

Supplementary Information

Enhanced efficiency and stability of blue perovskite light-emitting diodes through dual defect passivation

Xiaoying Bi,^a Xiao Yang,^a Shuang Xu,^a Yunfang Tong,^a Xiaopeng Liang,^a Yang Nan,^a Lin Zhu,^a Nana Wang*^a and Jianpu Wang*^{a,b,c}

^a Key Laboratory of Flexible Electronics (KLOFE), Institute of Advanced Materials (IAM) & School of Flexible Electronics (Future Technologies), Nanjing Tech University (NanjingTech), 30 South Puzhu Road, Nanjing 211816, China

^b Strait Laboratory of Flexible Electronics (SLoFE), Fuzhou 350117, Fujian, China

^c Changzhou University, 21 Middle Gehu Road, Changzhou 213164, China.

Corresponding authors: iamjpwang@njtech.edu.cn; iamnnwang@njtech.edu.cn

Experimental section

Materials and Preparation. The precursor solutions of perovskites were prepared by dissolving PEGDA, TPPB, CsBr, PbBr₂ and PbCl₂ with a molar ratio of $x/0.075/1.5/0.37/0.63$ at a concentration of 10 wt.%. The post-treatment solutions were prepared by dissolving various concentration PEGDA in toluene.

Film and Device Fabrication. The perovskite films were spin-coated on PEDOT:PSS (Clevios P VP 4083) layer with a spin-coating speed of 6000 rpm, and then annealed at 130 °C for 15 min. The post-treatments were conducted through spin-coating PEGDA in toluene solutions on annealed perovskite films with a speed of 3000 rpm. Finally, the TPBi electron-transport layer, and the LiF/Al electrode were thermally evaporated, respectively.

Device Characterization. All devices were characterized through a system combining a fibre integration sphere (FOIS-1) coupled with a Keithley 2400 source meter and a QE-6500 spectrometer. The stability of devices was measured in a nitrogen-filled glovebox.

Film Characterization. The PL spectra were obtained by using a QE65 Pro spectrometer, with perovskite films excited by a 375 nm CW laser. The excitation-intensity-dependent PLQEs were obtained by a PLQE-LD CP001 system (Nanjing Ouyi Optoelectronics Technology). The in-situ PL spectra were measured by an ISPL-HI001 system (Nanjing Ouyi Optoelectronics Technology). The perovskite films were excited by a 375 nm CW laser and the PL spectra were collected by using a QE Pro spectrometer. Time-resolved photoluminescence spectra were measured by using an Edinburgh FLS980. The films were excited by a 375 nm pulsed laser with an intensity of 4 nJ cm⁻². XPS spectra were measured by a PHI5000 VersaProbe. FTIR spectra were recorded by using a Thermo Scientific Nicolet iS50. The samples were spin-coated on substrates and measured with a reflection accessory. The XRD data were obtained by a RIGAKU Smartlab 3kW X-ray diffractometer. The SEM measurements were performed by using a JEOL JSM-7610F plus scanning electron microscope.

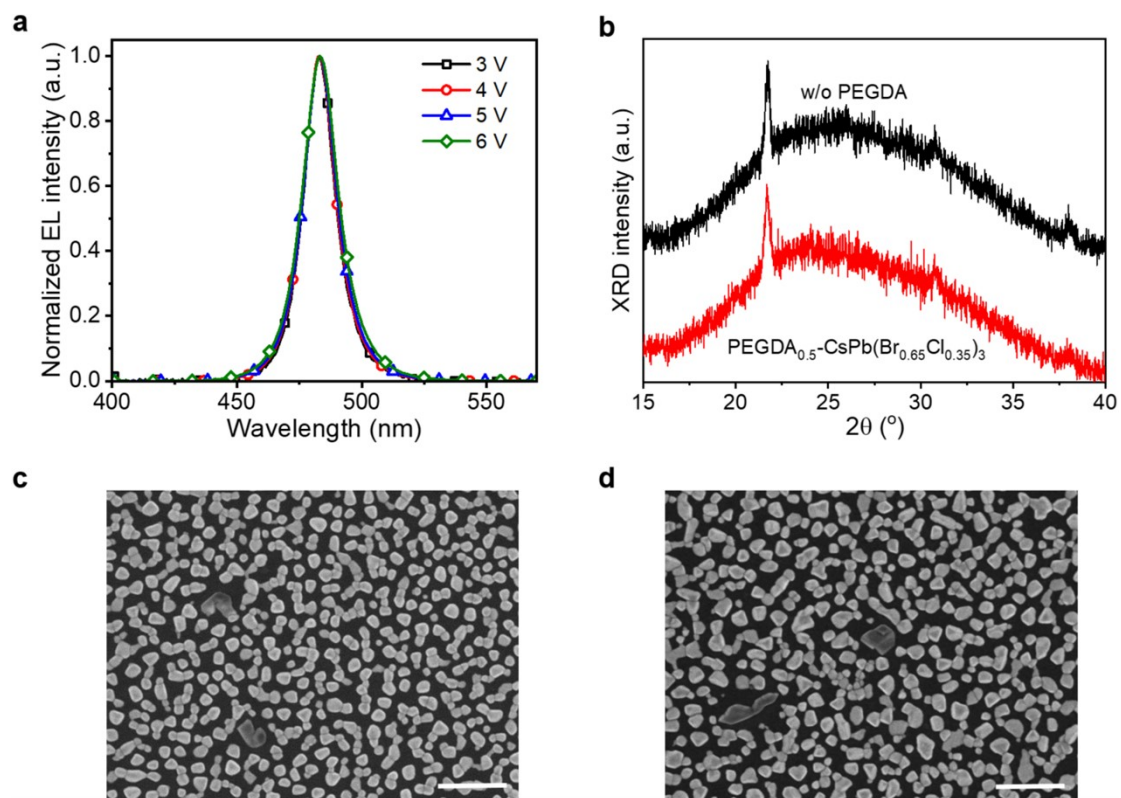


Fig. S1. Characteristics of perovskite films and devices with PEGDA additive. (a) EL spectra of PEGDA_{0.5}-CsPb(Br_{0.65}Cl_{0.35})₃ perovskite LED under various biases. (b) XRD data of perovskites without and with 0.5 mg mL⁻¹ PEGDA. (c-d) SEM images of perovskites without (c) and with 0.5 mg mL⁻¹ PEGDA (d). Scale bar, 1 μm.

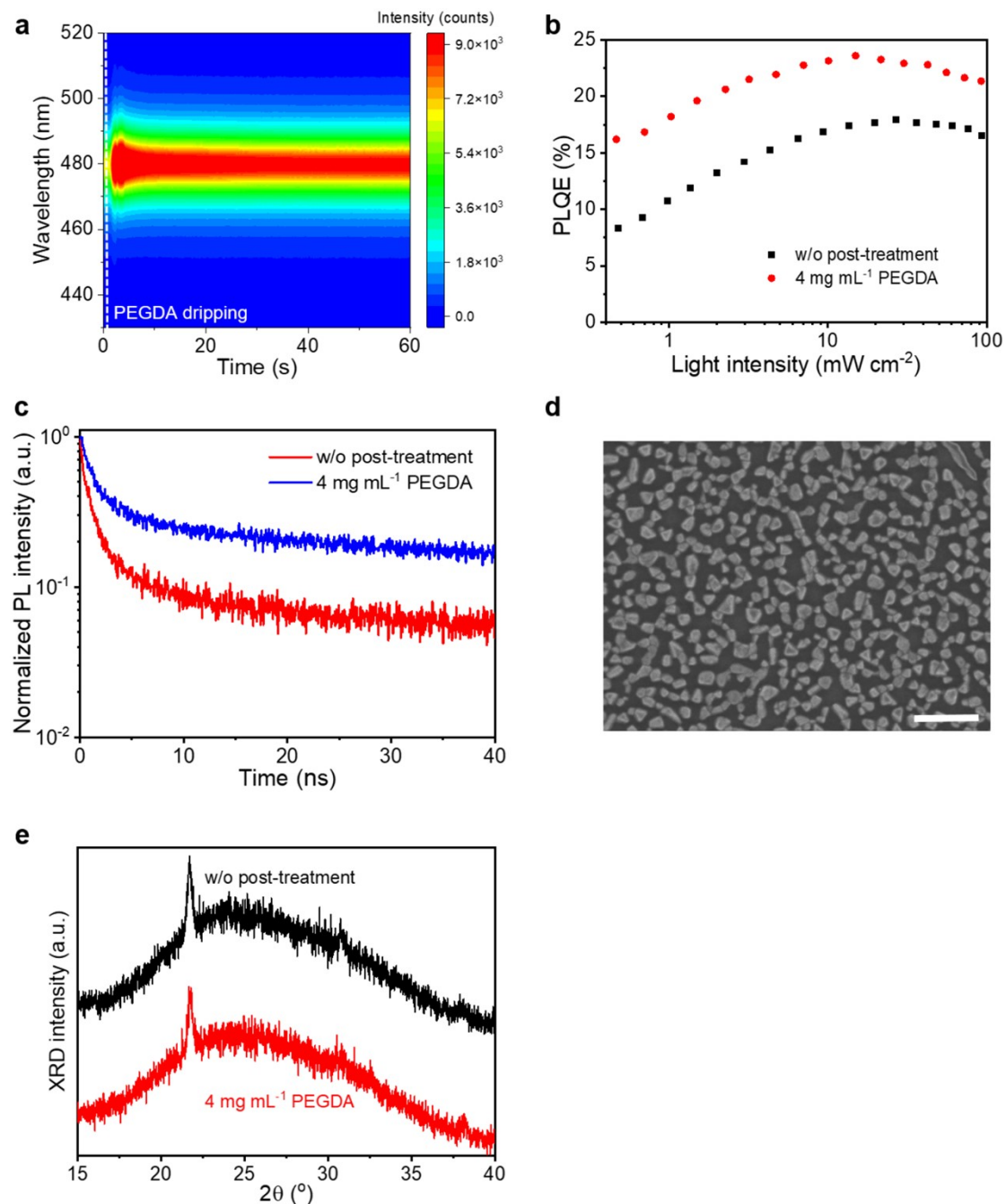


Fig. S2. Characteristics of perovskite films with PEGDA post-treatment. (a) Contour plot of in-situ PL spectra of perovskites with 4 mg mL⁻¹ PEGDA. (b) Excitation-intensity-dependent PLQEs of PEGDA_{0.5}-CsPb(Br_{0.65}Cl_{0.35})₃ films without and with 4 mg mL⁻¹ PEGDA. (c) Time-resolved PL decay transients of PEGDA_{0.5}-CsPb(Br_{0.65}Cl_{0.35})₃ films without and with 4 mg mL⁻¹ PEGDA. (d) SEM image of perovskite with 4 mg mL⁻¹ PEGDA. Scale bar, 1 μm . (e) XRD data of perovskites without and with 4 mg mL⁻¹ PEGDA.

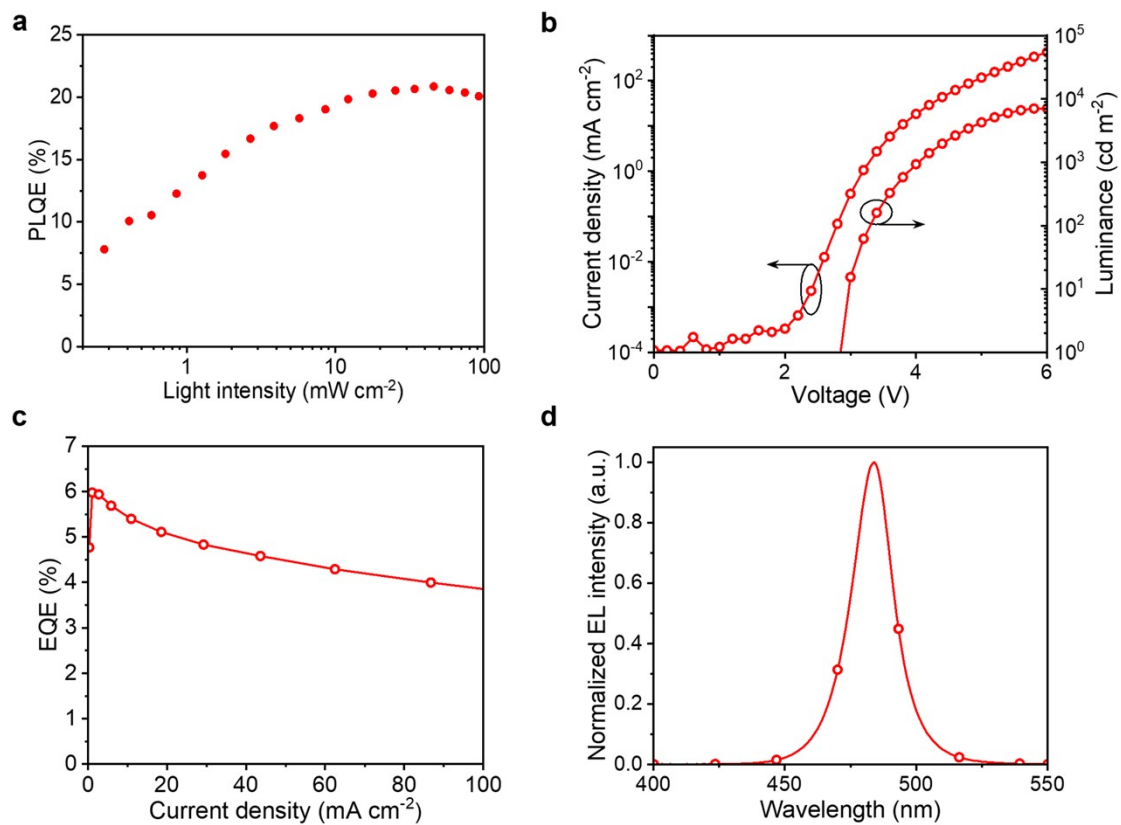


Fig. S3. Characteristics of the control CsPb(Br_{0.65}Cl_{0.35})₃ perovskite and LEDs with 4 mg mL⁻¹ PEGDA. (a) Excitation-intensity-dependent PLQEs. (b) Current density and luminance versus driving voltage. (c) Dependence of EQE versus current density. (d) EL spectra.

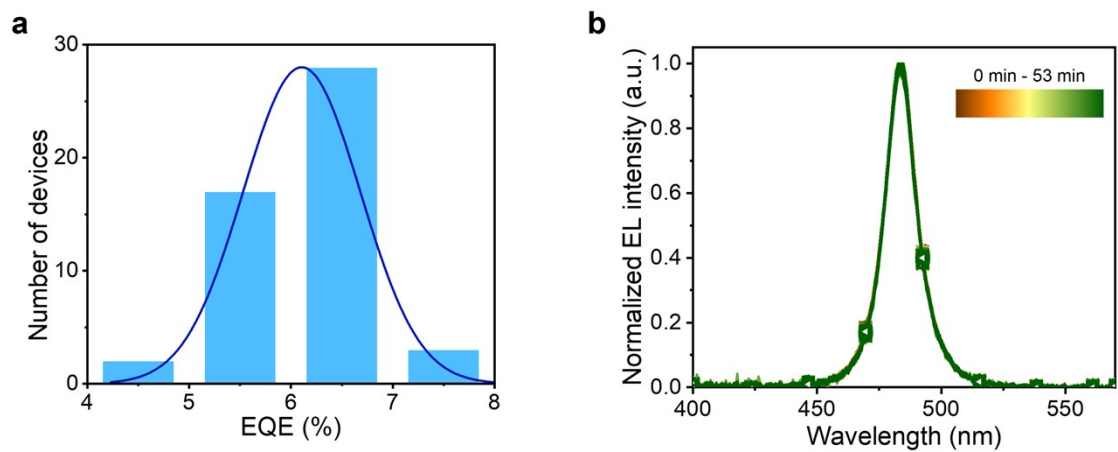


Fig. S4. Characteristics of devices based on $\text{PEGDA}_{0.5}\text{-CsPb}(\text{Br}_{0.65}\text{Cl}_{0.35})_3$ perovskite with 4 mg mL^{-1} PEGDA post-treatment. (a) Histogram of peak EQEs from 50 devices. (b) EL spectra of device under continuous measurement.