Supporting Information for

Submillimeter and Lead-free $Cs_3Sb_2Br_9$ Perovskite Nanoflakes: Inverse Temperature Crystallization Growth and Application for Ultrasensitive Photodetectors

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1. Complementary equations:

1.1 The relation between integral intensity I(T) and temperature (T) is shown as follows:

$$I(T) = \frac{I_0}{1 + A\exp(-\frac{E_b}{K_b T})} \tag{1}$$

where I_0 is the integral intensity at 0 K, A is a parameter of radiative lifetime, K_b is the Boltzmann constant. For the calculation of E_b, we plot 1/I as a function of 1/T.

1.2 This temperature dependent FWHM curve could be descriped by Boson model:

$$\Gamma(T) = \Gamma_0 + \sigma T + \frac{\Gamma_{op}}{\exp(\frac{h\omega_{op}}{K_B T}) - 1} \tag{2}$$

where Γ_0 is the inhomogeneous broadening contribution, σ show the interaction of exciton and acoustic phonon, Γ_{op} describe the exciton and optical phonon interaction, $h\omega_{op}$ is the optical phonon energy.

1.3 The responsivity of the photodetector is calculated using the following formula:

$$R = \frac{\Delta I}{PS} \tag{3}$$

where $\triangle I = I_{on}-I_{off}$, λ = 450 nm, P is light power, and S = 1.0 ×10^{-6} cm^2.

1.4 The detectivity can be described as follows:

$$D^* = \frac{R}{(2qI_{dark}/S)^{1/2}} \tag{4}$$

where q is electron charge (1.6×10^{-19} C), I_{dark} is the dark current.

2. Complementary figures:

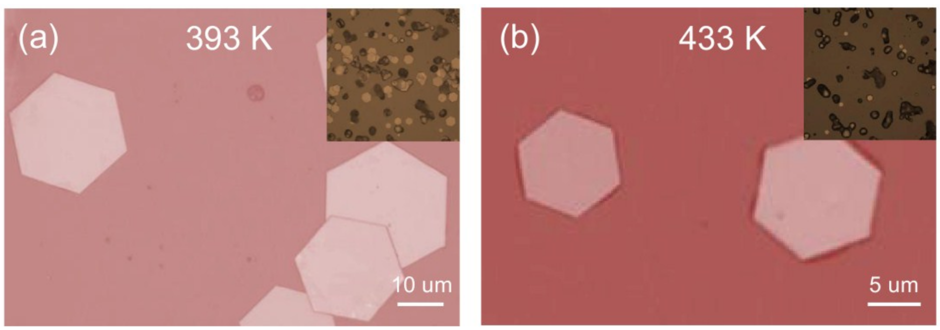

Fig. S1 (a) Synthesis of CPN at vaporation temperature at 393 K. (b) Synthesis of CPN at vaporation temperature at 433 K.

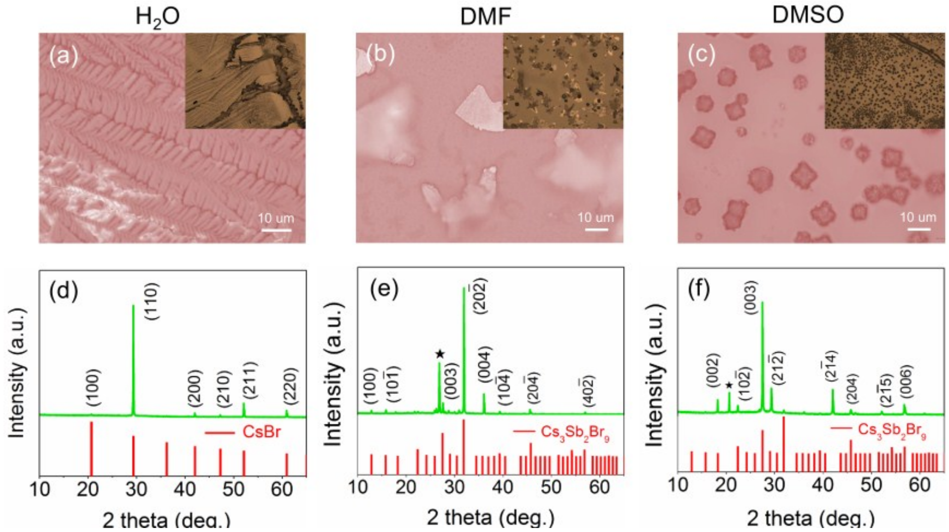

Fig. S2 (a-c) OM of synthesized CPN using solvent of H_2O, DMF and DMSO, respectively. Inset is the corresponding high magnification OM. (d-f) XRD of synthesized samples using solvent of H_2O, DMF and DMSO, respectively. The peak remarked asterisk is impurity.

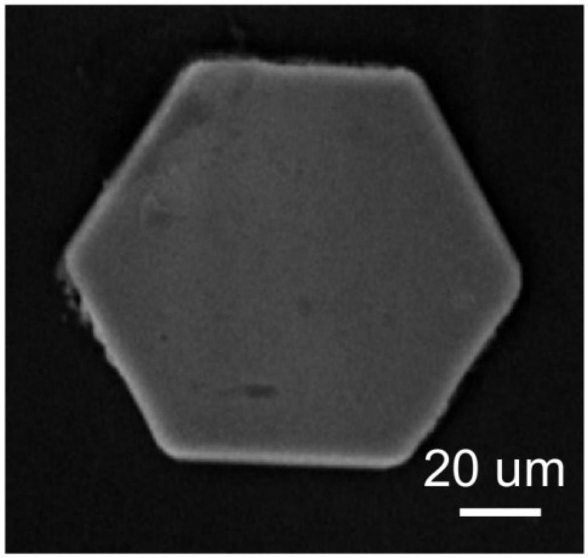

Fig. S3 SEM image of a typical CPN.

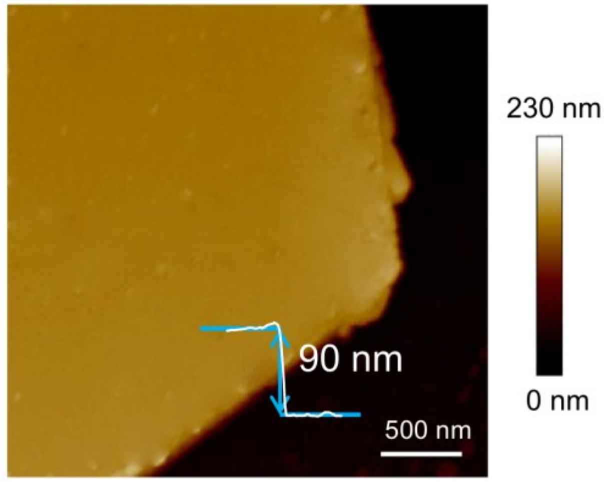

Fig. S4 AFM image of a typical CPN.

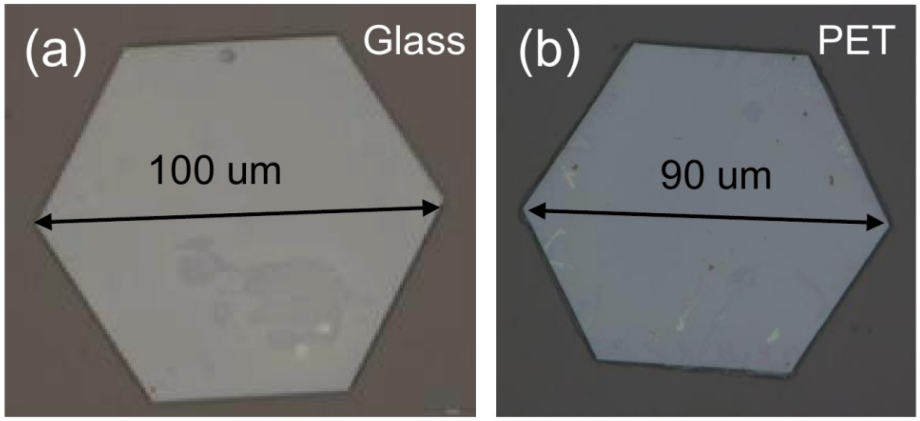

Fig. S5 (a,b) OM images for CPN growth on substrates of glass, PET.

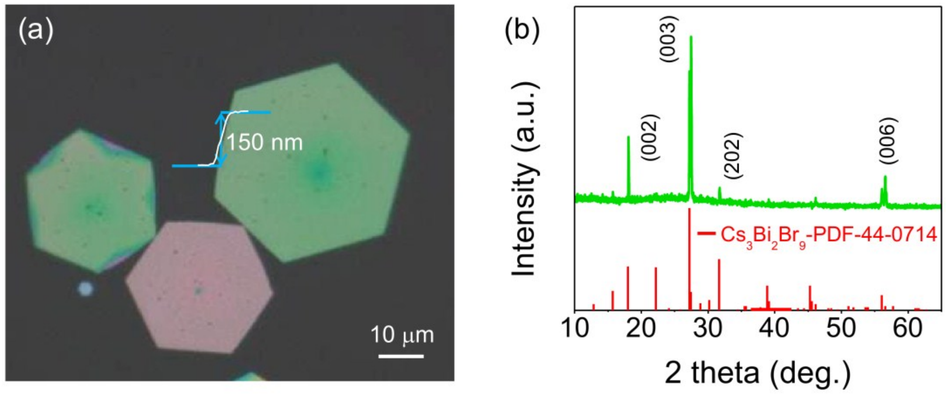

Fig. S6 (a) OM of $Cs_3Bi_2Br_9$ nanoflakes, the thickness of a typical nanoflake is 150 nm. (b) XRD patterns for $Cs_3Bi_2Br_9$ nanoflakes prepared in the HBr/H_2O hybrid solvent.

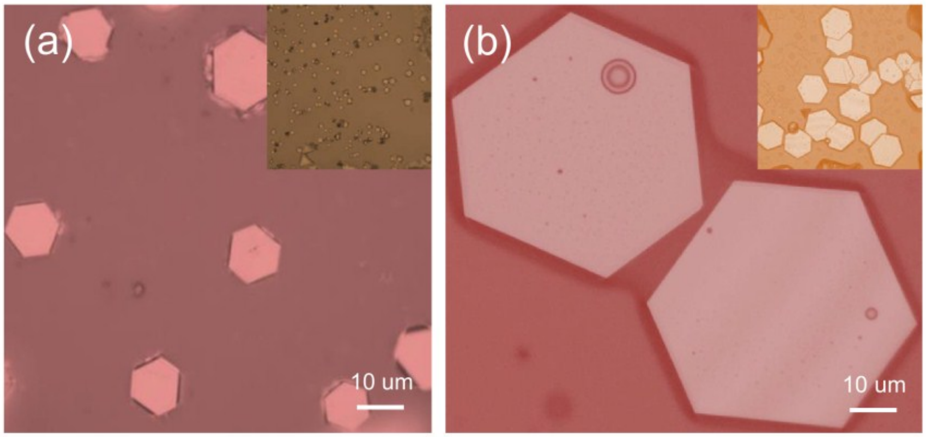

Fig. S7 Synthesis of CPN at (a) 0.04 mmol/L and (b) 0.12 mmol/L CsBr concentrations, respectively.

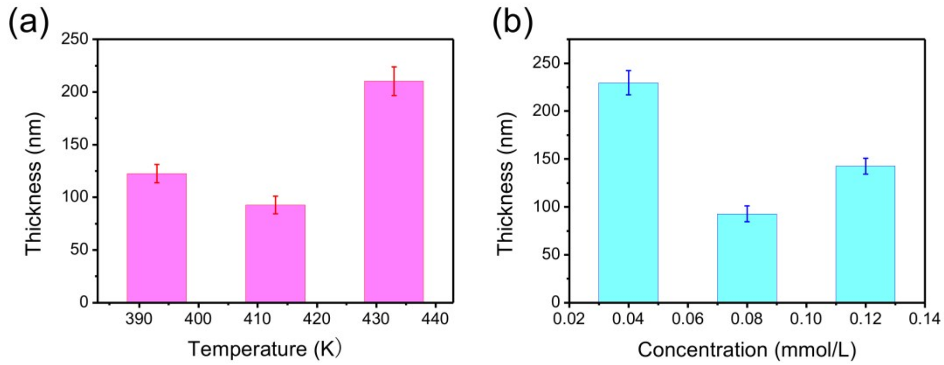

Fig. S8 Histogram of thickness for CPN synthesized at different temperatures and concentrations.

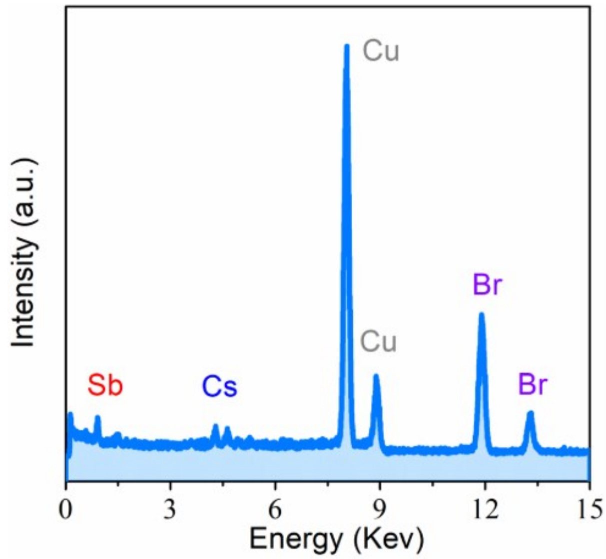

Fig. S9 EDS curve of CPN.

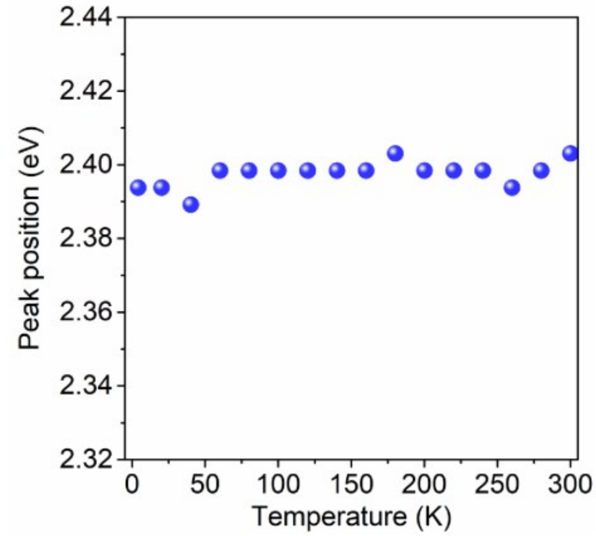

Fig. S10 Temperature dependence of peak position of PL peaks.

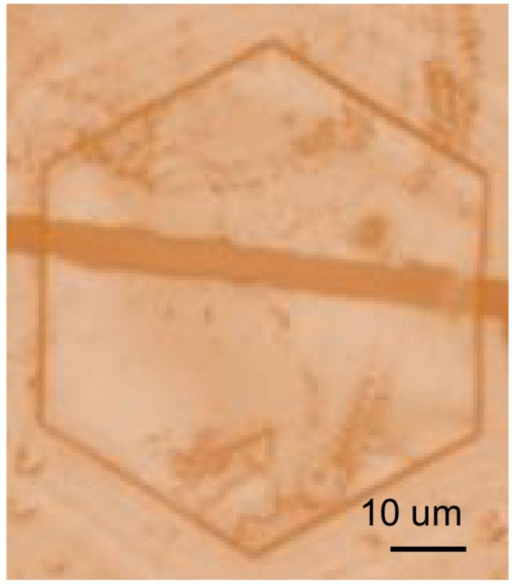

Fig. S11 OM image of CPN device fabricated via a dry transfer method.

Table S1. Comparison of devices based on pervoskite nanoplates

Photo detector	On-off ratio	Rise/Decay Time (ms)	Responsivity (A/W)	Detectivity (Jones)	Ref.
Gr/$MAPbI_3$/Gr heterostructure	~4	22/37	950	9.6×10^{10}	1
$MAPbI_3$ monolayer	3000	0.019/0.024	0.64	1.2×10^{12}	2
$CsPbBr_3$ nanosheets	~100	17.8/29.9	1.9×10^{-4}	2.2×10^{9}	3
$CH_3NH_3PbI_3$ nanoplates	<1	150/150	0.023	1.5×10^{9}	4
$CH_3NH_3PbI_3$ nanosheets	16	20/40	22	1.9×10^{8}	5
$CsPbBr_3$ monocrystalline film	>1000	0.4/9	2.5	1.1×10^{9}	6
$CsPbBr_3$ nanosheets	100	0.33/0.42	0.53	7.3×10^{12}	7
$Cs_3Sb_2Br_9$ nanoflakes	450	24/48	3.8	2.6×10^{12}	This work

References

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