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Zinc ion as effective film morphology controller in perovskite solar cells

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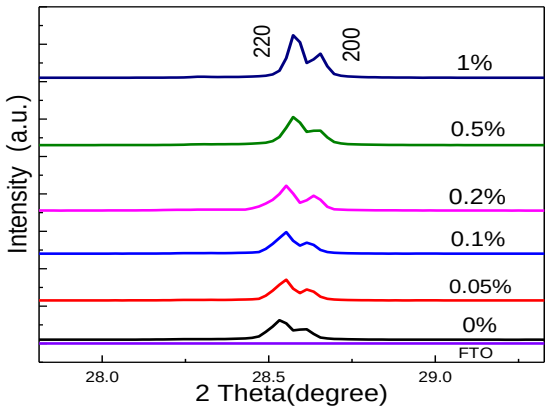

Figure S1. Enlarged picture of the (220) diffraction peak

The location of diffraction peak of (110), (220) and (200) is identified by the reported paper.[1-2]

The Scherrer equation, $\tau = \frac{k\lambda}{\beta \cos\theta}$ [3-4]

k is a dimensionless shape factor,

λ is the incident x-ray wavelength,

β is the FWHM,

θ is the bragg diffraction angle and the τ is defined as the calculated grain sizes.

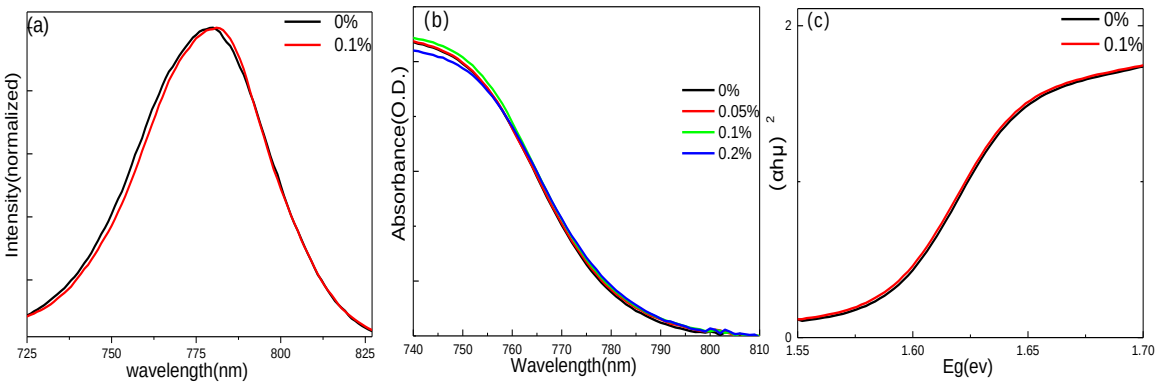

Figure S2. a) Normalized PL spectra, b) the enlarged absorption edges, c) tauc plots

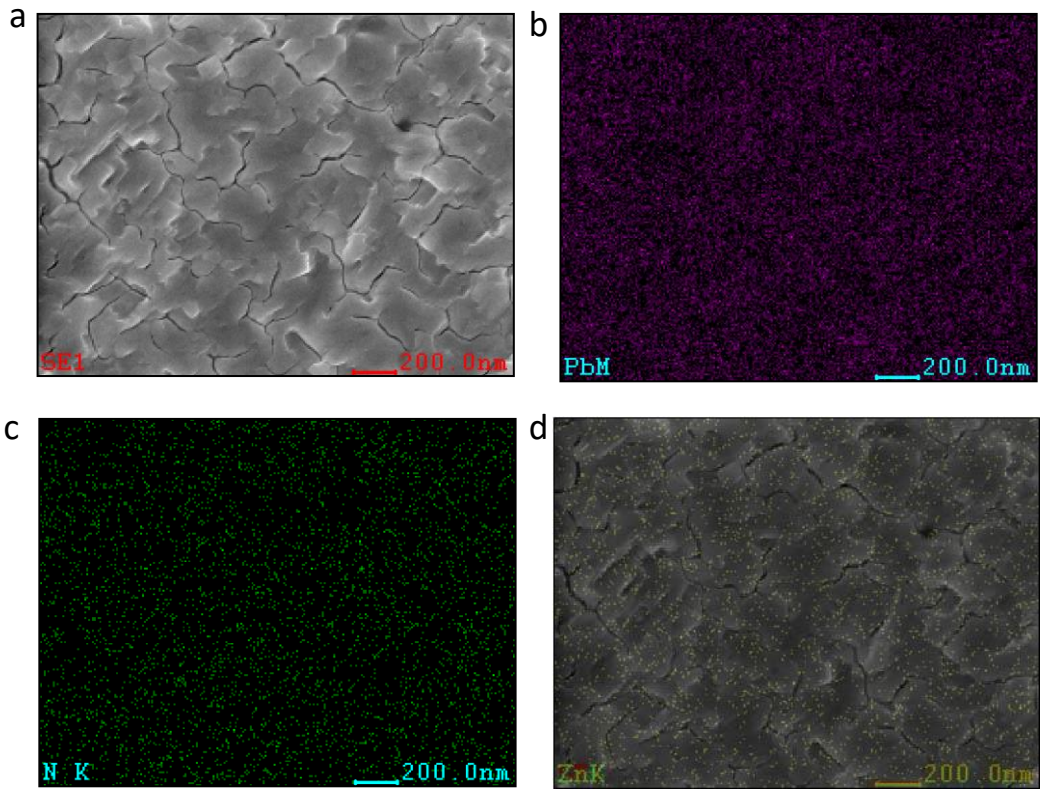

Figure S3. EDS mapping pattern. a) The SEM of Znic ion doped perovskite film (0.1%) on the top of TiO2 copmpact layer, b) Pb mapping, c) N mapping, d) Zn mapping.

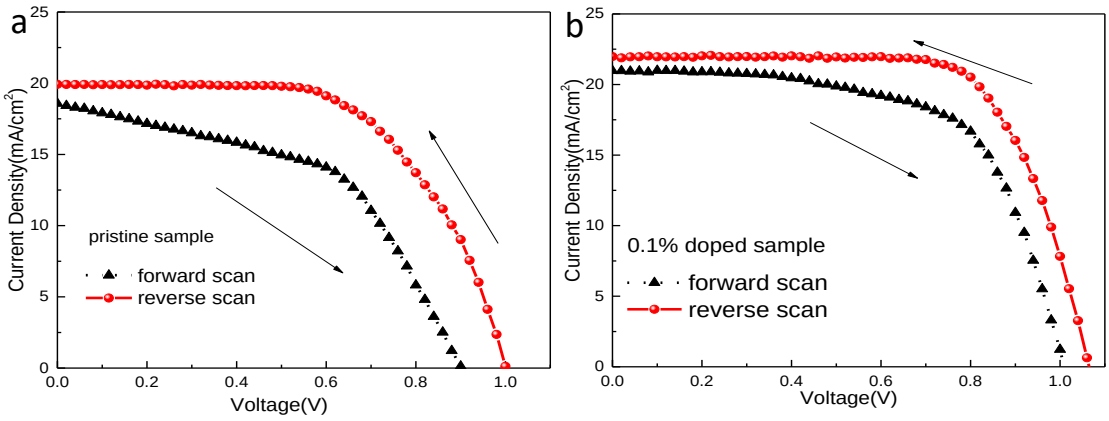

Figure S4. J-V curves measured by reverse scan and forward scan condition. a) pristine sample, b) target sample (0.1% doped).

All of J-V curves were recorded by the scan speed of 0.1 V/S with the scan step of 0.01 V and delay time of 50 mS. The J-V modified hysteresis index is defined by Equation 1:[5]

$$HI=\frac{Jrs(0.8Voc)-Jfs(0.8Voc)}{Jrs(0.8Voc)}$$

$J_{rs}(V_{oc})$ and $J_{fs}(V_{oc})$ respectively represent the photocurrent density at the point of the 80% open-circuit voltage in the reverse scan(open-circuit voltage to short-circuit current) and forward scan(from short-circuit current to open-circuit voltage). According to this equation 1, the HI of pristine sample is 0.258， and the target one is 0.127. This is an obvious suppression in the hysteresis behavior. The improvement could be contribute to better crystal quality with larger grain size and lesser pinholes in the target perovskite film.[6]

Table S1 detail information of the (220) diffraction peak

	FWHM (。)	Peak Location (。)	Grain size(nm)	Intensity(a.u.)
0%	0.096	28.533	93.1	10195
0.05%	0.092	28.548	97.2	11322
0.1%	0.090	28.554	99.3	11579
0.2%	0.085	28.558	105.2	13884
0.5%	0.083	28.576	107.7	15006
1%	0.077	28.577	116.1	22273

Table S2. The formulation of the series of perovskite precursor

Samples	$ZnCl_2$ (mg)	$PbCl_2$ (mg)	CH_3NH_3I (mg)
0%	0	222.49	381.36
0.05%	0.05	222.37	381.36
0.1%	0.11	222.26	381.36
0.2%	0.22	222.04	381.36
0.5%	0.55	221.37	381.36
1%	1.09	220.26	381.36

Table S3 the concentration of Zn in the resulting perovskite films.

Samples	Pb(At%)	Zn(At%)
0%	100	0
0.5%	99.32	0.68
1%	98.72	1.28

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