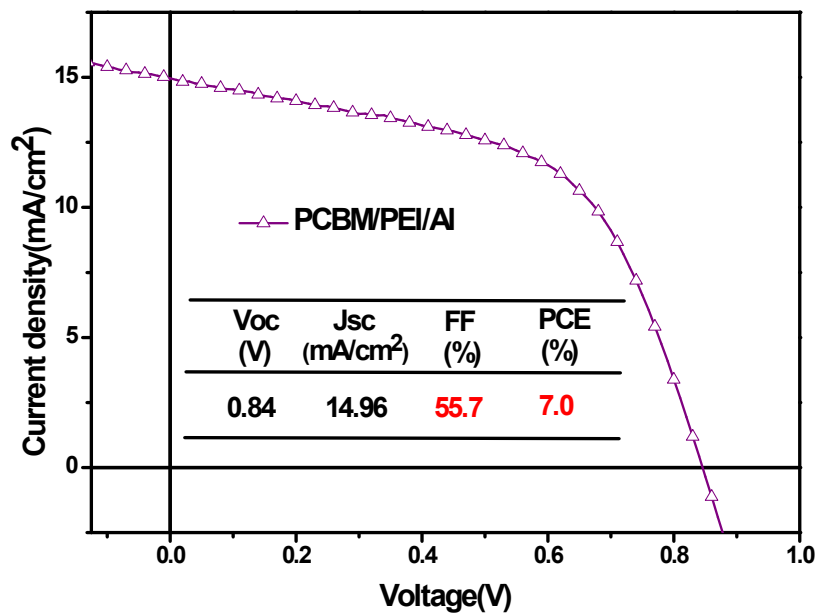
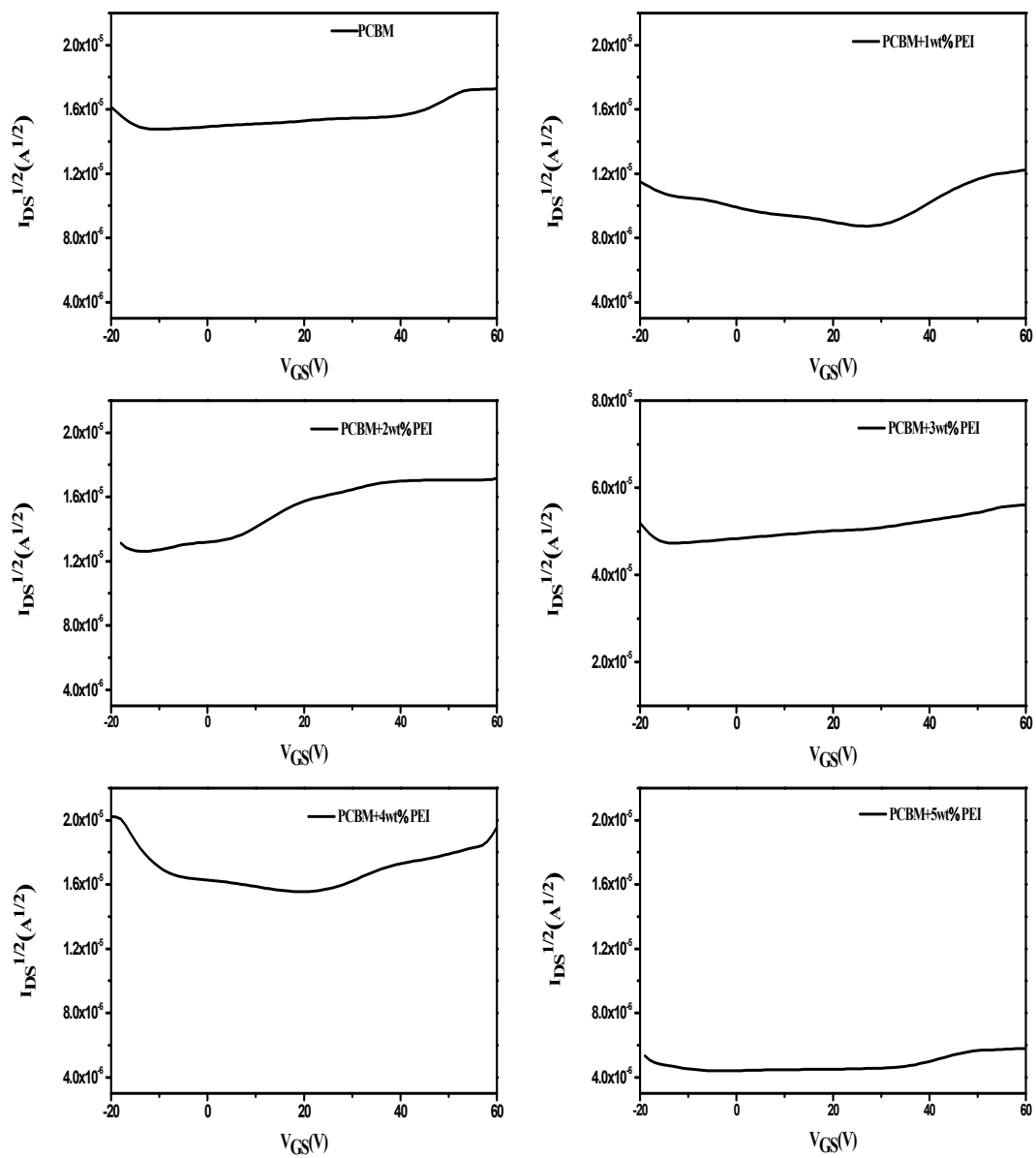


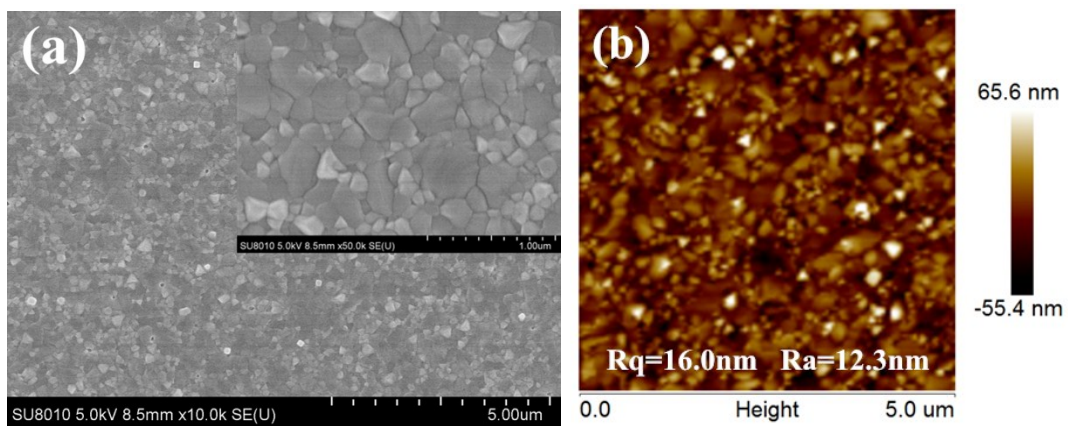
Fig. S2 J-V characteristics for the best device with a structure of ITO/PEDOT: PSS/perovskite/PCBM/PEI/AI

Table S1 The photovoltaic parameter of the best devices for ITO/PEDOT: PSS/perovskite/PCBM /AI and ITO/PEDOT: PSS/perovskite/ PCBM/PEI/AI

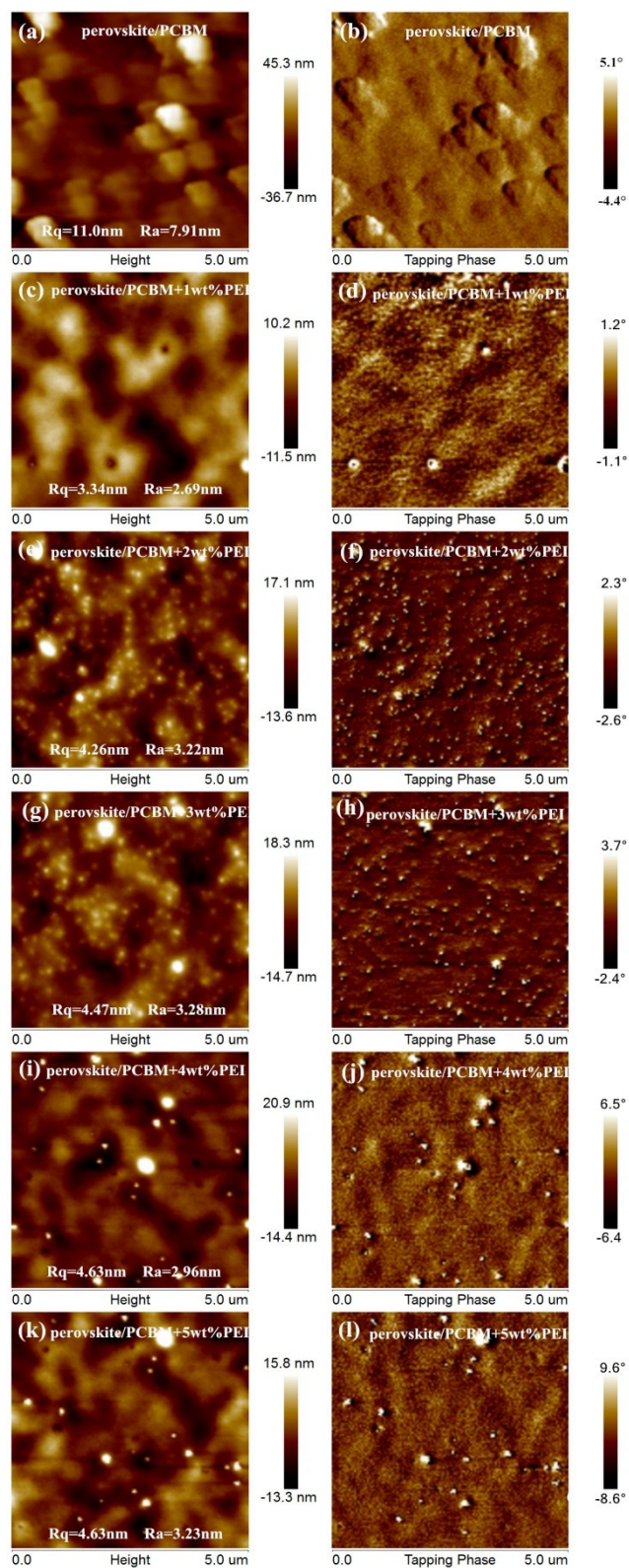
Device cathode configuration	Voc (V)	Jsc (mA/cm <sup>2</sup> )	FF (%)	PCE (%)
PCBM/AI	0.81	14.51	52.3	6.1
PCBM/PEI/AI	0.84	14.96	55.7	7.0



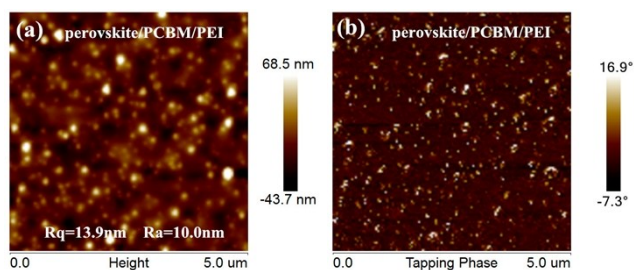
**Fig. S3 Transfer characteristics of  $I_{DS}^{1/2}$  - $V_{GS}$  for OFETs with PCBM and PCBM blended with different contents of PEI as channel materials**



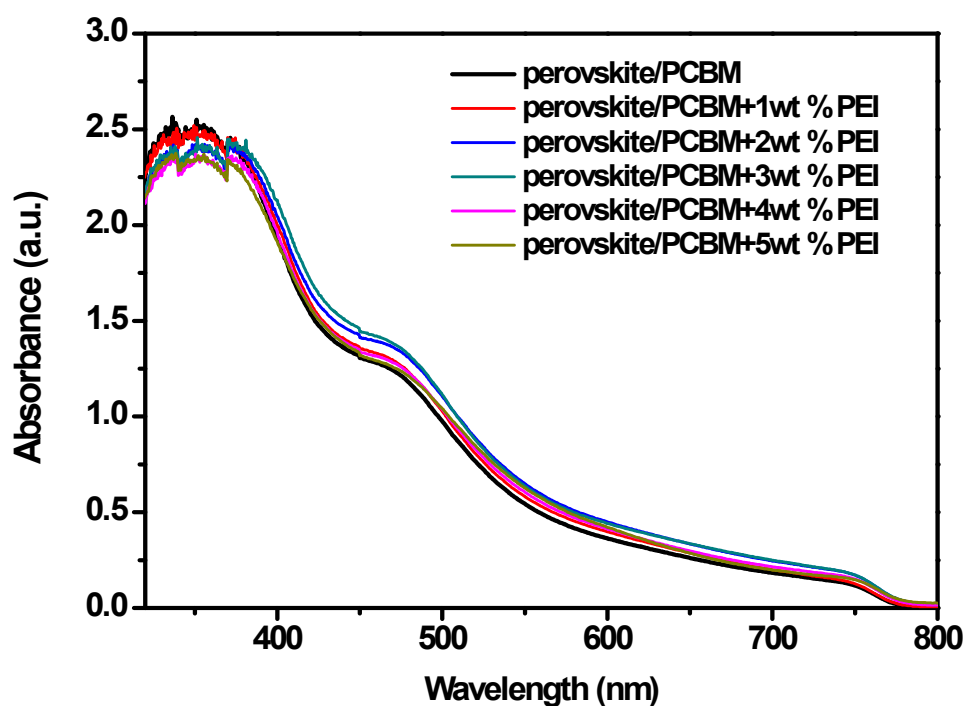
**Fig. S4 SEM images (a) and AFM topography (b) of the pristine perovskite layer**



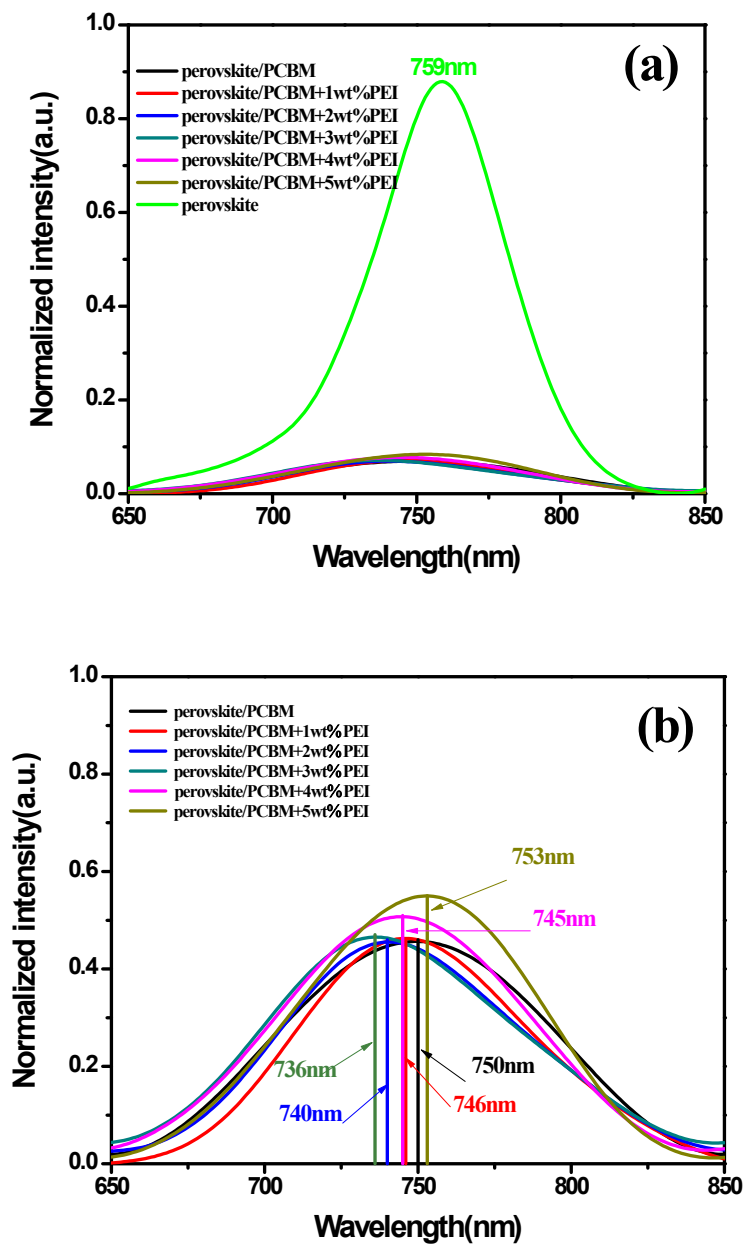
**Fig. S5** The AFM topography and phase images of the PCBM films (without or with 1~5 wt % PEI) coated on perovskite layer.



**Fig. S6 The AFM topography and phase images of the PEI film coated on PCBM/perovskite layer.**



**Fig. S7 UV-vis absorption spectra of the PCBM films (without or with 1~5 wt % PEI) coated on perovskite layer**



**Fig. S8** Steady-state PL spectra of the films perovskite, perovskite/PCBM, perovskite/PCBM+1~5 wt % PEI