Supplementary Information

Single-Mode Lasing of $CsPbBr_3$ Perovskite Nanowires Enabled by the Vernier Effect

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Experimental Section

Preparation of the $CsPbBr_3$ NWs and coupled-cavity: The $CsPbBr_3$ NWs were synthesized via a home-built CVD system. First, a quartz boat containing CsBr (Aladdin, 99.999%) and $PbBr_2$ (Aladdin, 99.999%) mixed powder (2:1) was put at the heating center of the tube furnace. Then, several pieces of cleaned mica with a size about $1.5 \times 2.5\ cm$ were placed inside the downstream of the quartz tube. After, the quartz tube was cleaned by 30 sccm flow of high purity N_2 (99.999%) for 30 min. Following, the quartz tube was heated to 570 ℃ at a rate of 30 ℃/min for 10 min. In the heating process, the pressure in the tube furnace is maintained at 30 Torr. At last, the furnace was naturally cooled down to room temperature. The coupled $CsPbBr_3$ NWs microcavity were fabricated by the FIB milling. At first, about 80 nm AZO protection layer was deposited on the $CsPbBr_3$ NWs' surface by the sputter coating at 4 mtorr Ar atmosphere. Then, the $CsPbBr_3$ NWs were milling by a FIB (FEI, Helios NanoLab 600i) using a Ga beam current of 7.7 pA. By adjusting the milling time and milling line width, various width of gap can be controllable prepared.

Morphology and structure characterization: The morphology of the as-prepared $CsPbBr_3$ NWs was tested by a SEM (Hitachi SU8020) and an optical microscope (Zeiss Observer Z1). The XRD patterns of the $CsPbBr_3$ NWs were conducted in X-ray diffractometer (PANalyticalX'Pert 3 Powder). TEM, SAED, EDS mappings were performed on a JEM-TEM-2100F equipped with an energy dispersive spectrometer (EDS, Oxford X-Max) operating at 80 kV.

Optical Measurement: The absorption spectrum of the $CsPbBr_3$ nanowires is obtained from a UV/vis/NIR spectrophotometer (Shimadzu UV 3600) by the common transmission mode like film samples. The PL spectrum was obtained using a laser confocal micro-Raman system (LabRAM HR Evolution). The laser properties characterization was performed in a confocal system. The excitation source is a 405 nm femtosecond pulsed beam with 190 fs pulse duration and 1 kHz repetition rate. The excitation source was focused to a diameter of ~20 μm spot by a $\times 40$ objective lens. The emitted light was detected via an optical multichannel analyzer (Andor, SR-500i-

D1-R, 1200 g mm^{-1} grating) and a CCD detector coupled with a confocal μ-PL system (Zeiss M1). Time-resolved PL (TRPL) measurements by employing a streak camera (Optronis Optoscope sc-10), and a 325 nm femtosecond pulsed laser (100 fs pulsed duration and 1 kHz repetition rate) as signal detector and excitation source.

Numerical simulation: The numerical simulation on the standing wave field distributions was performed by finite-different time-domain method (FDTD). Two-dimensional (2D) time-domain and frequency-domain finite element methods were performed with the aid of eigenfrequency analysis. The diameter of $CsPbBr_3$ NW is 850 nm, excitation wavelength is 405 nm. The refractive index of $CsPbBr_3$ NW is 2.3.

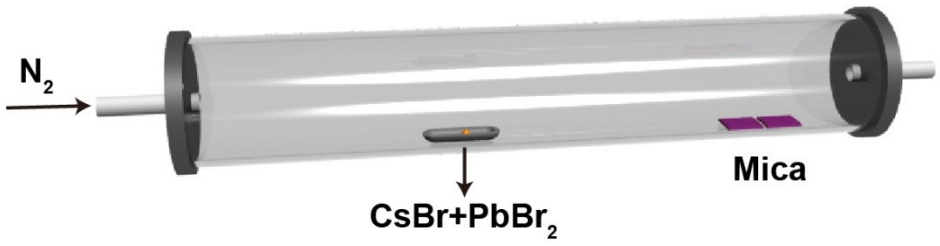

Figure. S1 Showed the schematic diagram of home-built chemical vapor deposit equipment.

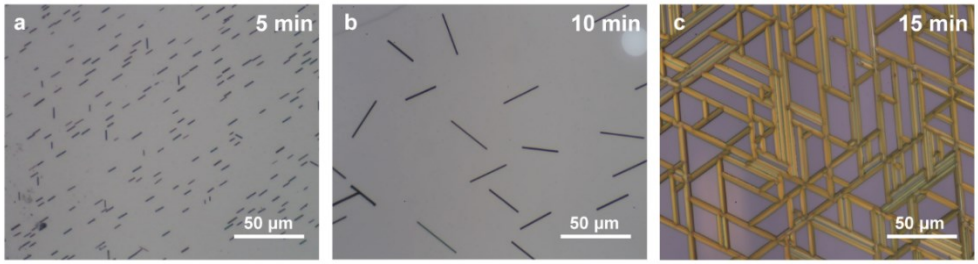

Figure. S2 showed the optical photographs of the CsPbBr3 NWs under the reaction time were 5 min, 10 min and 15 min, responsibility.

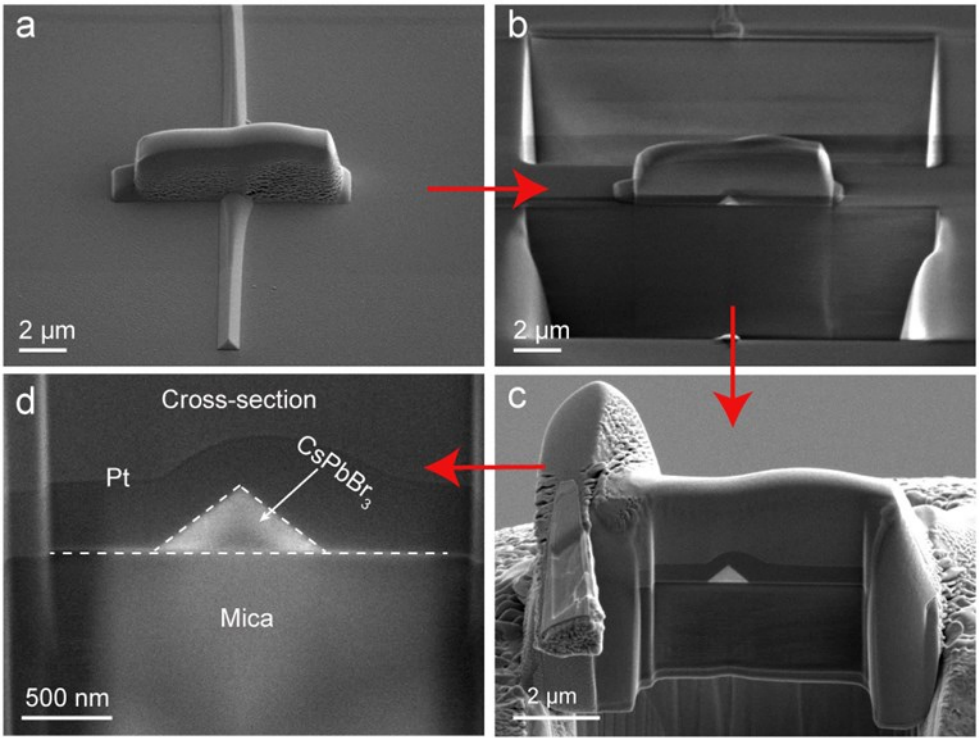

Figure S3 (a-d) Preparation of $CsPbBr_3$ NW slice for TEM measurement by focused ion beam milling.

The processes of preparation of $CsPbBr_3$ NW slice by focused ion beam (FIB) technology as shown in figure S3(a-d). Firstly, several micrometers thickness Pt was deposited on the $CsPbBr_3$ NW surface (figure S3a). Following, the $CsPbBr_3$ NW was cut into slice (figure S3b) by FIB milling. Next, the $CsPbBr_3$ NW slice was transferred on the copper grid by mechanical arm (figure S3c). Finally, the slice was reduced to a favorable thickness by FIB milling (figure S3d) again.

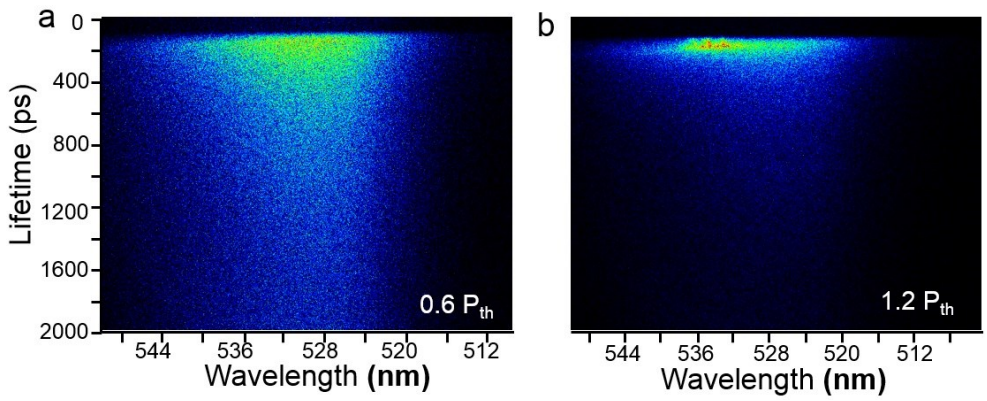

Figure S4 streak-camera images of single $CsPbBr_3$ NW when pump density below (a) and above (b) lasing threshold.

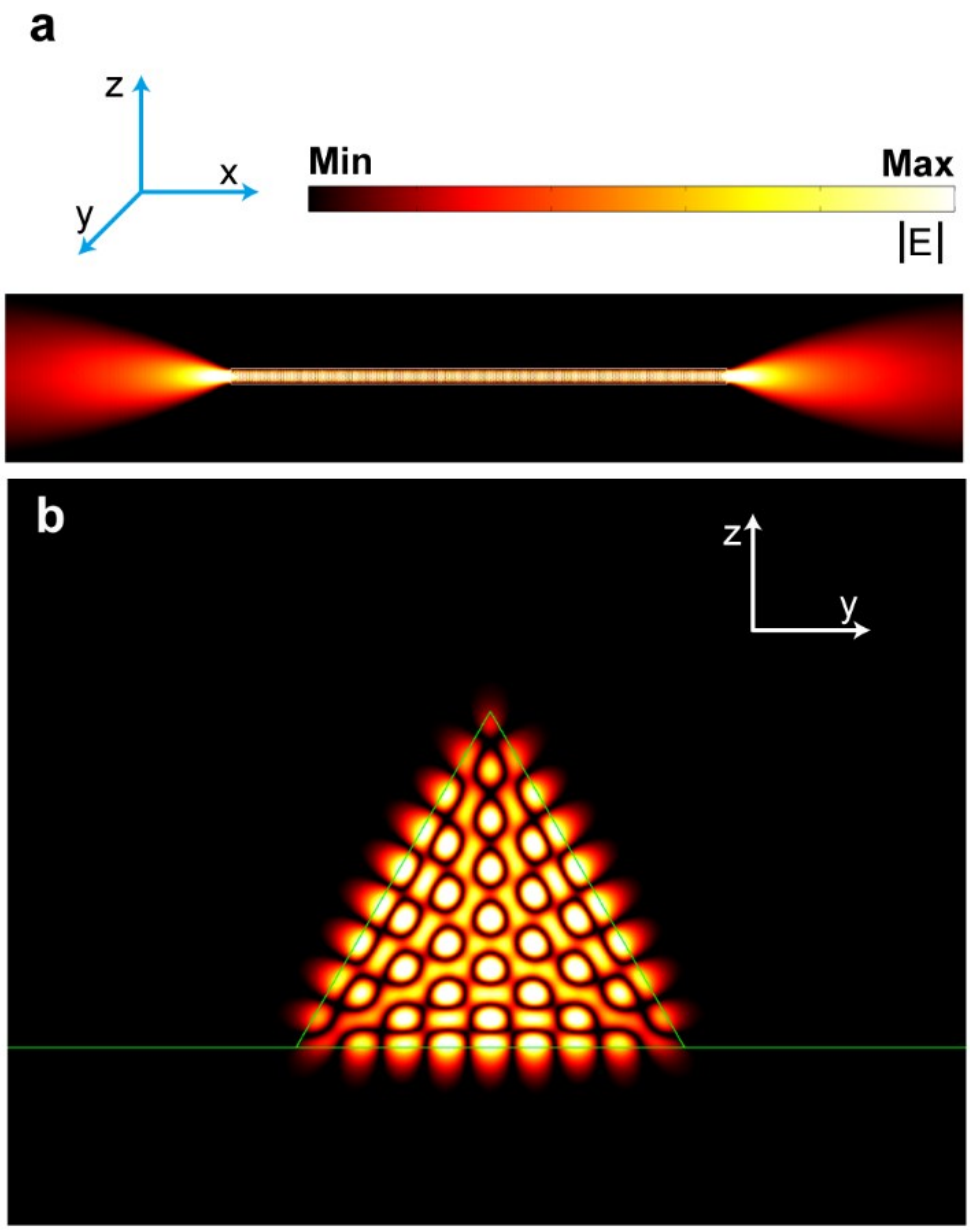

Figure. S5 (a) Showed the 2D electric field distribution along the CsPbBr3 NWs' axial and cross-section (b).

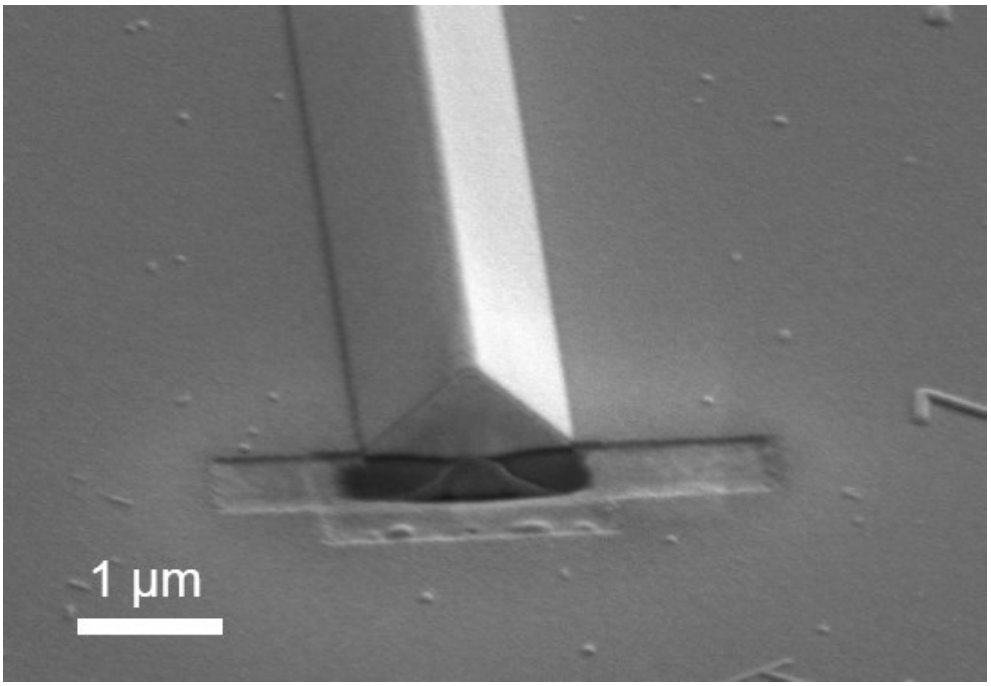

Figure. S6 Showed the SEM image of NWs after FIB milled.

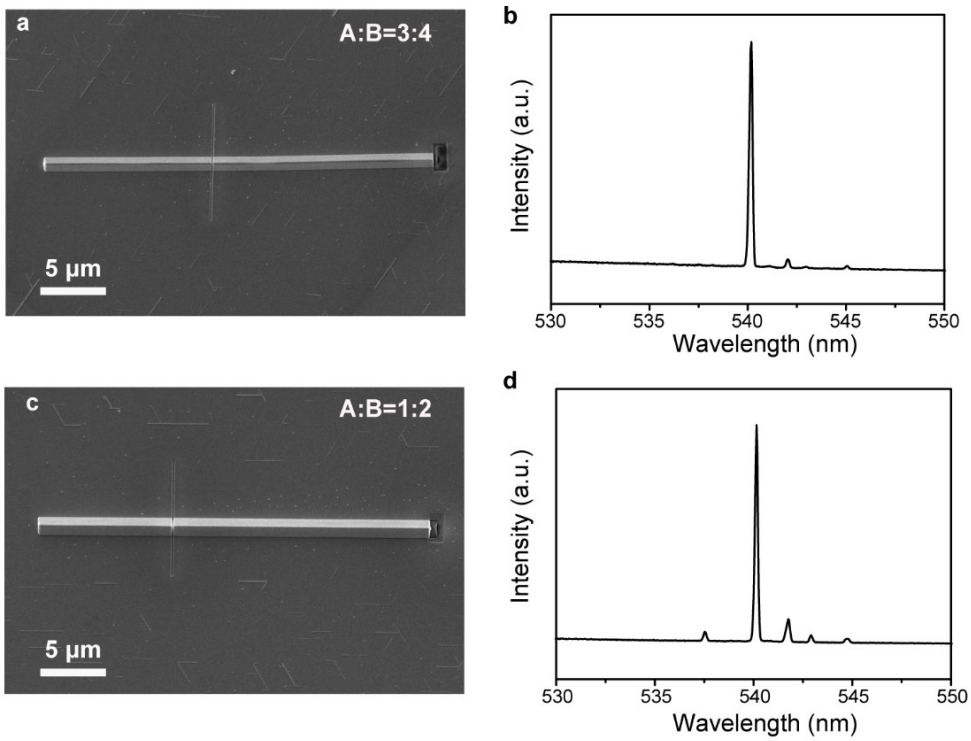

Figure. S7 (a) and (c) shows the SEM images of coupled-cavity with the length ratio is 3:4 and 1:2, (b) and (d) shows the corresponding lasing spectra, respectively.

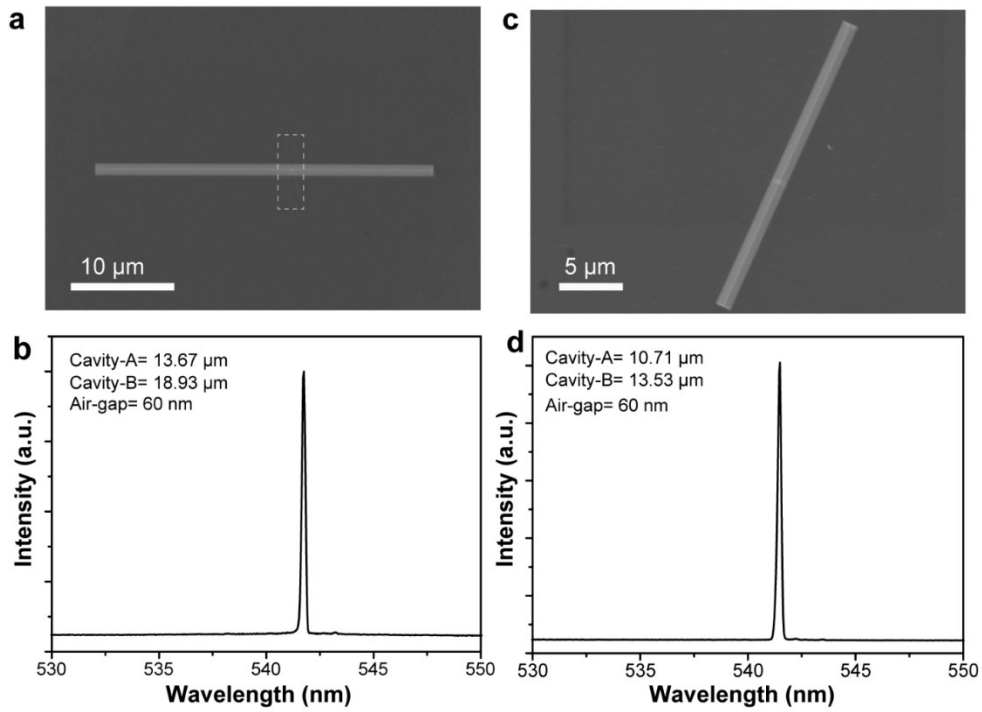

Figure. S8 (a) and (c) showed the SEM images of the coupled cavity with the different total length and cavity-A and cavity-B length ratio, (b) and (d) shows the corresponding lasing spectra, respectively.