

Supplemental information

Blade-coated perovskite nanoplatelets polymer composite for sky-blue light emitting diodes

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Methods

Materials and Chemicals.

Cesium carbonate (Cs_2CO_3 , Aldrich, 99.9%), oleic acid (OA, Sigma-Aldrich, 90%), 1-octadecene (ODE, Sigma-Aldrich, 90%), oleylamine (OLA, Acros Organics, 80–90%), lead bromide (PbBr_2 , ABCR, 98%), mesitylene (Aldrich, 97%), diphyl (Dowtherm@A, eutectic mixture of 26.5% diphenyl +73.5% diphenyl oxide, Aldrich), ethanol (EtOH, Aldrich, $\geq 99.8\%$, GC), hydrochloric acid (HCl, Aldrich, $\geq 37\%$), hydroiodic acid (HI, Aldrich, 57%), toluene (Fischer Scientific, HPLC grade), hexane (Sigma-Aldrich, $\geq 95\%$), poly(methyl methacrylate). All materials were used without any further purification.

Preparation of Cs-Oleate.

Cs_2CO_3 (0.4075 g), OA (1.25 mL), and ODE (20 mL) were added into a 50 mL 3-neck flask, dried for 1 h at 120 °C. Since Cs-oleate precipitates out of ODE at room-temperature, it must be preheated to 100 °C before injection.

Synthesis of CsPbBr_3 NPLs.

For the synthesis of the NPLs 138 mg of PbBr_2 , 1 mL of dried OA, and 1 mL of dried OAm were loaded into a 25 mL 3-neck flask in the glovebox. Mesitylene (5 mL) was added to the reaction mixture, and the flask was connected to the Schlenk line. The entire system was flushed three times at room temperature by quickly changing from vacuum to N_2 and left on N_2 . The reaction mixture was heated up to 115 °C, and Cs-oleate (0.8 mL of a stock solution prepared as described above) was swiftly injected.^{1, 2} In the next second from the injection, the flask was immersed in an ice-water bath to stop the reaction. After the reaction, 1 mL of crude solution was centrifuged for 3 min at 5000 rpm. The resulted precipitate was dispersed in 1 mL toluene, centrifuged again for 10 min at a maximum speed of centrifuge (13400 rpm), and, after this, the supernatant was filtrated and used further for different experiments. The typical concentration of the 492 nm emissive NPLs was about 8–10 mg/mL. The fresh NPLs solution was concentrated under the vacuum until we get the desired concentration.³

Device fabrication.

The patterned ITO glasses were cleaned with soap, deionized water, acetone, and isopropanol for 15 min, separately. A PEDOT:PSS (AI 4083) solution was spin-coated on UV-treated (20 minutes) ITO substrate at 3000 rpm for 60 s, and the films were annealed at 140 °C for 20 min in air. The fresh NPLs solution were concentrate in vacuum and ready for blade coating. The height of the blade was 900 μm , the temperature of the blade table was 25 °C, and the speed of the blade was from 1 to 10mm/s, without further annealing. Then the samples were transferred into a vacuum chamber and TPBi (40 nm), LiF (1 nm), and Al (100 nm) were deposited by thermal evaporation.

Characterization of CsPbBr_3 NPLs and LED devices.

Absorbance. UV–vis absorption spectra were collected using a Jasco V670 spectrometer in transmission mode. Photoluminescence (PL). PL emission spectra from solutions were recorded by using Fluorolog iHR

320 Horiba Jobin Yvon spectrofluorimeter equipped with a PMT detector. The absolute value of the PLQY was measured at room temperature on a Quantaaurus QY (C11347-11, Hamamatsu) equipped with an integrating sphere. AFM surface morphologies were measured by Bruker Dimension Icon with ScanAsyst mode. The luminance-current-voltage (L- I-V) characteristics were measured simultaneously with a Keithley 2400 after the sample was placed on a calibrated integrating sphere kept in nitrogen atmosphere.

Time resolved measurements were performed exciting the samples with the second harmonic (400 nm) of a mode-locked Ti:sapphire laser (Coherent Mira 900), emitting at a repetition rate of 76 MHz. The laser beam was adjusted in size through an iris and then focused on the sample with a lens of 150 mm focal length. The PL emission from the sample was collected with an achromatic doublet to a monochromator with a 50 lines mm⁻¹ grating. A Hamamatsu C5680-24 picosecond streak camera, in synchroscan mode was utilized to detect the signal. A time resolution of 2 ps was evaluated before performing the measurements.

Supplementary data

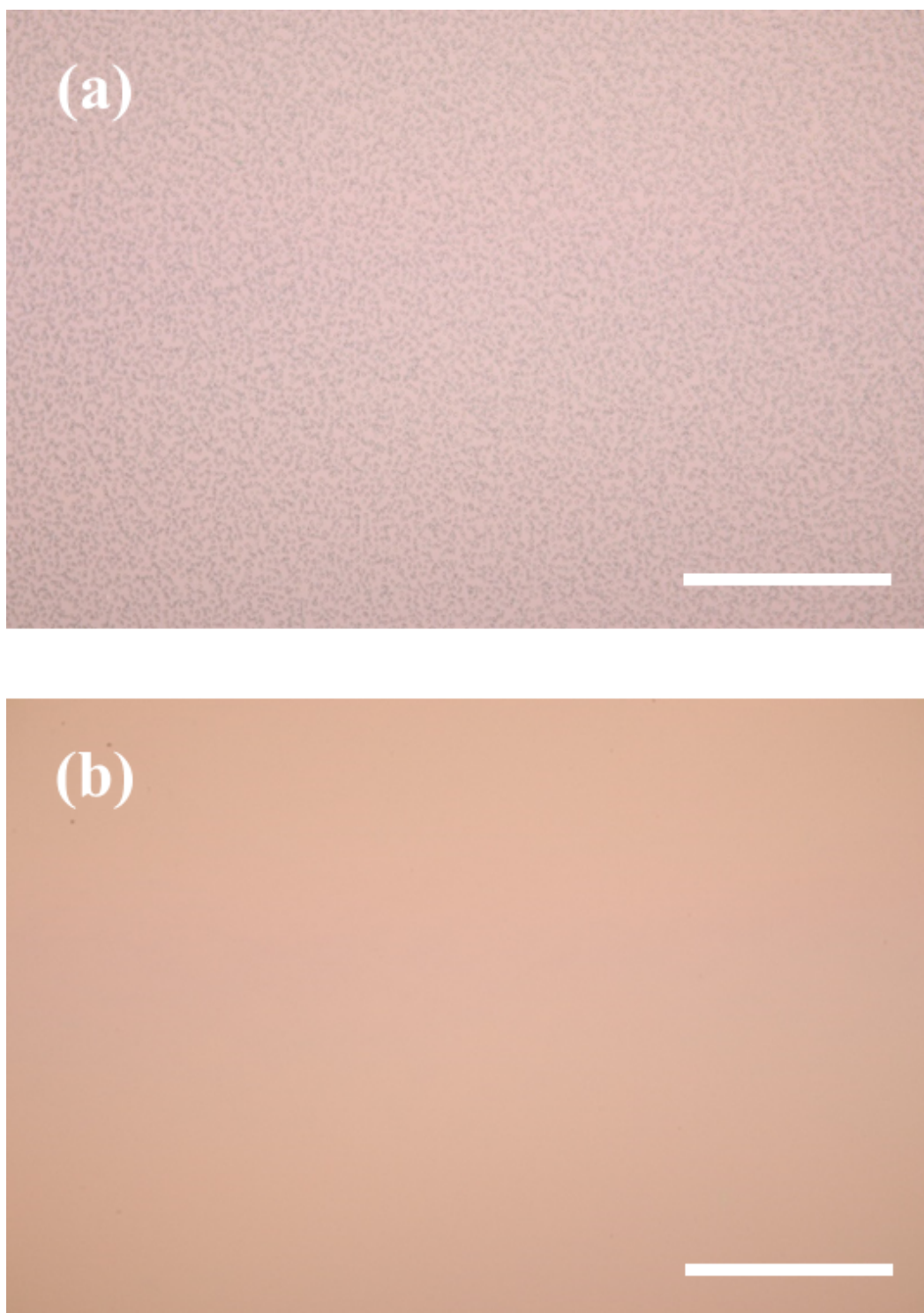


Figure S1. The optical micrograph of NPLs film. (a) for the films prepared with 5mg/ml solution and (b) for the films prepared with 10mg/ml solution. All white scale bars represent 1mm.

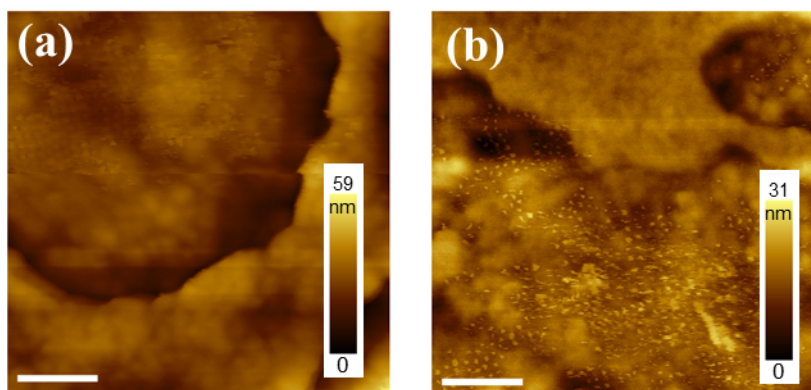


Figure S2. AFM surface morphologies of the blade-coated films with ratio of NPLs to Poly-TPD at 1:1.6. All white scale bars represent 500nm.

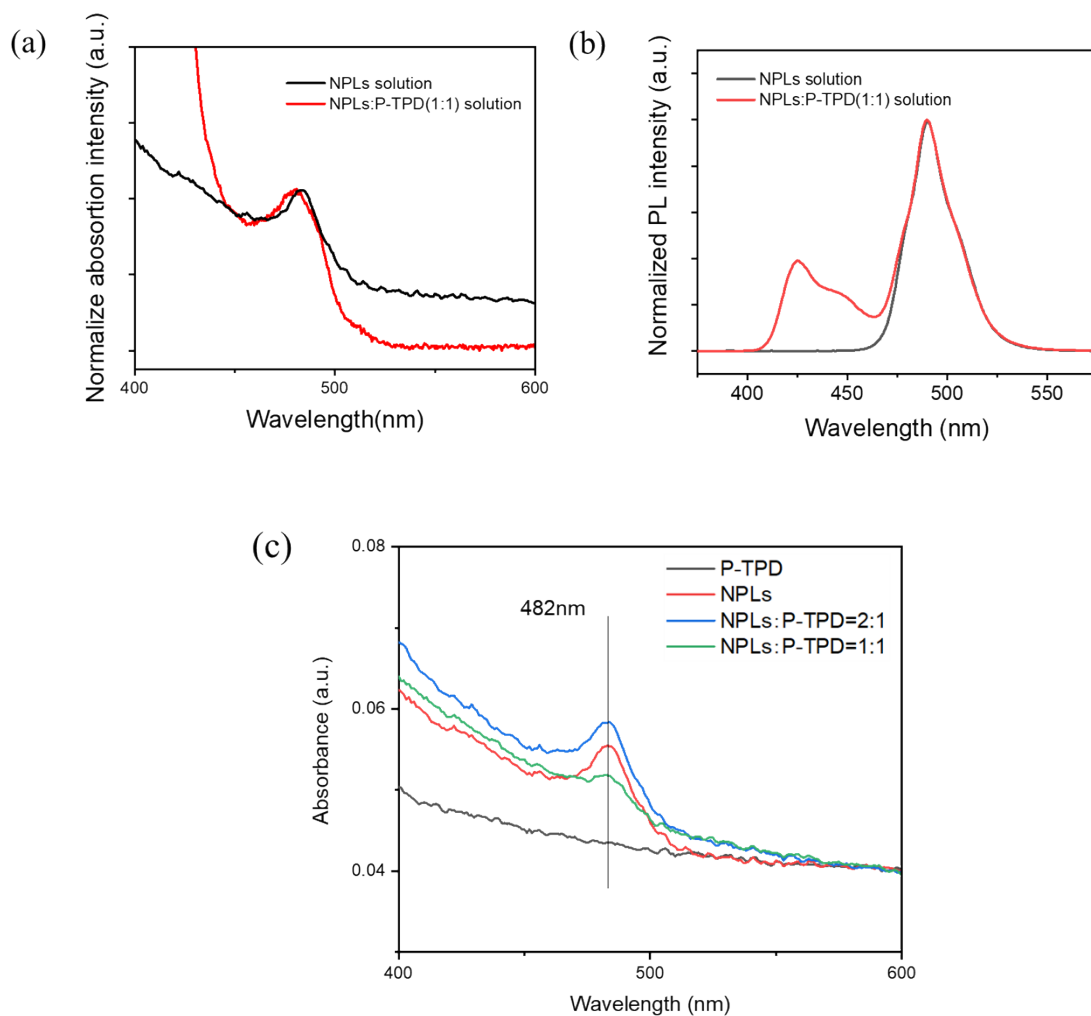


Figure S3. The (a) absorption and (b) PL spectra of CsPbBr₃ NPLs solution with/without P-TPD. (c) The absorption spectra of CsPbBr₃ NPLs film, P-TPD film and the corresponding composite film with ratio of 1:1 and 2:1.

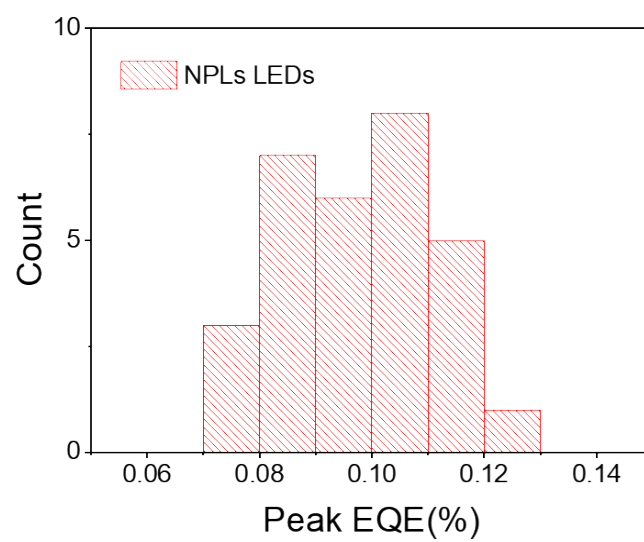


Figure S4. Peak EQE distribution of 30 tested devices.

References

1. F. Bertolotti, G. Nedelcu, A. Vivani, A. Cervellino, N. Masciocchi, A. Guagliardi and M. V. Kovalenko, *ACS Nano*, 2019, **13**, 14294-14307.
2. C. Otero-Martínez, J. Ye, J. Sung, I. Pastoriza-Santos, J. Pérez-Juste, Z. Xia, A. Rao, R. L. Z. Hoyer and L. Polavarapu, *Advanced Materials*, 2021, **n/a**, 2107105.