Electronic Supplementary Information for

Continuous wave Pumped Nanolasers of Single-mode in Inorganic Perovskites with Robust Stability and High Quantum Yield

Li Jiang, [a] Renming Liu, [a] Rongling Su, [a] Ying Yu, [a] Haofei Xu, [a] Yuming Wei, [a] Zhang-Kai Zhou,* [a] and Xuehua Wang [a]

[a] *State Key Laboratory of Optoelectronic Materials and Technologies, School of Physics, Sun Yat-sen University, Guangzhou 510275, China. L. Jiang and R. Liu contributed equally to this work.*

**Correspondence and requests for materials should be addressed to Z.K.Z. (Email: zhouzhk@mail.sysu.edu.cn)*

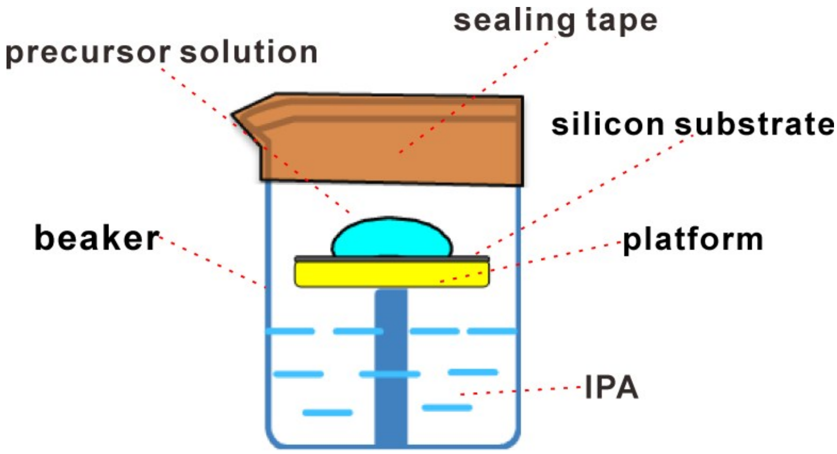

Fig. S1 Scheme of the beaker used for the growth of $CsPbX_3$ NWs using the gas-liquid transfer recrystallization method

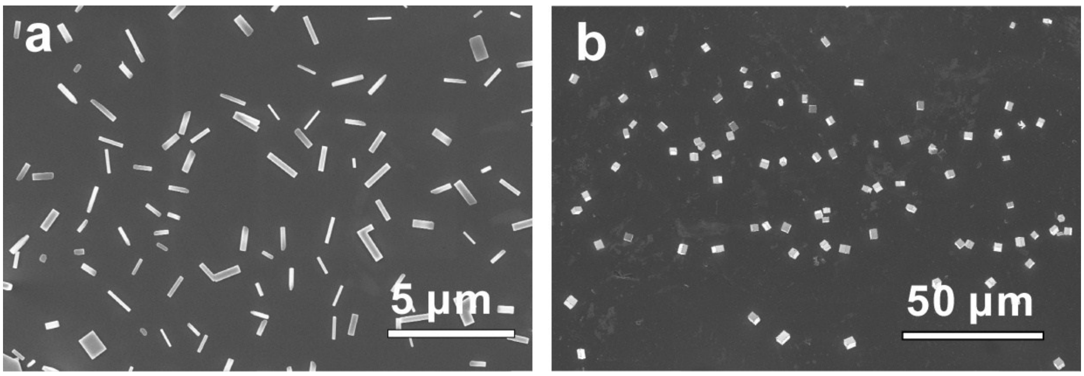

Fig. S2 The SEM photographs of $CsPbBr_3$ crystals from different volume of IPA (in a 100-mL beaker), (a) 50 mL, (b) 10 mL.

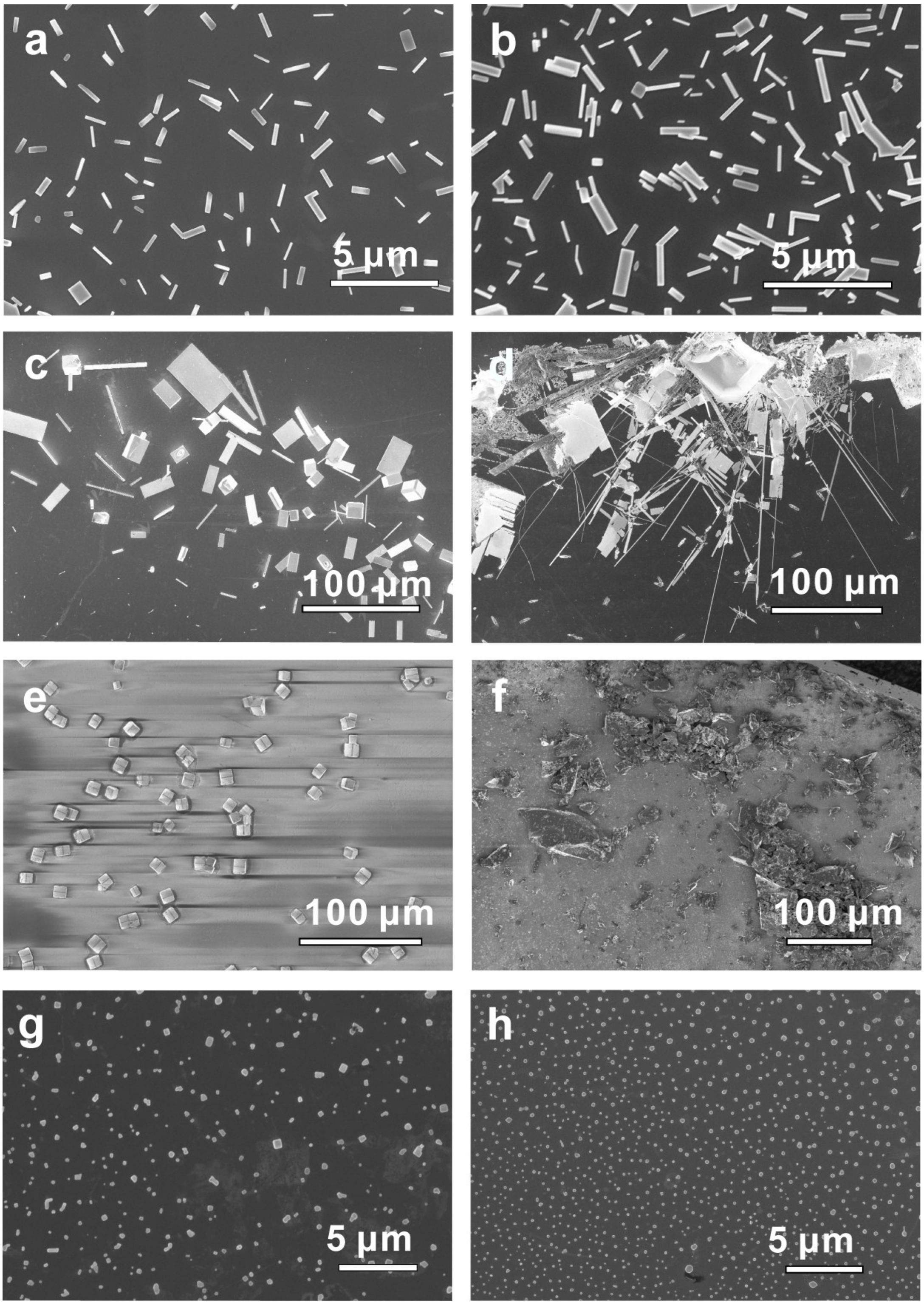

Fig. S3 The SEM photographs of $CsPbBr_3$ crystals from different vapor/atmosphere: (a) isopropanol, (b) n-propanol, (c) butyl alcohol, (d) cyclohexane, (e) dichloromethane, (f) ethanol, (g) Air, (h)nitrogen.

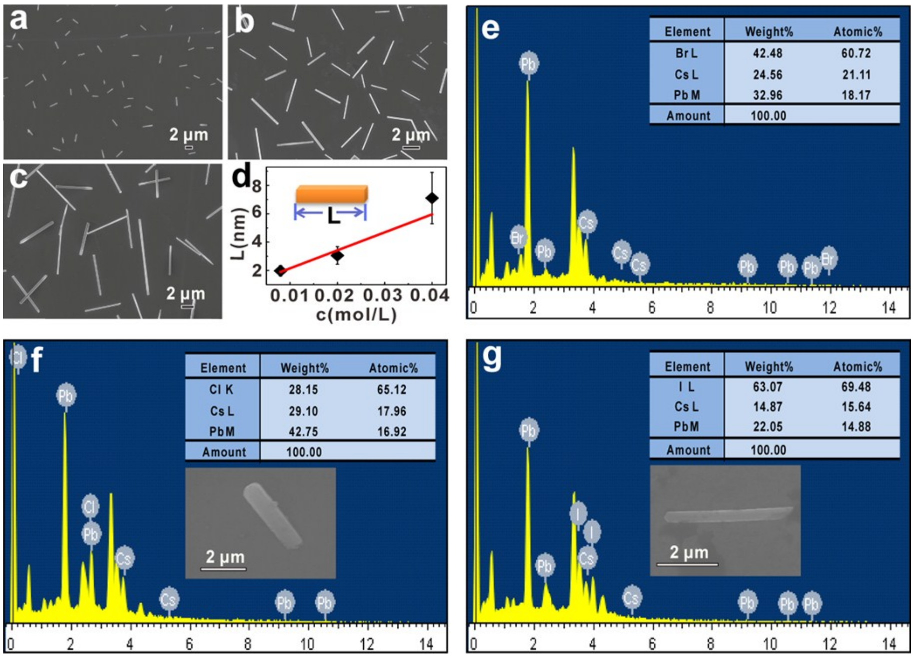

Fig. S4 (a-d) The morphological features (SEM images) of $CsPbBr_3$ NWs with diferent length. The length of the nanowires can be adjusted from 2~10µm, by controlling the precursor concentration. (e) A representative EDS spectrum of a single $CsPbBr_3$ NW on a silicon substrate. The inset shows quantitative elemental analysis of the corresponding EDS. (f) A representative EDS spectrum of a single $CsPbCl_3$ NW on a silicon substrate. The inset shows quantitative elemental analysis and SEM image of the corresponding EDS. (g) A representative EDS spectrum of a single $CsPbI_3$ NW on a silicon substrate. The inset shows quantitative elemental analysis and SEM image of the corresponding EDS, demonstrating Cs, Pb and X (Cl, Br, I) components with a quantified ration of 1:1:3.

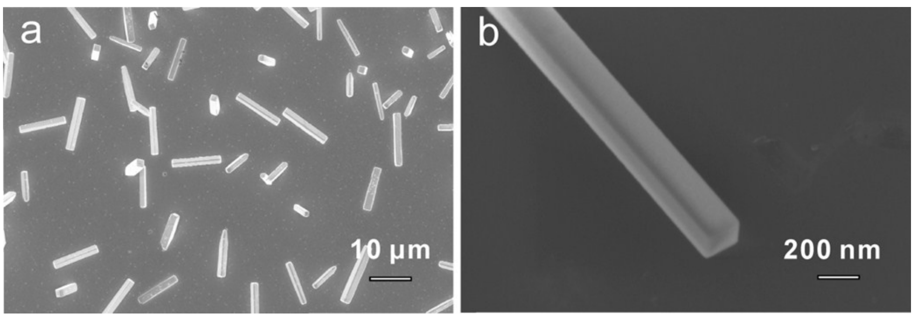

Fig. S5 More details about the morphological and cross section of $CsPbBr_3$ NWs

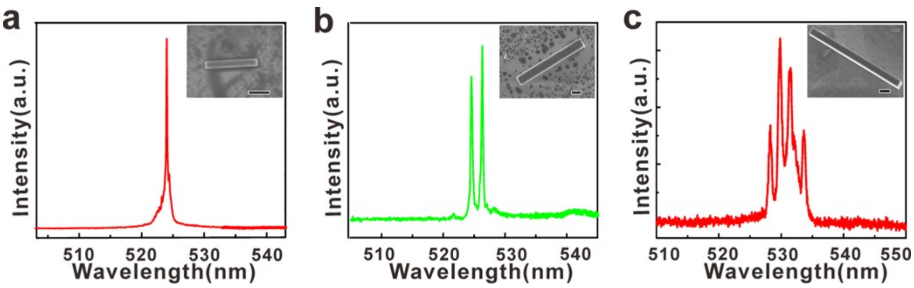

Fig. S6 Different lasing behaviors of a single perovskite nanowire. (a) single mode, (b) double-mode and (c) multi-mode. The undefined scale bar indicates 1 μm.

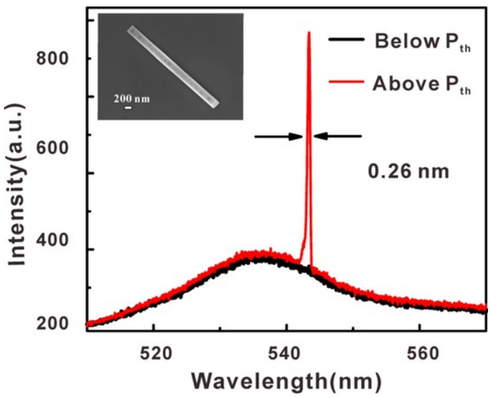

Fig. S7 Femtosecond-pumped PL intensities with below (black line) and above P_{th} (red line) from a single $CsPbBr_3$ NW, showing a linewidth of 0.26 nm..

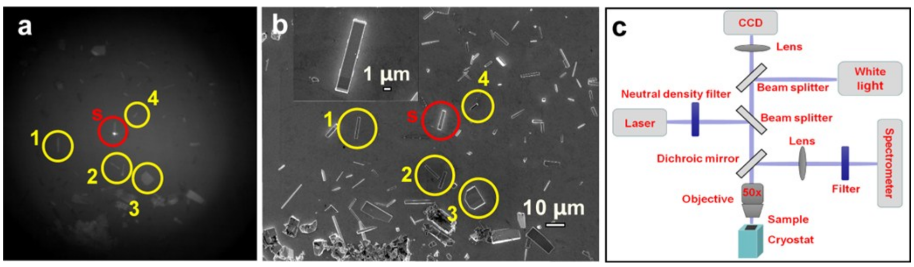

Fig. S8 Low temperature measurements of single nanowire. (a) Optical micrographs; (b) and the corresponding SEM image, inset: the magnification SEM images; (c) Schematic sketch of experimental system configuration for lasing measurements on a single nanowire at low temperature. By comparing the optical micrograph (a) and its corresponding SEM image (b), one can indentify a specific nanowire that has been measured (marked by red cycle). The well-controlled laser beams (laser spot, the diameter is ~2 μm) can also be clearly observed in the optical image (a), which demonstrates the excitation of a single nanwire.

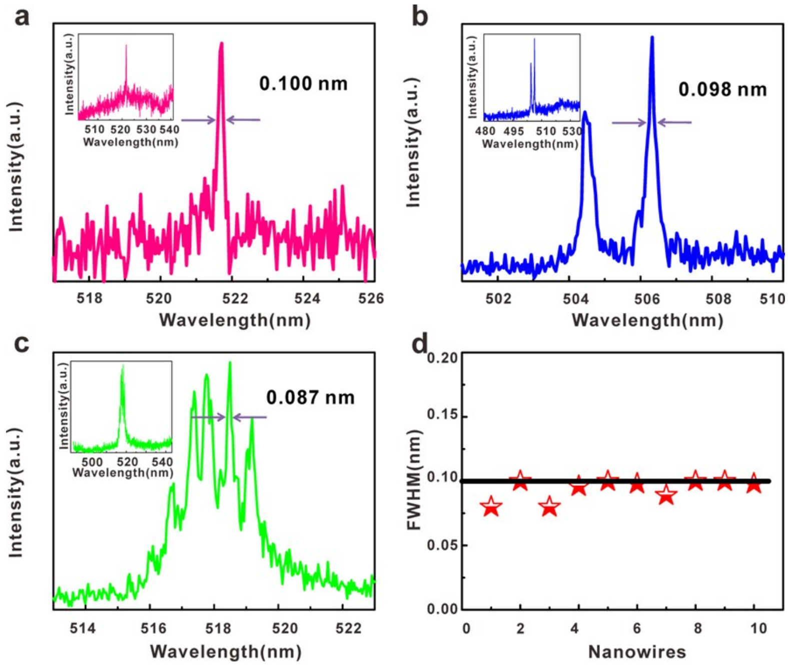

Fig. S9 The linewidth of $CsPbBr_3$ NWs lasing with single mode (a), double-mode (b) and multi-mode (c). (d) The corresponding statistical linewidth of lasing spectra.

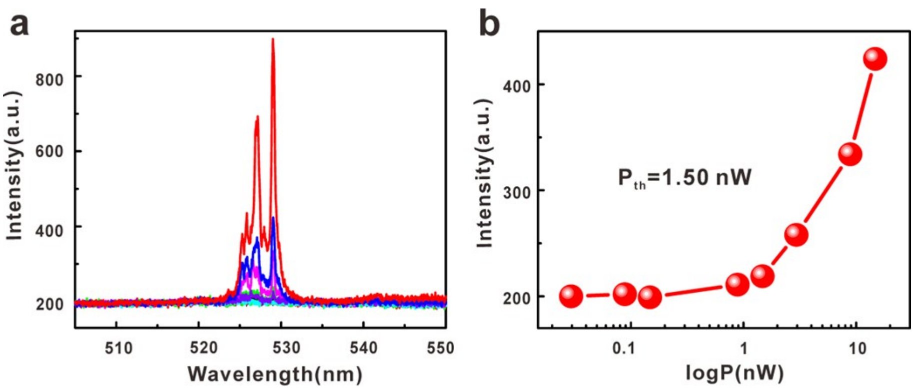

Fig. S10 Multi-mode lasing actions of a single $CsPbBr_3$ NW after reserving in clean room for over one year. (a) The fluence-dependent of lasing spectra from a single $CsPbBr_3$ NW with multi-mode lasing. (b) The fluence-dependent of the single mode lasing intensity showing a threshold of 1.50 nW.

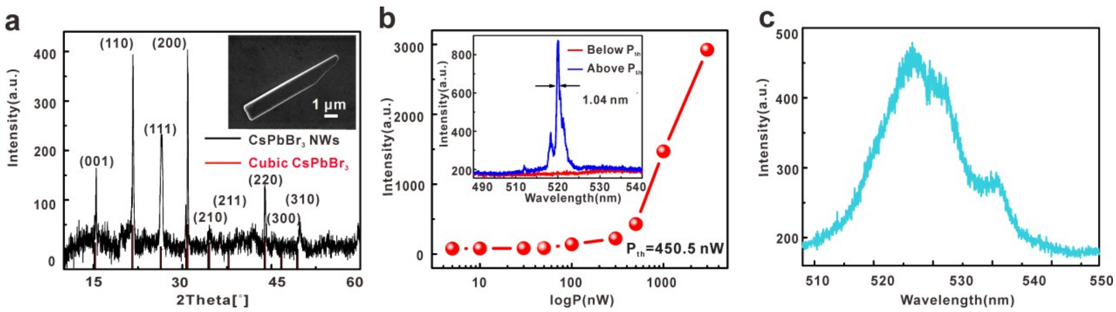

Fig. S11 Lasing reactions of $CsPbBr_3$ NW with poor crystallization. (a) XRD results and a typical SEM image of a $CsPbBr_3$ NW with poor crystallization. Such NWs are synthesized under ~30℃, which is ~8 ℃ higher than the suitable temperature. (b) Typical PL spectra and the fluence-dependent of lasing spectra from the single $CsPbBr_3$ NW. T the lasing threshold and linewidth are repectively 300 times higher and 10 times broader than those of the $CsPbBr_3$ NWs reported in the maintext. (c) The PL spectrum of the $CsPbBr_3$ NW with poor crystallization after one year preservation. No lasing action can be observed. In (b) and (c) the sample was pumped by CW laser, and the measurement temperature was 4 K.

P	***A***	**T_1 (ns)**	**T_2 (ns)**	***Bn***	***k_{lasing} n***	**Note QY(%)**	**Lasing QY (%)**
$0.5P_{th}$	0.3482×10^9	2.45	--	0.0599×10^9	--	15	--
$0.8P_{th}$	0.3482×10^9	2.25	--	0.0962×10^9	--	22	--
$1.1P_{th}$	0.3482×10^9	0.59	2.15	0.1169×10^9	0.4260×10^9	61	48
$2.0P_{th}$	0.3482×10^9	0.57	2.05	0.1396×10^9	0.5020×10^9	65	51
$3.0P_{th}$	0.3482×10^9	0.49	1.82	0.2012×10^9	0.7473×10^9	73	58

Table. S1 Estimated Quantum yields (QY) and lasing QY of a single $CsPbBr_3$ NWs (the data are analyzed from Fig. 3a.

Note: $$QY = \frac{\text{radiative rate}}{\text{total rate}} = \frac{Bn + k_{\text{lasing}}n}{A + Bn + k_{\text{lasing}}n} \quad (1)$$

$$\textit{Lasing QY} = \frac{\text{lasing rate}}{\text{total rate}} = \frac{k_{\text{lasing}}n}{A + Bn + k_{\text{lasing}}n} \quad (2)$$