Effects of co-doping SnO_2 electron transport layer with boron and indium on the photovoltaic performance of planar perovskite solar cells

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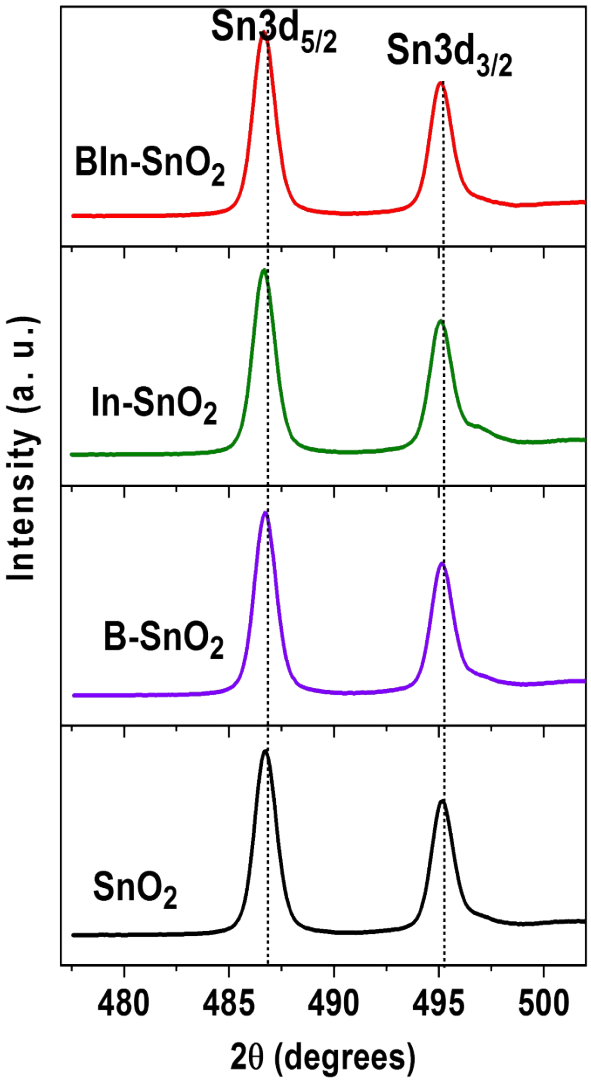

Figure S1. XPS spectra of SnO_2, B-SnO_2, In-SnO_2 and BIn-SnO_2 films at the peaks of Sn3d.

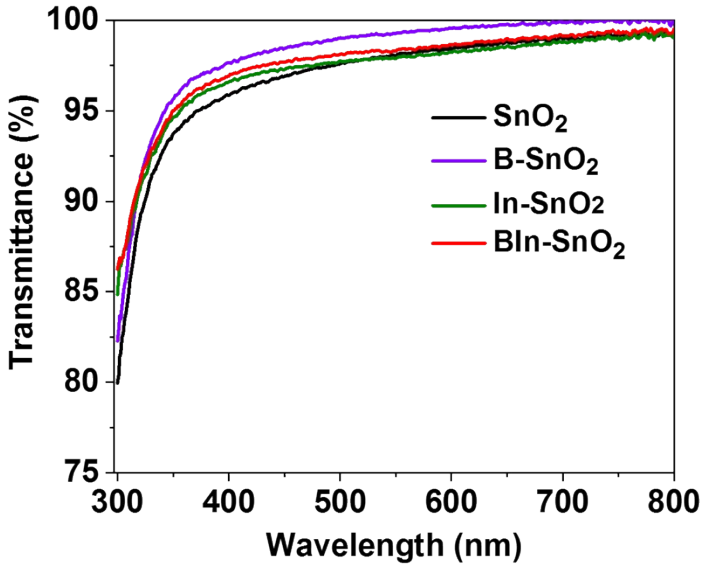

Figure S2. Transmittance spectra of SnO_2, B-SnO_2, In-SnO_2 and BIn-SnO_2 films.

Ultraviolet photoelectron spectroscopy (UPS) was used to analyze the energy-level of TiO_2, as illustrated in Figure S3. The energy levels of the valence band maximum (VBM) and conduction band minimum (CBM) energy level of TiO_2 film were calculated to be −7.12 and −3.92 eV, respectively.

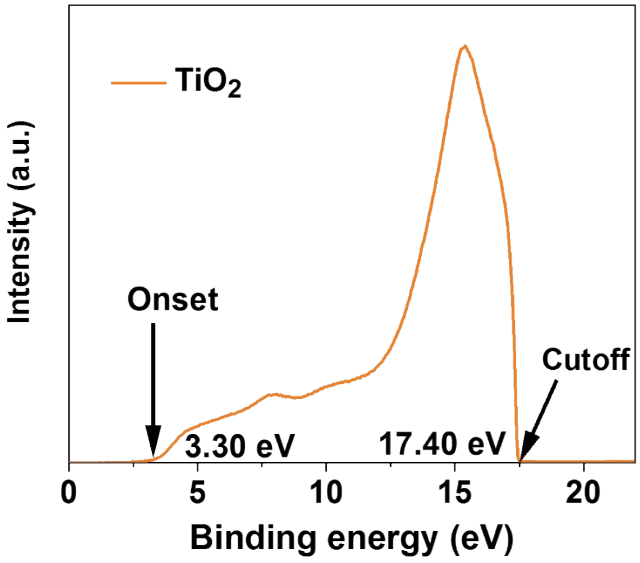

Figure S3. Ultraviolet photoelectron spectroscopy (UPS) spectra of TiO_2 film

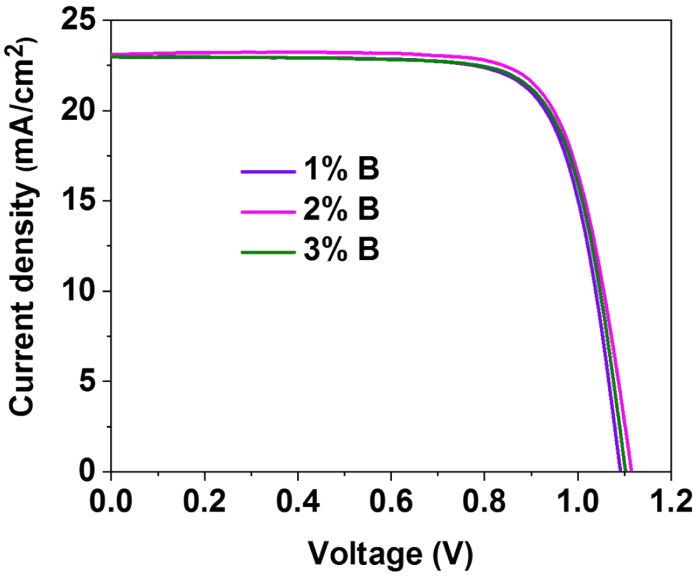

Figure S4. J-V curve of B-SnO_2 based PSCs.

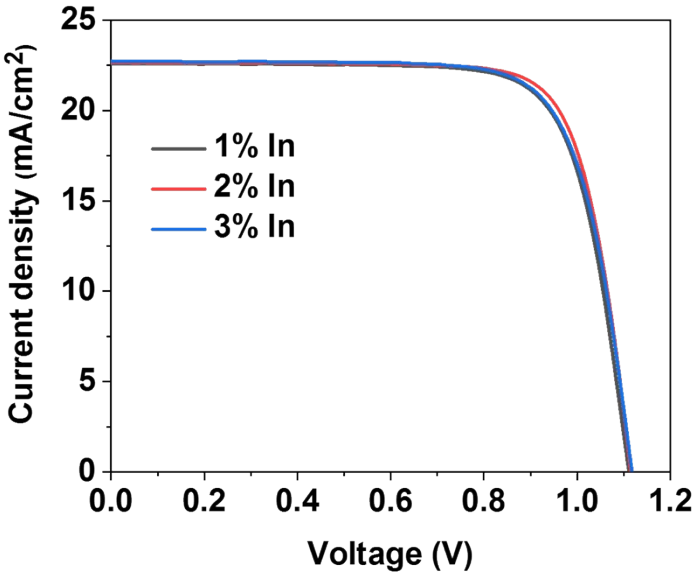

Figure S5. J-V curve of In-SnO_2 based PSCs.

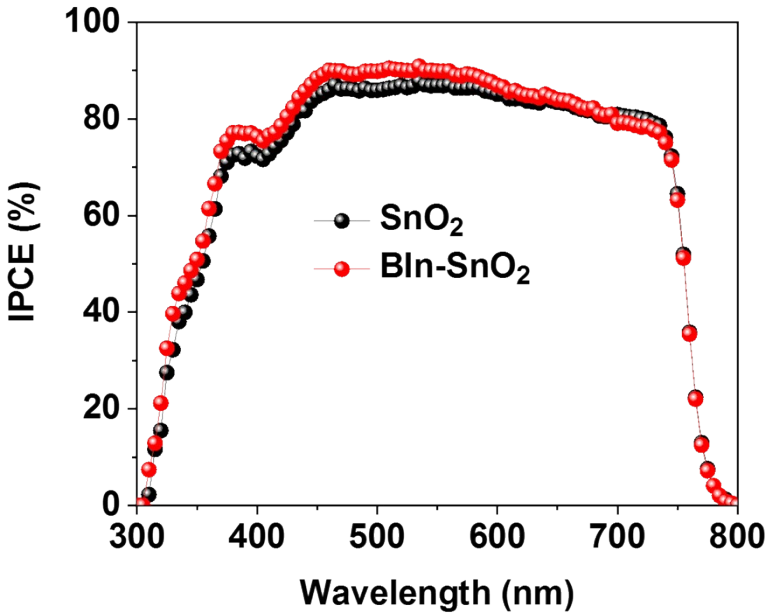

Figure S6. IPCE spectra of SnO_2 and BIn-SnO_2 based PSCs.

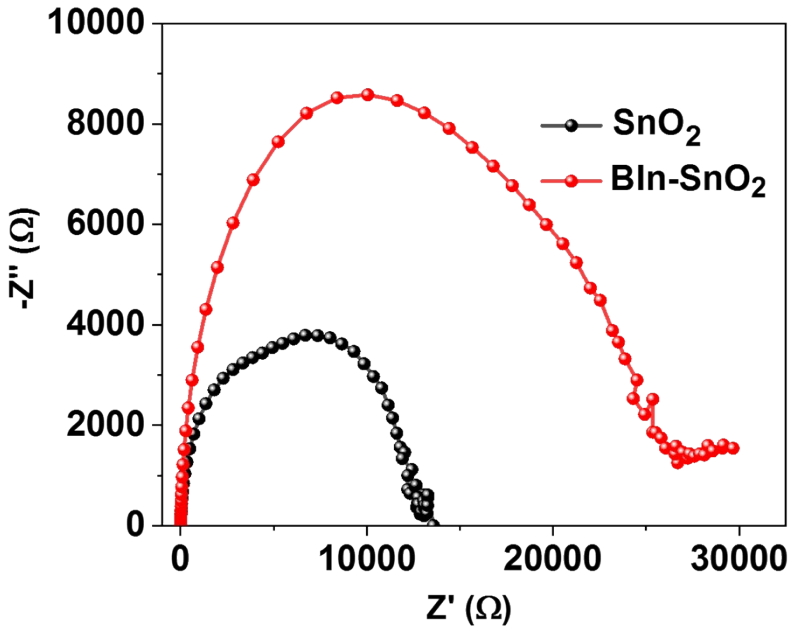

Figure S7. Nyquist plots of SnO_2 and BIn-SnO_2 ETL based perovskite devices.

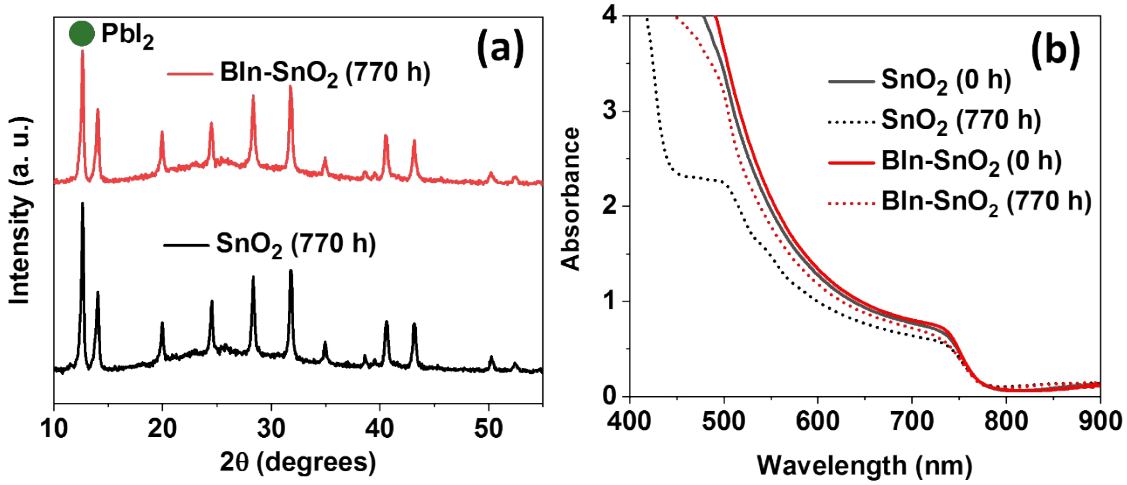

Figure S8. (a) XRD patterns and (b) UV-Vis absorption spectra of perovskite films on SnO_2 and BIn-SnO_2 substrates after 770 hours of storage under ambient conditions (40% RH, 25°C).

Table S1: Photovoltaic parameters of perovskite solar cells with various B concentration.

Devices	V_{oc} [V]	J_{sc} [mA cm^{-2}]	FF [%]	PCE [%]
1 % B-Sn O_2	1.09	22.95	75.56	18.93
2 % B-Sn O_2	1.11	23.10	75.54	19.44
3 % B-Sn O_2	1.10	22.96	75.45	19.09

Table S2: Photovoltaic parameters of perovskite solar cells with various In concentration.

Devices	V_{oc} [V]	J_{sc} [mA cm^{-2}]	FF [%]	PCE [%]
1 % In-Sn O_2	1.11	22.59	75.77	19.03
2 % In-Sn O_2	1.11	22.66	77.57	19.56
3 % In-Sn O_2	1.11	22.72	75.47	19.17