Electronic Supplementary Information

## Chlorine-doped SnO₂ hydrophobic surface for large grain Perovskite Solar Cells

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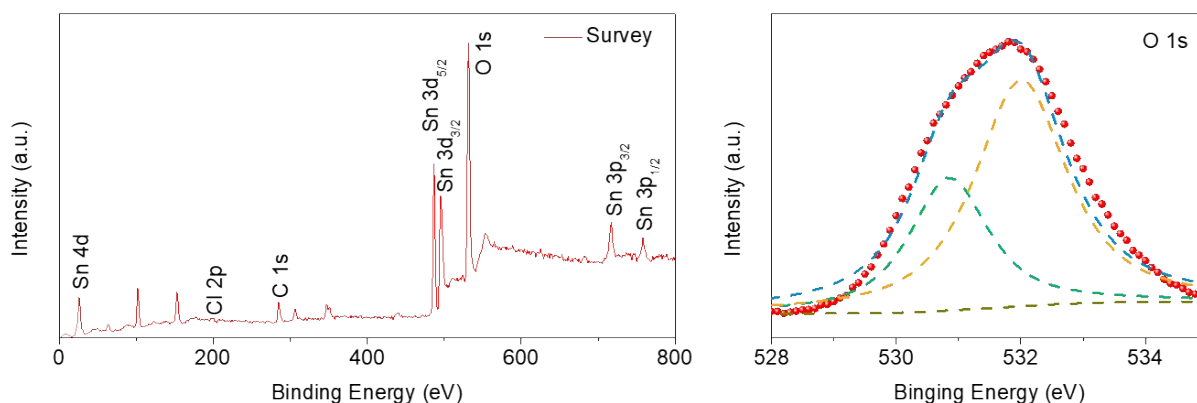
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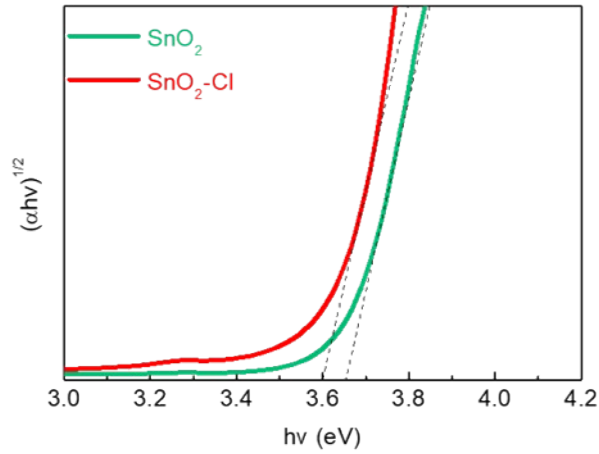
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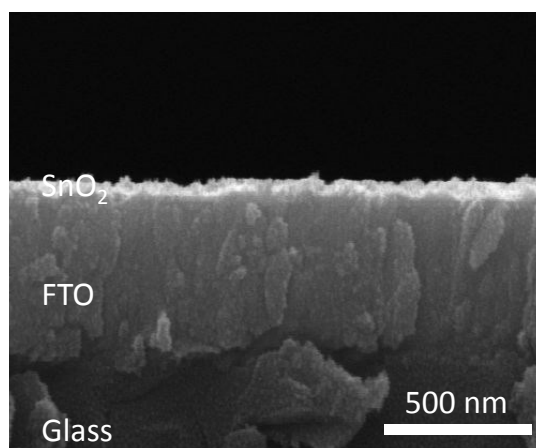
Fig. S1 The cross-sectional SEM images of SnO₂

Fig. S2 XPS survey spectrum and high resolution XPS graphs for the O elements in the SnO₂-Cl colloid.

Fig. S3 The Tauc-plots of SnO_2 and SnO_2-Cl films coated on FTO glass. The bandap are 3.65

eV and 3.61 eV for SnO_2 and SnO_2-Cl can be obtain through liner extrapolation of Tauc-plots.

Table S1. Fitted parameters of TRPL decay curves in perovskite films with using SnO_2 and SnO_2 -Cl ETL substrates.

ETLs	A_1	τ_1 [ns]	A_2	τ_2 [ns]	τ [ns]
SnO_2	0.1521	1.209	0.0751	16.042	14.08
SnO_2-Cl	0.6009	0.349	0.0546	4.461	2.56

The TRPL decay was fitted by a bi-exponential decay function with below equation:

$$PL_{int\,ensity} = A_1 e^{-t/\tau_1} + A_2 e^{-t/\tau_2}$$

where A_1 and A_2 are time-independent coefficients of amplitude fraction for each decay

component, τ_1 and τ_2 are decay time of a fast and slow component, respectively.

Table S2. Photovoltaic parameters of the PSCs measured under different scan directions.

ETLs	Scan direction	V_{OC} [V]	J_{SC} [mA cm^{-2}]	FF [%]	PCE [%]	R_S [Ω cm^2]	R_{SH} [Ω cm^2]	HI[a)]
SnO_2	Forward	0.99	21.09	60.2	12.6	142.4	6340.4	0.104
	Reverse	1.0	22.7	66.1	15.07	124.1	18187.6	
SnO_2-Cl	Forward	1.1	23.3	69.7	18.0	83.6	29151.1	0.013
	Reverse	1.1	23.6	69.2	18.1	118.0	37471.9	

Hysteresis index

Table S3. The average photovoltaic parameters of the PSCs fabricated by using SnO_2 and SnO_2-Cl ETLs, which are extracted from measuring current density-voltage curves at simulated one sun illumination (100 mW cm^{-2}, AM 1.5 G)

ETLs	V_{OC} [V]	J_{SC} [mA cm^{-2}]	FF [%]	PCE[a] [%]
SnO_2	1.01 ± 0.06	21.02 ± 3.93	59.64 ± 5.87	13.36 ± 1.8
SnO_2-Cl	1.08 ± 0.02	23.02 ± 0.91	69.38 ± 1.72	17.35 ± 0.56

Maximum values are in parentheses.