

Supporting Information for  
Acetone vapor-assisted growth of 2D single-crystalline organic  
lead halide perovskite microplates and their temperature-  
enhanced photoluminescence

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### **Materials**

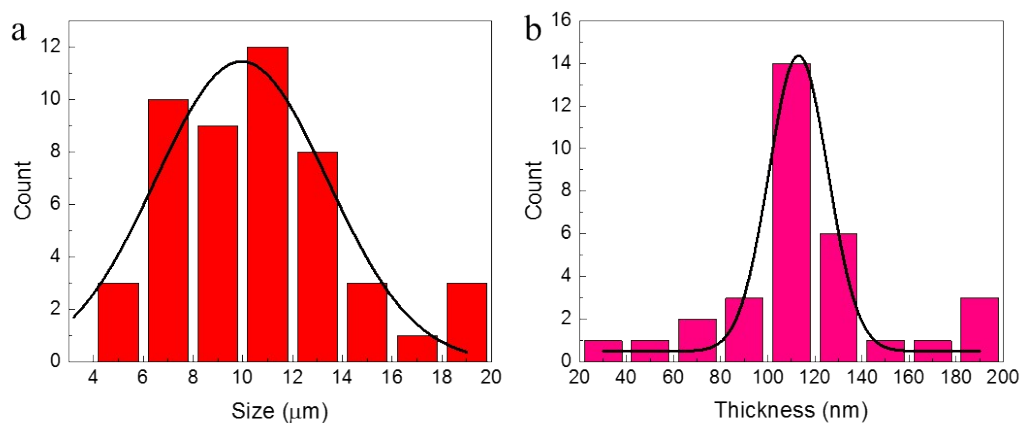
PEABr (99.5%) and PbBr<sub>2</sub> (99.99%) are purchased from Xi'an Polymer Light  
Technology Corporation. N, N-dimethylformamide (chromatographic grade) is  
purchased from Aladdin. Acetone (analytical grade) is purchased from Beijing Tong  
Guang Fine Chemicals Company. All reagents are used as received without further  
purification.

### **Characterizations**

Optical microscope images are obtained with a Zeiss Microscope (Axio  
Imager.A2m). Atomic force microscopy (AFM) is performed on Cypher S AFM  
(Asylum Research) in tapping mode. Scanning electron microscope (SEM) images are  
acquired on a high resolution field emission SEM (FEI NanoSEM 430) with an

accelerating voltage of 5 kV. Energy-dispersive X-ray spectroscopy (EDS) and EDS mapping are also performed on the SEM with an EDS detector operating at 15 kV. X-ray Diffraction (XRD) patterns are measured using X-ray diffraction platform (model PANalytical X'Pert Pro) with a Cu-K $\alpha$  radiation source ( $\lambda = 0.1541874$  nm) at 40 kV and 40 mA. The angle accuracy is within  $\pm 0.0025^\circ$ . Steady state photoluminescence (PL) spectroscopy is performed on an integrated Raman/PL system (Horiba JY HR800) with an Olympus 15X NUV lens excited by a 325 nm helium-cadmium (He-Cd) laser. Temperature dependent PL spectroscopy is also measured on the Raman/PL system in a liquid N<sub>2</sub> purged cryostage (Linkam THMS 600) with the temperature ranging from 78 to 298 K. Raman spectroscopy is obtained from the Raman/PL system with an Olympus 100X lens excited by a 473 nm laser.

### XRD patterns, SEM images, PL spectra and Raman spectroscopy

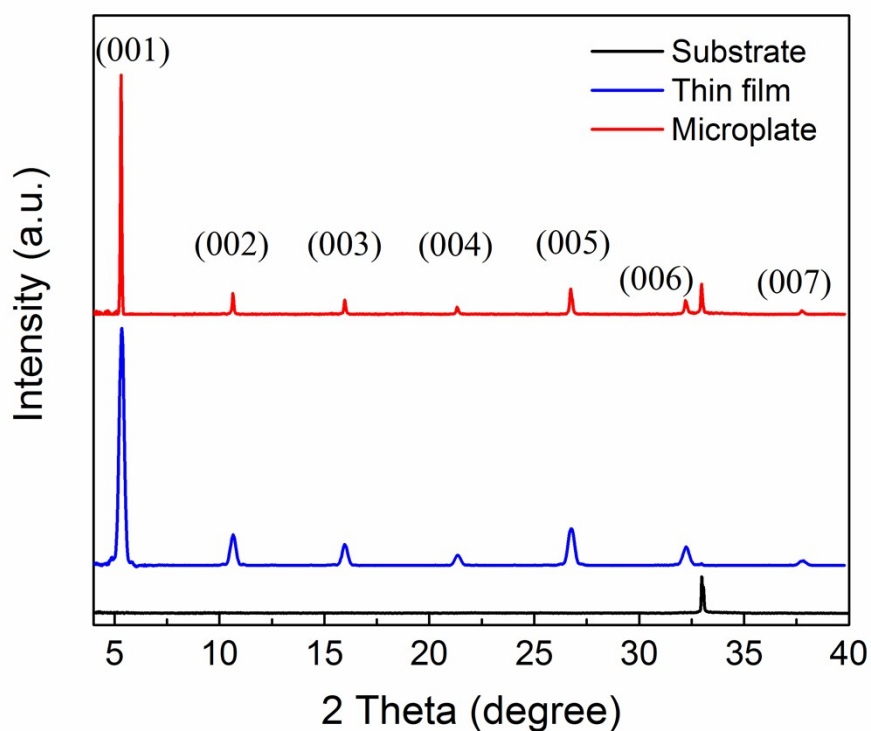


**Fig. S1** The statistical data of the sizes (a) and thicknesses (b) of 2D perovskite microplates.

The average size and thickness of the microplates are 11.4  $\mu\text{m}$  and 113 nm, respectively.

Indeed, the size distribution of the microplates is relatively broad, but mostly in the

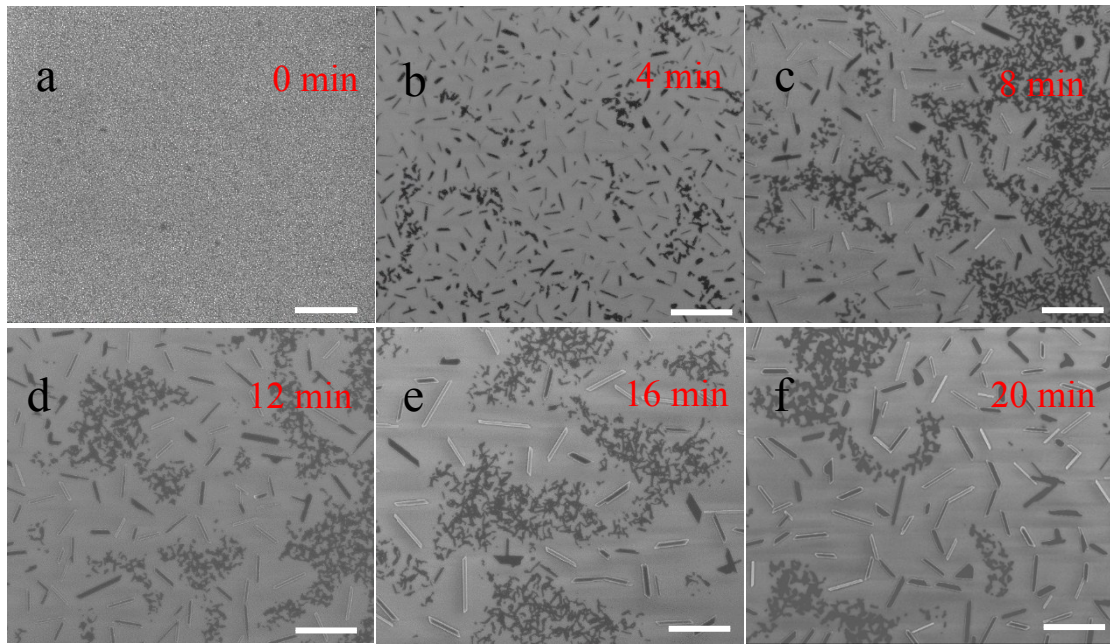
range of 7-15  $\mu\text{m}$ . As contrast, their thicknesses are quite uniform.



**Fig. S2** XRD patterns of the samples before (blue line) and after (red line) acetone vapor treatment.

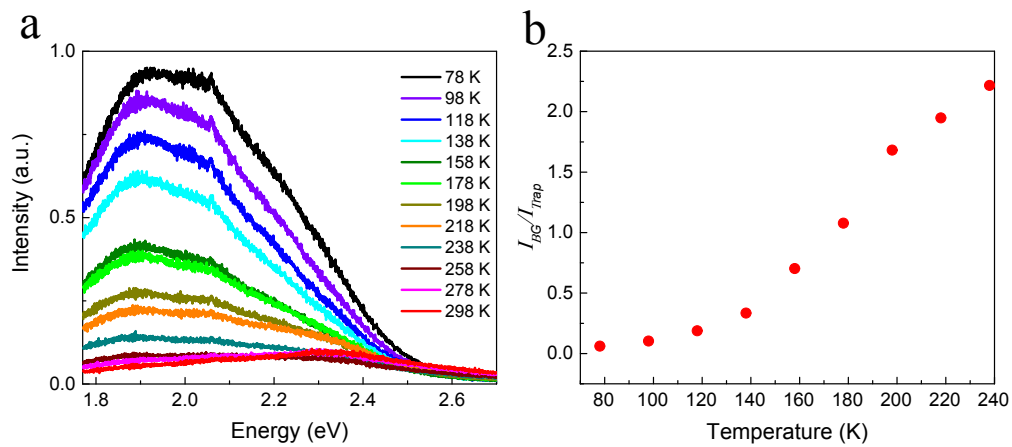
The substrate data (black line) are presented for comparison.

Diffraction peaks at 5.33 °, 10.65 °, 15.97 °, 21.35 ° and 26.76 ° are assigned to the (001), (002), (003), (004) and (005) lattice planes of the layered (PEA)<sub>2</sub>PbBr<sub>4</sub> structure, respectively.<sup>1</sup> The linewidth of the (001) peak for the samples after acetone vapor treatment is 0.0669 °, while that for the film samples is 0.2676 °. The peak at 32.98 ° originates from the Si/SiO<sub>2</sub> substrate.

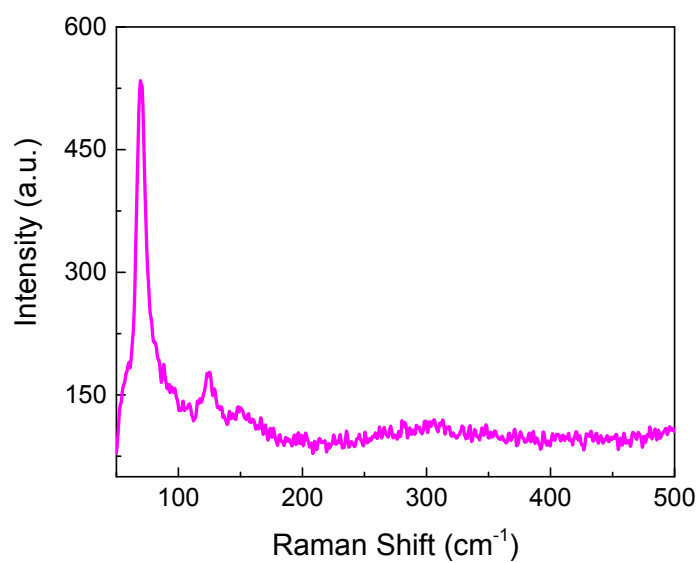


**Fig. S3** SEM images of the growth process of  $(\text{PEA})_2\text{PbBr}_4$  microcrystals. All scale bars are  $5 \mu\text{m}$ .

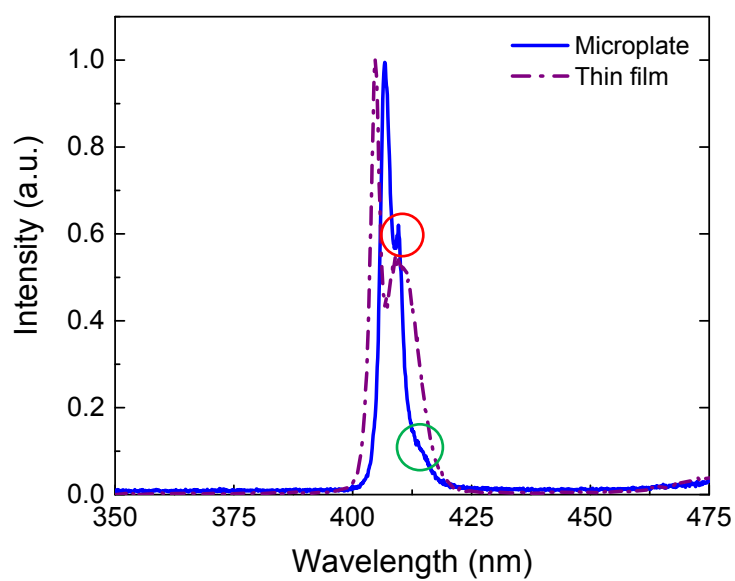
(a)  $(\text{PEA})_2\text{PbBr}_4$  thin film without acetone vapor treatment. (b-f)  $(\text{PEA})_2\text{PbBr}_4$  microcrystals grown with acetone vapor treatment at room temperature for different time, corresponding to 4 min, 8 min, 12 min, 16 min and 20 min, respectively.



**Fig. S4** (a) A magnification of temperature dependent PL spectroscopy ranging from 1.77 eV to 2.7 eV. (b) The ratio  $I_{BG}/I_{Trap}$  from 78 K to 238 K.



**Fig. S5** Raman spectrum of the (PEA)<sub>2</sub>PbBr<sub>4</sub> microplates.



**Fig. S6** PL spectra of the (PEA)<sub>2</sub>PbBr<sub>4</sub> microplates (blue) and thin film (purple) at 78 K. More concentrated solution is used to grow the thin film to get enough signals for the low temperature measurement.

**Table R1** Summary of the fitting results with the plot of linewidth

Parameters	Value	Standard error
$\Gamma_0$ (meV)	26	1
$\Gamma_{op}$ (meV)	276	36
$\hbar\omega_{op}$ (meV)	50	3

## References

1 D. Ma, Y. Fu, L. Dang, J. Zhai, I. A. Guzei and S. Jin, *Nano Res.*, 2017, **10**, 2117-2129.