Supporting Information

Template growth of perovskites on yarn fibers leading by capillarity for flexible photoelectric applications

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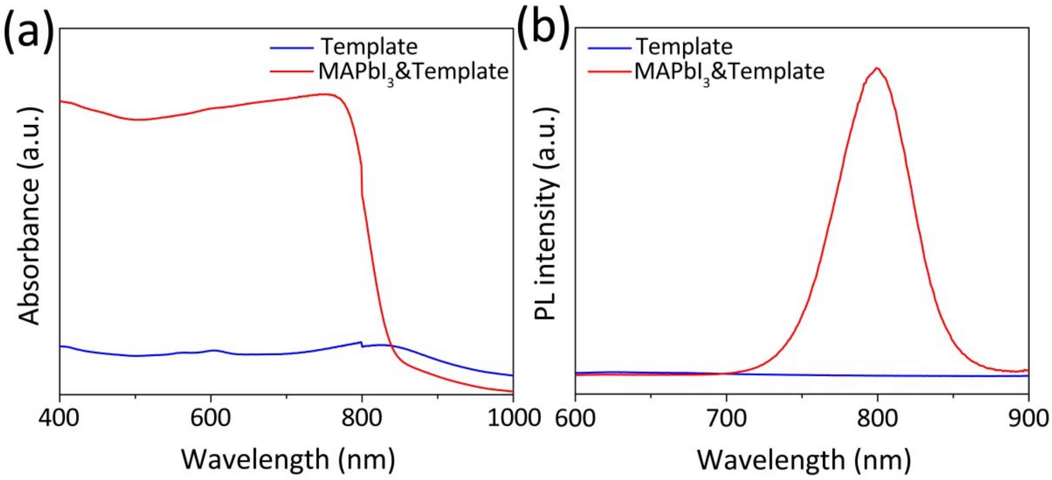

Fig. S1 UV-vis absorption spectra (a) and PL spectra (b) of template with and without $MAPbI_3$ crystals.

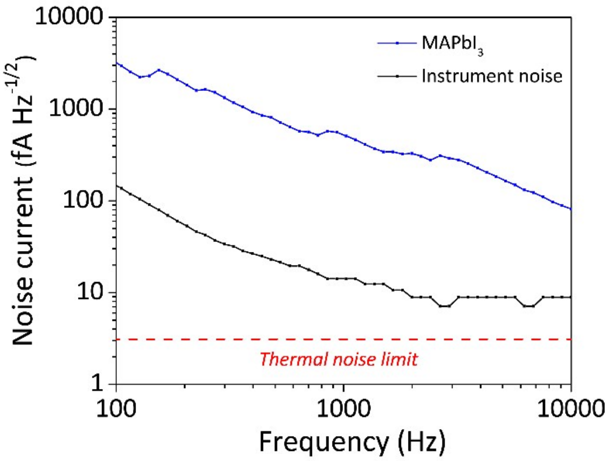

Fig.S2 Noise current spectra of photodetector as well as the instrument noise and thermal noise limit calculated based on the J–V curves under dark.

As shown in Fig.S2, the measured noise current of our detector is obviously larger than the instrument noise current, confirming the measured noise is mainly from the device. The thermal noise ($i_{n,t}$) and shot noise ($i_{n,s}$) of the device are calculated using the following equations:[S1]

$$i_{n,t} = \sqrt{\frac{4k_B TB}{R}}$$

$$i_{n,s} = \sqrt{2eI_d B}$$

where k_B is the Boltzmann constant, T is the temperature, e is the elementary charge, I_d is the dark current, B is bandwidth of the equipment, and R is the resistance of the device. The measurement was performed at room temperature, the bandwidth is 0.833 Hz, and the resistance of the device was calculated based on the J–V curves under dark condition. Here, the calculated thermal noise and shot noise are 3.1 fA $Hz^{1/2}$ and 31.8 fA $Hz^{1/2}$, respectively.

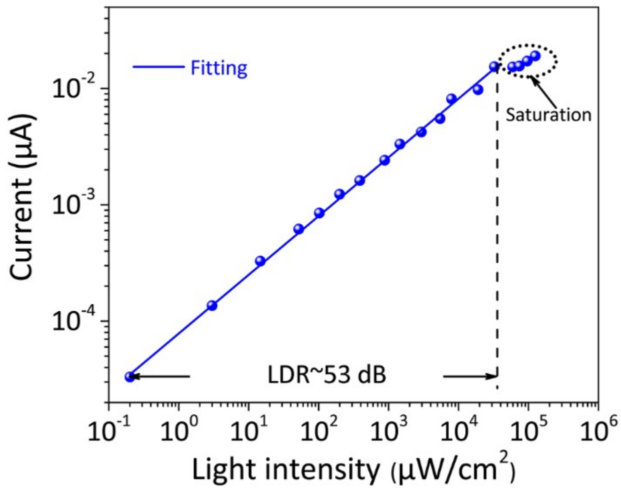

Fig.S3 Photocurrent of $MAPbI_3$-based photodetector under white-light illumination with various light intensities at a bias voltage of 0.5 V. The solid line is a linear fitting to the data.

We investigated the IV curves of the detector under different light illumination from 0.2 μW/cm^2 to 125 mW/cm^2. The linear dynamic range (LDR) is commonly expressed in a logarithmic scale as

$$LDR = 20\ log\frac{J_{upper} - J_d}{J_{lower} - J_d}$$

where J_{upper} and J_{lower} are the current values at which the response of the device deviates from linearity and the lower resolution limit, respectively.[S1]

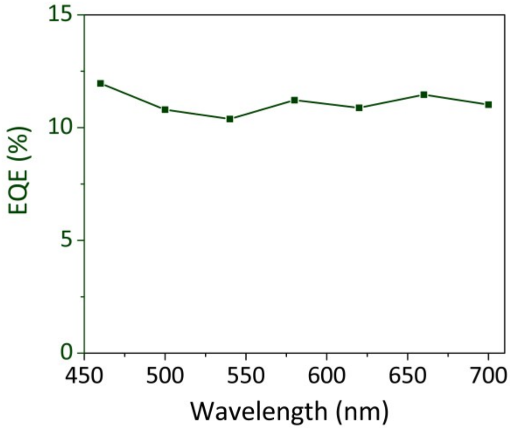

Fig. S4 Calculated EQE value of the photodetector under illumination from 460 nm to 700 nm at bias voltage of 5 V (120 μW/cm^2).

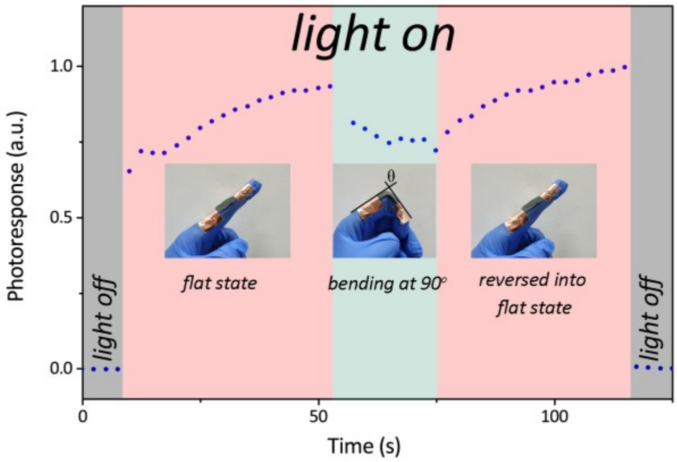

Fig. S5 Photo-response performance of the device which was measured in cycle of flat state and bending state.

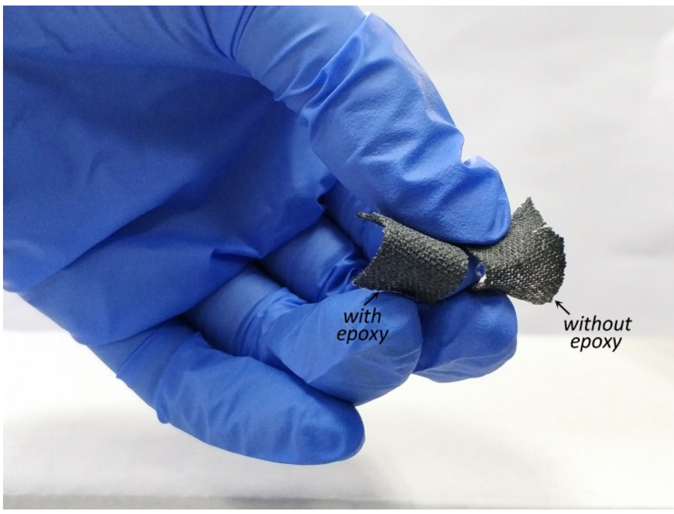

Fig.S6 Photograph of $MAPbI_3$ crystals / knitted fibrous yarn bundles hybrid structure with and without epoxy resin.

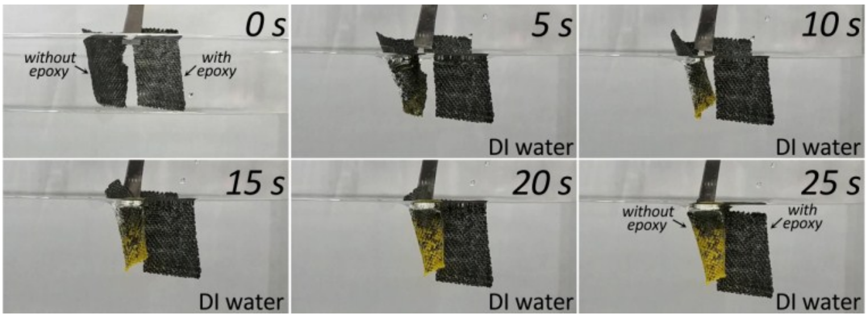

Fig. S7 Photographs taken from samples ($MAPbI_3$ crystals on knitted fibrous yarn bundles) with and without epoxy immersing into the distilled water for 0 s to 25 s.

Table S1. The performance comparison of flexible perovskite photodetectors

Device	Irradiance	ON/OFF ratio	Photoresponsivity (mA/W)	Detectivity (Jones)	t_{rise}/t_{decay} (ms)	Ref.
$MAPbI_3$ "quasi-spring" network/yarn bundles/Ag	**10 μW/cm^2**	**4.5×10^4**	**137.2**	**2.2×10^{11}**	**~4/10**	**This work**
$MAPbI_3$ film/PDPP3T/PET	500 μW/cm^2	-	150	3.2×10^9	10/10	[S2]
$MAPbI_3$ NWs/PET/Au	-	~250	15	3.5×10^{11}	12/22	[S3]
$MAPbI_3$ NWs/PET	1 mW/cm^2	-	-	-	120/210	[S4]
$MAPbI_3$ film/Spiro-OMeTAD/ TiO_2/carbon cloth	-	2.2×10^3	-	-	<200	[S5]
$MAPbI_3$/ZnO/mica	4.23 mW/cm^2	-	-	-	<400	[S6]
Al/PCBM/$MAPbI_3$/PEDOT:PSS/Au/PEN	-	-	314	-	~400	[S7]
$MAPbI_3$ MWs/PEN	50 μW/cm^2	2×10^4	-	2.5×10^{12}	50/50	[S8]

Reference

[S1]. Huan Wang and Dong Ha Kim, Perovskite-based photodetectors: materials and devices, Chem. Soc. Rev., 2017, 46, 5204-5236.

[S2]. Shan Chen, Changjiu Teng, Miao Zhang, Yingru Li, Dan Xie, Gaoquan Shi, A Flexible UV-Vis-NIR Photodetector based on a Perovskite/Conjugated-Polymer Composite. *Adv. Mater.* 2016, **28**, 5969–5974.

[S3]. Dingjun Wu, Hai Zhou, Zehao Song, Ronghuan Liu, Hao Wang, The effect of N,N-dimethylformamide on $MAPbI_3$ nanowires for application in flexible photodetectors. *J. Mater. Chem. C*, 2018, **6**, 8628-8637.

[S4]. Pengchen Zhu, Shuai Gu, Xinpeng Shen, Ning Xu, Yingling Tan, Shendong Zhuang, Yu Deng, Zhenda Lu, Zhenlin Wang, Jia Zhu, Direct Conversion of Perovskite Thin Films into Nanowires with Kinetic Control for Flexible Optoelectronic Devices. *Nano Lett.* 2016, **16**, 871–876.

[S5]. Haoxuan Sun, Tianyu Lei, Wei Tian, Fengren Cao, Jie Xiong, Liang Li, Self-Powered, Flexible, and Solution-Processable Perovskite Photodetector Based on Low-Cost Carbon Cloth. *small* 2017, **13**, 1701042.

[S6]. Ting Gao, Qi Zhang, Junnian Chen, Xing Xiong, Tianyou Zhai, Performance-Enhancing Broadband and Flexible Photodetectors Based on Perovskite/ZnO-Nanowire Hybrid Structures. *Adv. Optical Mater.* 2017, **5**, 1700206.
[S7]. Chunxiong Bao, Weidong Zhu, Jie Yang, Faming Li, Shuai Gu, Yangrunqian Wang, Tao Yu, Jia Zhu, Yong Zhou, Zhigang Zou, Highly-Flexible Self-Powered Organolead Trihalide Perovskite Photodetectors with Gold Nanowire Networks as Transparent Electrodes. *ACS Appl. Mater. Interfaces*, 2016, **8 (36)**, 23868-23875.
[S8]. Yantao Chen, Junyao Zhang, Jiachen Zhou, Yingli Chu, Bilei Zhou, Xiaohan Wu, Jia Huang, Long-Term Stable and Tunable High-Performance Photodetectors Based on Perovskite Microwires. *Adv. Optical Mater*. 2018, **6**, 1800469.