

Supporting Information

Highly efficient perovskite solar cells based on a Zn_2SnO_4 compact layer

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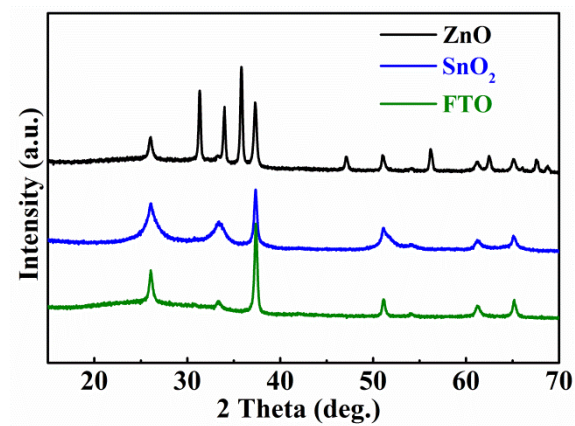


Figure S1 XRD patterns of the FTO deposited with ZnO and SnO₂ compact layers

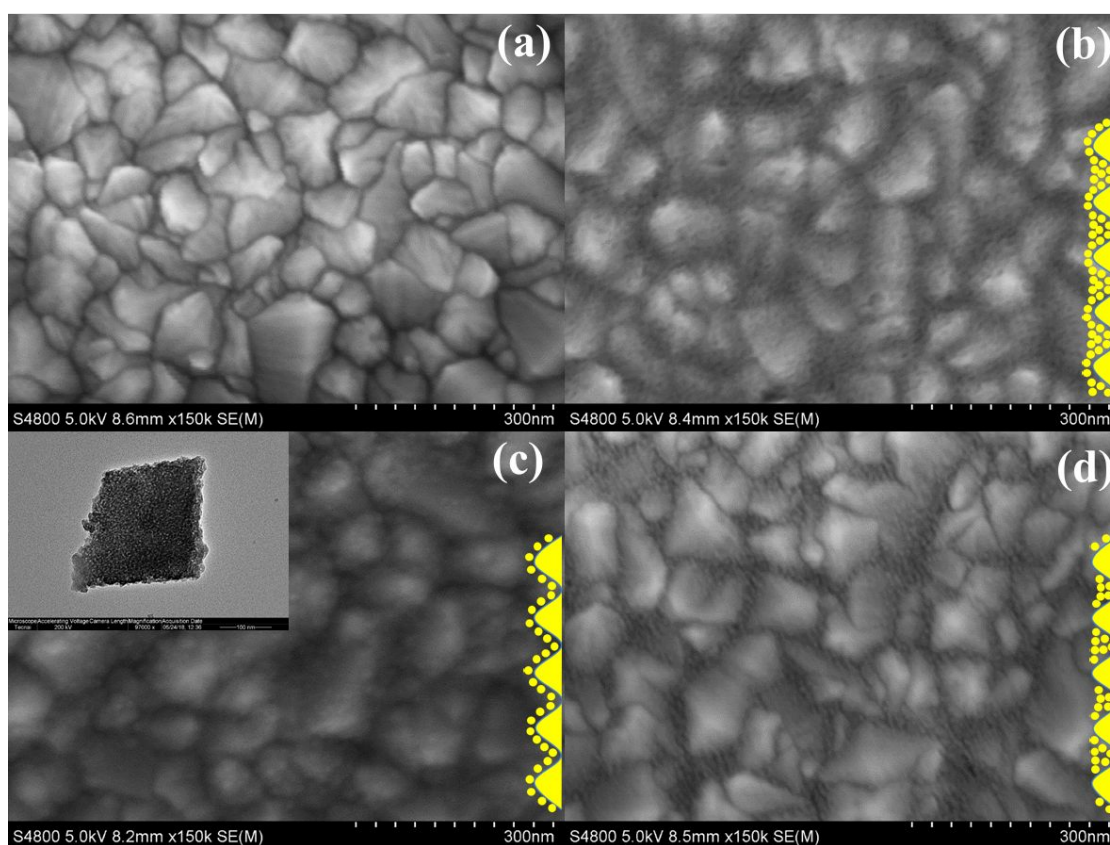


Figure S2 Top-view SEM images of (a) the FTO substrate, (b) FTO-Zn₂SnO₄, (c) FTO-ZnO, and (d) FTO-SnO₂ (Inset: schematic diagrams of FTO deposited with different compact layer architectures and the TEM image of Zn₂SnO₄ powder flaking from its compact layer).

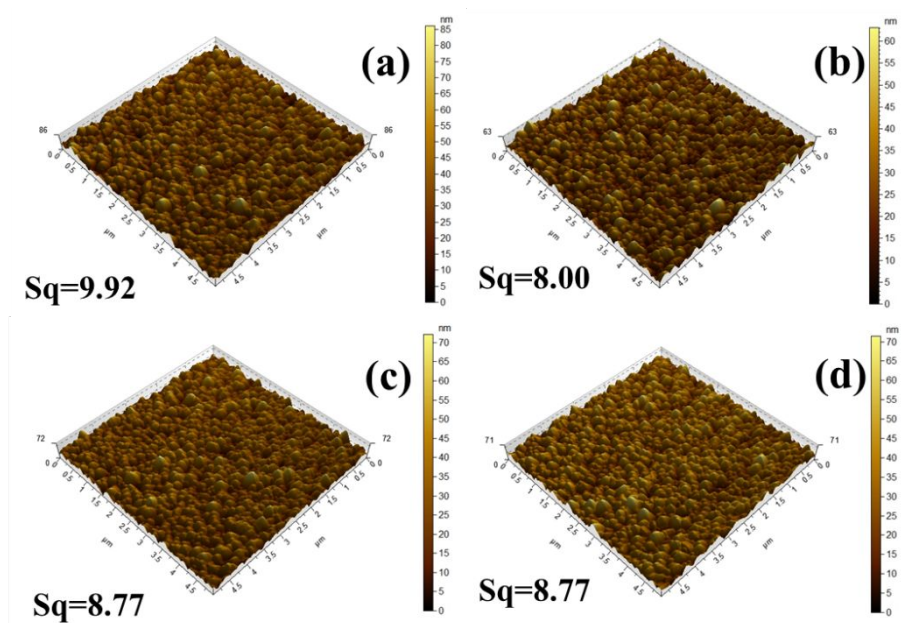


Figure S3 AFM topography images of (a) the FTO substrate, (b) FTO- Zn_2SnO_4 , (c) FTO-ZnO, and (d) FTO- SnO_2 .

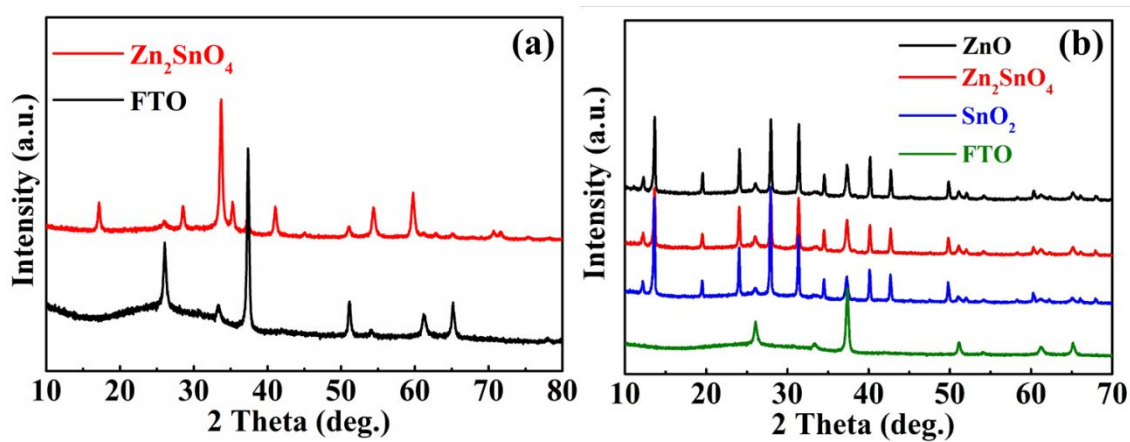


Figure S4 XRD patterns of (a) Zn_2SnO_4 mesoporous layer and (b) perovskite films deposited on different compact layers.

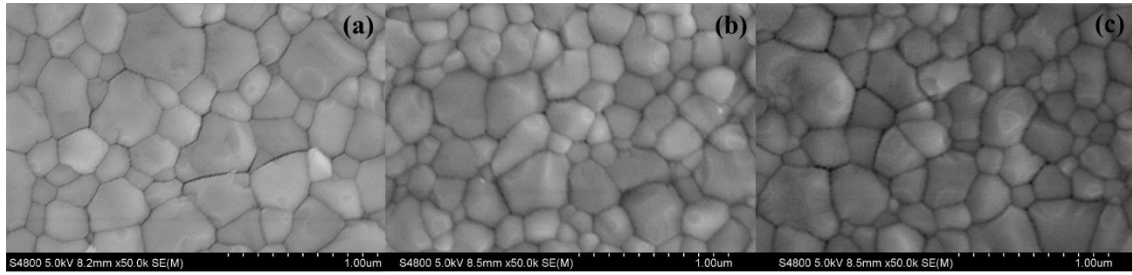


Figure S5 the top-view SEM images of the perovskite layer formed on the (a) Zn_2SnO_4 , (b) ZnO and (c) SnO_2 compact layer.

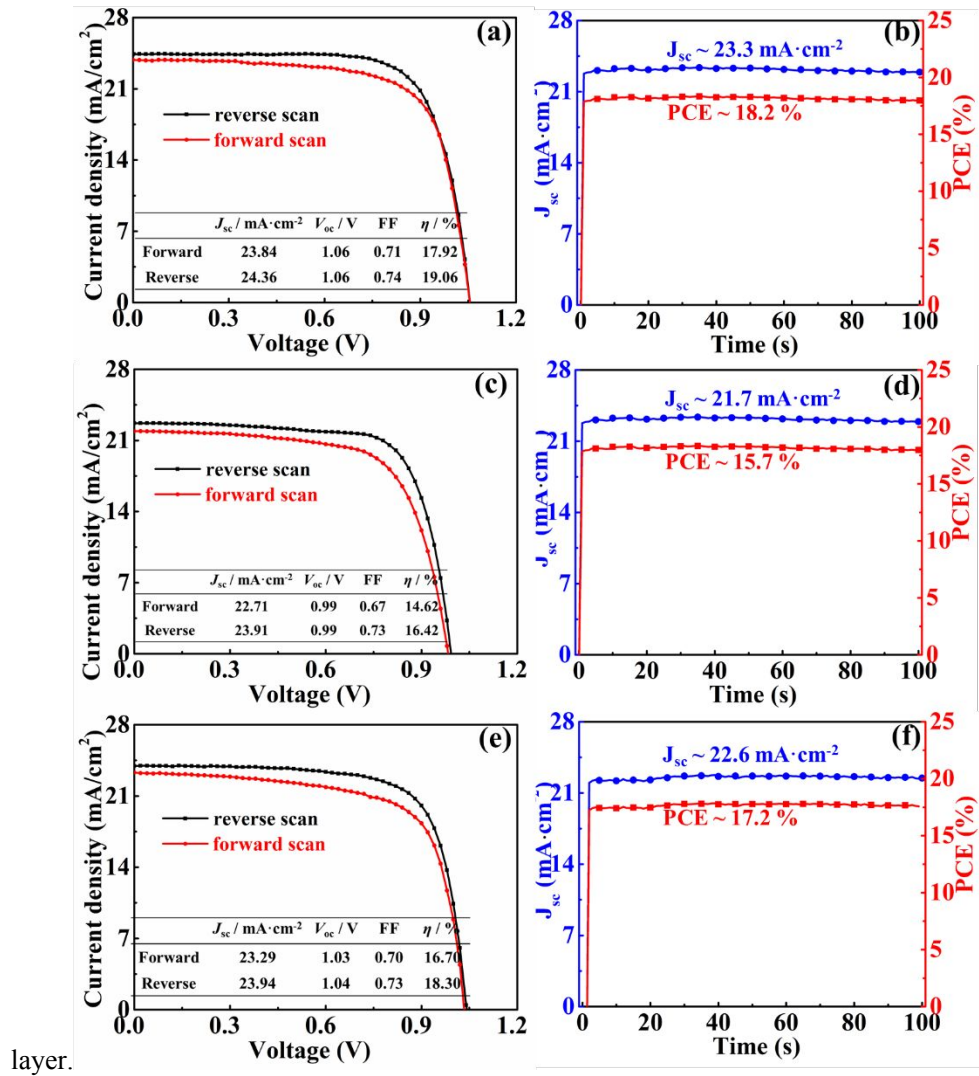


Figure S6 J-V curves of the PSCs based on (a) Zn_2SnO_4 , (c) ZnO and (e) SnO_2 compact layers at reverse and forward scans; the stabilized PCE of devices based on (b) Zn_2SnO_4 , (d) ZnO and (f) SnO_2 compact layers obtained from MPP tracking for 100 s.

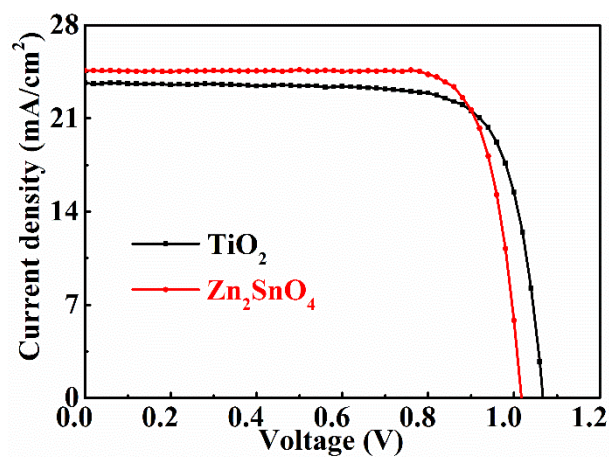


Figure S7 J–V curves for PSCs composed of different ETLs.

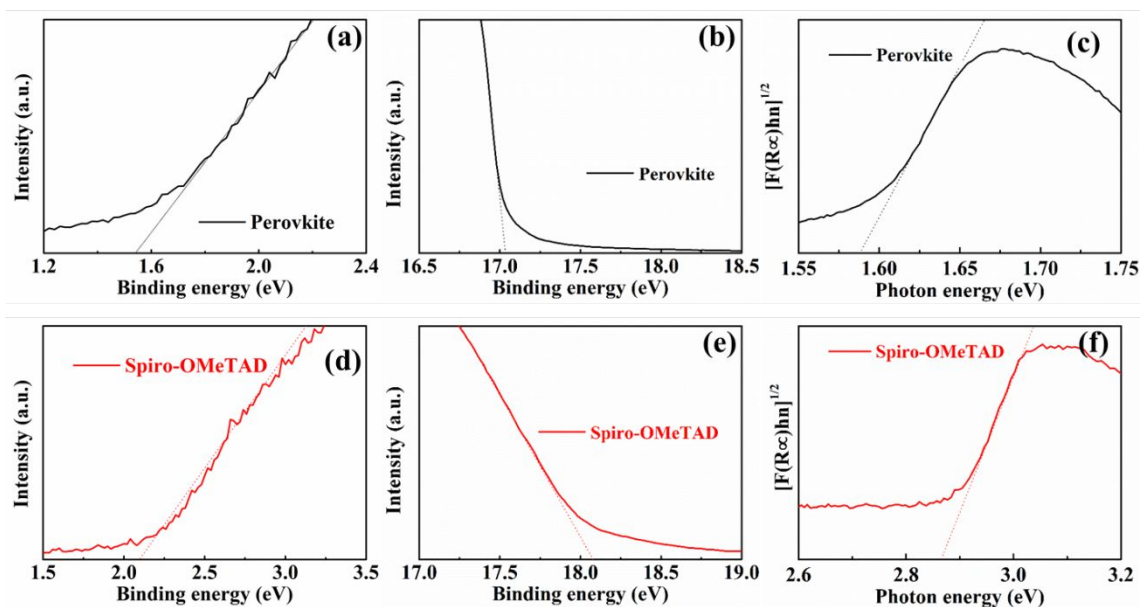


Figure S8 Ultraviolet photoelectron spectrometer (UPS) absorption spectra of (a, d) the Fermi edge, (b, e) cut-off energy, and (c, f) plots of $[F(R\infty)hn]^{1/2}$ versus photon energy ($h\nu$) of FTO deposited on perovskite active layer and HTL.

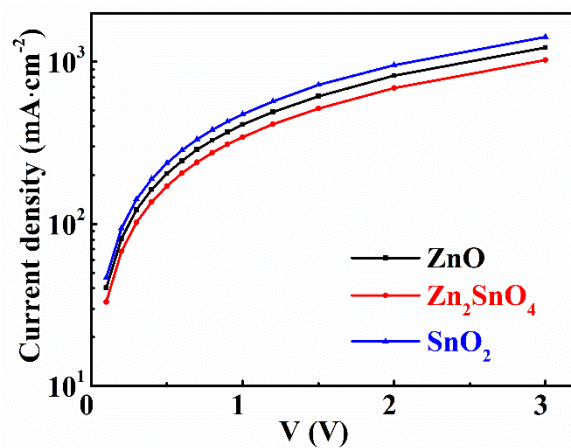


Figure S9 Variations in the SCLC for different compact layers

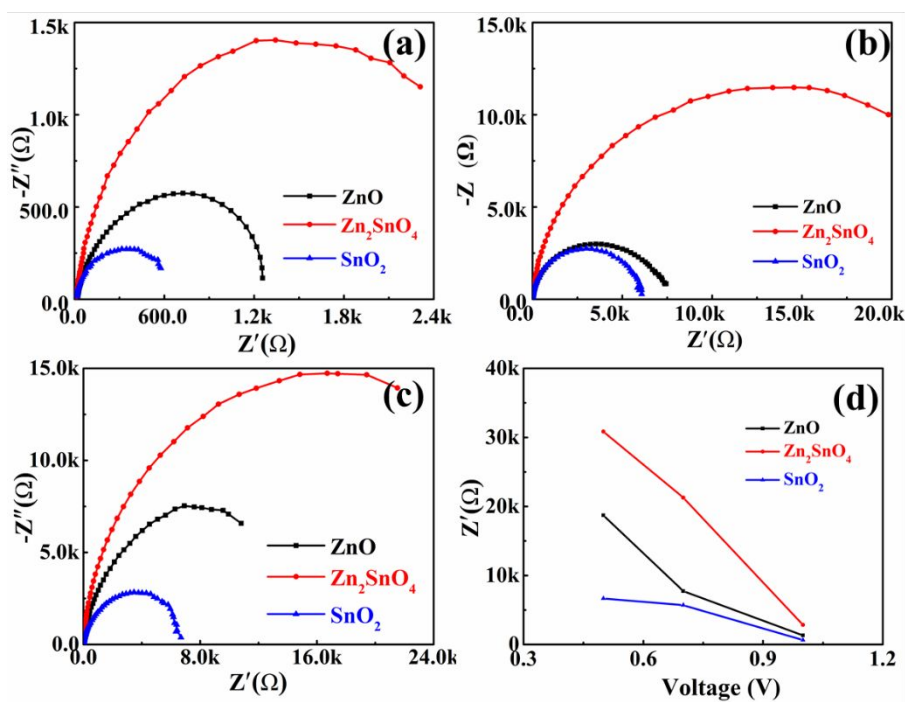


Figure S10 Nyquist plots of PSCs with different compact layers at (a) -1.0 V, (b) -0.7 V, (c) -0.5 V under dark conditions, and (d) fitted data of R_{ct} versus the different biases.

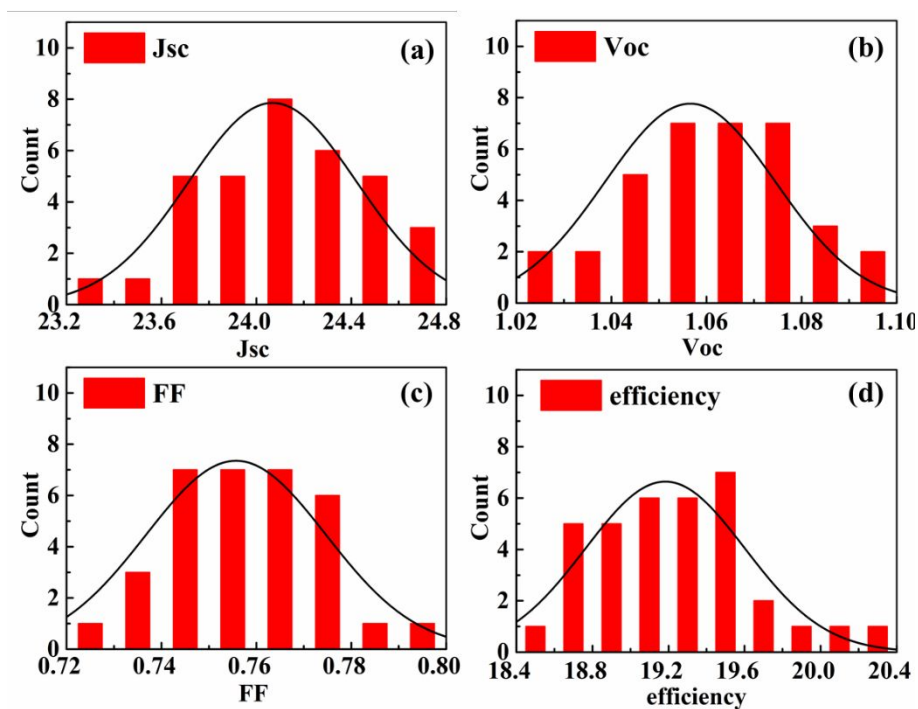


Figure S11 Histograms of (a) J_{sc} , (b) V_{oc} , (c) FF and (d) efficiency for PCEs

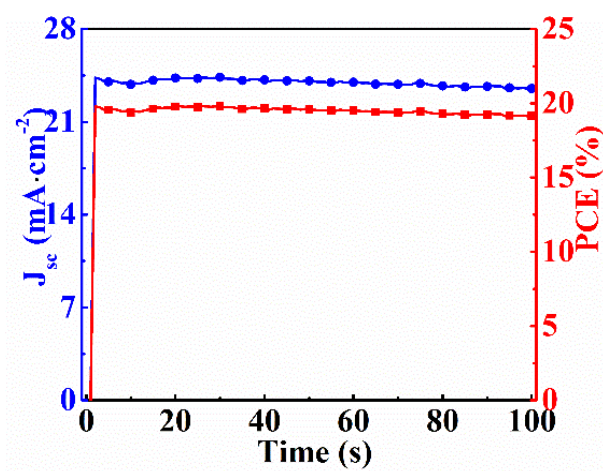


Figure S12 The stabilized PCE of device obtained from MPP tracking for 100 s.

Table S1 Photovoltaic parameters of the PSCs fabricated by different compact layers.

Device	$J_{sc} / \text{mA} \cdot \text{cm}^{-2}$	V_{oc} / V	FF	$\eta / \%$
TiO ₂	23.64	1.07	0.77	19.05
Zn ₂ SnO ₄	24.58	1.02	0.79	19.97

Table S2 Energy band parameters of FTO deposited on different films.

	E_{vb}/eV	E_g/eV	E_{cb}/eV
ZnO	-7.79	3.13	-4.66
Zn ₂ SnO ₄	-7.85	3.67	-4.18
SnO ₂	-8.24	3.60	-4.64
Perovskite	-5.71	1.59	-4.12
Spiro-OMeTAD	-5.23	2.87	-2.36

Table S3. The summary of carrier lifetime from TRPL analysis.

Film	Ratio/%	τ_1/ns	Ratio/%	τ_2/ns	τ_{ave}/ns
ZnO	12.6	14.6	87.4	608	606
Zn ₂ SnO ₄	13.0	12.6	87.0	435	433
SnO ₂	16.9	11.8	83.1	281	279