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Supporting Information

Inverted Planar Solar Cell with 13% Efficiency and Sensitive Visible Light Detector Based on Orientation Regulated 2D Perovskites

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Keywords: 2D perovskite, Morphology regulation, Additive, Merged annealing, High fill factor

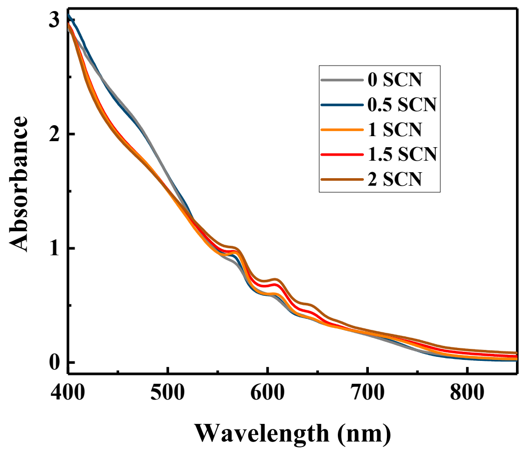

Fig. S1 Absorption spectra of $(PEA)_2(MA)_4Pb_5I_{16}$ (n = 5) perovskite films with various amounts of NH_4SCN additive on ITO/PEDOT:PSS substrate.

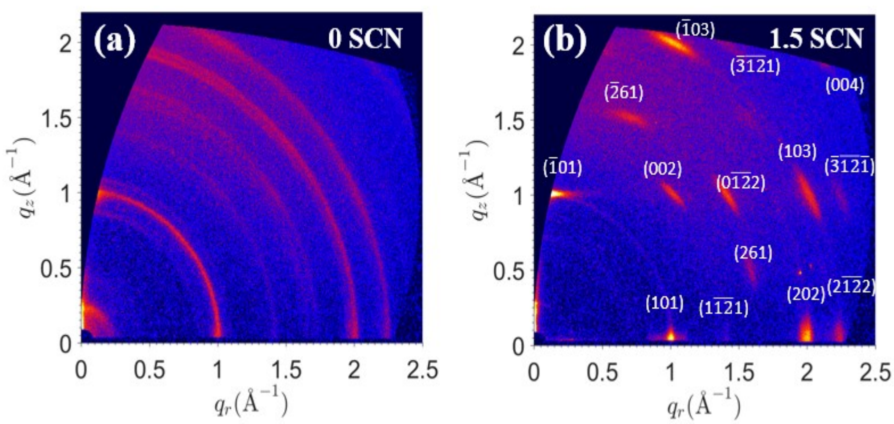

Fig. S2 2D GIWAXS patterns of $(PEA)_2(CH_3NH_3)_4Pb_5I_{16}$ (n=5) films made by MA process (a) without and (b) with 1.5 SCN addition.

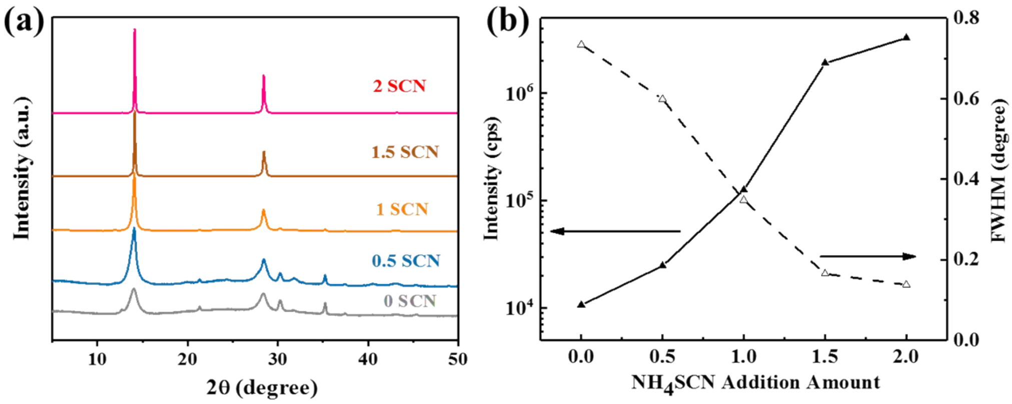

Fig. S3 (a) XRD patterns and (b) the corresponding diffraction peak intensity and FWHM of the MA-based $(PEA)_2(CH_3NH_3)_4Pb_5I_{16}$ (n=5) perovskite films with various addition ratio of NH_4SCN on ITO/PEDOT:PSS substrate.

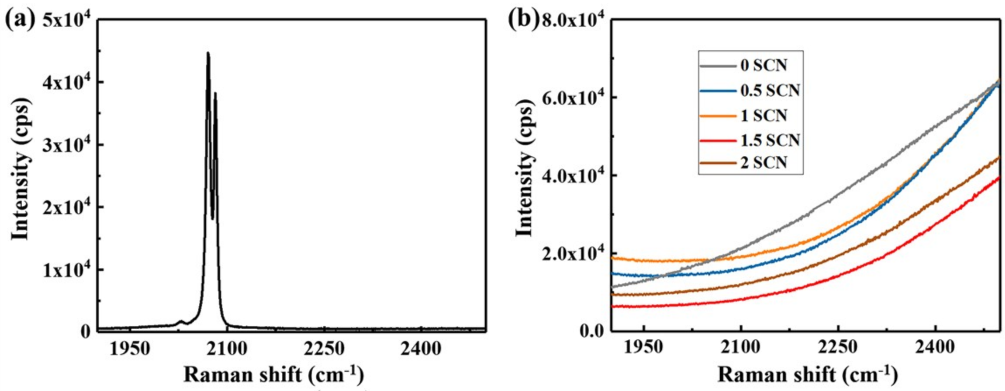

Fig. S4. Raman spectra of pristine NH_4SCN (a) and $(PEA)_2(MA)_4Pb_5I_{16}$ films with various amounts of NH_4SCN addition after thermal annealing (b).

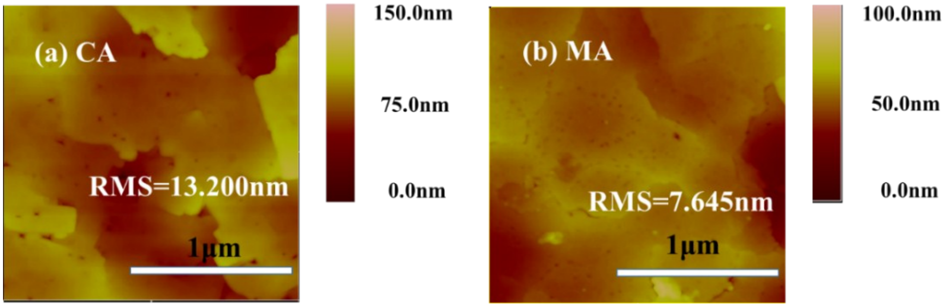

Fig. S5 Atomic force microscopy of the $(PEA)_2(CH_3NH_3)_4Pb_5I_{16}$ (n=5) perovskite films fabricated by (a) CA and (b) MA processes on ITO/PEDOT:PSS substrate.

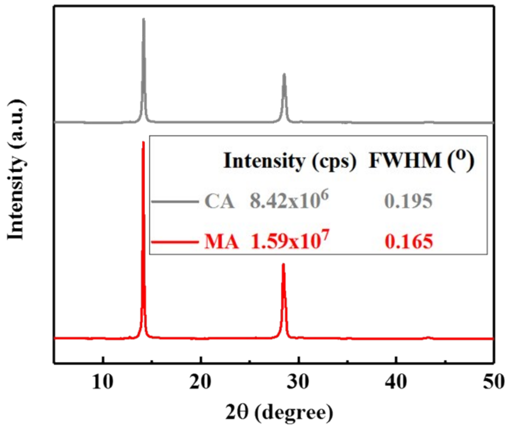

Fig. S6 XRD patterns of perovskite films fabricated by CA and MA processes.

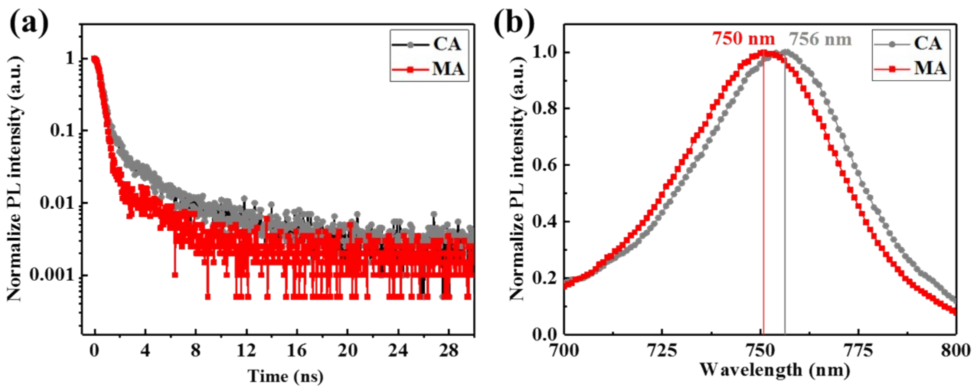

Fig. S7 (a) Time-resolved photoluminescence measurements, (b) Steady-state photoluminescence spectra of the perovskite films on the PEDOT:PSS substrates with $PC_{61}BM$ above.

Spectral densities of 1/f noise, shot noise and thermal noise of the MA-based device.

The 1/f noise ($S_I(1/f)$) can be calculated by equation of $S_I(1/f) = |I(f)|^2/(Fs \times N)$, in which $I(f)$ is the discrete Fourier transform of the dark current waveform $I(t)$, Fs is the sampling rate, N is the number of data points. The calculated spectral density of 1/f noise is shown in Fig. S8. At a modulation frequency of 10 Hz, the value of $S_I(1/f)$ is about $2.0\times10^{-21} A^2/Hz$.

The shot noise ($S_I(shot)$) can be expressed as $S_I(shot) = 2\times q\times I_{dark}$, where q is the elemental charge, I_{dark} is the dark current of the device. The calculated $S_I(shot)$ is about 9.67×10^{-27} A^2/Hz.

The thermal noise ($S_I(thermal)$) is calculated by using Nyquist's equation, $S_I(thermal) = 4\times k_B\times T/r$, where k_B is the Boltzmann's constant, T is the temperature and r is the differential resistance of the device in the dark. The calculated $S_I(thermal)$ at room temperature (300K) is about 5.00×10^{-27} A^2/Hz.

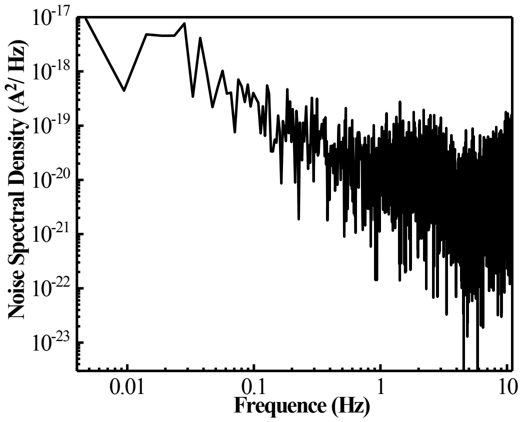

Fig. S8 Spectral density of 1/f noise for the MA-based device at -0.1V.

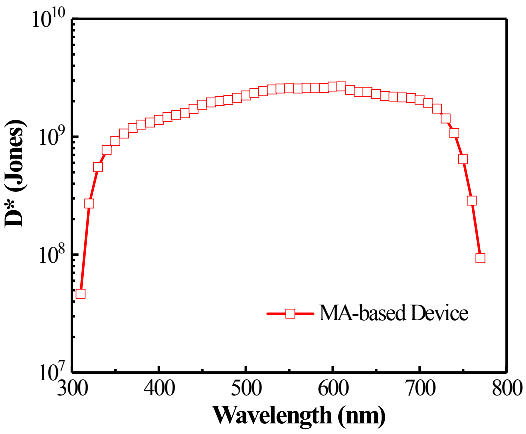

Fig. S9 Specific detectivity of the PVSC fabricated by MA process as the function of incident wavelength.

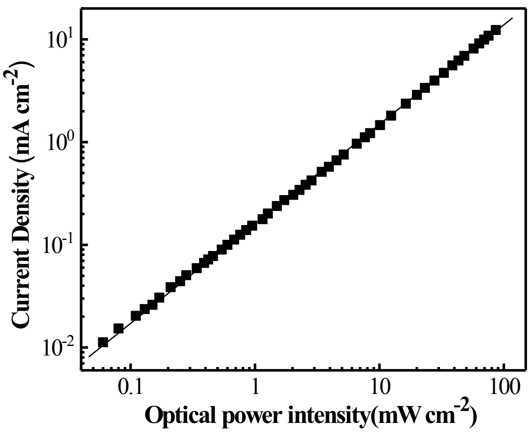

Fig. S10 Photocurrent of MA-based device under the illumination of white light with various intensities at -0.1V bias.

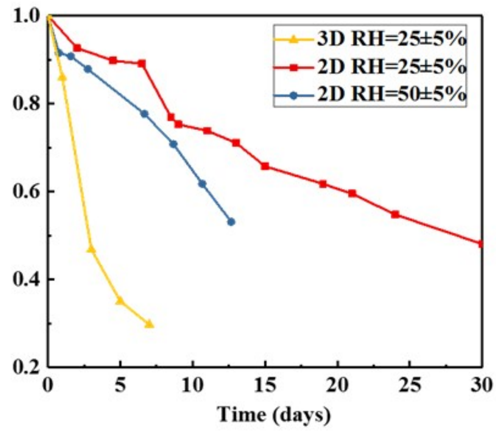

Fig. S11 Device stability of the corresponding unencapsulated 2D, 3D PVSC in air with different humidity.

Table S1. Time-resolved PL data of $(PEA)_2(CH_3NH_3)_4Pb_5I_{16}$ perovskite films on ITO/PEDOT:PSS substrates.

Method	τ_1 (ns)	frac. τ_1 (%)	τ_2 (ns)	frac. τ_2 (%)	Lifetime (ns)
CA	0.97	21.99	12.67	78.01	10.10
MA	1.51	49.28	7.77	50.72	4.68