Solvent-assisted preparation of low-temperature SnO₂ electron transport layers for efficient and stable perovskite solar cells made in ambient conditions
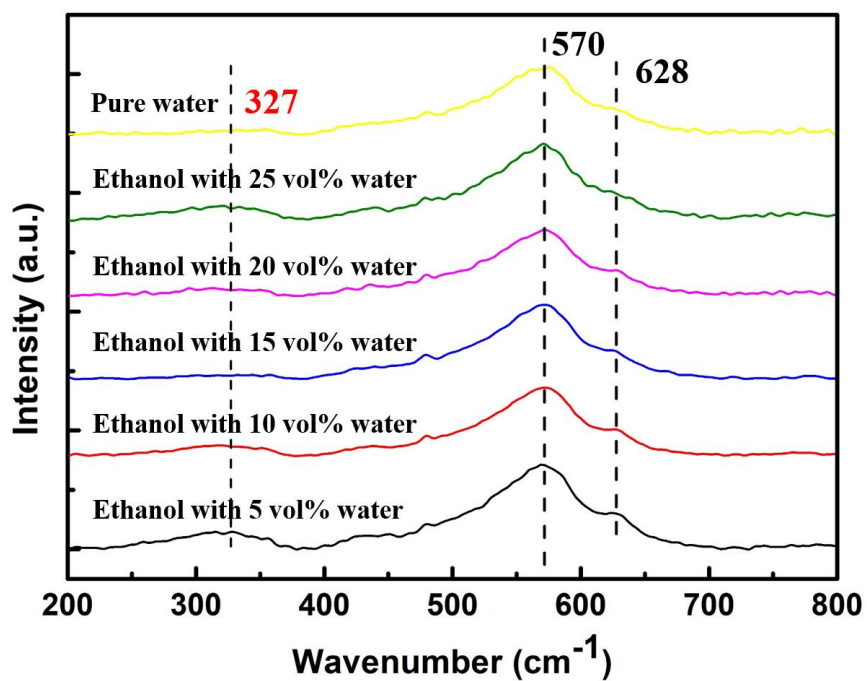
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Fig. S1. Raman spectra of SnO_2 nanocrystals which prepared using different solutions.
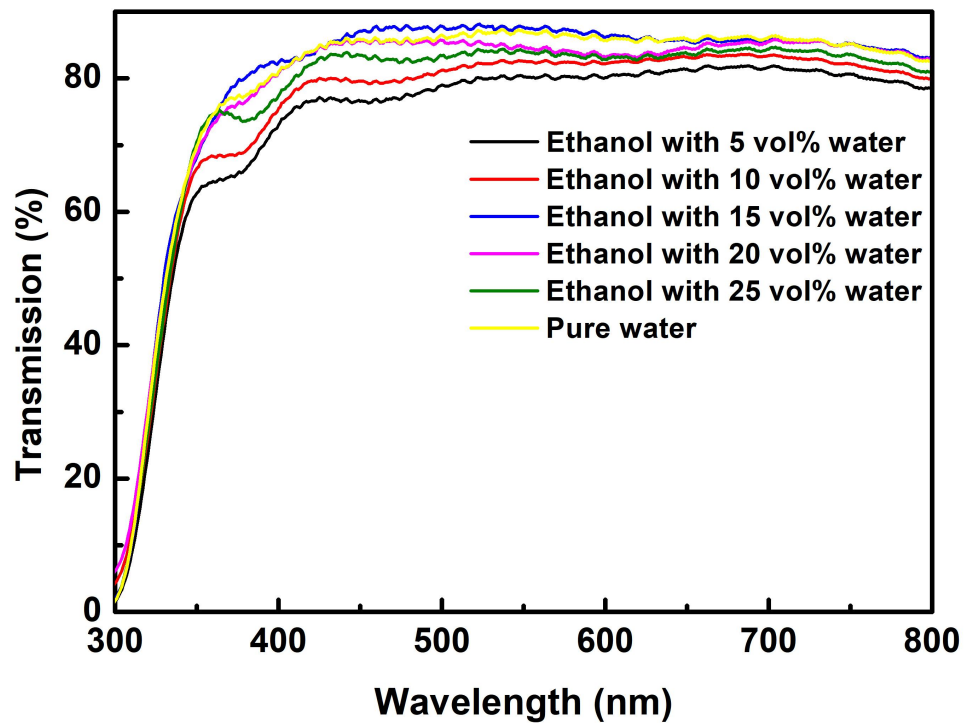
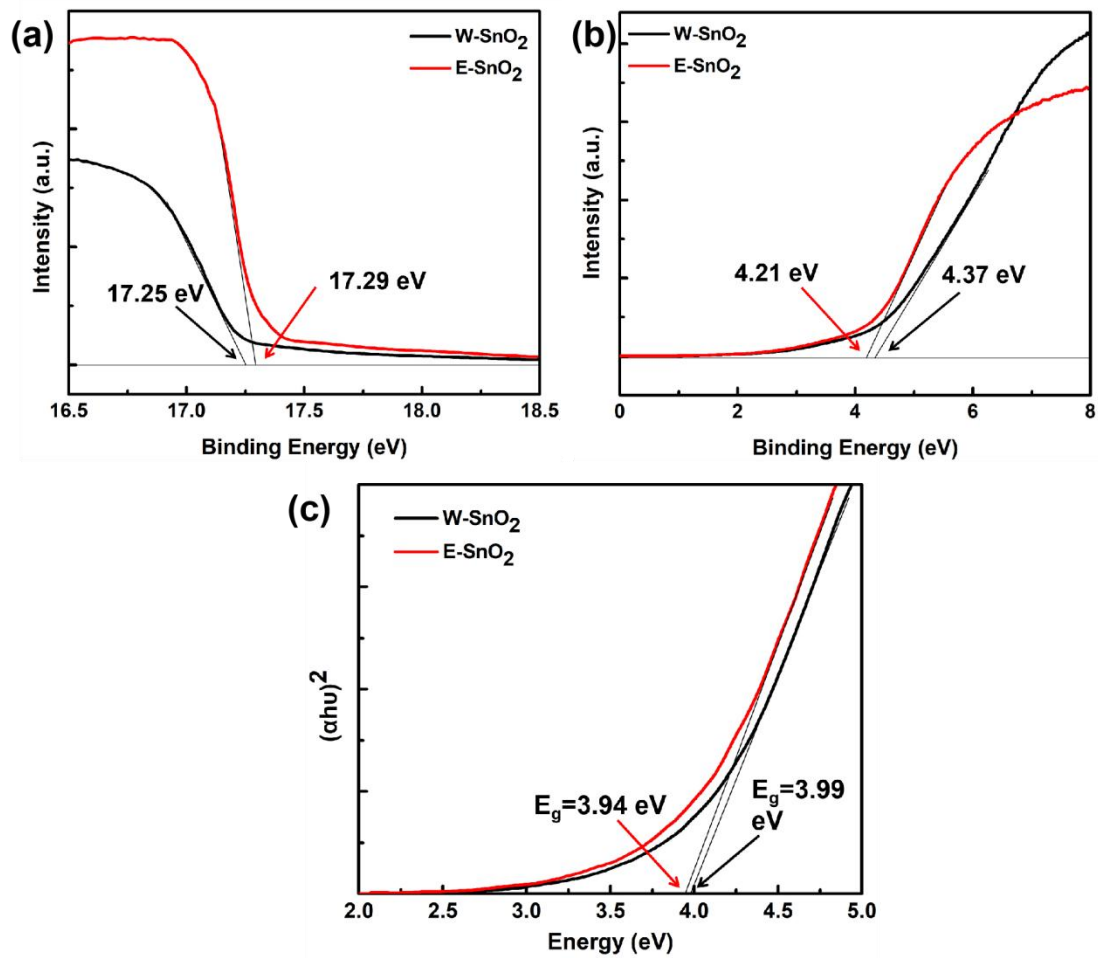**Fig. S2.** UV-visible spectra of FTO/SnO$_2$ prepared using different solutions.

Fig. S3. (a), (b)UPS spectra describing the cut-off energy and onset energy boundaries for W-SnO$_2$ and E-SnO$_2$. (c) The band gaps of W-SnO$_2$ and E-SnO$_2$.

The average decay time (τ_{ave}) is calculated by Eq. (S.1) [1]

$$\tau_{ave} = \sum_{i=1}^{n} A_i \tau_i \qquad \text{(S.1)}$$

Here, τ_{ave} is average decay time, A_i is the decay amplitude, and τ_i is the decay time.

The hysteresis index (HI) is calculated by Eq. (S.2)

$$HI = \frac{PCE_{reverse} - PCE_{forward}}{PCE_{reverse}} \qquad (S.2)$$

The trap-state density (n_{trap}) is calculated by the the Eq. (S.3) [2]

$$n_{trap} = \frac{2\varepsilon\varepsilon_0 V_{TFL}}{eL^2} \tag{S.3}$$

Where ε_0 is the vacuum permittivity ($\varepsilon_0 = 8.85 \times 10^{-12}$ F/m), ε is the relative dielectric constant of the perovskite ($\varepsilon_{perovskite} \approx 35$), e is the elemental charge ($e = 1.6 \times 10^{-19}$ C), and L is the thickness of the measured perovskite film.

Table S1. ZView2 fitting parameters obtained from the EIS data of the champion E-SnO$_2$-PSC and W-SnO$_2$-PSC.

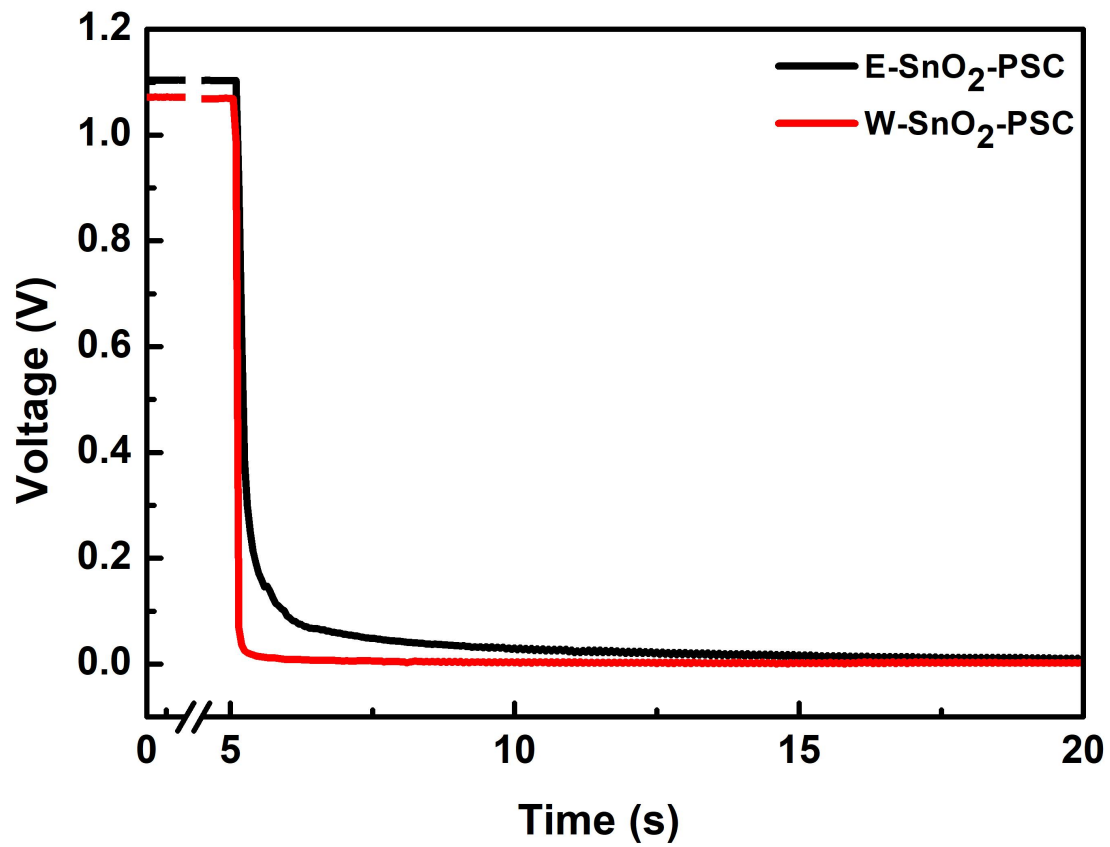| Device	R_S	R_{rec}	C
E-SnO$_2$-PSC	49.38	1816.04	7.831E^{-9}
W-SnO$_2$-PSC	68.41	952.32	5.081E^{-9}

Fig. S4. OCVD curves for E-SnO$_2$-PSC and W-SnO$_2$-PSC.

References:

[1] B. Wu, K. Fu, N. Yantara, G. Xing, S. Sun, T. Sum, N. Mathews, Adv. Energy Mater. 5 (2015) 1500829.

[2] Q. Dong, Y. Fang, Y. Shao, P. Mulligan, J. Qiu, L. Cao, J. Huang, Science 347 (2015) 967-970.