Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Introduction of carbon nanodots into SnO_2 electron transport layer for efficient and UV stable planar perovskite solar cells

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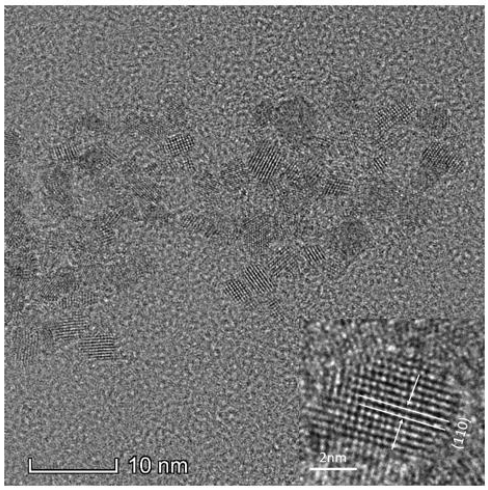

Fig. S1 The TEM image of the SnO_2 particles obtained from the SnO_2 nanocolloid.

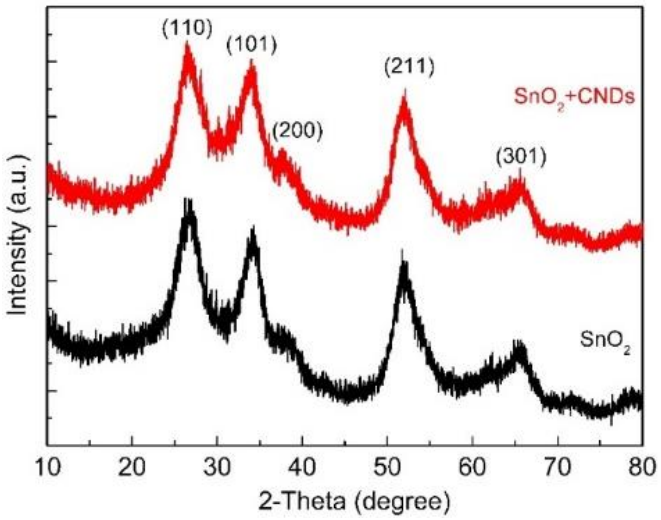

Fig. S2 XRD patterns of SnO_2 and SnO_2:CNDs.

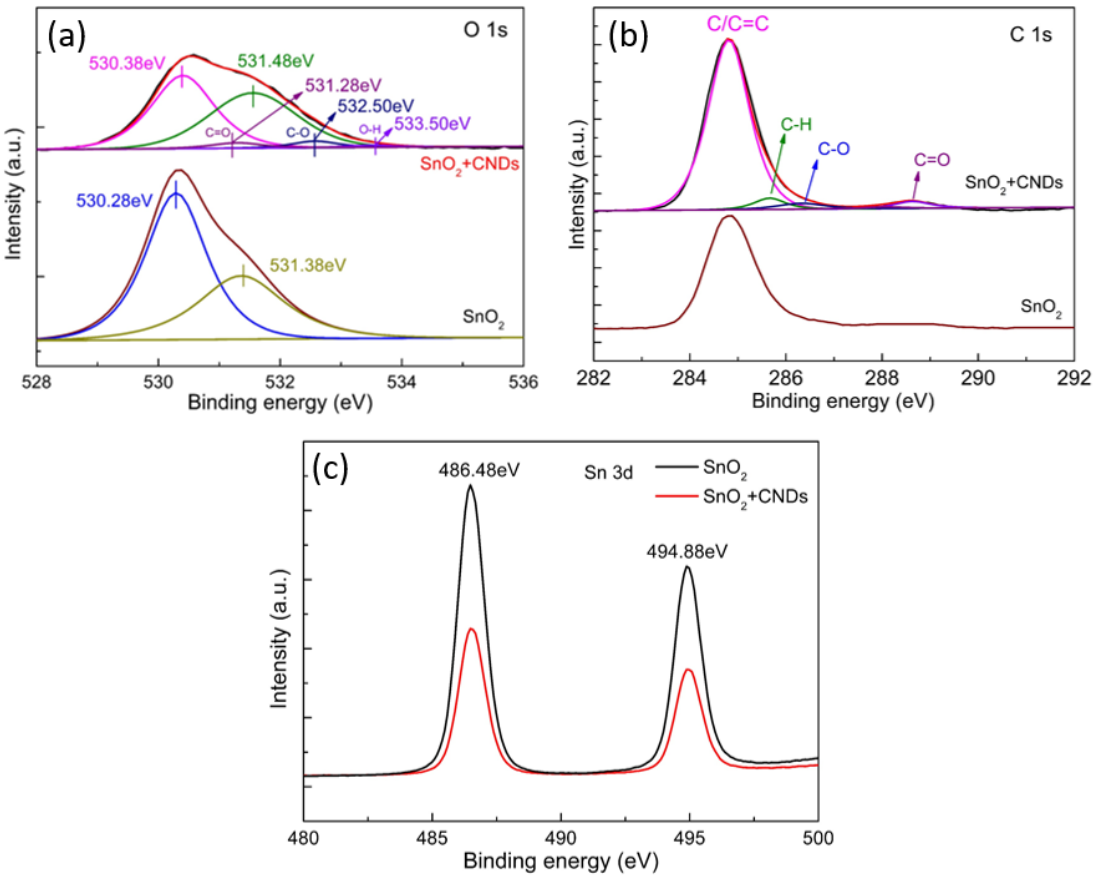

Fig. S3 XPS spectra of (b) C 1s, (c) O 1s and (d) Sn 3d peaks of SnO_2 and SnO_2:CNDs.

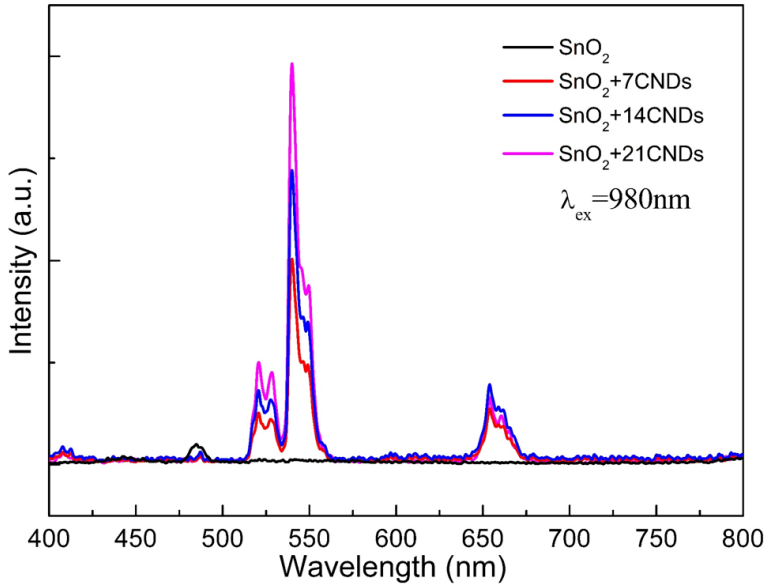

Fig. S4 Up-conversion luminesce spectrum of SnO_2 and SnO_2:CNDs films with various amount of CNDs deposited on quartz glass. (excitation Source: 980 nm)

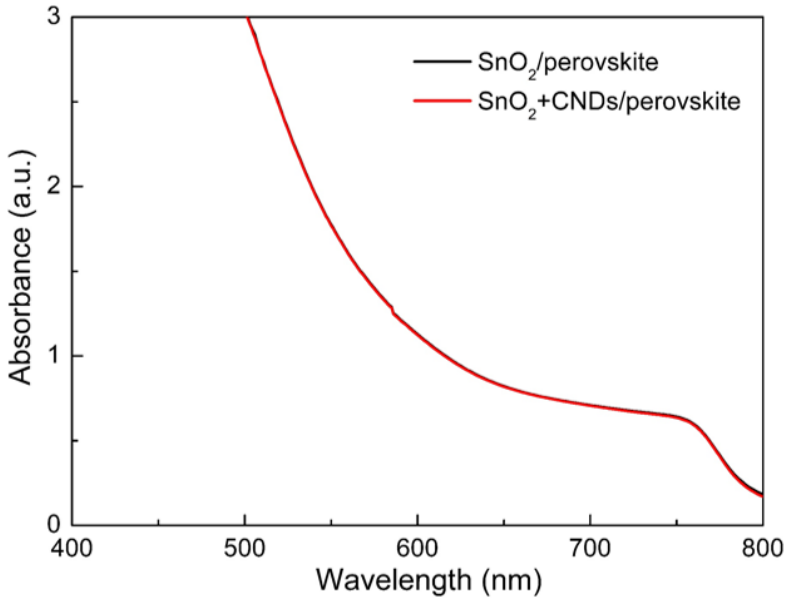

Fig. S5 UV-vis absorption spectra of the perovskite film deposited on (a) SnO_2 and (b) SnO_2:CNDs.

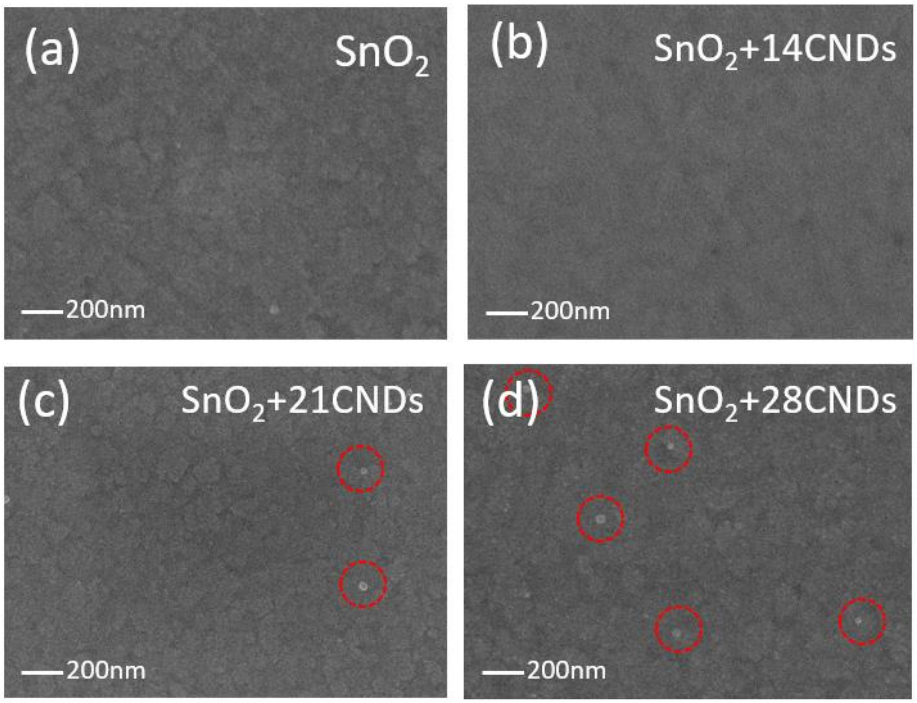

Fig. S6 The Top-view SEM images of (a) SnO_2 and modified SnO_2 doped with different amount of CNDs. (b) 14mg, (c) 21mg and (d) 28 mg.

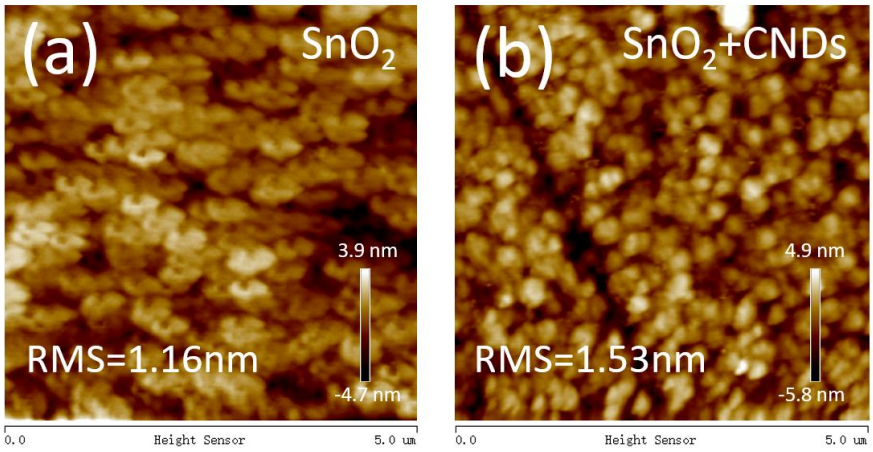

Fig. S7 The AFM images of the SnO_2 and SnO_2:CNDs films

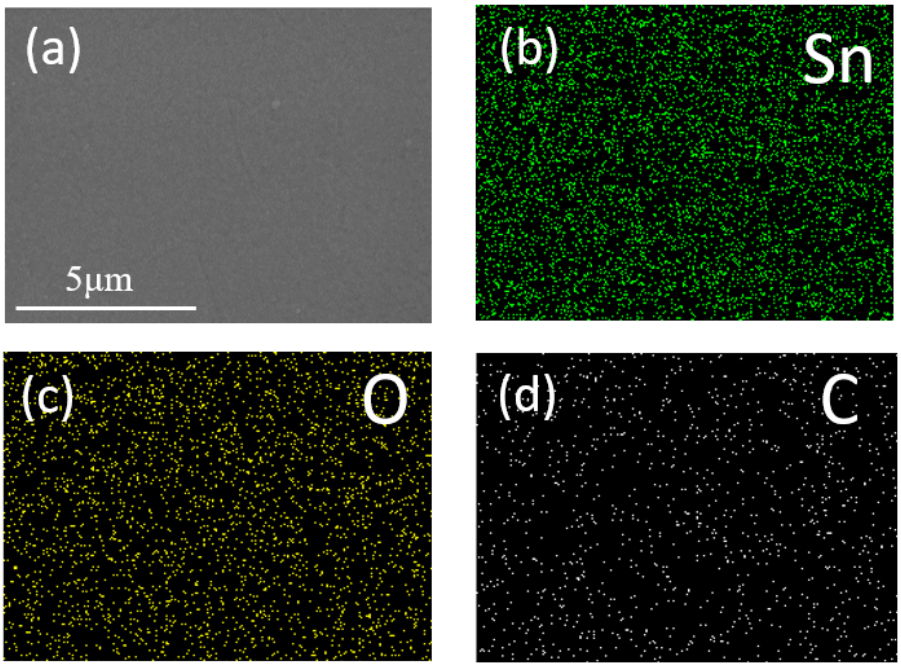

Fig. S8 The Elemental maps of (a) SnO_2:CNDs thin film. (b) Sn, (c) O and (d) C.

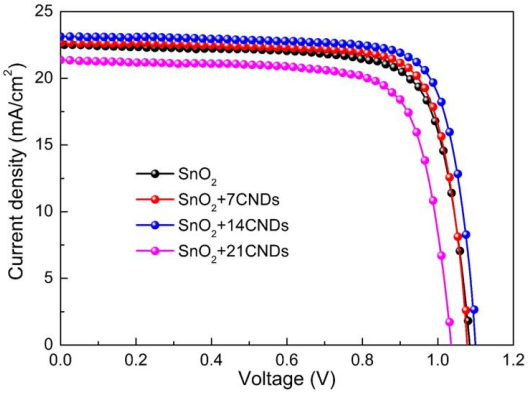

Fig. S9 The current density-voltage curves of the device based on the SnO_2 ETLs with different amount of CNDs.

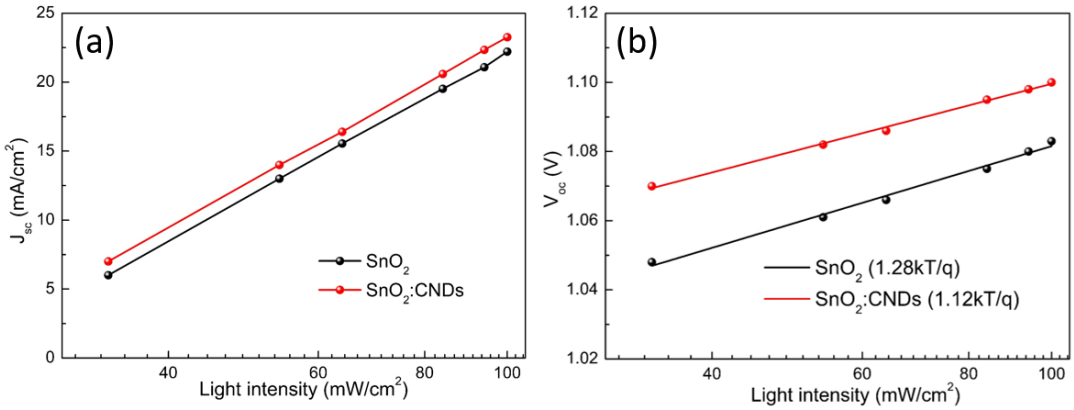

Fig. S10 (a) J_{sc} dependence on light intensity. (b) V_{oc} dependence on light intensity.

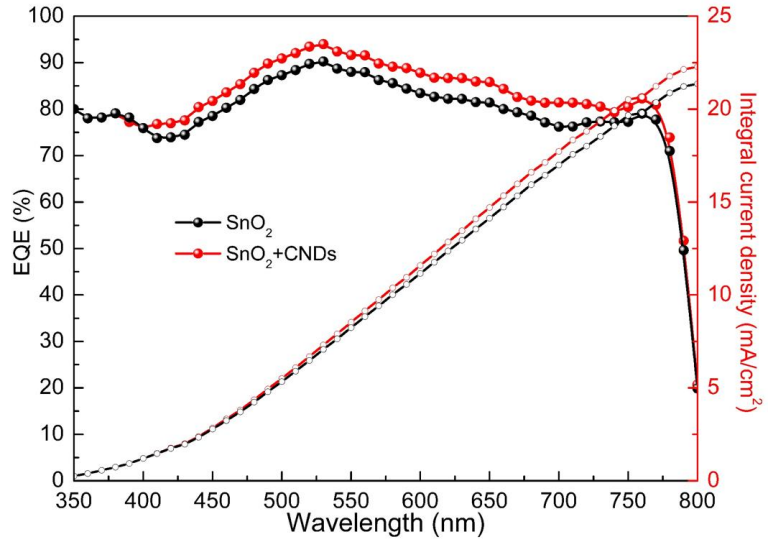

Fig. S11 EQE spectra of the device based on SnO_2 and SnO_2:CNDs.

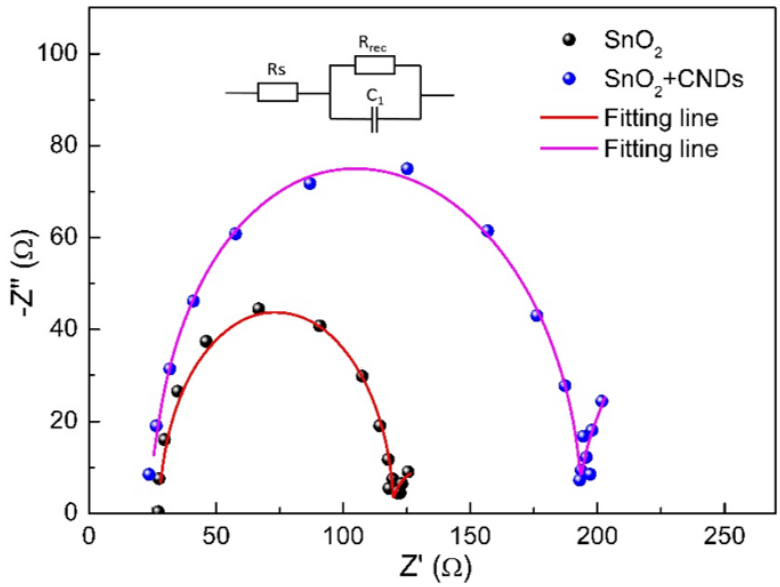

Fig. S12 Nyquist plot of the cells based on SnO_2 and SnO_2:CNDs measured with the frequency range from 1 MHz to 100 Hz under AM 1.5G irradiation at a direct current bias of 0 V. Symbols are experimental data and solid lines correspond to the fits using

the equivalent circuit (inset).

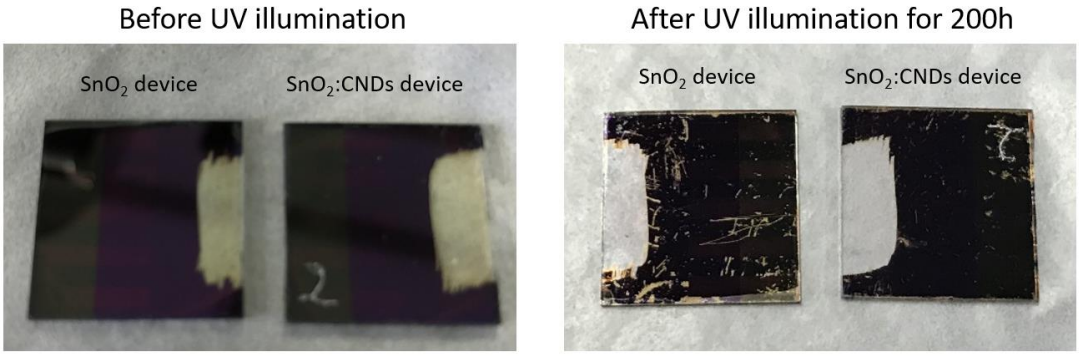

Fig. S13 Photographs of the SnO_2 device and SnO_2:CNDs device under UV continuous illumination for 200h.

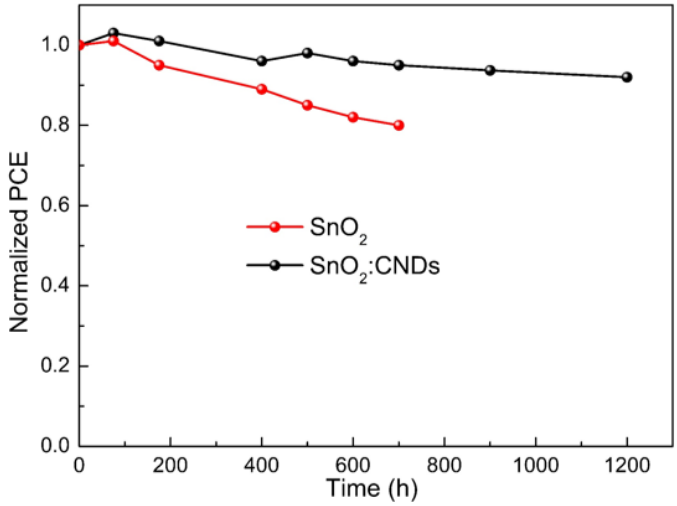

Fig. S14 Long-term stability of the devices in dry condition for 1200 h. All the devices are measured without any encapsulation.

Table S1 Slope of the Mott-Schottky plots and doping densities of ETLs.

ETL	Slope ($10^{13}\times F^{-2}\ V^{-1}$)	N ($10^{18}\times cm^{-3}$)
SnO_2	5.99	7.37
SnO_2:CNDs	5.19	8.51

Table S2 The parameters of the device based on different ETLs.

Sample	J_{sc} (mA/cm^2)	V_{oc} (V)	FF	PCE (%)
SnO_2	22.51	1.08	0.76	18.54
SnO_2+7CNDs	22.67	1.07	0.79	19.17
SnO_2+14CNDs	23.14	1.10	0.79	20.03
SnO_2+21CNDs	21.38	1.03	0.76	16.67