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Supplementary Information

Improved Performance of Inverted Planar Perovskite Solar Cells with F4-TCNQ Doped PEDOT:PSS Hole Transport Layer

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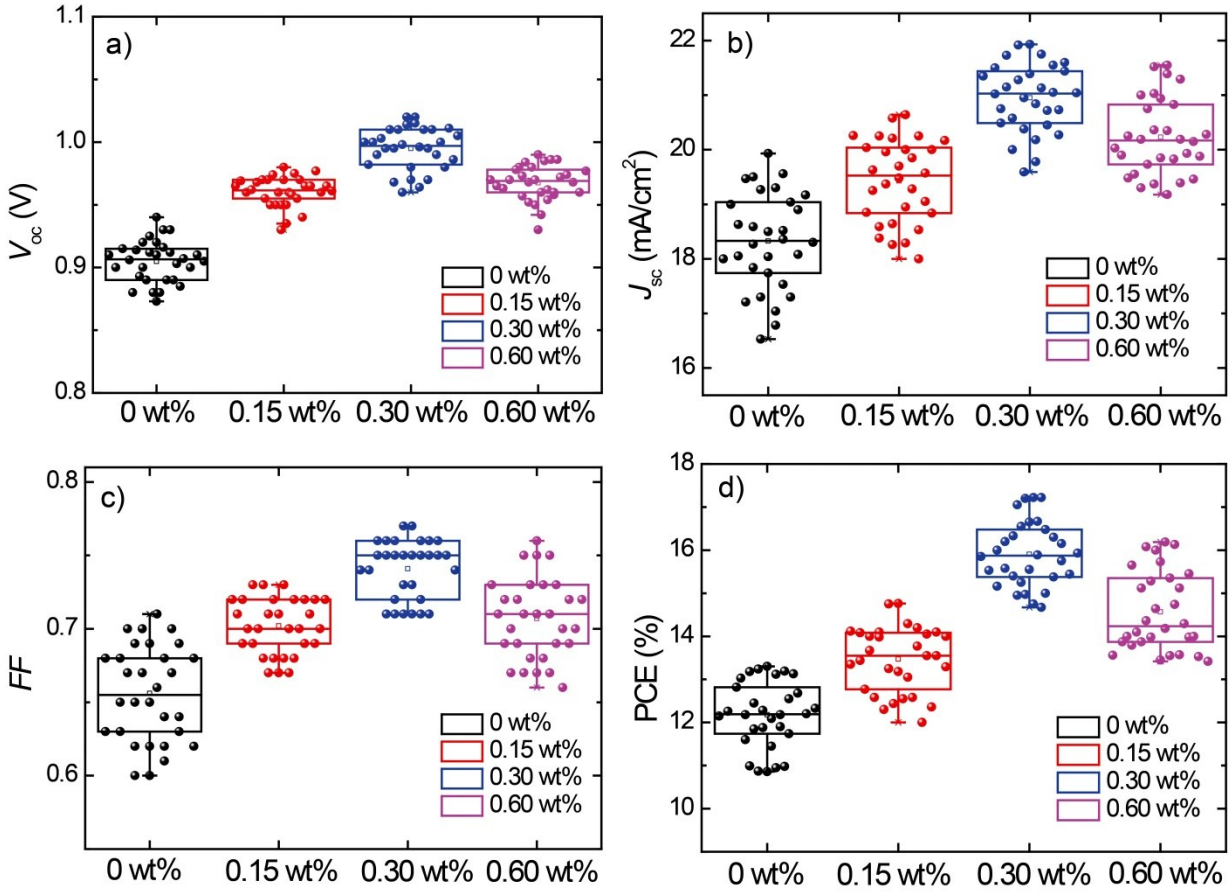

Fig. S1. Statistics of 30 controls (undoped) and 120 doped PEDOT:PSS based (different F4-TCNQ doping concentration) devices as collected over 13 different batches.

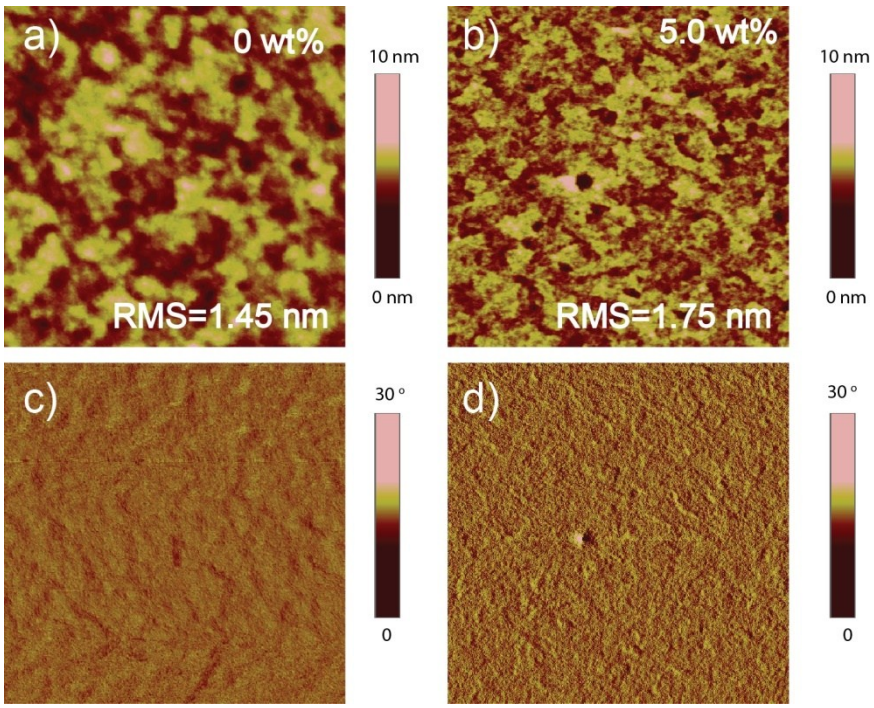

Fig. S2. AFM height images (a,b) and phase images (c,d) of PEDOT:PSS films doped with (a, c) 0 wt% and 5 wt% (b, d) of F4-TCNQ.

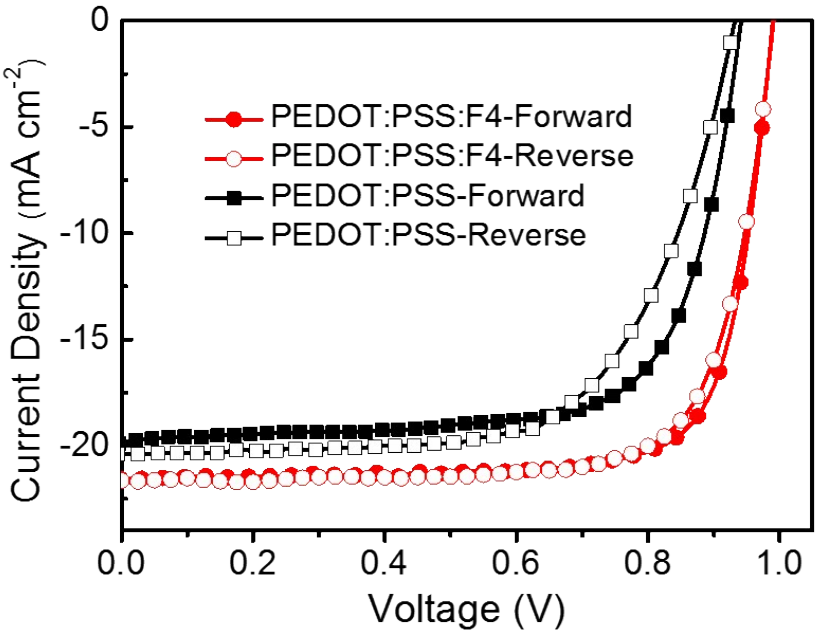

Fig. S3. *J-V* curves of PSCs under recorded in forward (from J_{sc} to V_{oc}) and reverse (from V_{oc} to J_{sc}) scanning directions

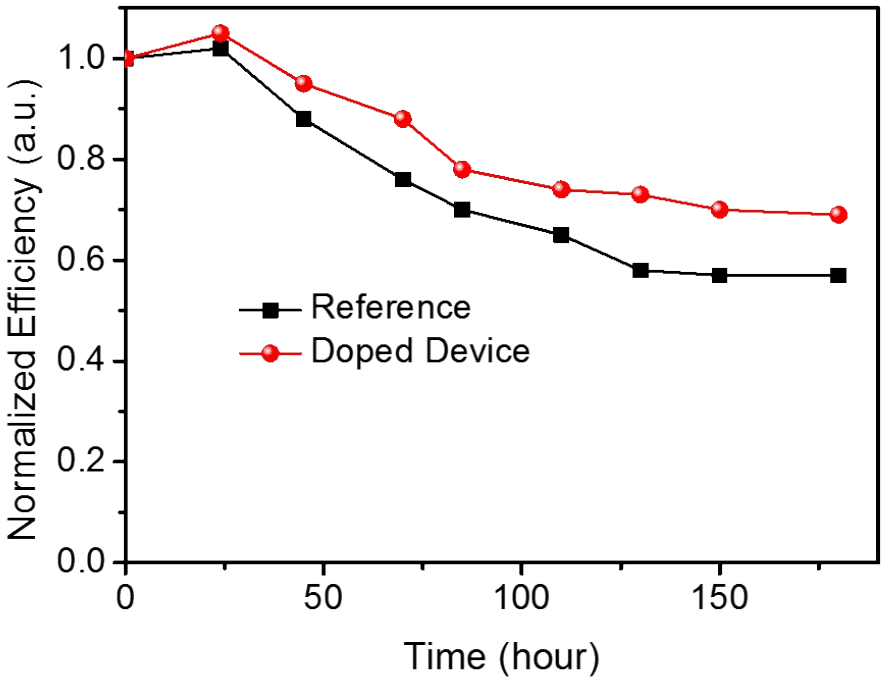

Fig. S4. Solar cells with PEDOT:PSS and F4TCNQ doped PEDOT:PSS without encapsulation under ambient atmosphere.

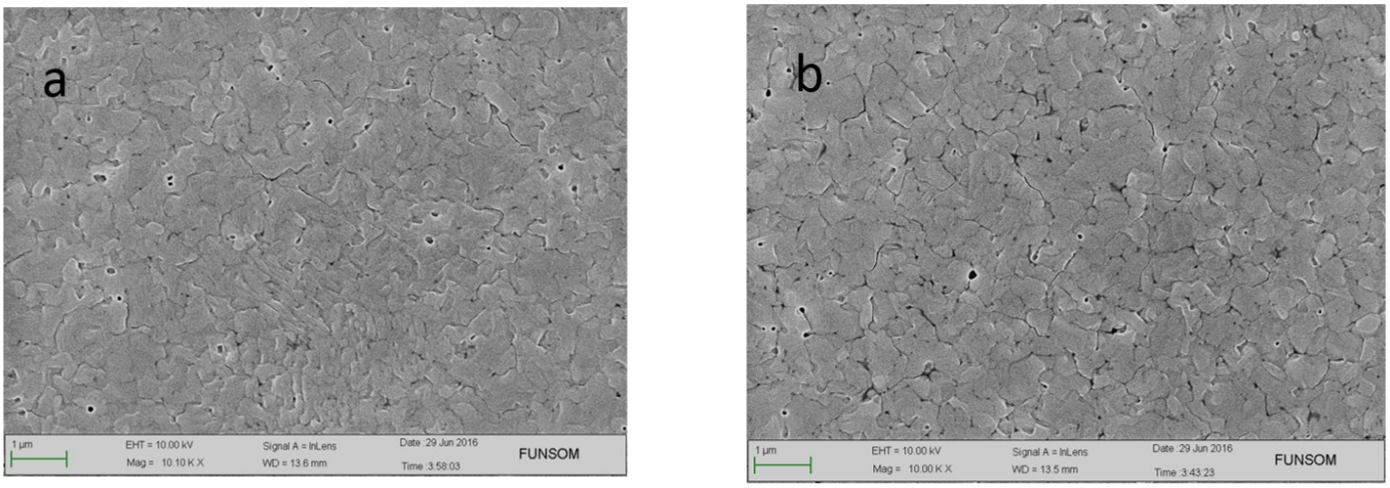

Fig. S5. (a) SEM images of perovskite deposited onto PEDOT:PSS and (b) F4-TCNQ doped PEDOT:PSS HTLs.

Table S1. Performance comparison of different inverted planar perovskite solar cells

Device Configuration	V_{oc} (V)	J_{sc} (mA/cm^2)	FF	PCE(%)	Reference
ITO/PEDOT:PSS(DMF)/$MAPbI_3$/PCBM(PMMA)/Ag	1.02	22.38	82	18.72	1
ITO/PEDOT:PSS(PSS-Na)/$MAPbI_3$/PCBM/Al	1.11	18.43	76	15.56	2
ITO/PEDOT:PSS(PSS-Na)/$MAPbBr_3$/PCBM/Al	1.52	6.20	50.8	4.79	2
ITO/PEO-PEDOT:PSS/$MAPbI_3$/PCBM/Ag	0.88	23.42	80.10	16.52	3
ITO/PEDOT:PSS/ $MAPbI_3$ /PCBM/Au	1.1	20.9	79	18.2	4
ITO/PEDOT:PSS/$MAPbI_{3-x}Cl_x$ /PCBM/Al	0.94	22.4	83	17.4	5
ITO/PEDOT:PSS/$MAPbI_{3-x}Cl_x$ /PCBM/PFN/Al	1.05	20.3	80.2	17.1	6
ITO/PEDOT:PSS/$MAPbI_{3-x}Cl_x$ /PCBM/ZnO/Al	1.02	22.0	74.2	16.8	7
ITO/PEDOT:PSS (F4-TCNQ) /$MAPbI_{3-x}Cl_x$ /PCBM/BCP/Ag	1.02	21.93	77	17.22	This work

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Table S2. Values for Time-resolved PL characteristics by fitting decay curves of different devices

Interlayer	T1(ns)	F1(%)	T2(ns)	F2 (%)	Average(ns)
PEDOT:PSS/perovskite	2.77	5.23	9.10	94.77	8.69
Doped PEDOT:PSS/perovskite	2.41	81.04	5.38	18.96	2.97