Supporting Information

Ultrasensitive Photodetectors Based on Island-Structured $CH_3NH_3PbI_3$ Thin Films

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Materials and Methods:

CH_3NH_3I was synthesized by mixing 33 wt% methylamine (purchased from Sigma-Aldrich) in ethanol and 57 wt% hydroiodic acid (purchased from Acros) in water, in an ice bath for 2 h with stirring. After removing the solvent by rotary evaporator, the obtained solids were washed with ethyl acetate for several times. Similarly, CH_3NH_3Cl was synthesized by reacting 33 wt% methylamine and 33 wt% hydrochloric acid in an ice bath for 2h with stirring followed by vacuum drying and cleaning with acetonitrile.

$CH_3NH_3PbI_3$ perovskite precursor solutions were synthesized by adding 1.5 mmol PbI2 (purchased from Sigma Aldrich), 1.5 mmol CH_3NH_3I and CH_3NH_3Cl in N,N-Dimethylformamide (DMF), followed by a gentle sonication until a homogeneous solution was formed. For the islands -structured CH3NH3PbI3 films, 0.75 mmol CH_3NH_3Cl was used. For the compact film, 1.5 mmol CH_3NH_3Cl was used. Note that the amount of CH_3NH_3Cl used is essential to the resulted thin-film morphology. (J. Phy. Chem. C 2014, 118 (18), 9412-9418) Si/SiO2 substrates were cleaned by ultra-sonication in acetone, isopropanol and ultrapure water for 30 min respectively followed by N2 drying, and then treated by plasma cleaning for 5 min (Plasma Cleaner PDC-32G).

The photodetector devices were fabricated by spin-coating the precursor solutions onto the cleaned substrates at 2500 rpm for 30 s, followed by thermal annealing at 100 ºC for 25 min. During the fabrication process, the color of the $CH_3NH_3PbI_3$ perovskite film changed from light yellow to black after thermal annealing, indicating that the ABO_3 structure was gradually formed at high temperature during the evaporation of the DMF solvent. 80 nm gold electrodes were deposited by thermal evaporation. A shadow mask with channel width of 600μm and channel length of 200μm was used to pattern electrode pads on the film. To protect the device from the moisture in air, PMMA thin films were spin-coated onto the surface of devices used for electrical measurement. All device fabrications were performed in a glove box filled with Ar. The Electrical characterizations were performed using a Keithley 4200 Semiconductor Characterization System connected to a vacuum probe station.

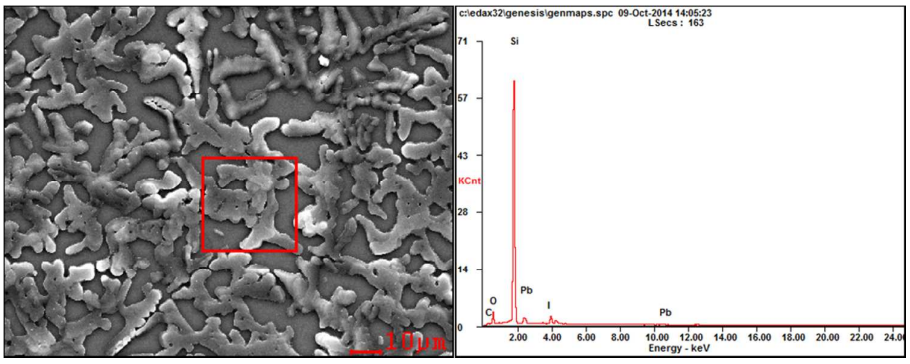

Figure S1. Energy Dispersive Analysis System of X ray (EDX) result of perovskite thin film.

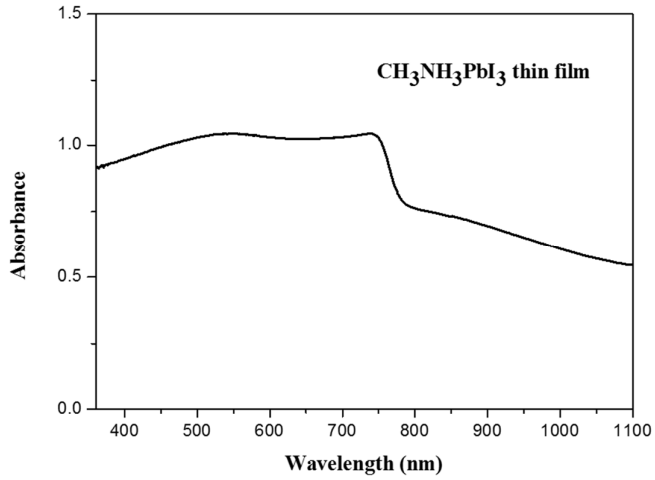

Figure S2. UV-Visible absorbance spectrum of hybrid perovskite thin film.

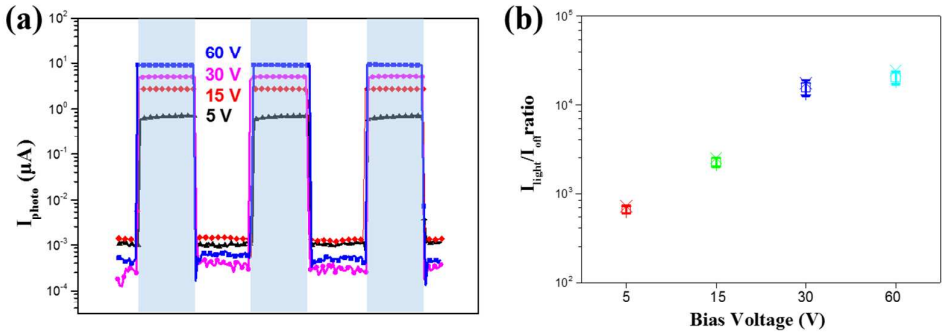

Figure S3. (a) Transient photoresponse properties with bias voltage of 5, 15, 30 and 60 V by log scale. (b) The dependency of light photocurrent to dark ratio on bias voltage. The light power density is 6.58 mW/cm^2.

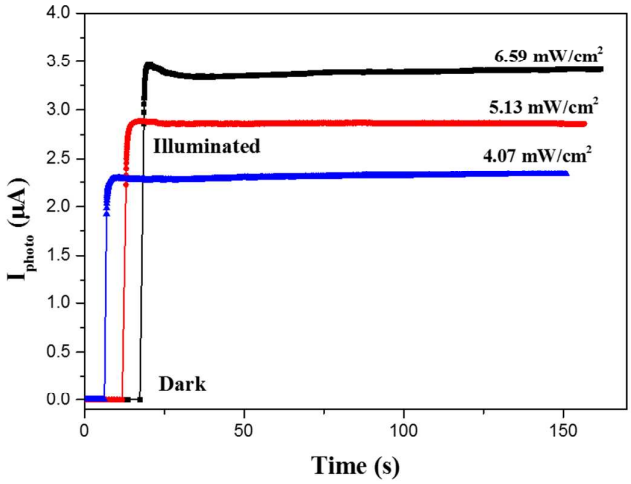

Figure S4. Working stability test of perovskite photodetector at 6.59, 5.13 and 4.07 mW/cm^2 power density, respectively.

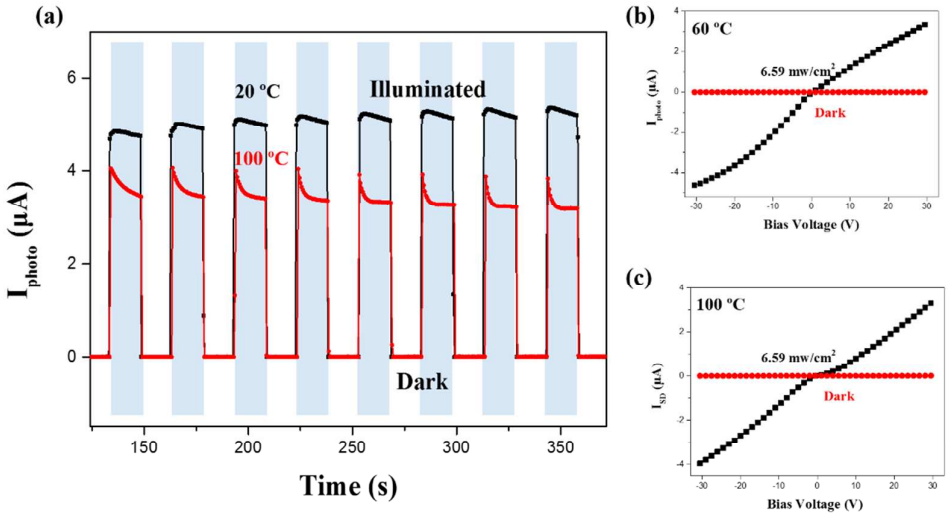

Figure S5. Transient photoresponse (a) and I-V character (b) and (c) of $CH_3NH_3PbI_3$ perovskite photodetector at various temperature.

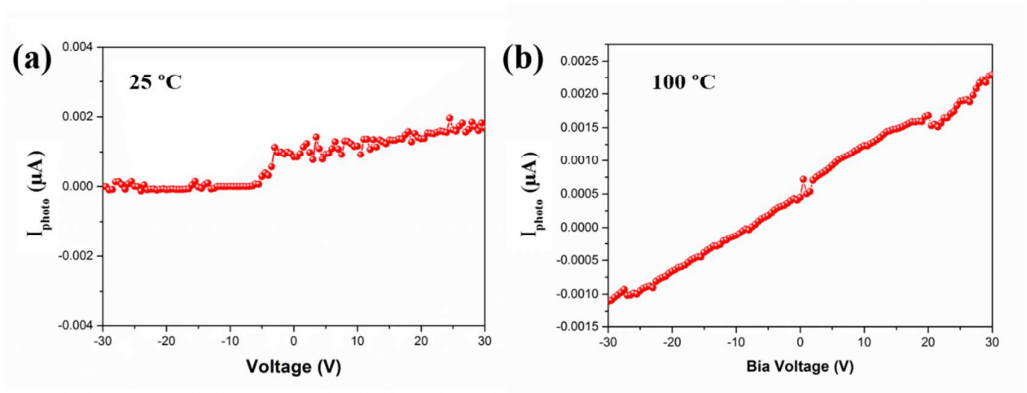

Figure S6. The dark I-V curve of island-structured $CH_3NH_3PbI_3$ photodetector at (a) room and (b) high temperature.