Supporting Information

Promising ITO-free Perovskite Solar Cells with WO_3-Ag-SnO_2 as Transparent Conductive Oxide

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Figure S1

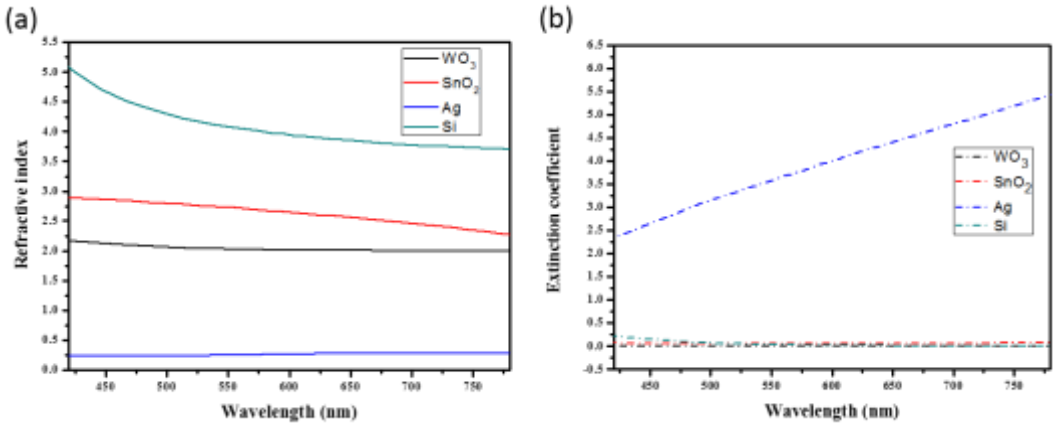

Figure S1. (a) Refractive indexes and (b) extinction coefficients of WO_3, SnO_2, Ag and Si used in the FDTD solution simulation.

Figure S2

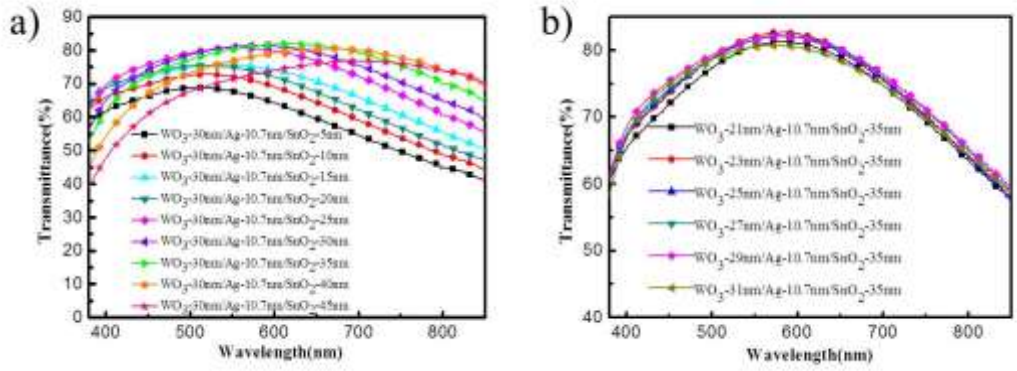

Figure S2. Transmission spectra of WO_3 (30nm)/Ag (10.7nm)/SnO_2 (x nm) with varying thicknesses of SnO_2 layer (a), and of WO_3 (x nm)/Ag (10.7nm)/SnO_2 (35 nm) with varying thicknesses of WO_3 layer (b).

Figure S3

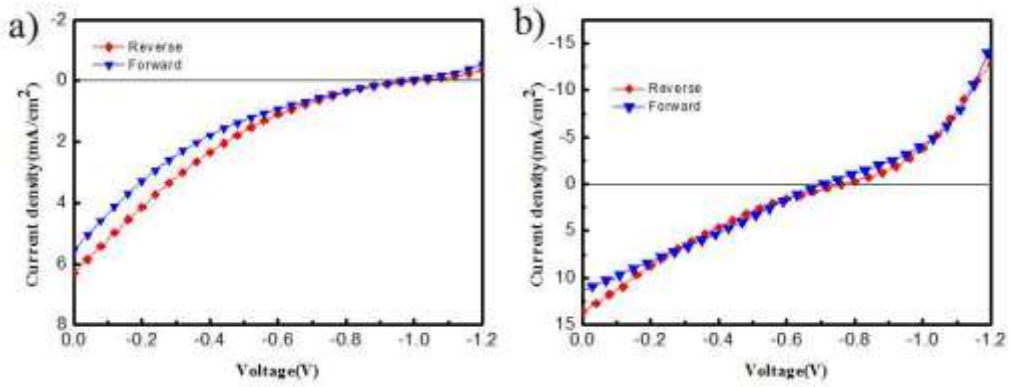

Figure S3. J-V curves of a typical device with the WO_3 (23nm)/Ag (10.7nm)/SnO_2 (35nm) as the transparent electrode (without SnO_2 NPs) (a) and with ITO as the transparent electrode (without SnO_2 NPs) (b).

Figure S4

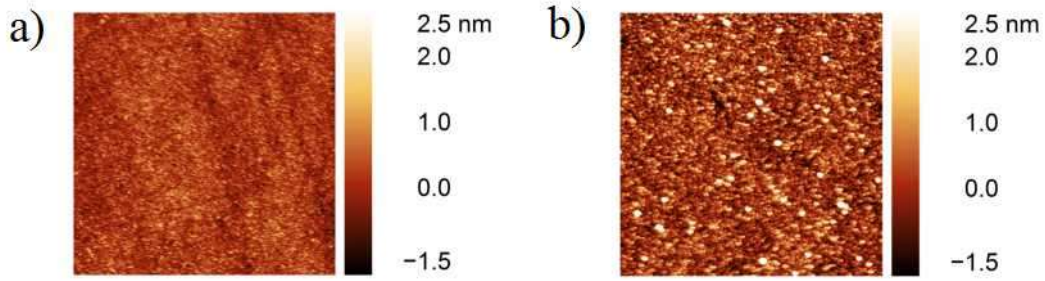

Figure S4. AFM topographic images of the WAS and WAS/SnO2 NPs, respectively. The scan size is 5μm×5μm.

Figure S5

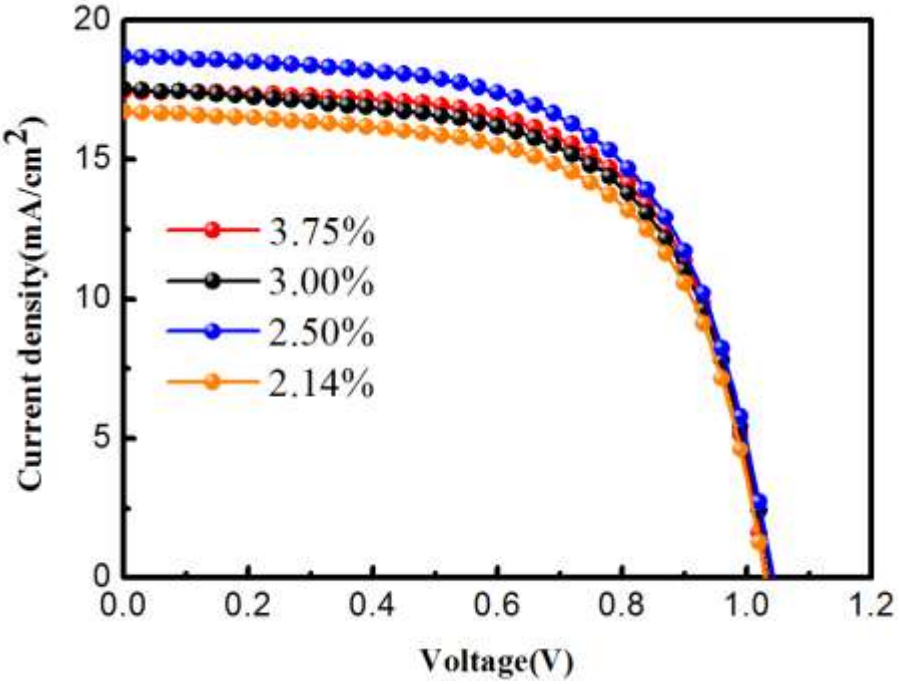

Figure S5. J-V curves of the devices with the SnO_2 NPs interlayer deposited by different concentrations (mass fraction) of the 7nm SnO_2 NPs precursor solution.

Figure S6

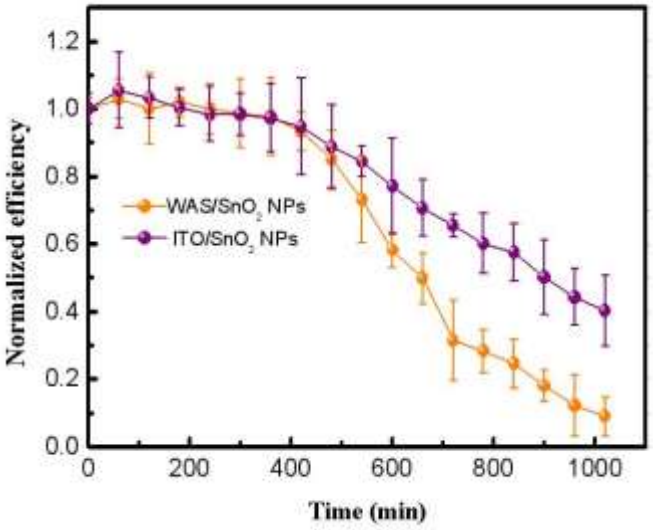

Figure S6 . Stability of the unpackaged perovskite solar cells with the WAS and ITO as bottom electrodes under ambient atmosphere (37%RH and 25^{o}C) under the illumination of AM 1.5 G simulated sunlight. There are 6 devices for each kind of devices.

Tables

Table S1.Summary of photovoltaic parameters of the WAS based PSCs with a SnO_2 NPs interfacial layer. The device aperture area is 0.1cm^2 .

Small Devices	*Scandirection*	*Jsc(mA/cm²)*	*Jsc by EQE(mA/cm²)*	*Voc(V)*	*FF(%)*	*PCE(%)*
WAS/SnO_2 NPs	Reverse	18.30±0.3 (18.6)	18.13	1.045±0.03 (1.045)	69.3±2.7 (72)	13.2±0.7 (14.0)
	Forward	18.4		1.028	69	13.1

Table S2. Summary of the PL lifetime parameters from fitting curves of the TRPL decay spectra of three kinds of samples below.

Samples	τ_1 *(ns)*	A_1 *(%)*	τ_2 *(ns)*	A_2 *(%)*	*Weighted average (ns)*
Glass/Perovskite	9.75	0.41	146.27	99.59	146.22
WAS/Perovskite	9.45	3.39	70.88	96.61	70.59
WAS/SnO_2 NPs/Perovskite	4.15	17.07	37.87	82.93	37.13