Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Supporting Information

$(CH_3)_2C=NHCH_3PbBr_3/CH_3NH_3PbBr_3$ Core-Shell Heterostructure Fabricated by In-Situ A-Site Reaction for Fast Response 1D Perovskite Photodetectors

Wei Wang, Jie Zhao, Lin Jiang, Shaochao Liu, Li Wang**

School of Physics and Materials Science, Nanchang University, Nanchang 330031, P.R. China

E-mail: ncu915@outlook.com (J.Z.); wl@ncu.edu.cn (L.W.)

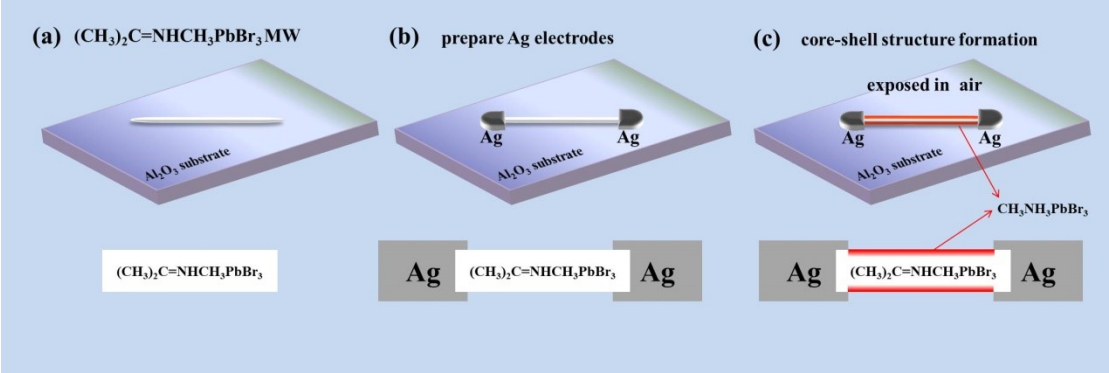

Figure S1 The schematic diagram of the fabrication of $(CH_3)_2C=NHCH_3PbBr_3$/ $CH_3NH_3PbBr_3$ core-shell device.

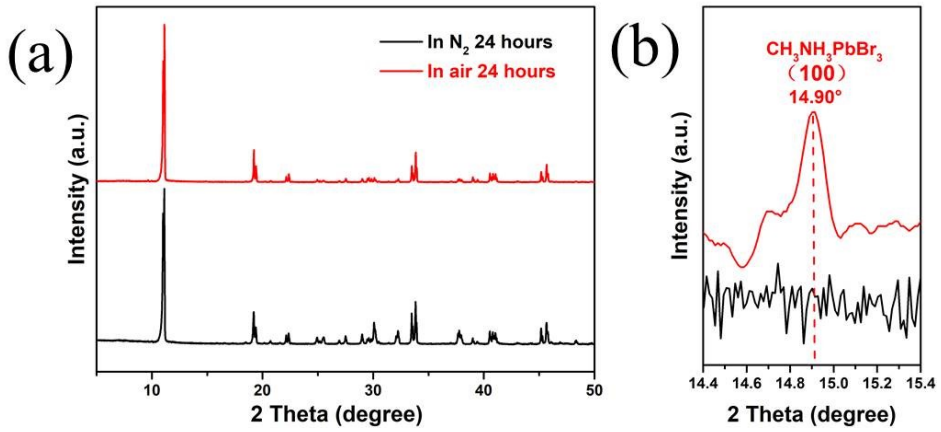

Figure S2. The XRD patterns of MWs in air and N_2 with 1 atm, right is the enlargement from 14.4° to 15.4°.

In order to study the effect of water on the reverse transition, we put the fresh $(CH_3)_2C=NHCH_3PbBr_3$ microwires in a vacuum device, evacuated first and then ventilate with nitrogen (1 atm), and store it for 24 hours. For comparison, some fresh microwires were exposed in air (relative humidity >80%) for 24h. The XRD results are shown in **Figure 10**, after 24 hours, the latter shows weak diffraction peaks at 14.9 corresponding to the (100) lattice planes of the $CH_3NH_3PbBr_3$ cubic structure, but the former without $CH_3NH_3PbBr_3$ perovskite signal peaks. This proves that water molecules played an important role in the reversible phase transition of $(CH_3)_2C=NHCH_3PbBr_3$ to $CH_3NH_3PbBr_3$.

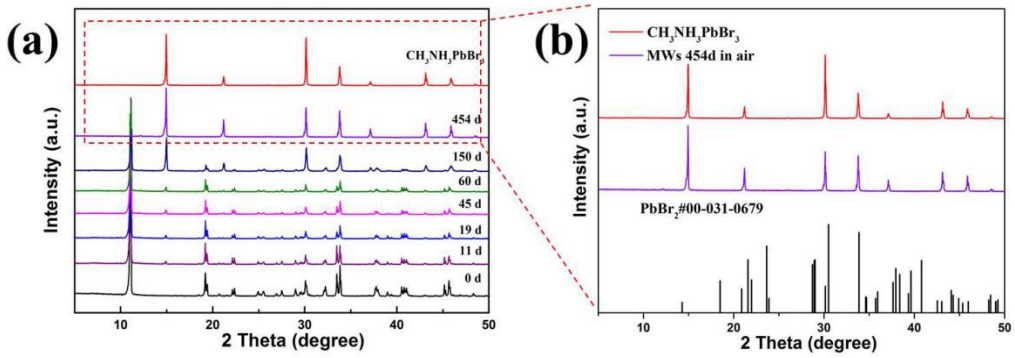

Figure S3. (a) The XRD pattern during core-shell MWs evolution. (b) XRD patterns of core-shell MWs stored after 454 days, $CH_3NH_3PbBr_3$ powder, and the $PbBr_2$ reference pattern #00-031-0679 (black bars).

The phase transition rate from $(CH_3)_2C{=}NHCH_3PbBr_3$ to $CH_3NH_3PbBr_3$ is very slow. The microwires cannot completely transform back to the $CH_3NH_3PbBr_3$ phase, even if they are exposed in the air after 150 days. The reversed $CH_3NH_3PbBr_3$ shell exhibits strong water stability over 454 days aging [1].

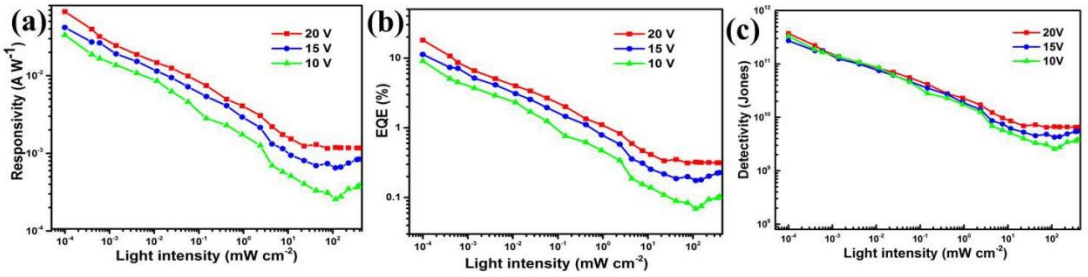

Figure S4. (a) Responsivity (*R*), (b) external quantum efficiency (*EQE*) and detectivity (*D**) of the photodetectors. The wavelength of the light source is 460 nm, the illumination intensity is from 1×10^{-4} to 389 mW cm^{-2}, and the bias voltage is 10V, 15 V and 20 V.

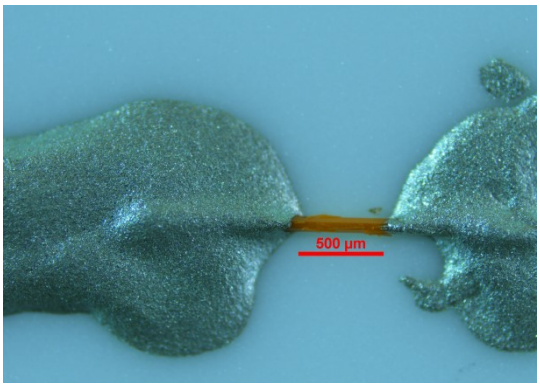

Figure S5. The optical microscopy image of single core-shell photodetector.

Table S1. Comparison of the key performance parameter for 1D $CH_3NH_3PbBr_3$ perovskite photodetectors reported in literature and the present measurements

Year	Device structure	Responsivity (mA/W) @V bias/ light intensity	Detectivity (Jonse) @V bias	EQE (%) /Gain	On/off ratio / light intensity	Response Speed(ms) (rise/decay)	Ref
2015	Au/ $CH_3NH_3PbBr_3$ NW @TiO_2@P_3HT /Au	-	-	-	61.9/ 27.5 mW cm^{-2}	120/86	[2]
2018	InGa/$CH_3NH_3PbBr_3$MW/InGa	525@ 2V/-	-	-	-	407/895	[1]
2019	Au/ $CH_3NH_3PbBr_3$ NW/Au	2100@2V/-	1.2×10^{12}	-	5×10^3/ 83.3 mW cm^{-2}	900/200	[3]
2019	Au/ $CH_3NH_3PbBr_3$NP@Si NW/Au	223@2V/50 mW cm^{-2}	7.2×10^{10}	-	-	320/280	[4]
	Ag/$(CH_3)_2C$=$NHCH_3PbBr_3$-	66.8@20V/	3.7×10^{11}	18.0	3428/	2.8/0.8	Our

	$CH_3NH_3PbBr_3$ NW/Ag	0.1uW cm^{-2}			76.1 mW cm^{-2}		work

NWs = Nanowires; NPs = Nanoplatelets; '-' = Not Given

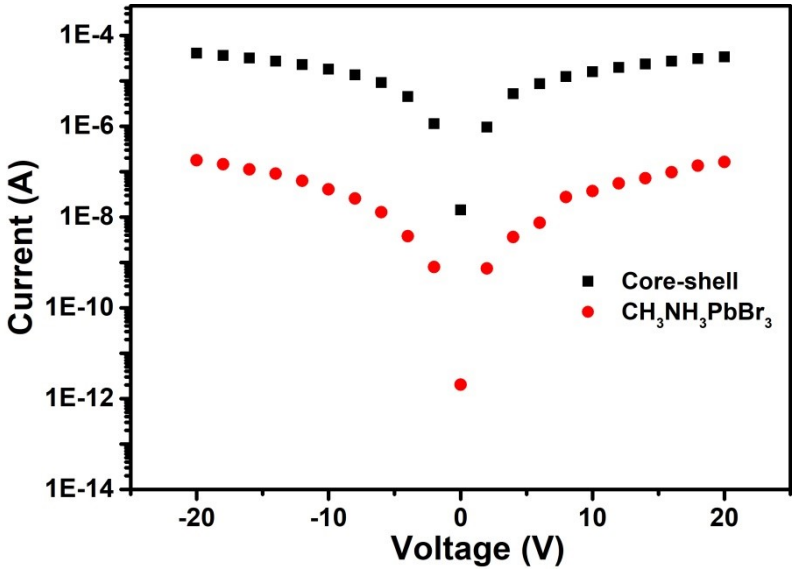

Figure S6. The I-V of the core-shell MW and $CH_3NH_3PbBr_3$ MW based photodetector device measured under 460 nm wavelength illumination, 20V bias.

Supplementary Notes

Calculation of figures of merit of $(CH_3)_2C{=}NHCH_3PbBr_3/CH_3NH_3PbBr_3$ hetero-structured microwire photodetectors (HMPs)

To evaluate photoresponse characteristics, several parameters need to be determined. Althoughcertain applications require different features, the key figure-of-merit parameters in photodetectors are the responsivity (R), external quantum efficiency (EQE) and specific detectivity (D^*).

The R is defined as the ratio of photocurrent to the incident-light intensity, which calculated using the following formula [5]:

$$R = \frac{\triangle I}{PS}$$

where $\triangle I$ is the difference between the light current and dark current ($\triangle I = I_{on} - I_{off}$), P is the irradiance power density, and S is the effective illuminated area.

The EQE indicates the photon-electron conversion effciency and is calculated as following [6]:

$$EQE = R\frac{hc}{\lambda q}$$

where R is the responsivity, h the Planck constant, c the velocity of light, q the elementary charge, and λ the wavelength of incident light.

The D^*, the minimum signal that can be detected of the photodetector. If considering that the noise current is dominated by shot noise in the dark current, D^* can be simply expressed as:

$$D^* = R/(2eI_d)^{1/2}$$

where e is the absolute value of electron charge (1.6×10^{-19} Coulomb), and I_d the dark current density

Supplementary References:

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