

## Supplementary Information

# Synthesis of Lead Halide Perovskite Nanocrystals by Melt Crystallization in Halide Salts

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## Experimental Section

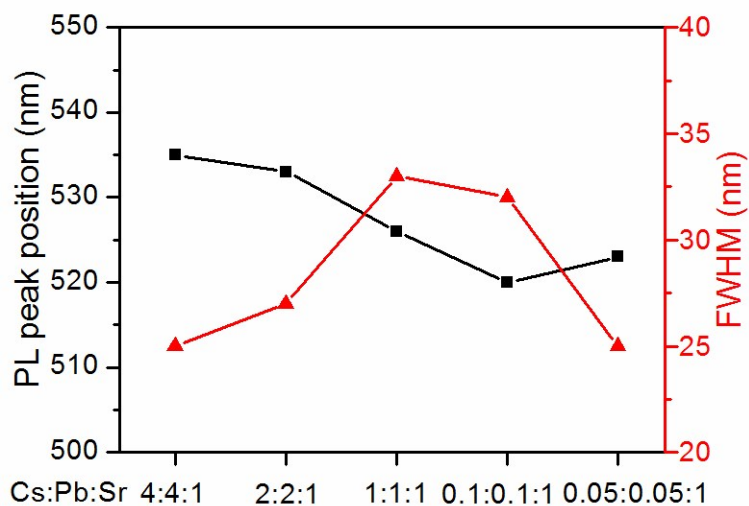
**Chemicals:** Lead bromide ( $\text{PbBr}_2$ , 99%), cesium bromide ( $\text{CsBr}$ , 99.5%), lead chloride ( $\text{PbCl}_2$ , 99.99%), cesium chloride ( $\text{CsCl}$ , 99.5%) were purchased from Aladdin. Magnesium bromide hexahydrate ( $\text{MgBr}_2 \cdot 6\text{H}_2\text{O}$ , 98+%), calcium bromide hydrate ( $\text{CaBr}_2 \cdot x\text{H}_2\text{O}$ , 95%), strontium bromide hexahydrate ( $\text{SrBr}_2 \cdot 6\text{H}_2\text{O}$ , 95%), barium bromide dehydrate ( $\text{BaBr}_2 \cdot 2\text{H}_2\text{O}$ , 98+%), sodium bromide ( $\text{NaBr}$ , 99+%), potassium bromide ( $\text{KBr}$ , 99+%), rubidium bromide ( $\text{RbBr}$ , 99.8%), strontium chloride hexahydrate ( $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$ , tech) were purchased from Alfa Aesar. All chemicals were used without further purification.

**Preparation of  $\text{CsPbBr}_3$  NCs by metal halide high temperature melt crystallization.** Three raw materials were weighed and mixed thoroughly according to the molar ratio of  $\text{CsBr}:\text{PbBr}_2:\text{SrBr}_2 \cdot 6\text{H}_2\text{O} = 0.05:0.05:1$  (named as  $\text{Cs}:\text{Pb}:\text{Sr} = 0.05:0.05:1$ ). The calcining temperature for the sample was set as  $800\text{ }^\circ\text{C}$  at a heating rate of  $5\text{ }^\circ\text{C}/\text{min}$ , keeping 60 min on  $200\text{ }^\circ\text{C}$  and 10 min on  $800\text{ }^\circ\text{C}$ , respectively, subsequently cooling down to room temperature. The whole synthetic process performed under a nitrogen atmosphere.  $\text{CsPbBr}_3$  NCs embedded in  $\text{SrBr}_2$  matrixes (named as  $\text{CsPbBr}_3@\text{SrBr}_2$ ) were obtained through grinding calcined products at ambient conditions. The products for different molar ratios, temperatures, and time were taken the same procedure by changing the molar ratio, calcining temperature and time, respectively. For  $\text{CsPbCl}_3$  NCs were just exchanged bromide salts with corresponding chloride salts.

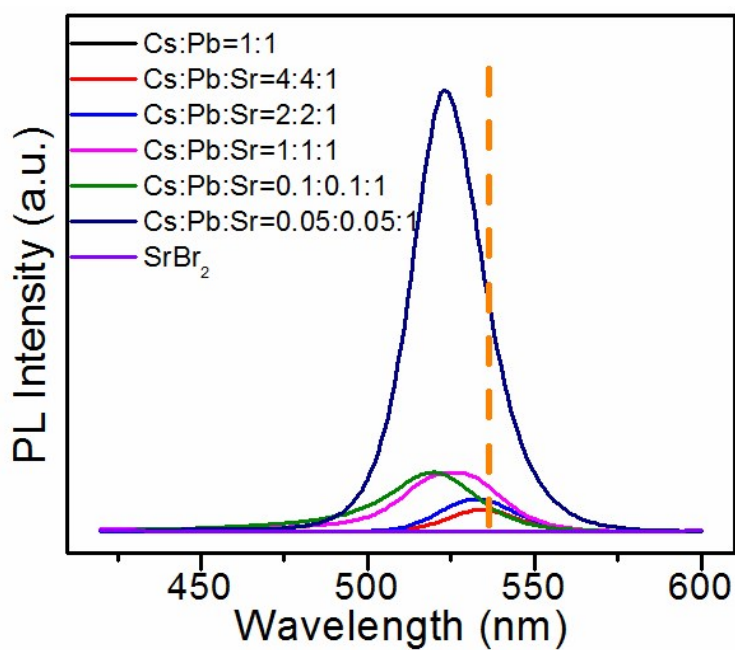
**Thermal Stability Test.** The  $\text{CsPbBr}_3@\text{SrBr}_2$  powders were added into a sample bottle; the  $\text{CsPbBr}_3$  NCs solution was dropped into a sample bottle to form a film. Then, they were put into an oven with  $100\text{ }^\circ\text{C}$  for the thermal stability test, and the photoluminescence (PL) spectra at different time intervals were recorded by using an ocean optical fluorescence spectrometer after the bottles were taken from the oven and cooled down. (The caps were tightened when the bottles taken from the oven.) For data processing, the integral area of PL for the original sample was set as the standard, and the integral areas of PL at different time intervals were compared with that of the original sample; then, the remnant PLQY of these samples were obtained.

**Characterization.** The UV-vis absorption spectra were recorded on the Lambda 950 UV-vis-NIR spectrophotometer. PL spectra were recorded by Hitachi F-7000 fluorescence spectrometer. X-ray powder diffraction (XRD) patterns were detected by the BrukerD8 Advance X-ray Diffractometer at 40 kV and 30 mA using  $\text{Cu K}_\alpha$  radiation ( $\lambda=1.5406\text{ \AA}$ ). The scanning electron

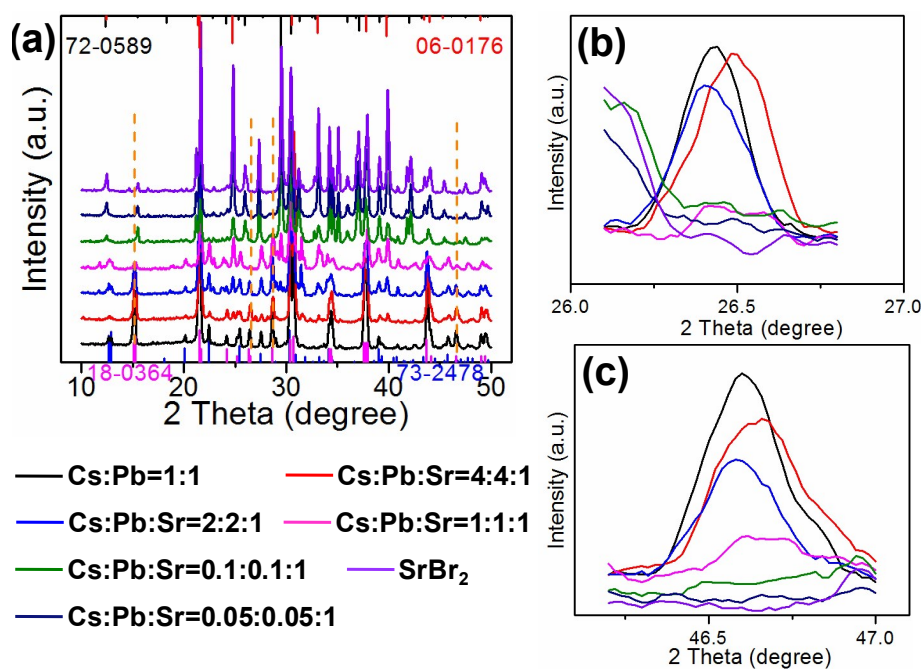
microscope (SEM) images were obtained from the JEOL JSM-7800F field emission scanning electron microscope. The high-resolution transmission electron microscope (HR-TEM) and high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) images were obtained from the FEI Talos F200X TEM instruments operated at an accelerating voltage of 200 kV. The absolute photoluminescence quantum yields (PLQY) were measured using an Edinburgh Instruments FLS1000 fluorescence spectrometer with an integrating sphere, exciting the powders at 450 nm. Thermogravimetric analysis-differential scanning calorimetry (TGA-DSC) was conducted on a Mettler Toledo analyzer from 30 to 800 °C at a heating rate of 5 °C/min, keeping 60 min on 200 °C and 10 min on 800 °C, respectively, subsequently cooling down to 30 °C at a rate of 5 °C/min, and all test was performed under a nitrogen atmosphere with a flow rate of 30 mL/min.



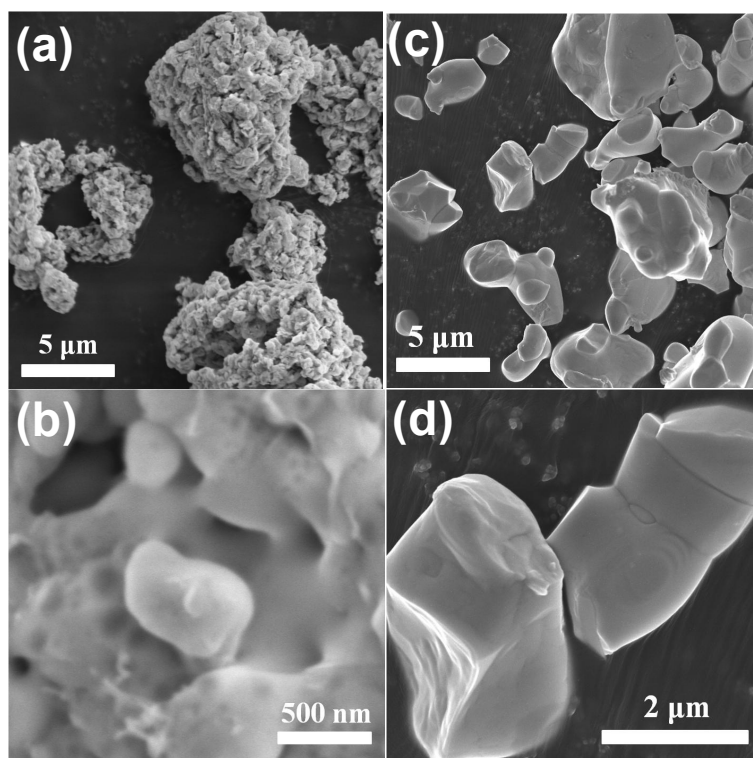
**Figure. S1** The FWHM and the PL peaks position of different molar ratios of CsBr:PbBr<sub>2</sub>:SrBr<sub>2</sub> samples calcined 10 min at 800 °C under a nitrogen atmosphere.



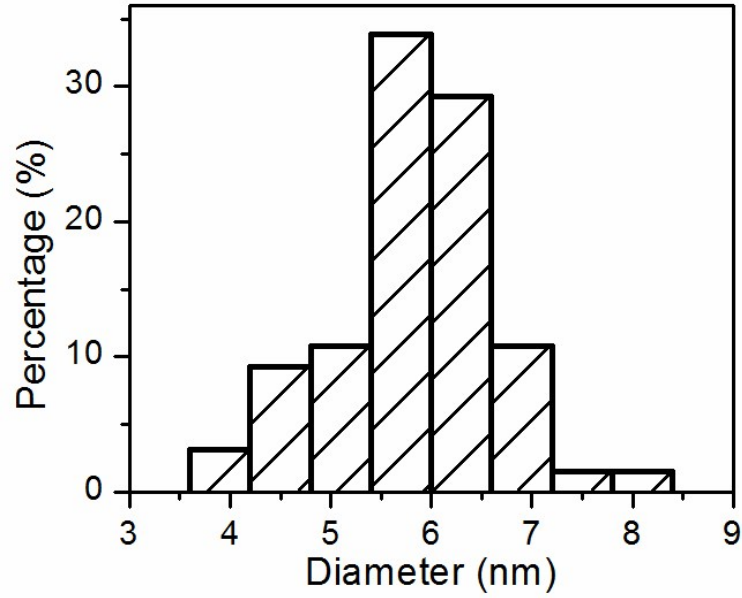
**Figure. S2** PL spectra with different molar ratios of CsBr:PbBr<sub>2</sub>:SrBr<sub>2</sub> samples calcined 10 min at 800 °C under a nitrogen atmosphere.



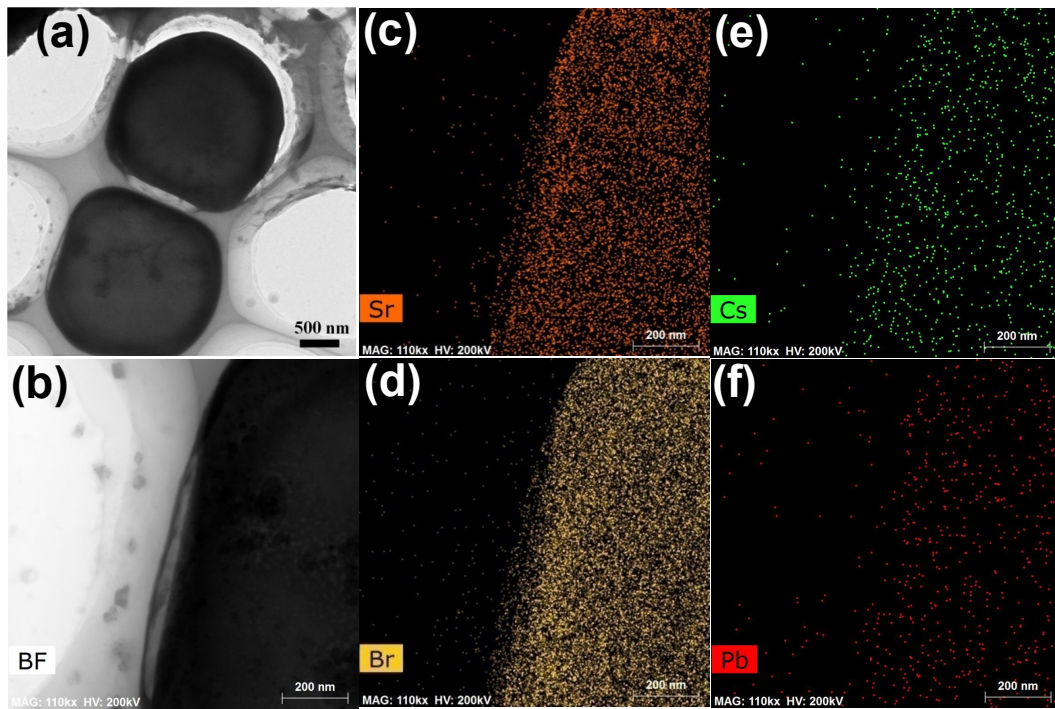
**Figure. S3** XRD patterns with different molar ratios of CsBr:PbBr<sub>2</sub>:SrBr<sub>2</sub> samples calcined 10 min at 800 °C under a nitrogen atmosphere (a) and the local enlarged CsPbBr<sub>3</sub> diffraction peaks (b,c).



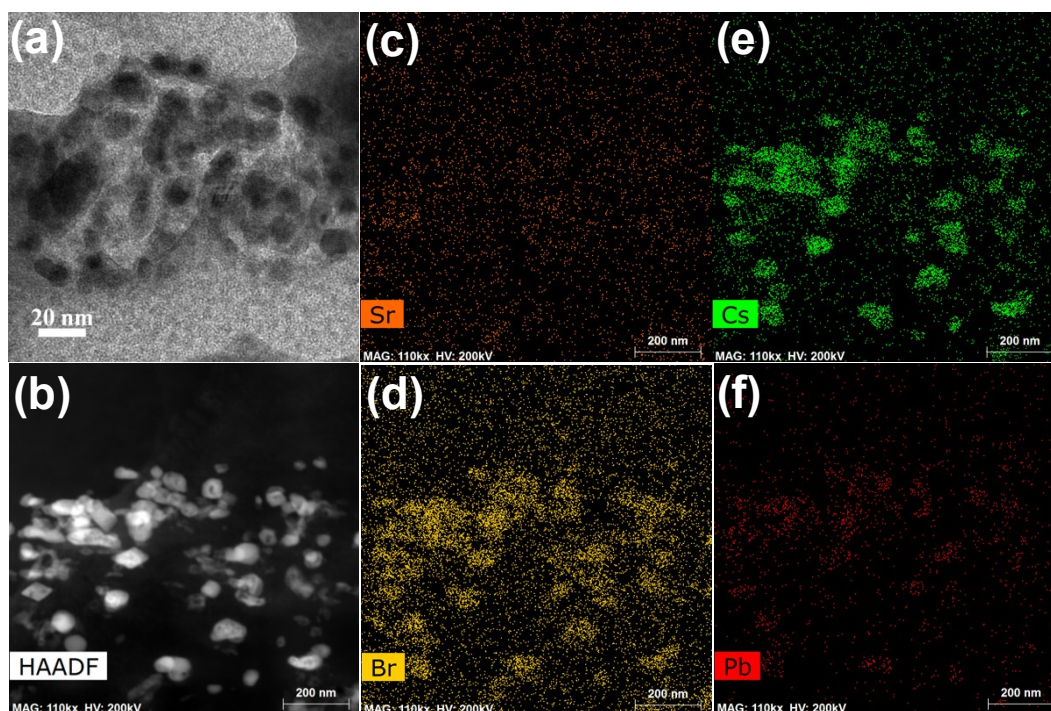
**Figure. S4** The SEM images of SrBr<sub>2</sub> (a,b), and CsBr:PbBr<sub>2</sub> = 1:1 (c,d) samples calcined 10 min at 800 °C under a nitrogen atmosphere.



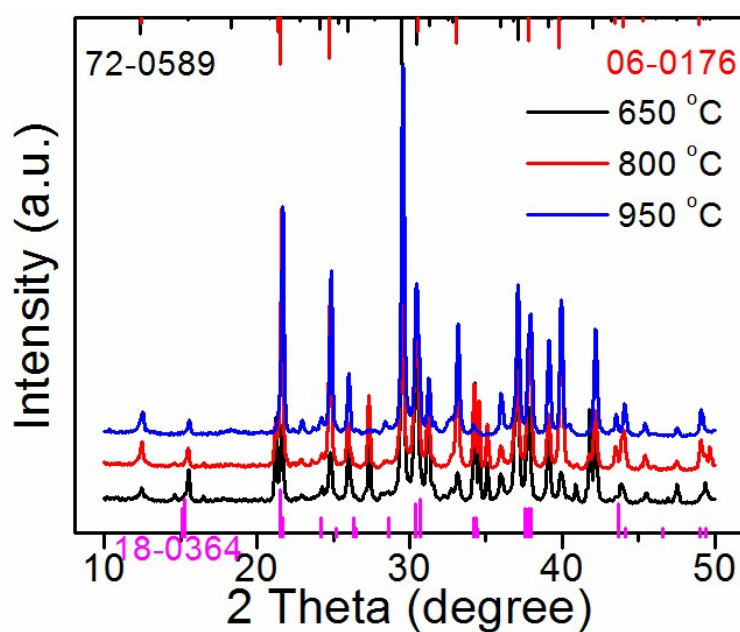
**Figure. S5** The size distributions of CsPbBr<sub>3</sub> NCs for CsBr:PbBr<sub>2</sub>:SrBr<sub>2</sub> = 0.05:0.05:1 sample calcined 10 min at 800 °C under a nitrogen atmosphere.



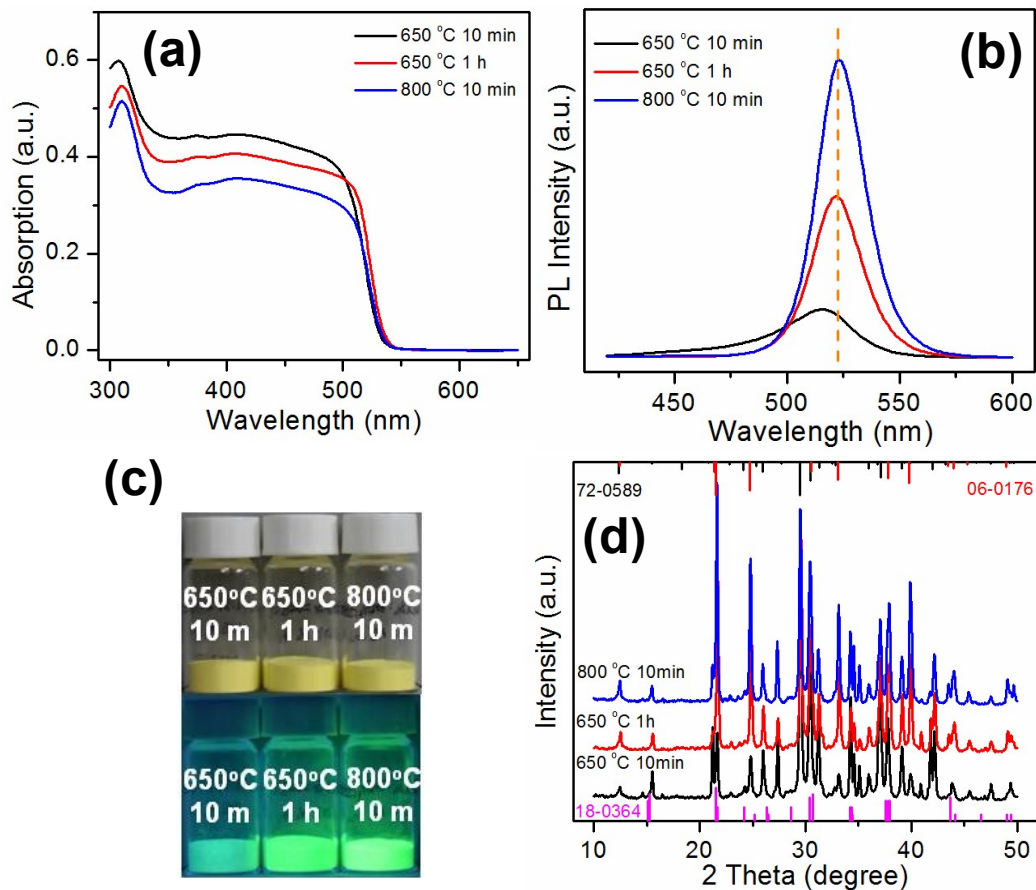
**Figure. S6** The TEM images of CsBr:PbBr<sub>2</sub>:SrBr<sub>2</sub> = 0.05:0.05:1 sample calcined 10 min at 800 °C under a nitrogen atmosphere (a,b), and the corresponding maps of (c) Sr, (d) Br, (e) Cs, and (f) Pb.



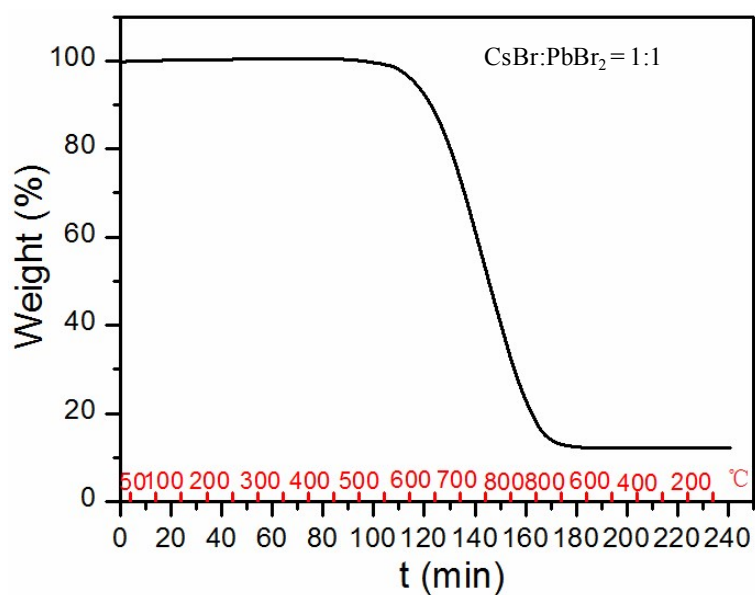
**Figure. S7** The TEM and HAADF images of CsBr:PbBr<sub>2</sub>:SrBr<sub>2</sub> = 0.05:0.05:1 sample calcined 10 min at 800 °C under a nitrogen atmosphere (a,b), and the corresponding maps of (c) Sr, (d) Br, (e) Cs, and (f) Pb. (The sample used for TEM was obtained by ultrathin section.)



**Figure S8** The XRD patterns of CsBr:PbBr<sub>2</sub>:SrBr<sub>2</sub> = 0.05:0.05:1 samples calcined 10 min at different temperatures under a nitrogen atmosphere.

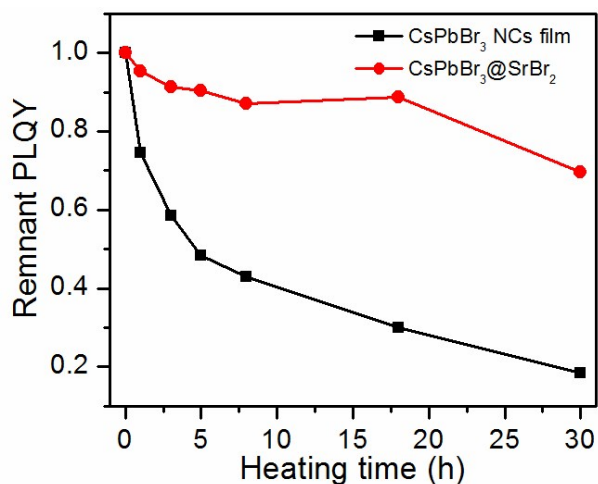


**Figure. S9** The absorption (a) and PL (b) spectra, photo images (c) under ambient light (top) and 365 nm lamp (bottom), and XRD patterns (d) of CsBr:PbBr<sub>2</sub>:SrBr<sub>2</sub> = 0.05:0.05:1 sample calcined for different time at different temperatures under a nitrogen atmosphere.

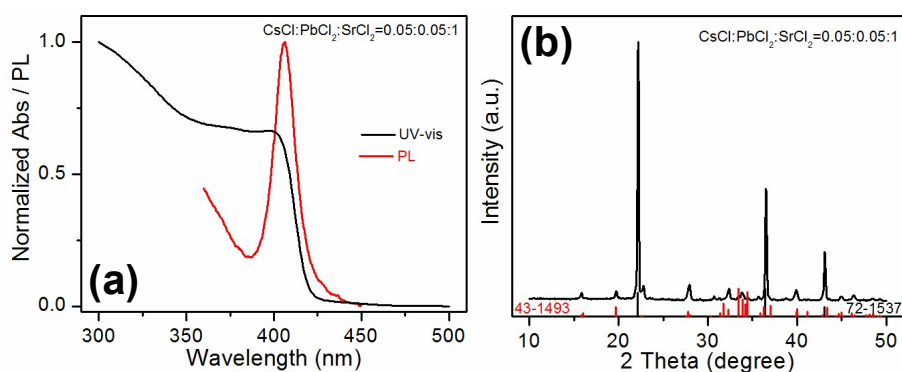


**Figure. S10** The TGA of CsBr:PbBr<sub>2</sub> = 1:1 sample.

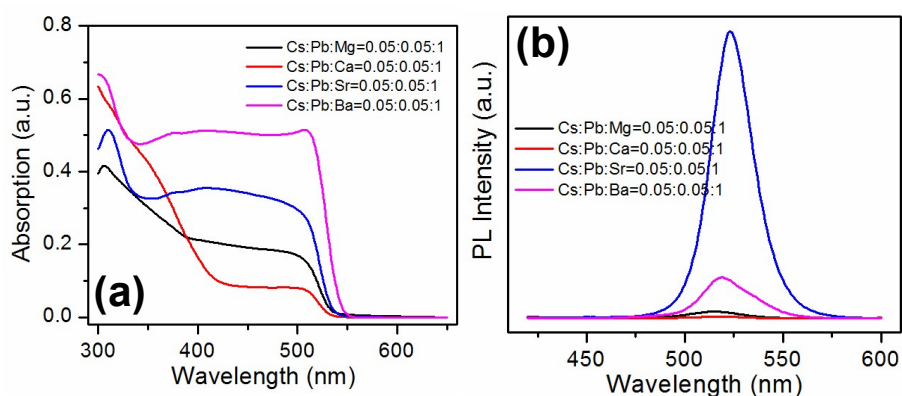




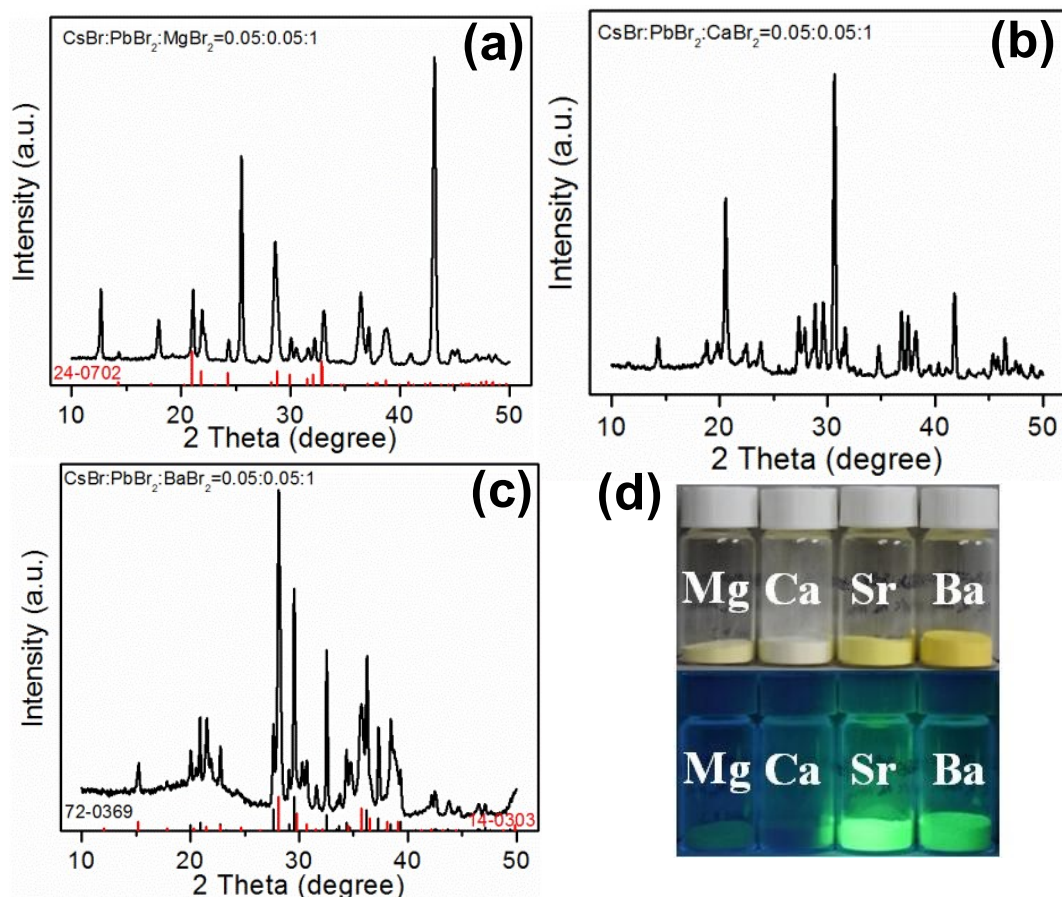
**Figure. S11** The thermal stability of CsPbBr<sub>3</sub>@SrBr<sub>2</sub> powders and CsPbBr<sub>3</sub> NCs film.



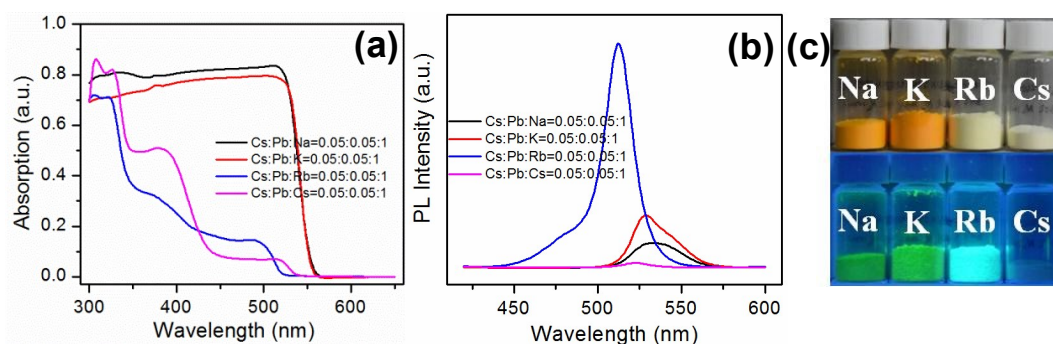
**Figure. S12** The absorption and PL spectra (a), and XRD patterns (b) of CsCl:PbCl<sub>2</sub>:SrCl<sub>2</sub> = 0.05:0.05:1 sample calcined 10 min at 800 °C under a nitrogen atmosphere. (red line: SrCl<sub>2</sub>·2H<sub>2</sub>O JCPDS 43-1493, black line: SrCl<sub>2</sub> JCPDS 72-1537)



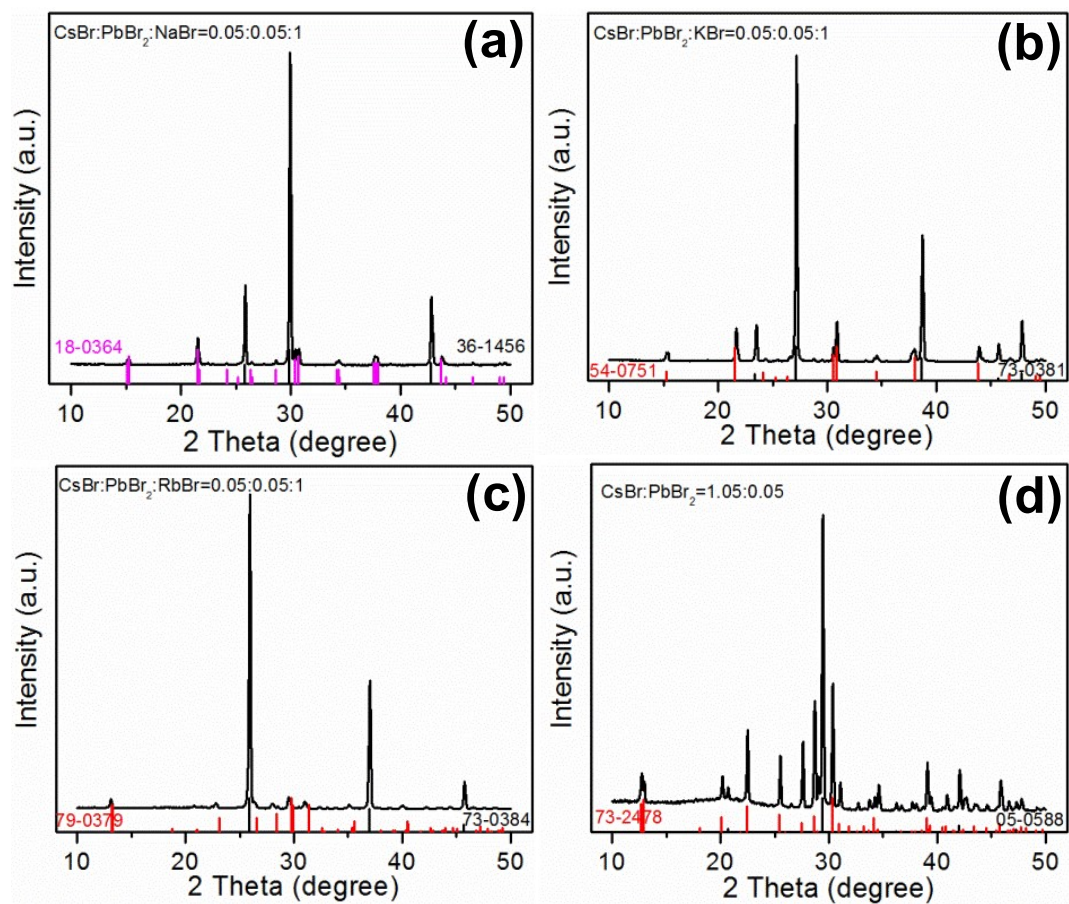
**Figure. S13** The absorption (a) and PL (b) spectra of CsBr:PbBr<sub>2</sub>:NBr<sub>2</sub> = 0.05:0.05:1 (N = Mg, Ca, Sr, and Ba) samples calcined 10 min at 800 °C under a nitrogen atmosphere.



**Figure. S14** The XRD patterns (a,b,c), and photo images (d) under ambient light (top) and 365 nm lamp (bottom) of CsBr:PbBr<sub>2</sub>:NBr<sub>2</sub> = 0.05:0.05:1 (N = Mg, Ca, Sr, and Ba) samples calcined 10 min at 800 °C under a nitrogen atmosphere.



**Fig. S15** The absorption (a) and PL (b) spectra, and photo images (c) under ambient light (top) and 365 nm lamp (bottom) of CsBr:PbBr<sub>2</sub>:MBr = 0.05:0.05:1 (M = Na, K, Rb, and Cs) samples calcined 10 min at 800 °C under a nitrogen atmosphere.



**Fig. S16** The XRD patterns of CsBr:PbBr<sub>2</sub>:MBr = 0.05:0.05:1 (M = Na, K, Rb, and Cs) samples calcined 10 min at 800 °C under a nitrogen atmosphere.