Supporting Information

Ionic Liquid enables High-Performance, Self-Powered $CsPbBr_3$ Perovskite Nanonet Photodetector

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Experimental section

(1) Materials

Tin dioxide (15% (wt%)) is purchased from Alfa Aeser, polyvinyl pyrrolidone (PVP), 2,2 '- azodiisobutyronitrile (AIBN) (99%), styrene (>99.5%), sodium dodecyl sulfate (>99%), dimethyl sulfoxide (>99.9%), cesium bromide (99.999%), lead bromide (99.99%), 1-butyl-3-methylimidazole bromide (>97%), and chlorobenzene (99%) are all purchased from Aladdin.

(2) Substrate treatment

The patterned ITO glass substrate in an orderly manner on a cleaning rack, and place it in a 250 mL beaker. Add washing solution, deionized water, acetone, and anhydrous ethanol in sequence and ultrasonically clean for 30 min to make the substrate surface as smooth as a mirror. After cleaning, put it in a 60℃ oven to remove the ethanol on the substrate surface. Then, place the substrate in a UV ozone cleaner for 30 min to improve the adhesion of the substrate surface.

(3) Preparation of SnO_2 electron transport layer

Place the treated ITO substrate onto the spin coater, and 150 μL of SnO_2 solution is added to the substrate surface, and spin-coated at 3000 rpm for 30 s. Then, the substrate is put onto a hot plate at 150℃ for approximately 30 min.

(4) Preparation of monolayer PS microspheres

Drop 100 μL of ethanol dispersion containing PS microspheres into a beaker filled with deionized water. After the PS microspheres are evenly dispersed on the surface of the water, drop 1 mL of SDS solution from the edge of the beaker to form a dense monolayer of PS microspheres on the water surface. Insert the ITO substrate below the liquid surface and slowly lift it up to obtain a monolayer of PS microspheres. Use a piece of absorbent paper to remove the water at the edge, so that the PS microspheres can evenly attach to the substrate surface. Then place the substrate on a heating plate at 60℃ for 1 hour for annealing.

(5) Preparation of $CsPbBr_3$ nanonet film

To investigate the effect of BMIMBr ionic liquid on the $CsPbBr_3$ perovskite PD, different concentrations of BMIMBr ionic liquid is added to the precursor solution to determine the optimal concentration. The specific experimental steps are as follows:

Dissolve various concentrations (0, 0.5, 1, 2, and 5 mg) of BMIMBr ionic liquid, 0.1064 g cesium bromide (99.999%), and 0.1835 g lead bromide (99.99%) in 1 mL of DMSO (99.9%) to form $CsPbBr_3$ solutions. After 12 hours of standing to ensure complete dissolution, the $CsPbBr_3$ solution is filtered through a filter head. Then, 80 μL of the $CsPbBr_3$ solution is evenly dropped onto the substrate, and the spin coater is set to 1500 rpm for 40 s. After that, the substrate is transferred to a heating plate and annealed for 30 min. Finally, the prepared $CsPbBr_3$ thin film is immersed in a glass bottle filled with chlorobenzene for 1 min to remove the PS spheres, and then placed on a heating plate at 100 °C for 30 min to remove residual chlorobenzene.

(6) Fabrication of carbon electrode

A layer of carbon paste is scraped on the surface of the $CsPbBr_3$ film and annealed at 120 ℃ for 20 min to to obtain the $CsPbBr_3$ nanonet PD in this experiment.

(7) Characterization and measurement of devices

The field emission scanning electron microscope (FESEM, JEOL, JSM-6700F) is used to characterize the SEM images of the $CsPbBr_3$ nanonet film. X-ray diffraction (XRD, D8 FOCUS X-ray diffraction) is used to characterize the XRD patterns of the film. The UV-Vis-NIR spectrophotometer was used to measure the absorption spectrum of the film. Keithley 2400 source meter is used to measure the I-V and I-t curves of the PD, and the oscilloscope is used to measure the response time of the device. A 405 nm laser is used as the light source, and its intensity was calibrated by a standard silicon photodiode. The PL spectra of the nanonet film are measured using FluoTime 300 (PicoQuant GmbH).

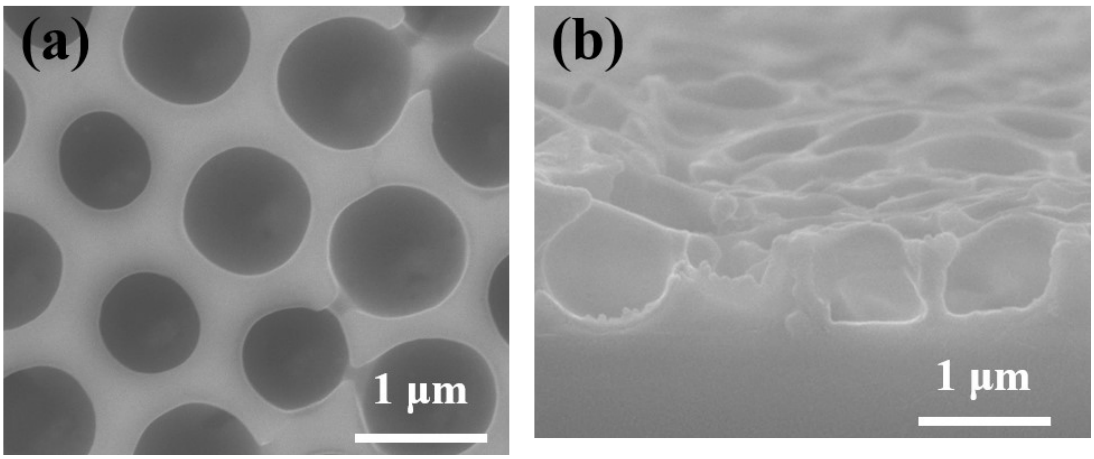

Figure S1 Top (a) and cross-sectional (b) SEM image of the $CsPbBr_3$ perovskite nanonet film without BMIMBr ionic liquid.

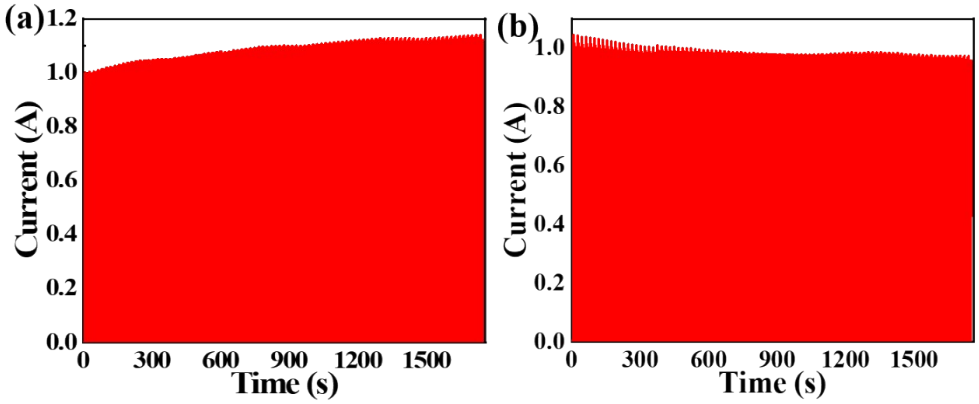

Figure S2 The I-t curve of the $CsPbBr_3$ PD under 2 mW/cm^2 light: (a) without and with BMIMBr ionic liquid.

Table S1. Performance comparison of reported perovskite based-PDs.

Device structure	Responsivity (A/W)	Detectivity (Jones)	τ_{rise} /τ_{fall} (ms)	LDR	Ref.
SnO_2/$Cs_2AgBiBr_6$/ Carbon	7.5×10^{-2}	1.87×10^{12}	0.24/0.29	-	1

ITO/SnO_2/$MAPbI_3$/Spiro-OMeTAD)/MoO_3/Cu	0.48	2.7×10^{13}	0.054/0.011	-	2
ZnO/$MAPbI_3$	0.003	1.3×10^{11}	0.006/0.414	-	3
NiO/MAPbI3/PMMA/PCBM/ZnO/BCP/Al	0.47	1.07×10^{12}	0.05/0.017	127	4
Au/$CsPbBr_3$(PMMA)/ITO	3.7	-	6.6/11.3	-	5
Au/ $CsPbBr_3$ single crystal/Au	0.028	10^{11}	<100	-	6
Au/ $CsPbBr_3$/Au	55	0.9×10^{13}	0.43/0.318	-	7
ITO/SnO_2/$CsPbBr_3$ nanonet film/Carbon	0.19	4.31×10^{12}	0.06/0.26	140	This work

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