Electronic Supplementary Information (ESI)

Concrete Perovskite for Pouring High-quality Micro-Laser Arrays

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Experimental Section

1. **Materials:** The raw material of perovskite was purchased from Xi'an Bao Laite Polymer Optoelectronics Technology Co., Ltd. and can be used directly: CsBr (99.9%, 25g); MABr (99.5%, 10g); $PbBr_2$ (99.99%, 10g). All other reagents were purchased from Sigma-Aldrich.

2. **Preparation of perovskite precursor solution:** We first synthesized CsPbBr3 powder, dissolved $PbBr_2$ in hydrobromic acid (8 ml), and then added an equimolar mass of CsBr dissolved in 3 ml of water dropwise to give an orange precipitate. The precipitate was suction filtered, washed twice with ethanol and dried in a vacuum oven at 60 ° C for 12 hours. The $CsPbBr_3$ powder was dissolved in DMSO solvent to prepare a 0.5 M starting solution. Then, the MABr powder is added to the prepared $CsPbBr_3$ solution in a molar ratio to prepare different ratios of the doping solution.

3. **Concrete $CsPbBr_3$@MABr perovskite film preparation:** High quality hydrophilic glass slides are chosen as substrate for spin-coating and PDMS template printing. The slide should be washed with deionized water, hot H_2SO_4:H_2O_2 (2:1) solution, deionized water twice, and isopropyl alcohol twice then dried by using a N_2 gas. After these preliminary treatments, the precursor solution can easily spread on the surface of these substrates. The solution from the previous step was spin coated onto the substrate at 2000 rpm for 60 s and quickly rinsed with 500 microliters of toluene at 30 s. The above steps were all carried out in the glove box.

4. **Preparation of PDMS soft template:** A silicon master template consisting of convex vertical patterns should be firstly designed and prepared by photolithography. Then the well mixed PDMS prepolymer (Dow Corning) was casted on the silicon master template. After 4 h incubation at 70°C, the PDMS pad with a thickness of about 1 cm was peeled off the

master and cut into 1 × 1 cm^2 prior to use. The dimensions of pattern on the PDMS pad were determined by design the convex silicon. One schematic diagram is added to make these details more complete (see Fig. S5).

5. **Morphology and structure measurements:** The morphology and size of the micro-ring and NW array was viewed using a field emission scanning electron microscope (Hitachi S-4300) at an accelerating voltage of 10-15 kV. The X-ray diffraction pattern of the diffraction angle from 5° to 50° was measured by D / max 2500 X-ray.

   μ-PL image placed on the slide glass was examined using an Olympus Research Inverted System microscope (FV1000-IX81, Tokyo, Japan) equipped with a charge coupled device (CCD, Olympus DP71, Tokyo, Japan). The excitation source is a xenon lamp equipped with a bandpass filter (325-375 nm).

6. **ASE measurement:** For ASE measurements, the second harmonic of the regenerative amplifier (Spitfire, Spectra Physics) (400 nm, 150 fs, 1 kHz) is seeded with a mode-locked Ti: sapphire laser (Tsunami, Spectra Physics) with vertical focus through a focal length of 75 mm The cylindrical lens vertically collects the emission from the edge of the film as an optical waveguide on a perovskite film having a size of ×0.1×3 mm 2 and is attached to the CCD (SPEC-10-400B / LbN, Roper Scientific) by liquid nitrogen cooling. Color meter (Spectropro-550i, Acton).

7. **Laser measurement**: Laser characterization measurements were performed on a self-contained inverted fluorescence microscope equipped with a 50 x 0.9 NA objective. The second harmonic (400 nm, 150 fs, 1 kHz) of a regenerative amplifier (Spitfire, Spectra Physics) seeded with a mode-locked Ti:Sapphire laser (Tsunami, Spectra Physics) is focused

to a point of 100 μm diameter to excite the perovskite Micro array. The PL spectrum is collected in a reflective mode with a movable aperture on the optical path at the front focal plane. In this way, a spatially resolved PL spectrum from a selected single microcircle can be collected and cooled with a liquid nitrogen cooled CCD (SPEC-10-400B / LbN, Roper) connected to a polychromator (Spectropro-550i, Acton) Scientific) detection.

8. Addition sections

Fig. S1

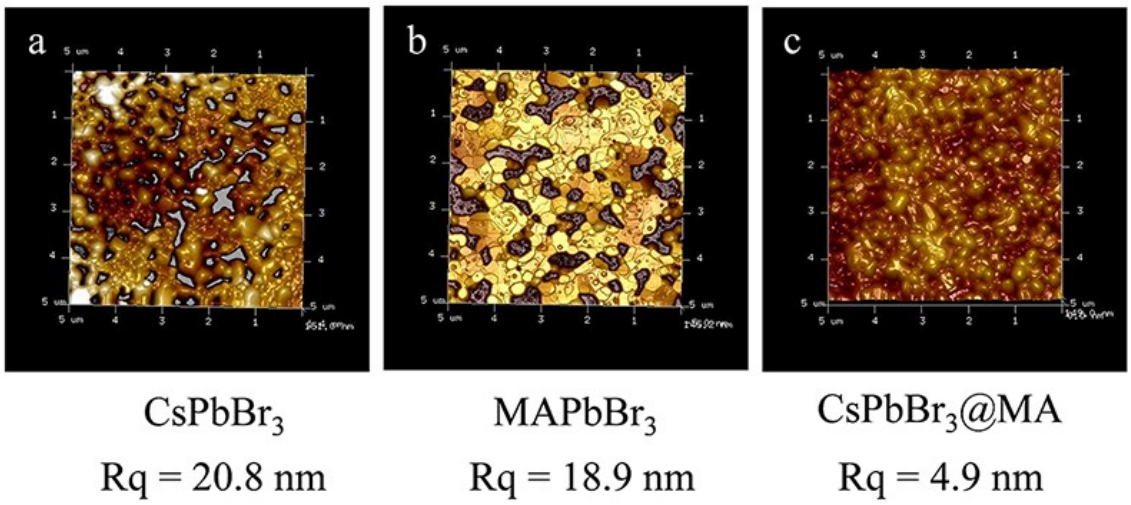

Fig. S1 Surface morphology and root mean square roughness (r.m.s) of $CsPbBr_3$, $MAPbBr_3$ and concrete $CsPbBr_3$@MABr perovskite thin-film by atomic force microscopy (AFM).

Fig. S2

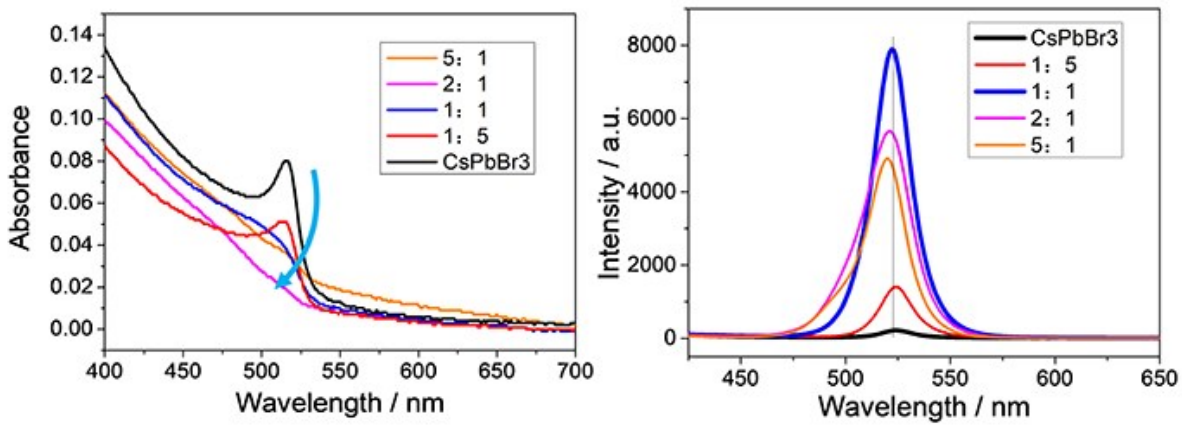

Fig. S2 Normalized absorbance and PL spectra of the thin-film spin coated by using different ratio of MABr:$CsPbBr_3$=0, 1:5, 1:1,2:1 and 5:1, respectively.

Fig. S3

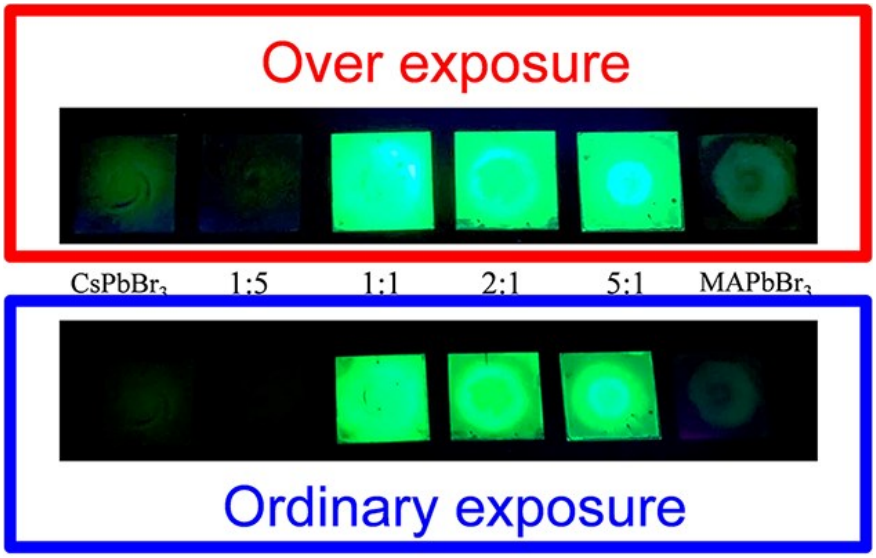

Fig. S3 Optical images of spinning-coated perovskite films in different ratio under 365-nm ultraviolet light radiation.

Fig. S4

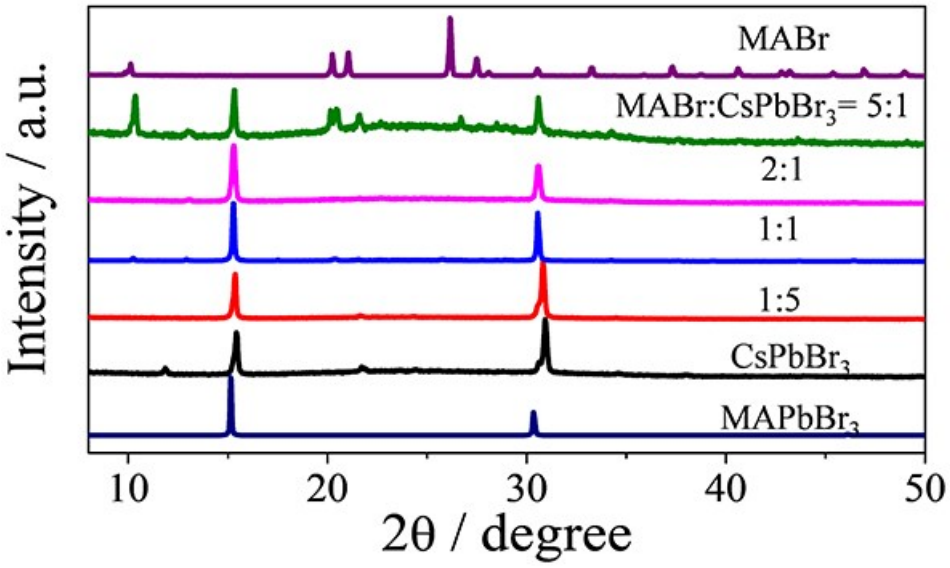

Fig. S4 Normalized XRD data of the thin-film spin coated by using different ratio of MABr:$CsPbBr_3$=0, 1:5, 1:1, 2:1, and 5:1, respectively. MABr and $MAPbBr_3$ were added for comparation.

Fig. S5

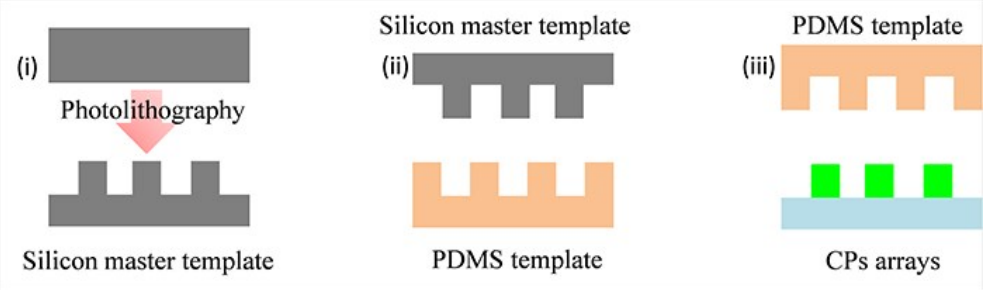

Fig.S5 Schematic diagram of PDMS soft templates and Concrete perovskite arrays fabrication.

Fig. S6

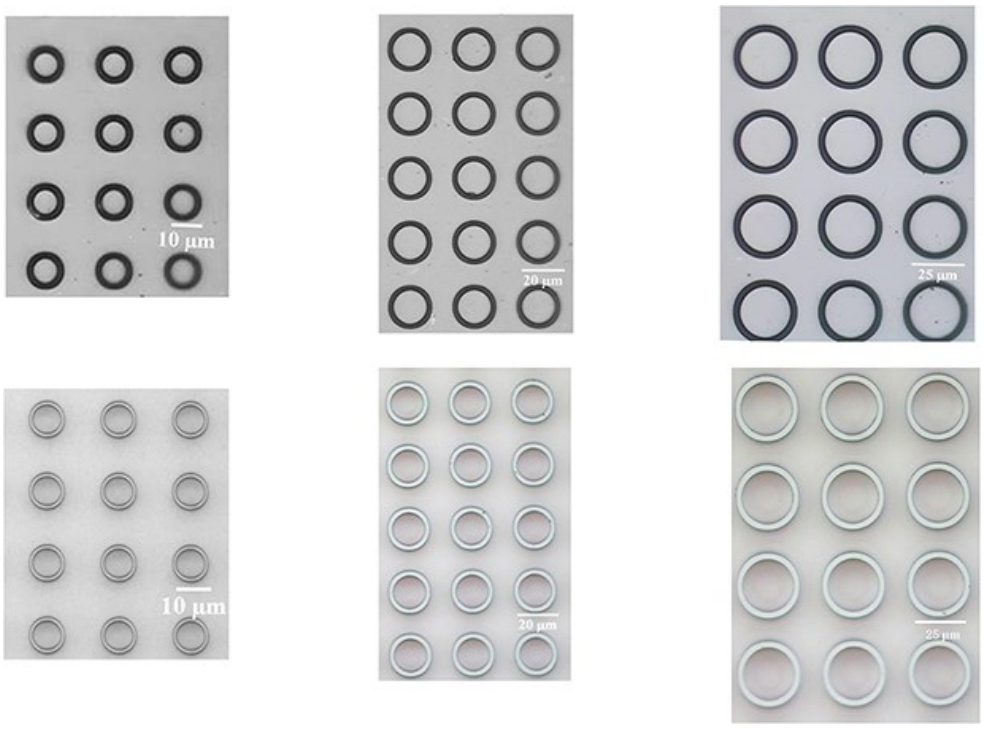

Fig.S6 Optical image of PDMS template with diameter of 10um, 15um and 30um, respectively.

Fig. S7

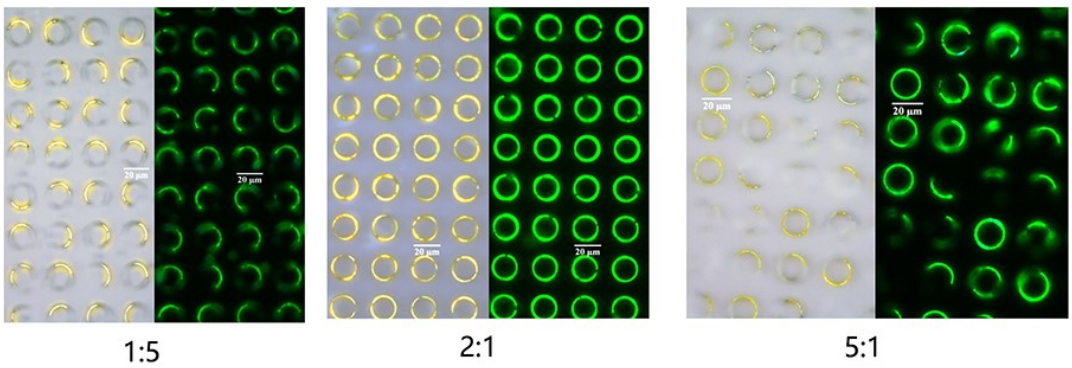

Fig.S7 Photoluminescent images of micro-ring preparation by using PDMS methods in different ratio of MABr:$CsPbBr_3$=1:5, 2:1 and 5:1, respectively. The 1:1 ratio depicted the homogeneous size and precise position.

Fig. S8

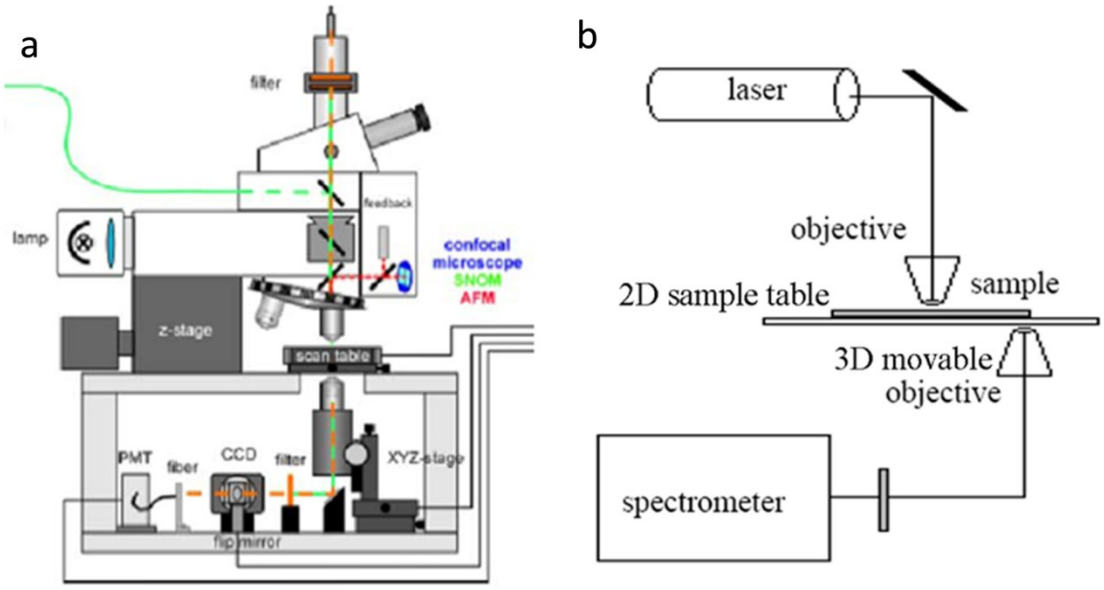

Fig. S8 Schematic illustration of (a) the near-field scanning optical microscopy and (b) the transmittance optical path for the μ-spectra measurements.

Fig. S9

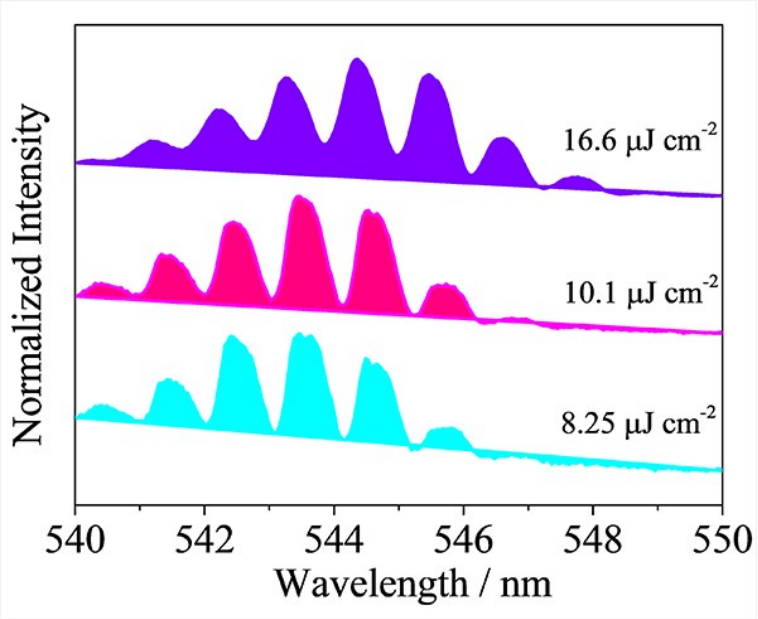

Fig. S9 The high-resolved laser spectra of individual micro-rings under 8.25, 10.1 and 16.6 μJ cm^{-2} pump density shown in Fig. 3a.

Fig. S10

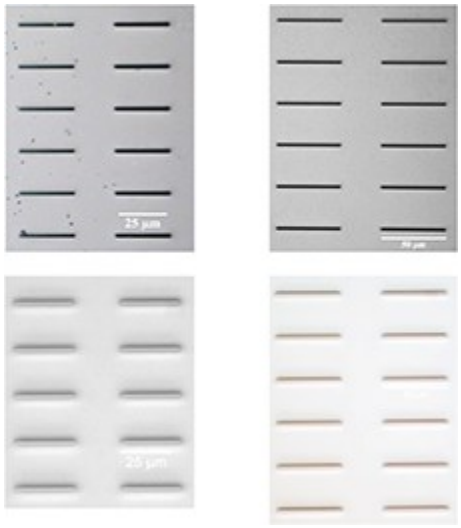

Fig. S10 The optical image of NWs PDMS template with length of 30um and 50um, respectively.

Fig. S11

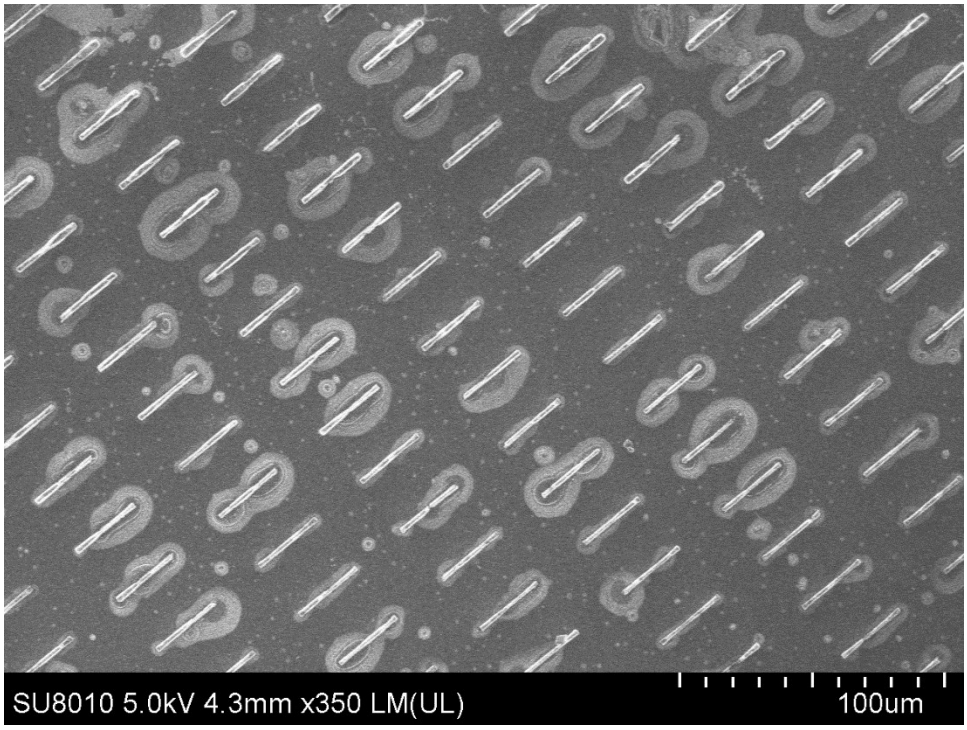

Fig.S11 SEM image of as-prepared $CsPbBr_3$@MABr NWs with length of 30um within homogeneous size and precise position.