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Supporting information

Highly stable and efficient perovskite solar cells passivated by a functional amorphous layer

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Experimental Section

Preparation of PSCs: ITO/glass substrates were sequentially washed with distilled water, acetone and isopropanol (IPA). Then, PTAA (Sigma) dissolved in toluene (2.0 mg/mL) was spin-coated on the ITO/glass substrates at a spin rate of 3000 rpm for 40 s. The films were subsequently annealed on a hotplate at 100 ℃ for 10 min. The perovskite films were prepared by spin-coating the perovskite precursor solution containing CH_3NH_3I (Dyesol): 159 mg, PbI_2 (Alfa, 99.99%): 484 mg, DMF (Sigma, anhydrous, 99.9%): 720 μL, DMSO (Sigma, anhydrous, 99.9%): 78 μL, at 4000 rpm for 30 s. During the spin coating process, 0.5 ml of diethyl ether (Sigma, anhydrous, 99.7%) was slowly dripped on the rotating substrate in 10 secs after starting. For 5-SSA doped films, different amount of 5-SSA were added into the perovskite precursor solution. All perovskite films were annealed at 100 ℃ for 15 min. Next, electron transport layers (ETLs) were prepared by spin coating a solution of PCBM (Nano-C) in chlorobenzene (20 mg/ml) at 3000 rpm for 30 s. Bathocuproine (BCP, Sigma, 96%) dissolved in IPA (0.5 mg/ml) was spin-coated on the PCBM films at 4500 rpm for 30 s. Finally, devices were completed with the evaporation of silver (Ag) top electrodes through a shadow mask. The area of the PSC is designed to be 6 mm^2.

Material and device characterization: Scanning electron microscopy (SEM) images of perovskite thin films were obtained under a Hitachi S-4300 microscope. The TEM images of perovskite films were conducted using JEOL JEM-2100F TEM/STEM operated at 200 kV, using Gatan Enfina electron spectrometer (CA, USA). X-ray diffraction (XRD) measurement was performed using a Rigaku SmartLab X-ray

Diffractometer operating at room temperature. Time-resolved photoluminescence (PL) measurements of the samples were carried out by using an Edinburgh FLSP920 fluorescence spectrophotometer. A 632-nm laser was used as an excitation light source.

The current density versus voltage (J-V) characteristics of the PSCs were measured by using a Keithley 2400 source meter under the illumination of an AM 1.5 solar simulator with a light intensity of 100 mW/cm^2 (Newport 91160, 300W). The light intensity was calibrated with a standard silicon solar cell. The external quantum efficiencies (EQEs) of the PSCs were measured with a standard test system, including a xenon lamp (Oriel 66902, 300W), a Si detector (Oriel 76175_71580), a monochromator (Newport 66902) and a dual channel power meter (Newport 2931_C). The J-V and EQE measurements were performed in ambient air without encapsulation of devices.

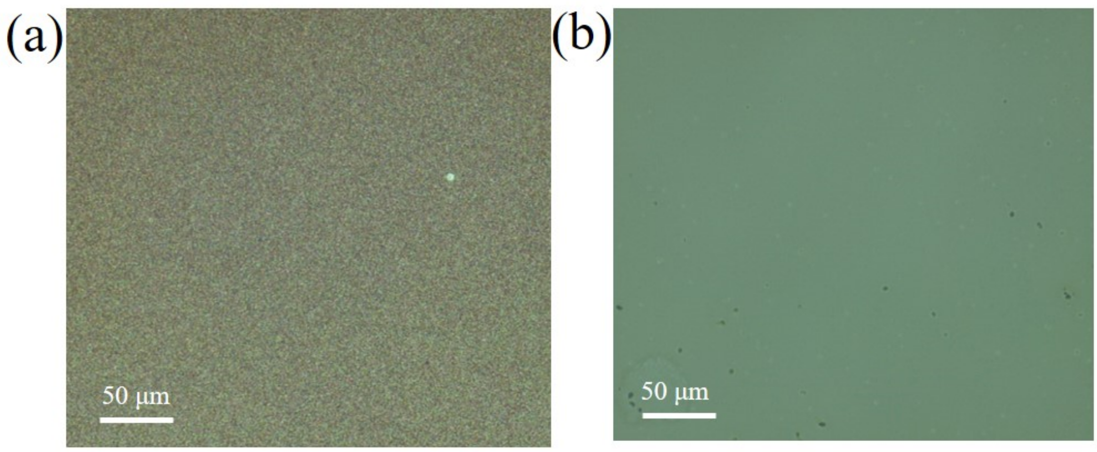

Figure S1. Optical microscopy images (a) PbI_2 and (b) 5-SSA/PbI_2 films.

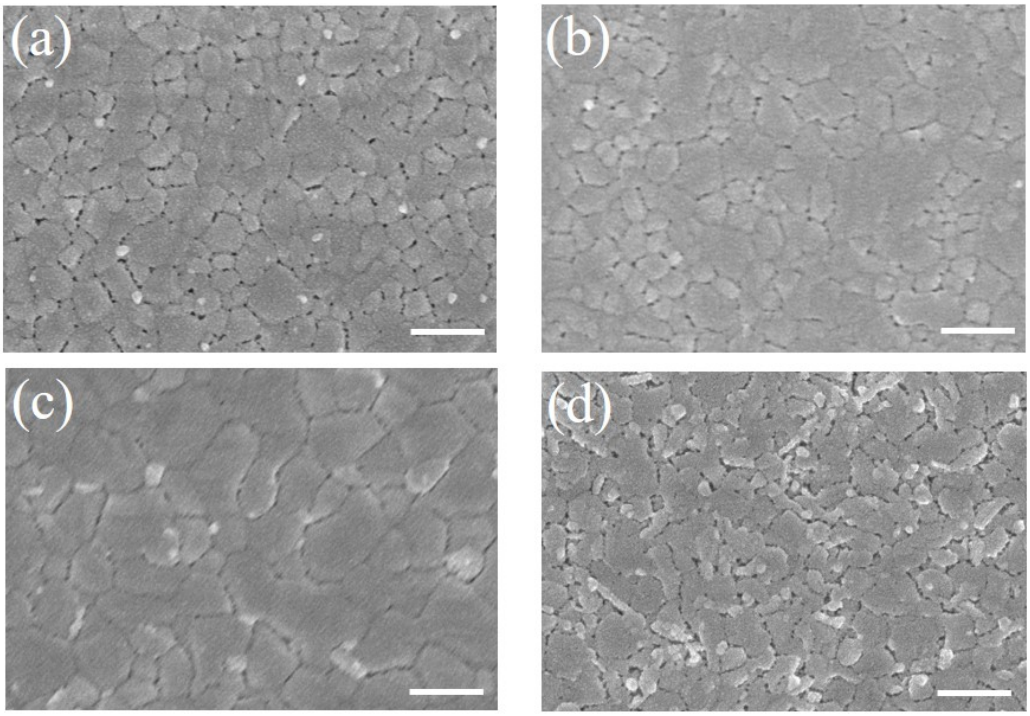

Figure S2. Top-view SEM images of $MAPbI_3$ films with 0 mol% a), 1.0 mol% b), 2.5 mol% c) and 5.0 mol% d) of 5-SSA.

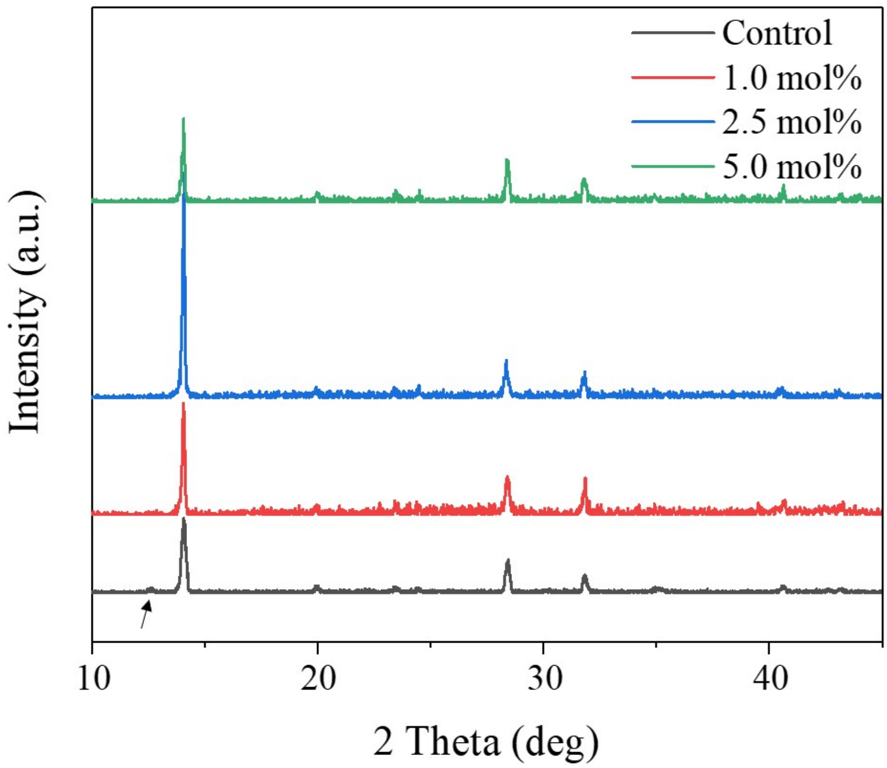

Figure S3. XRD patterns of $MAPbI_3$ films with different amount of 5-SSA.

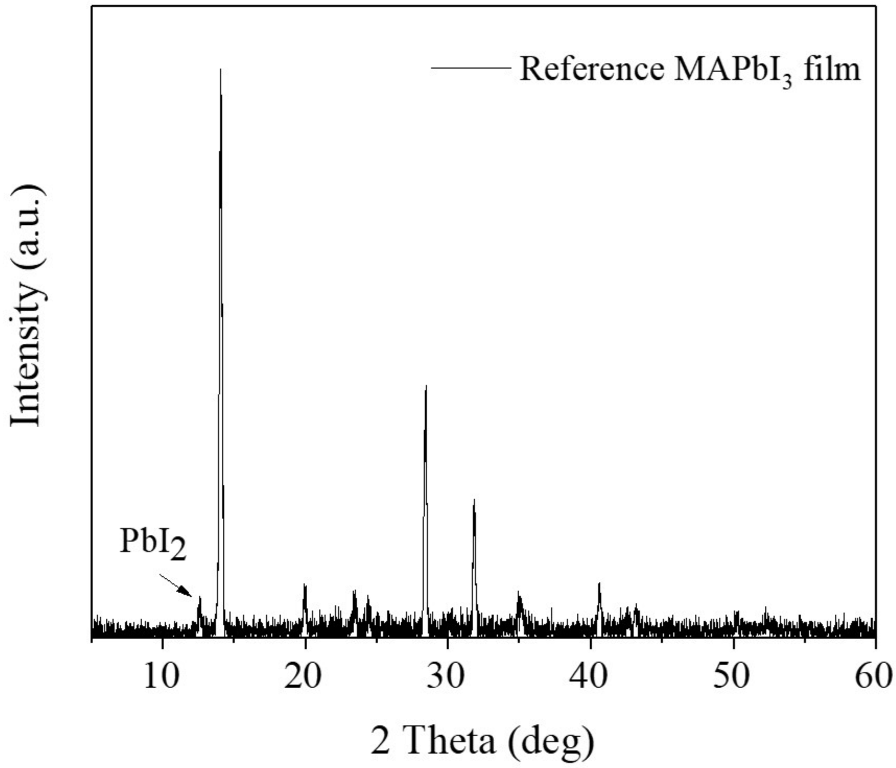

Figure S4. XRD pattern of a reference $MAPbI_3$ film.

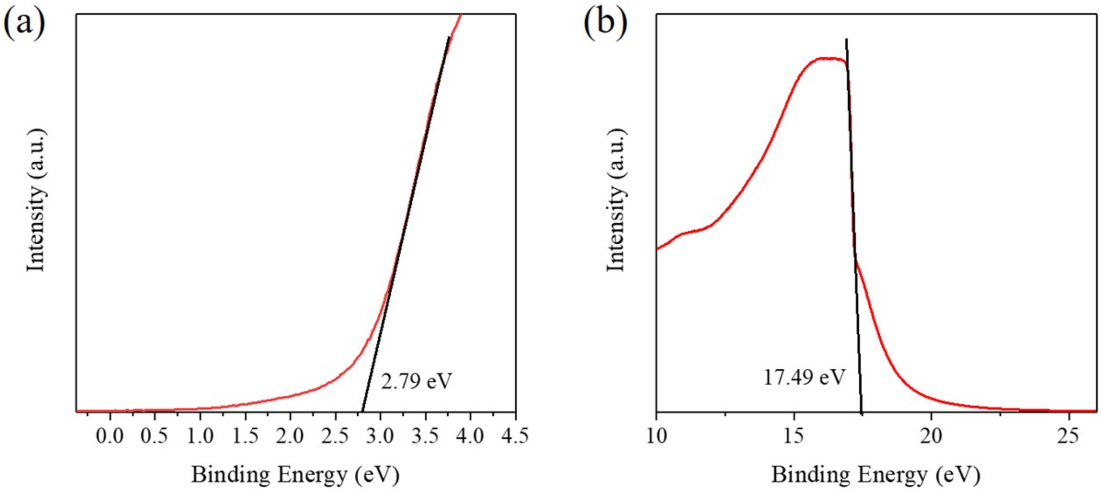

Figure S5. a) Near EF region and b) cutoff region of the UPS spectra of 5-SSA/PbI_2 film.

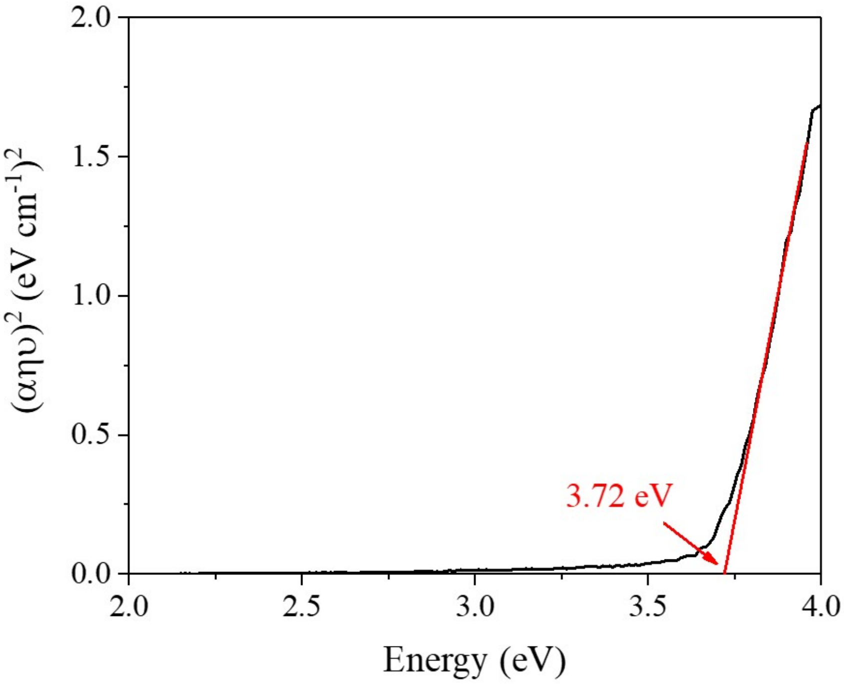

Figure S6. The Tauc plot of 5-SSA/PbI_2 film.

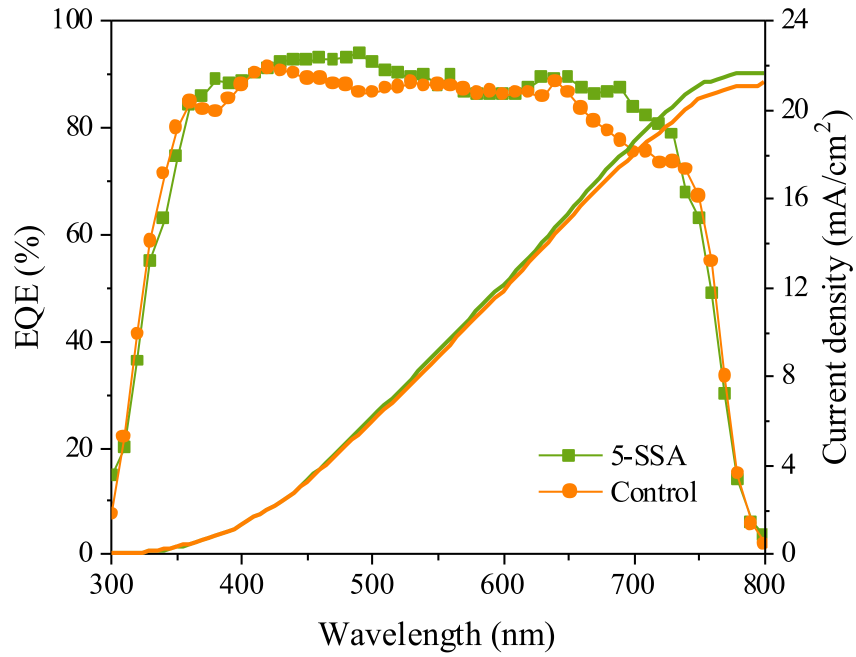

Figure S7. The EQE spectra of champion solar cells.

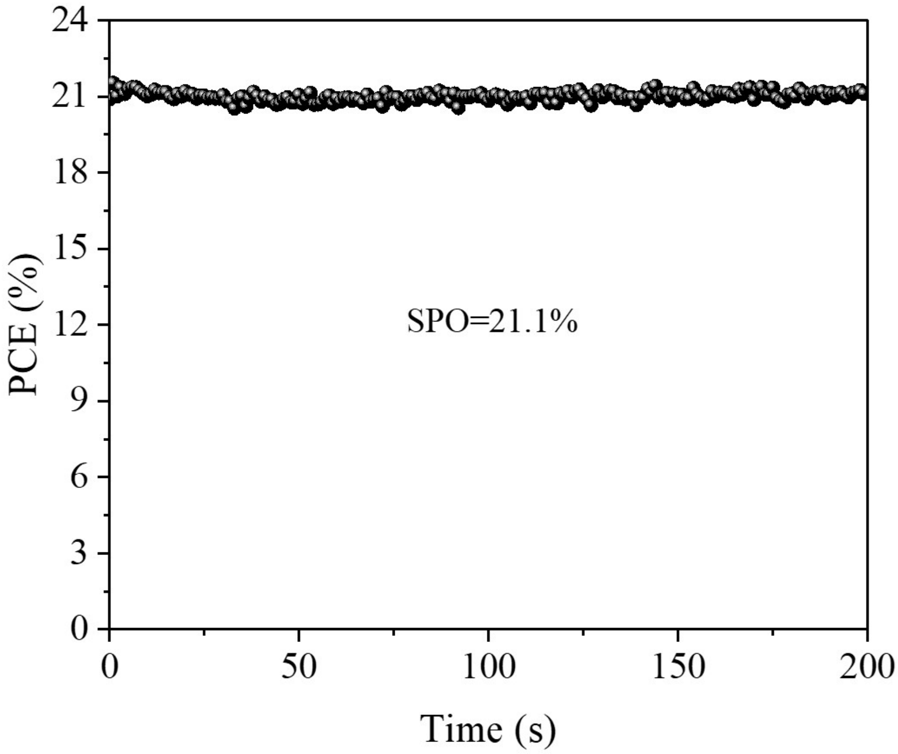

Figure S8. The stable power output of a PSC with the 5-SSA/PbI_2 amorphous passivation layer.

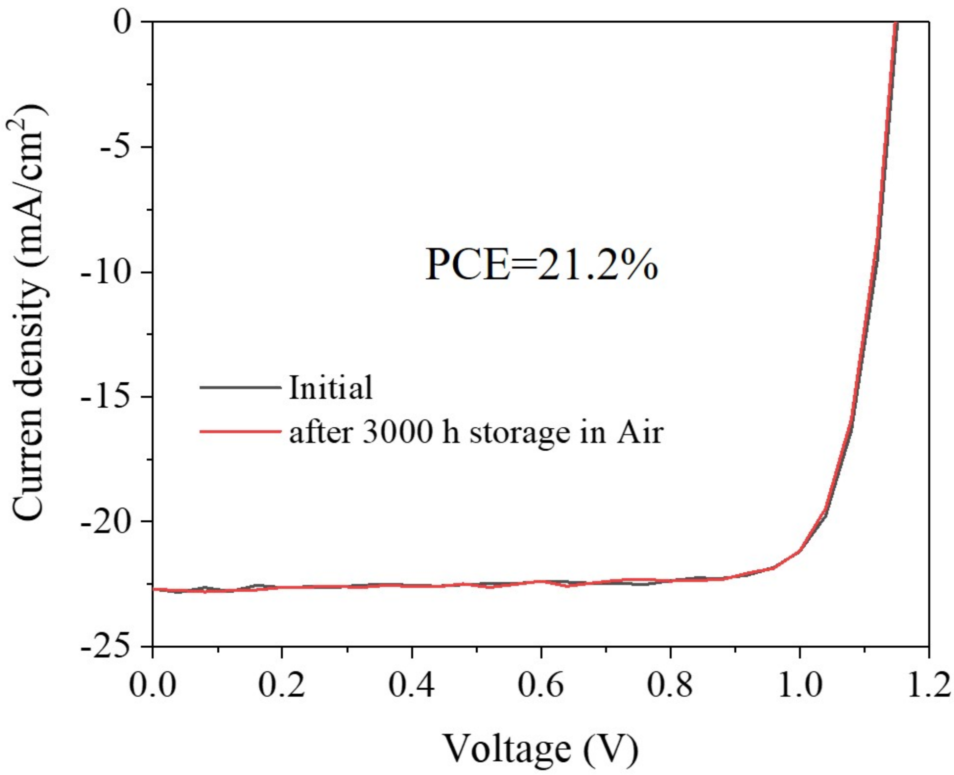

Figure S9. The J-V curves of a PSC before and after 3000 hours storage in dark air with 20% humidity.