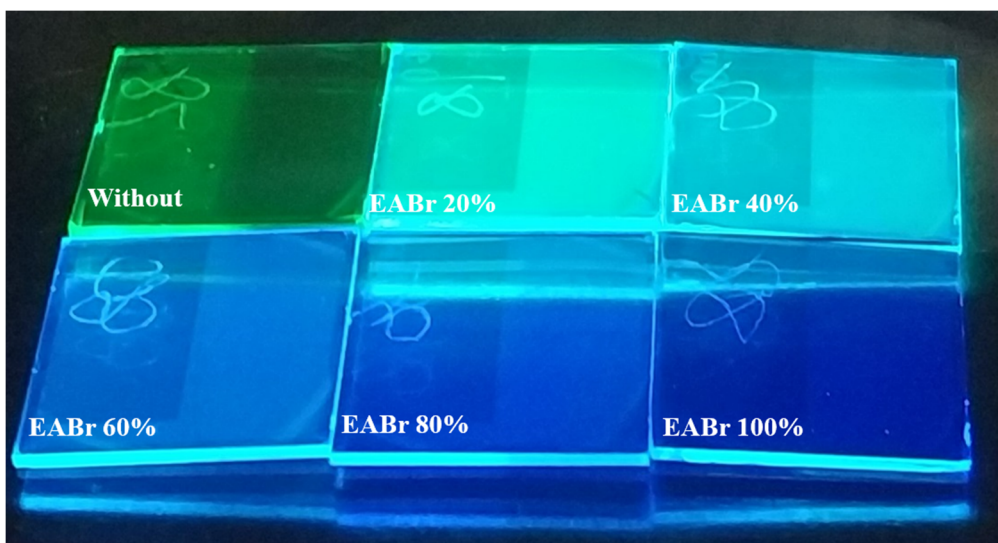


# Supplementary Information

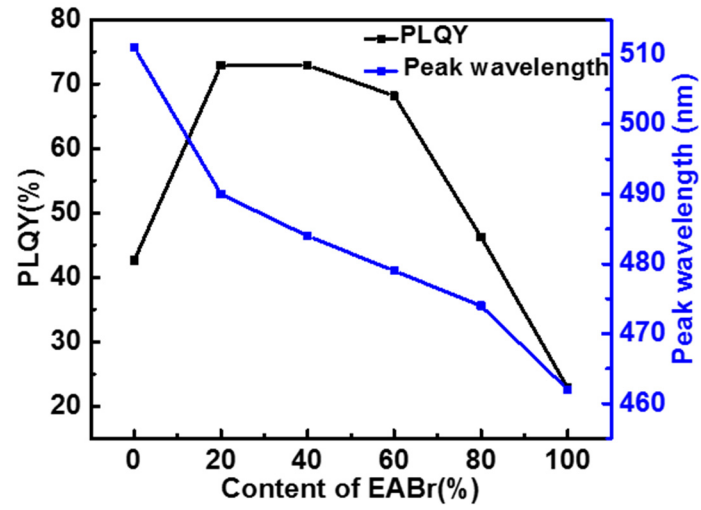
## Large cation ethylammonium incorporated perovskite for efficient and spectra stable blue light-emitting diodes

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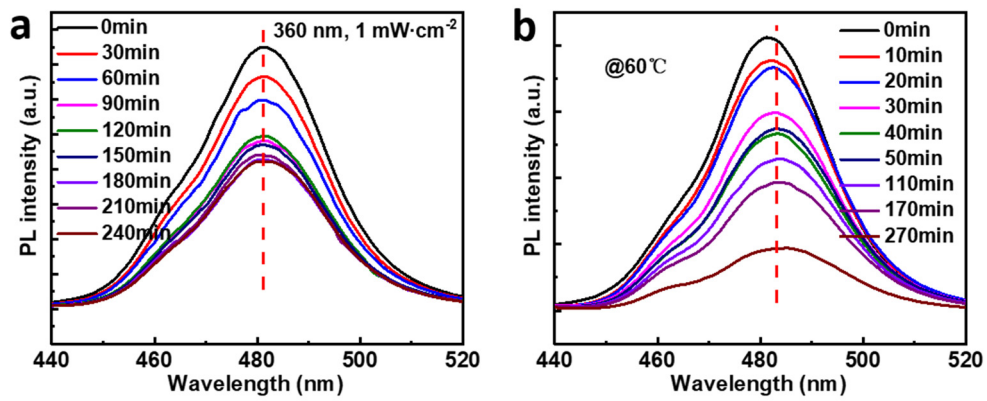
<sup>1</sup>Key Laboratory of Semiconductor Materials Science, Institute of Semiconductors, Chinese Academy of Sciences, Beijing, P. R. China. 100083, <sup>2</sup>Center of Materials Science and Optoelectronics Engineering, University of Chinese Academy of Sciences, Beijing, P. R. China. 100049. <sup>3</sup>State Key Lab Superlattices & Microstruct, Beijing 100083, Institute of Semiconductors, Chinese Academy of Sciences, Beijing, P. R. China. 100083. \*Corresponding author. E-mail: xwzhang@semi.ac.cn (X. Z.) or jyou@semi.ac.cn (J. Y.)



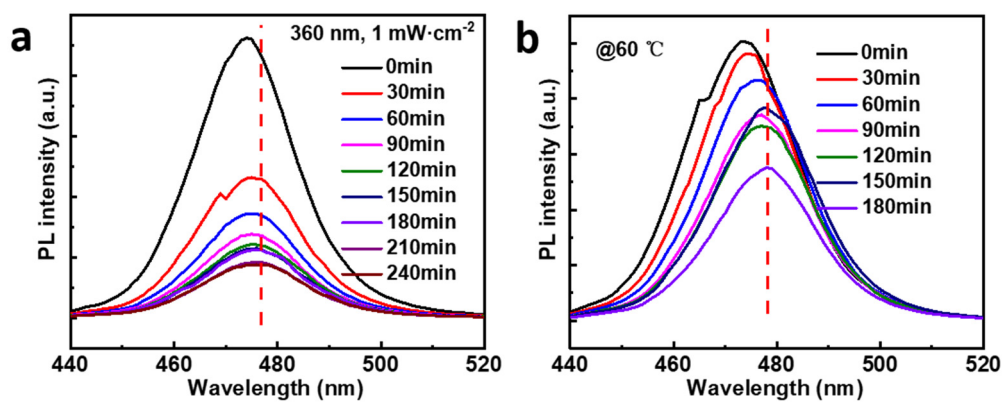
**Supplementary Figure 1** | The emission images of perovskite films with different ratios of EABr under ultraviolet excitation (365 nm).



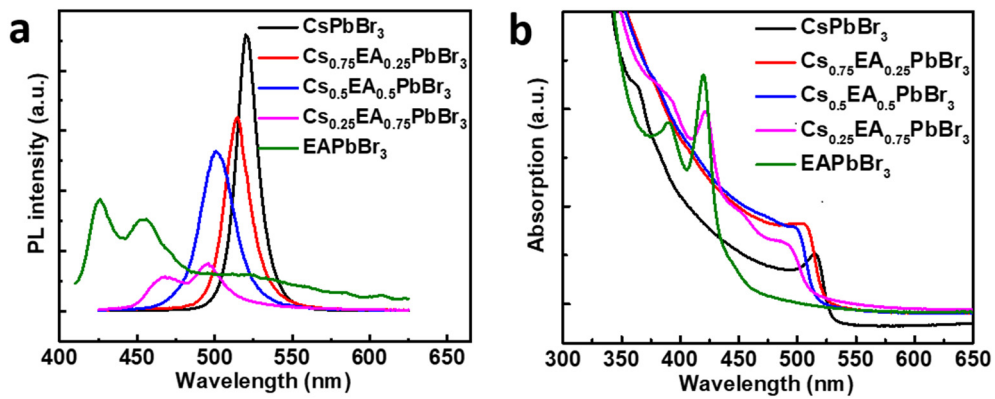
**Supplementary Figure 2** | The photoluminescence quantum yield (PLQY) and the emission peak wavelength of perovskite films with different ratios EABr.



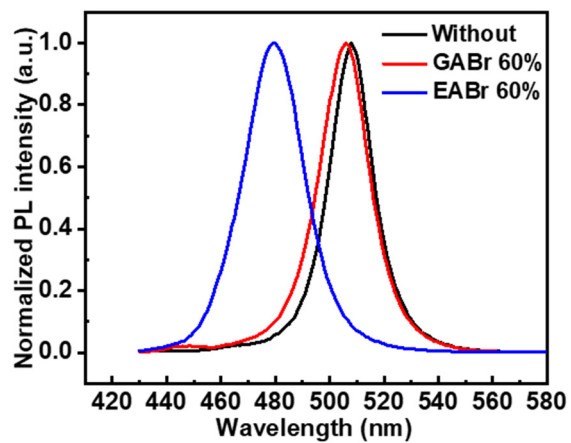
**Supplementary Figure 3** | The spectra stability of quasi-2D perovskite films with 60 % EABr. **a**, PL spectra of perovskite films under continuous UV radiation (360 nm, 1 mW · cm<sup>-2</sup>) for different exposure times. **b**, PL spectra of perovskite films after continuous thermal treatment (60 °C) for different times.



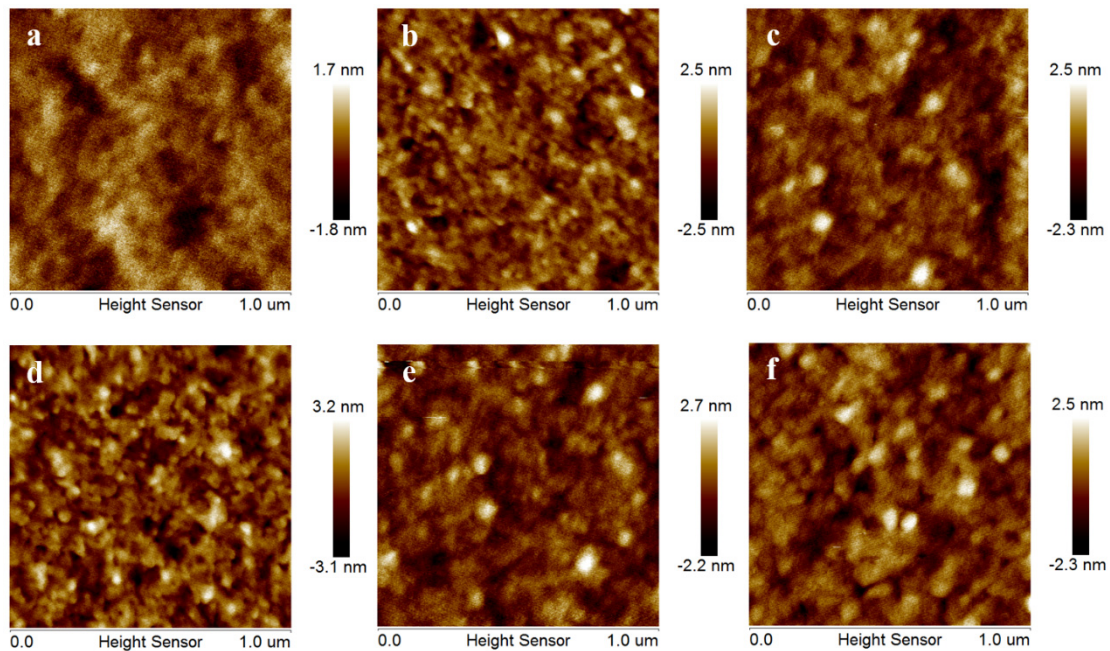
**Supplementary Figure 4** | The spectra stability of the  $\text{PEA}_2\text{PbBr}_4\text{CsPb}(\text{Br}_{0.1}\text{Cl}_{0.9})_3$  films. **a**, The PL spectral redshift from 474 nm to 477 nm under UV light soaking for 240 min. **b**, The PL spectral redshift from 474 nm to 478 nm after annealing at 60 °C for 180 min.



**Supplementary Figure 5** | Characteristics of  $\text{Cs}_{1-x}\text{EA}_x\text{PbBr}_3$  ( $x = 0, 0.25, 0.5, 0.75$  and 1) films. **a**, Steady-state PL spectra of  $\text{Cs}_{1-x}\text{EA}_x\text{PbBr}_3$  films. **b**, UV-vis absorption of  $\text{Cs}_{1-x}\text{EA}_x\text{PbBr}_3$  films.

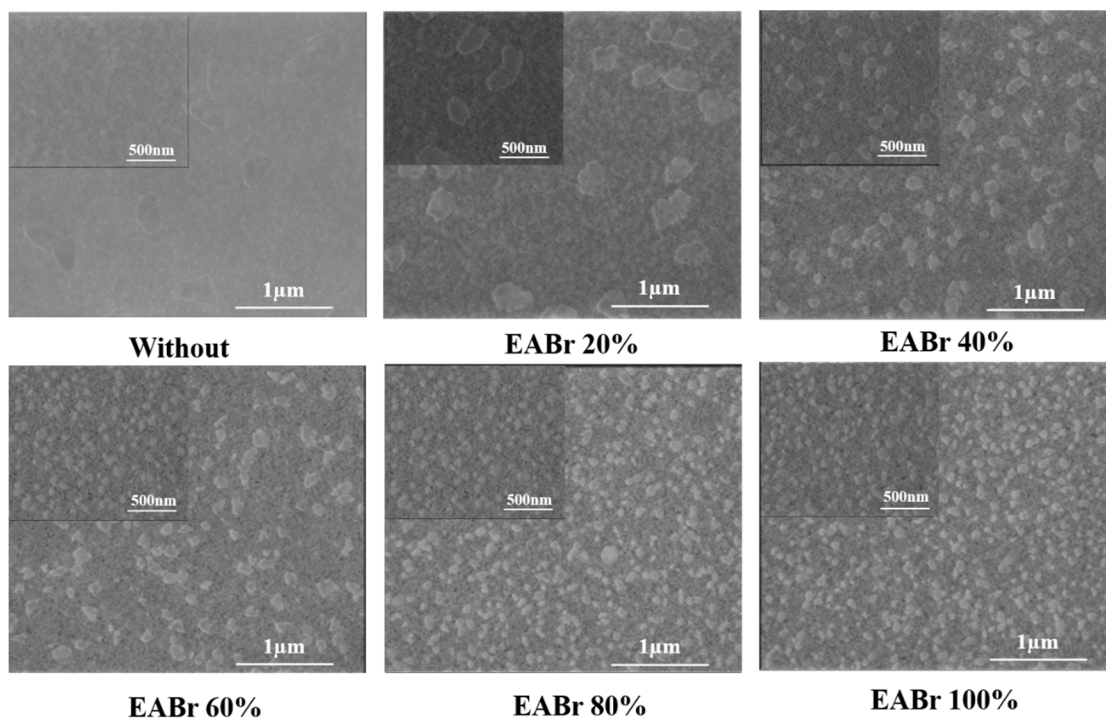


**Supplementary Figure 6** | The PL measurement of the quasi-2D perovskite film without or with 60% EABr or 60% GABr.

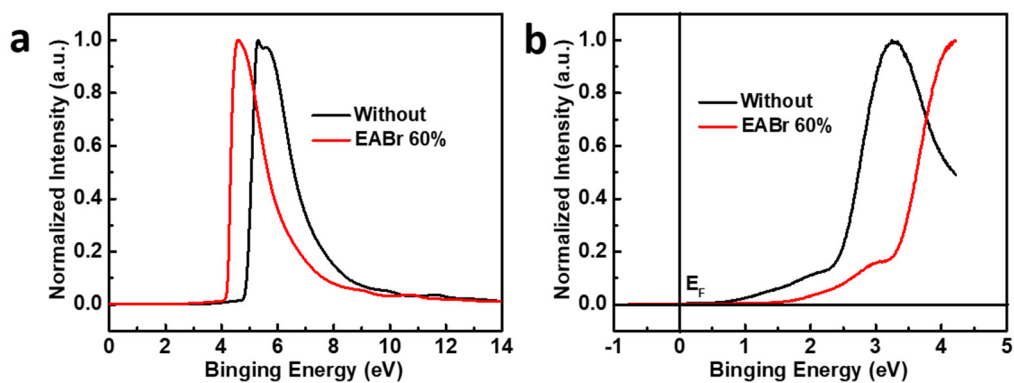


**Supplementary Figure 7** | The atomic force microscopy images of quasi-2D perovskite films with different ratio EABr. a, 0%. b, 20%. c, 40%. d, 60%. e, 80%. and f, 100%.

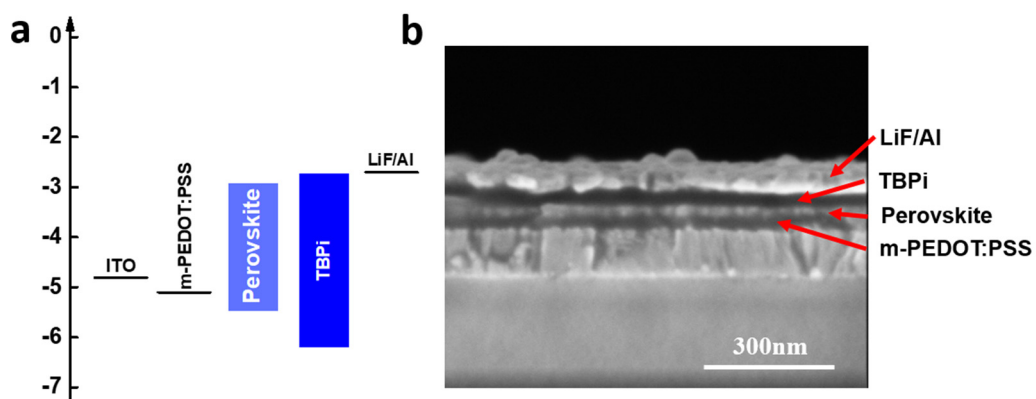




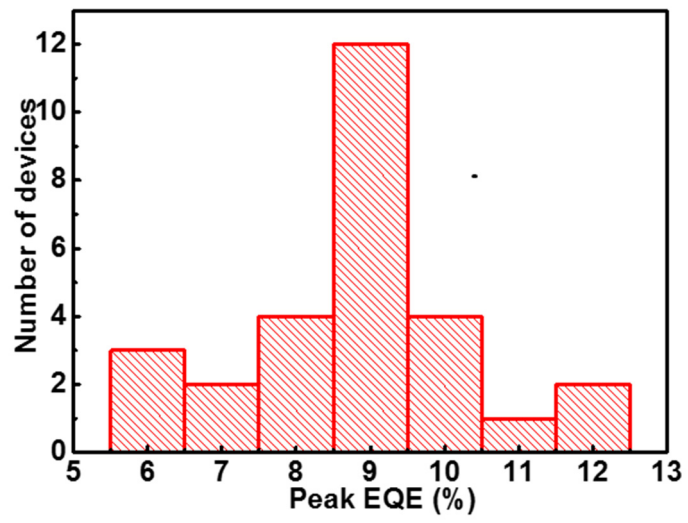
**Supplementary Figure 8** | The scanning electron microscopy of quasi-2D perovskite films with different ratios of EABr.



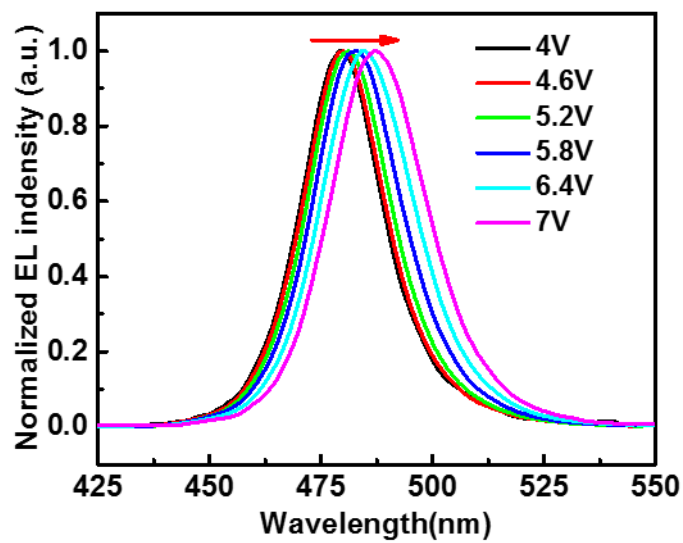
**Supplementary Figure 9** | Band structure properties of the perovskite films with varying amount of EABr (without and 60%). **a**, Ultraviolet photoelectron spectroscopy (UPS) cutoff edge of perovskite films. **b**, Valence band spectra of perovskite films from UPS measurements.



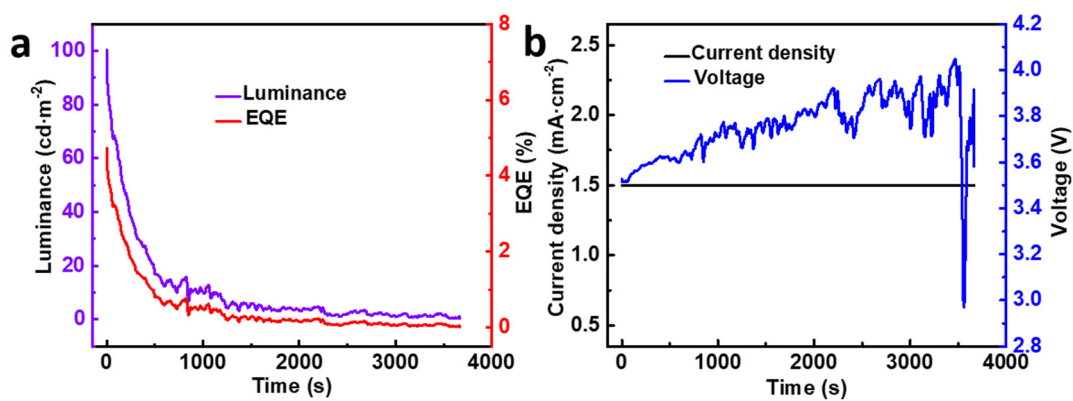
**Supplementary Figure 10** | The structure of the completed device. **a**, The band alignment diagram of the devices. **b**, The cross-section SEM image of the device.



**Supplementary Figure 11** | A histogram of peak EQEs from 28 devices.



**Supplementary Figure 12** | The electroluminescence spectra of mixed-halide perovskite ( $\text{PEA}_2\text{PbBr}_4 \cdot \text{CsPb}(\text{Br}_{0.1}\text{Cl}_{0.9})_3$ ) LEDs with increasing applied voltage.



**Supplementary Figure 13** | **a**, The stability of the PeLEDs without encapsulation under a constant injection current (1.5 mA·cm<sup>-2</sup>) in nitrogen filled glove box. **b**, The variation of input voltage with the operation time.

**Supplementary Table 1** | Summary of the emission properties of  $\text{PEA}_2(\text{EA}_x\text{Cs}_{1-x}\text{PbBr}_3)_2\text{PbBr}_4$  quasi-2D perovskite with different ratios of EABr.

<b>EABr ratio</b>	<b>PL peak (nm)</b>	<b>FWHM (nm)</b>	<b>QY (%)</b>
<b>0%</b>	508	22	42.64
<b>20%</b>	490	26	72.85
<b>40%</b>	488	26	72.90
<b>60%</b>	481	30	68.17
<b>80%</b>	473	30	46.26
<b>100%</b>	466	30	22.85