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Supplementary Information

Yongqiang Ji, Minqiang Wang*, Zhi Yang, Shangdong Ji, Hengwei Qiu

Electronic Materials Research Laboratory (EMRL), Key Laboratory of Education Ministry, International Center for Dielectric Research (ICDR), Shanxi Engineering Research Center of Advanced Energy Materials and Devices, School of Electronic and Information Engineering, Xi'an Jiaotong University, Xi'an 710049, China. E-mail: mqwang@xjtu.edu.cn

Experimental details

Materials.

The cesium carbonate (Cs_2CO_3, 99.99%), oleic acid (OA, 85%), oleyamine (OLA, 80-90%),1-octadecene (ODE, >90%), LiF (99.99%) were purchased from Aladdin. The lead(II) bromide ($PbBr_2$, 99.999%), Poly (3,4-ethylenedioxythiophene)/poly (styrenesulfonate) (PEDOT: PSS,4083), N, N'-Bis(3- methylphenyl)-N, N'-bis(phenyl)benzidine (poly-TPD), and 1,3,5-Tris(1-phenyl-1Hbenzimidazol-2-yl)benzene (TPBi) was purchased from Xi'an Polymer Light Technology Corp, and the n-hexane and ethyl acetate purchased from Shanghai Chemical Industrial Company. All the reagents were used without further purification.

Synthesis of $CsPbBr_3$ NCs of Diverse Shapes

All syntheses were performed in air and without any pre-dried chemicals or solvents. During the synthesis of Cs-OA, 0.4 g Cs_2CO_3 dissolved in 1.5 mL OA and 15 ml ODE in a 20 ml vial on a hotplate set to 100 °C. After the Cs_2CO_3 was completely dissolved, the vial was moved to a room temperature, and the solution was allowed to cool. The $PbBr_2$ (1 mmol) was dissolved in 10 mL ODE, OA (0.5 ml for $CsPbBr_3$ NWs, 1ml for $CsPbBr_3$ 1DSCs, 1 ml for $CsPbBr_3$ NSs) and OLA (1 ml for $CsPbBr_3$ NWs, 1 ml for $CsPbBr_3$ 1DSCs, 0.5 ml for $CsPbBr_3$ NSs) in a 30 mL vial on a hotplate set at 120 °C. After the Cs_2CO_3 was completely dissolved. 1 mL of Cs-OA was swiftly injected. After about 30 seconds the reaction turned turbid white, depending on the required thickness, was quickly cooled down after 0-300 s to RT with a cold water bath. In addition, PbI_2 (0.5 mmol) replaced $PbBr_2$ (0.5 mmol) to synthesize $CsPbBr_{1.5}I_{1.5}$ at 170. $PbCl_2$ (0.5 mmol) replaced $PbBr_2$ (0.5 mmol) to synthesize $CsPbBr_{1.5}Cl_{1.5}$ at 200℃. 1 ml TOP was added to dissolve $PbC1_2$.

Isolation and Purification

First, equal volume ethyl acetate was added to the crude solution of 1DSCs. The solutions were first centrifuged at 5000 rpm for 5 min to remove excess by-products. Then, the supernatant was discarded and the aggregated QDs were redispersed in toluene.

Device Fabrication

Patterned ITO coated glass was successively cleaned with soap, deionized water, ethanol, chloroform, acetone, and isopropanol and treated with UV and ozone for 10 min. A 40 nm PEDOT:PSS film was spin-coated onto ITO glass at 3000 rpm for 45 s and annealed in air at 120°C for 30 min. Then the substrate was transferred into a glovebox, and 40 nm poly-TPD (dissolved in chlorobenzene at a concentration of 10 mg/mL) was spin-coated onto the PEDOT:PSS film at a speed of 4000 rpm for 40 s and annealed at 110 °C for 30 min. The perovskite NCs (~15 mg mL-1) active layer was spin-cast from their colloidal solution at 2000 rpm for 45 s. TPBI (40 nm), LiF (1 nm), and Al (150 nm) layers were sequentially deposited by thermal evaporation in a vacuum deposition clamber (1×10^{-5}Torr). The Al cathode was deposited through a shadow mask defining device area of 2 mm×2 mm.

Measurement and characterization

The transmission electron microscopy (TEM) studies were carried out using JEOL JEM-2100 at 200 kV. The energy dispersive spectrometer (EDS) patterns were investigated by field emission scanning electron microscope (FESEM, FEI Quatan FEG 250) equipped with an energy dispersive spectrometer. X-ray photoelectron spectroscopy (XPS) spectra were measured by an X-ray photoelectron spectrometer (Thermo Fisher ESCALAB Xi+). The

photoluminescence (PL) spectra and fluorescence lifetimes were recorded on an Edinburgh Instruments FLS9 spectrometer. The ultraviolet-visible (UV-Vis) absorption spectra were recorded by PE Lambda 950. The x-ray diffraction (XRD) patterns were obtained using the DB-ADVANCE X-ray diffraction analyzer diffractometer. The particle size distribution studies were carried out using Zetasizer Nano ZSE.

Introduce and discuss some equations

There are three main equations corresponding to these reaction, Firstly, is a tri-exponential fitting function:

$$I = A_1\exp\left(-\frac{t}{\tau_1}\right) + A_2\exp\left(-\frac{t}{\tau_2}\right) + A_3\exp\left(-\frac{t}{\tau_3}\right) \quad \text{Equation 1}$$

Where A_1, A_2 and A_3 are constants, t is time, and τ_1, τ_2, τ_3 represent the decay lifetimes. The average lifetime (τ_{ave}) can be calculated as follows：

$$\tau_{ave} = \frac{A_1\tau_1^2 + A_2\tau_2^2 + A_3\tau_3^2}{A_1\tau_1 + A_2\tau_2 + A_3\tau_3} \quad \text{Equation 2}$$

Third, is a Gibbs-Thomson equation, which can written as

$$C_n = C_b exp(\frac{2\rho v_m}{rRT}) \quad \text{Equation 3}$$

In which C_n and C_b are the solubility of the nanoparticle and the corresponding bulk solid; σ is the specific surface energy; V_m is the molar volume of the material; R is the gas constant and T is the absolute temperature.

Introduce one tables

Table 1 Tri-exponential fitting parameters of time-resolved PL decay curves for 1DSCs at different reaction time.

	A_1(%)	τ_1(ns)	A_2(%)	τ_2(ns)	A_3(%)	τ_3 (ns)	τ_{avg}(ns)
10 seconds	1.54	1.2685	38.37	7.0920	60.08	24.3774	17.3866 ns
60 seconds	3.09	1.3896	20.48	7.3471	76.43	38.5696	31.0263 ns
300 seconds	3.19	1.5231	18.90	7.5081	77.91	40.0838	32.6969 ns

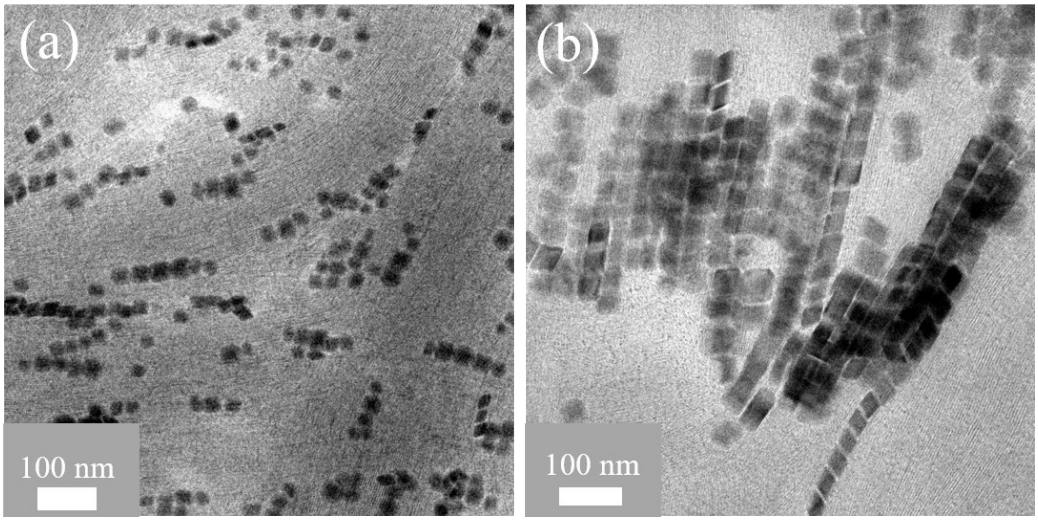

Fig. S1 TEM images of the self-assembled 1DSCs of (a) $CsPbCl_{1.5}Br_{1.5}$ and (b) $CsPbBr_{1.5}I_{1.5}$.

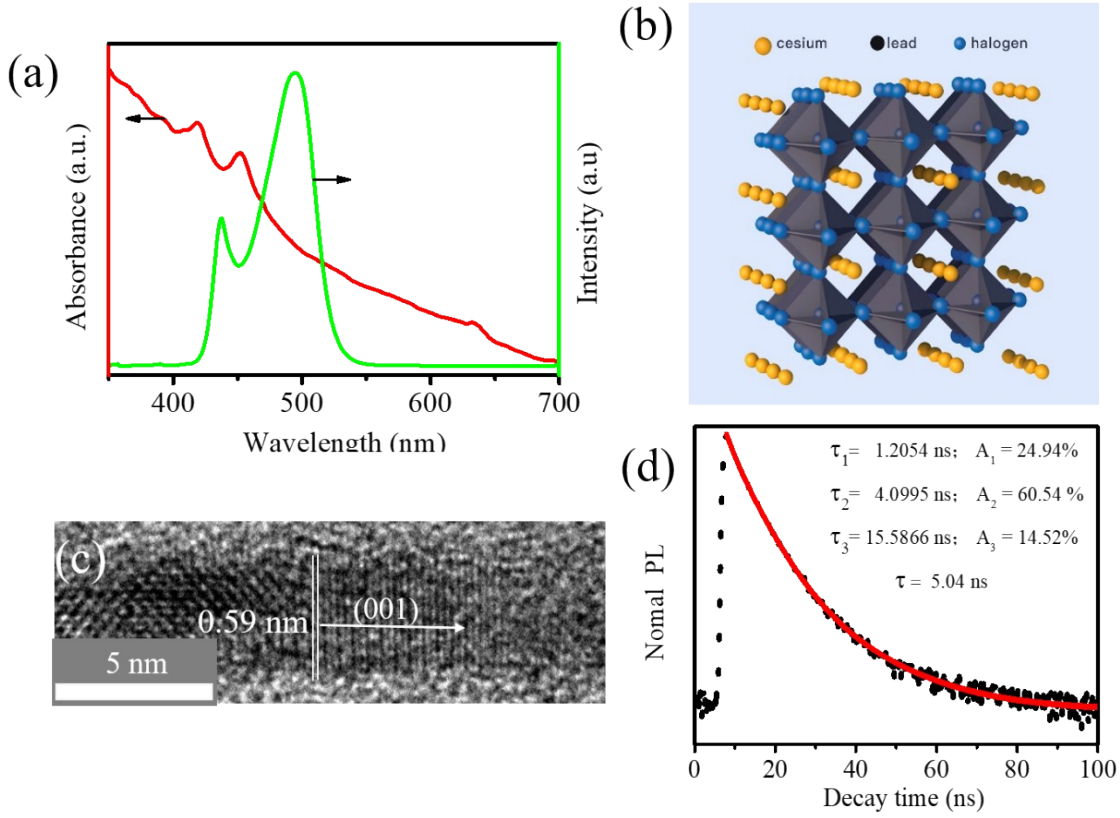

Figure S2 (a) UV-visible absorption (red line) and photoluminescence (green line) spectra of $CsPbBr_3$ NCs. The photoluminescence spectrum was collected at 365 nm excitation wavelength. (b) Crystal structure of cubic $CsPbBr_3$. (c) High-resolution TEM image of $CsPbBr_3$ NWs. (d) Time-resolved PL decay curves of $CsPbBr_3$ NCs.

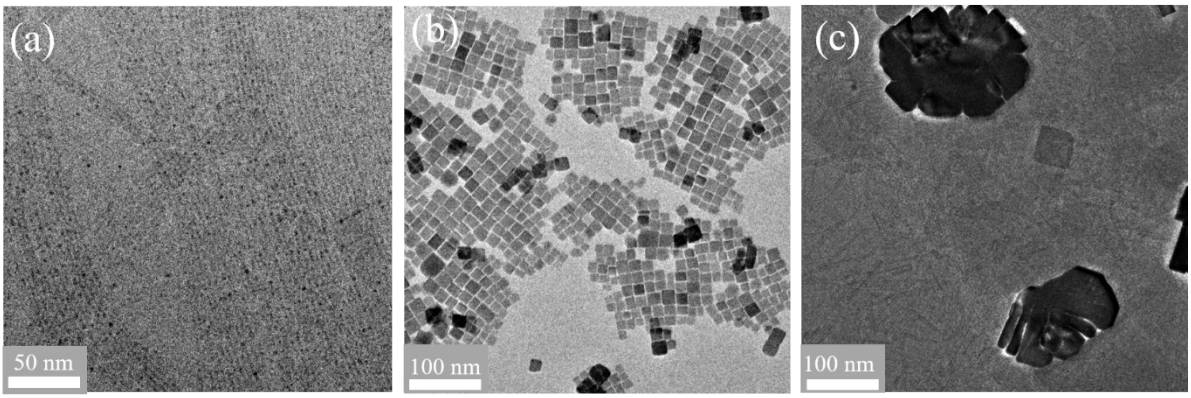

Figure S3 TEM images of $CsPbBr_3$ NCs: (a) NWs. (b) NSs. (c) Structure collapse of NWs and NSs.

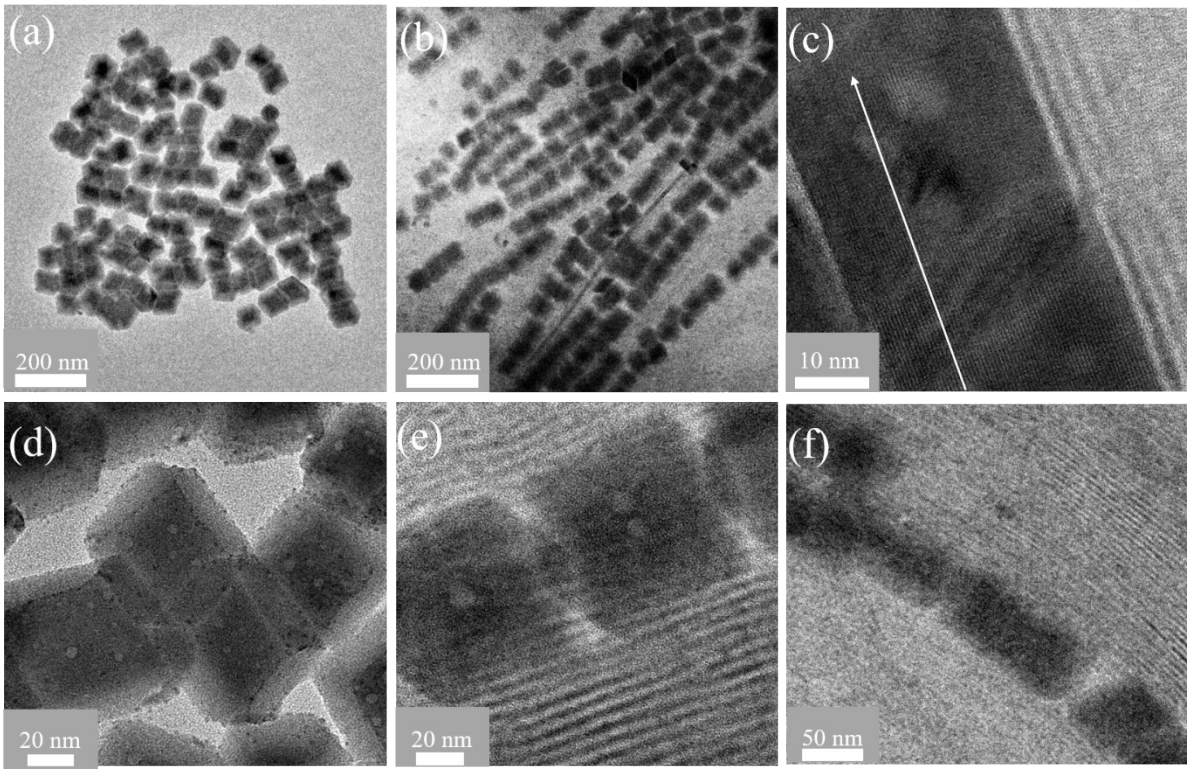

Figure S4 TEM images of randomly dispersed thick $CsPbBr_3$NSs: (a) Low resolution. (d) High resolution. TEM images of 1DSCs with the same orientation as the NWs: (b, e) c-1DSCs. (c) s-1DSCs. (f) bent 1DSCs.

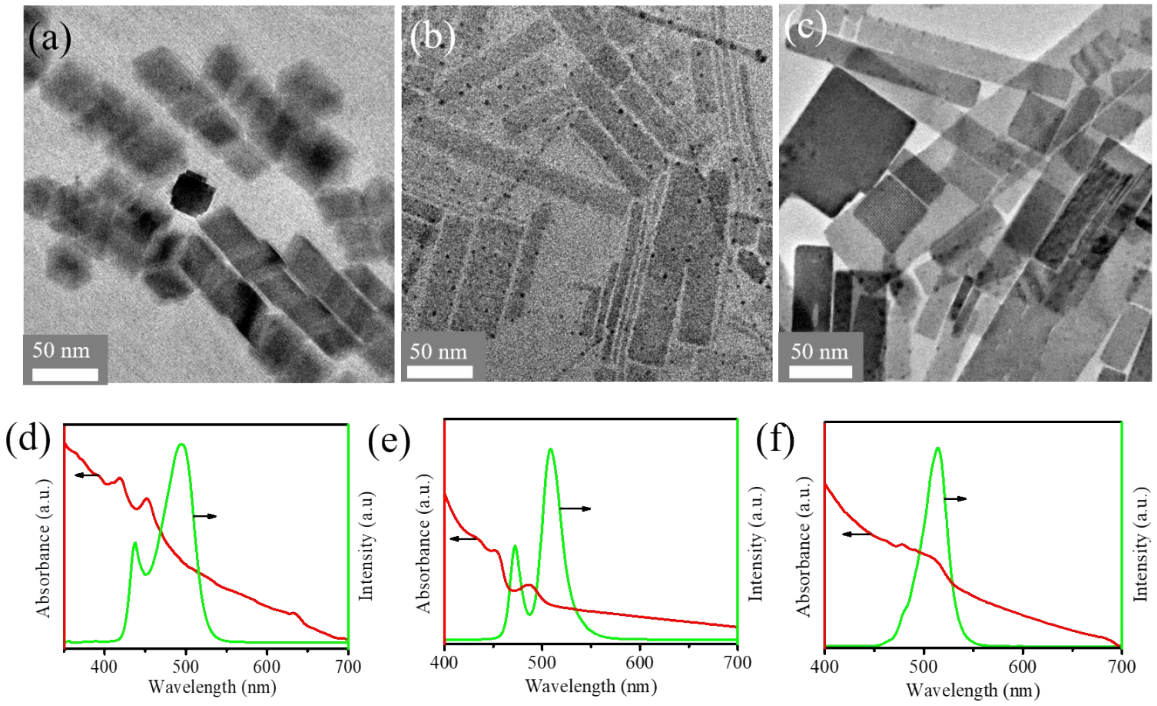

Figure S5 TEM images of CsPbBr3 1DSCs；(a) initial 1DSCs. (b) Ethanol-treated 1DSCs within 5 min. (c) Ethanol-treated 1DSCs within 1 hours. UV-visible absorption (red line) and photoluminescence (green line) spectra of $CsPbBr_3$ NCs: (d) initial 1DSCs. (e) Ethanol-treated 1DSCs within 5 min. (f) Ethanol-treated 1DSCs within 1 hours.

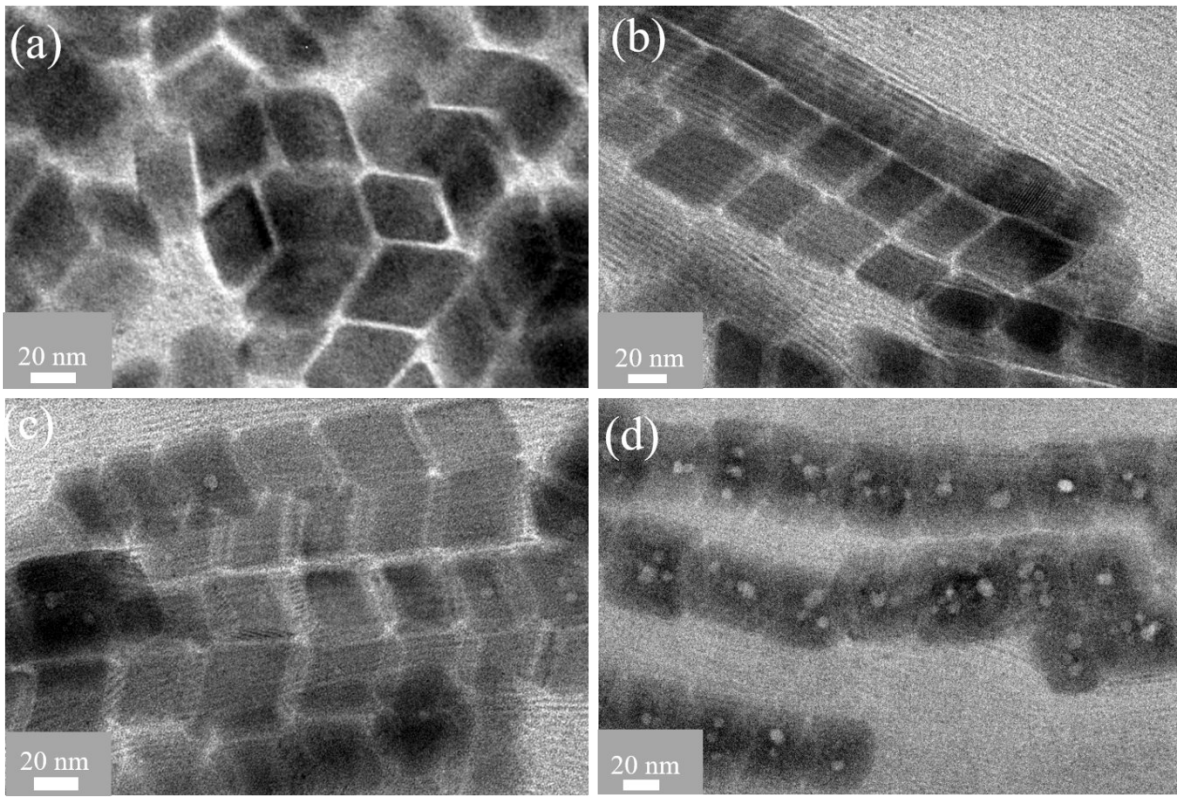

Figure S6 TEM images of $CsPbBr_3$ NCs: (a) Randomly dispersed NSs. (b) s-1DSCs. (c) Mutual vertical s-1DSCs. (d) c-1DSCs.

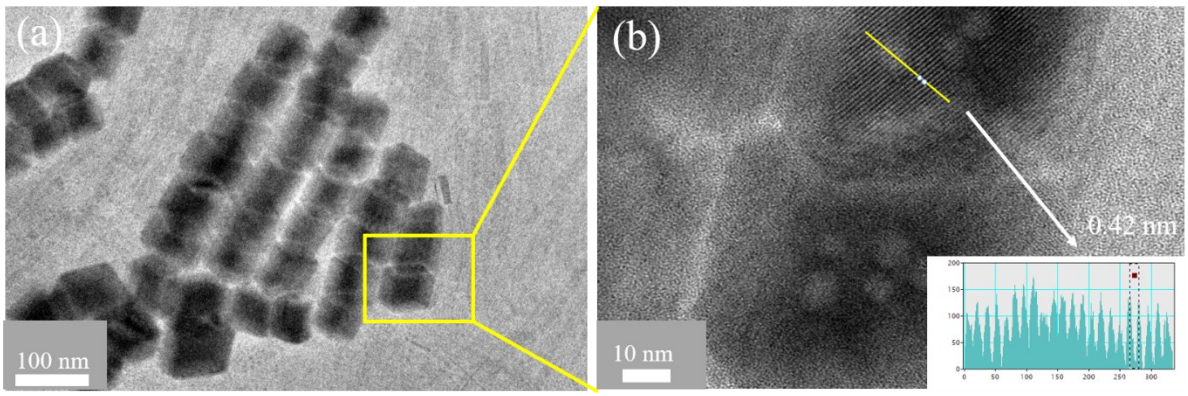

Figure S7 (a) TEM images of the c-$CsPbBr_3$ 1DSCs: (a) Low resolution. (b) High resolution.

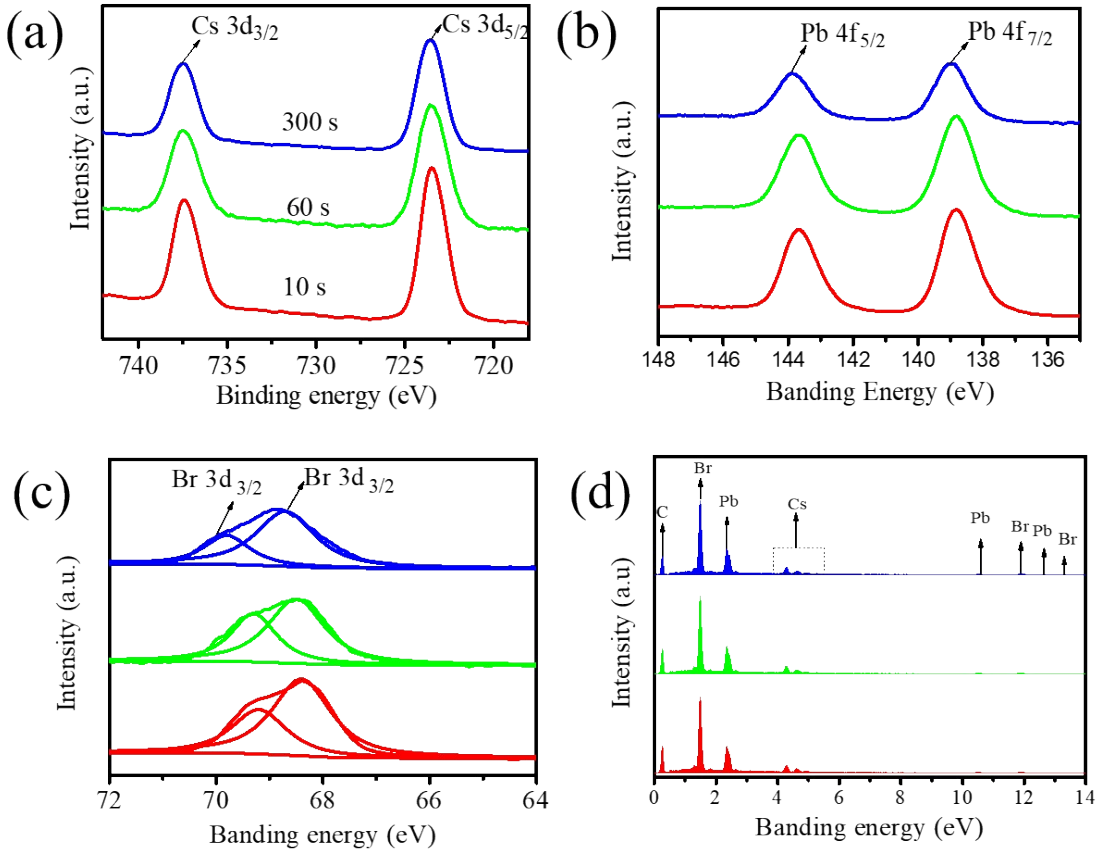

Figure S8. High-resolution XPS spectra of $CsPbBr_3$ NCs: (a) Cs 3d. (b) Pb 4f. (c) Br 3d. (d) EDS spectra of $CsPbBr_3$ NCs.

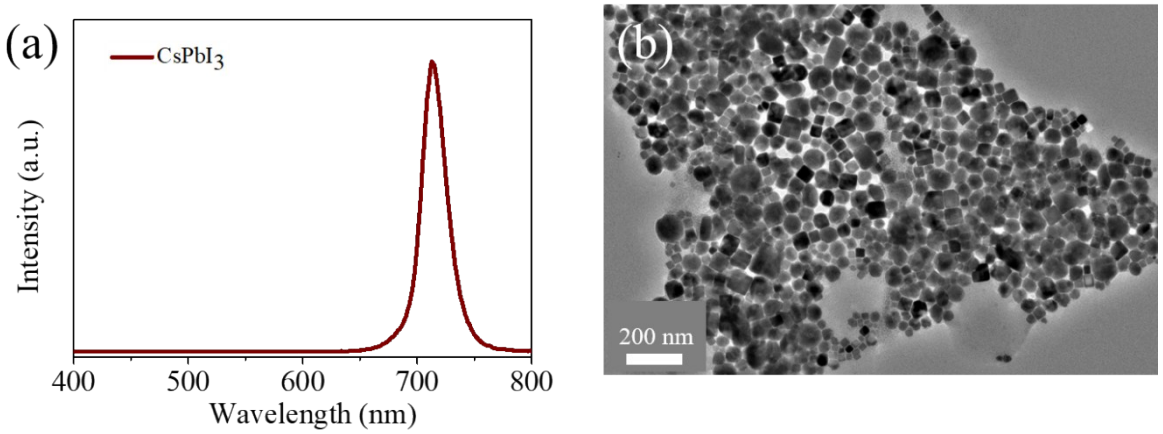

Figure S9 (a) Photoluminescence spectrum of $CsPbI_3$ NCs. (b)TEM image of $CsPbBr_3$ NSs.

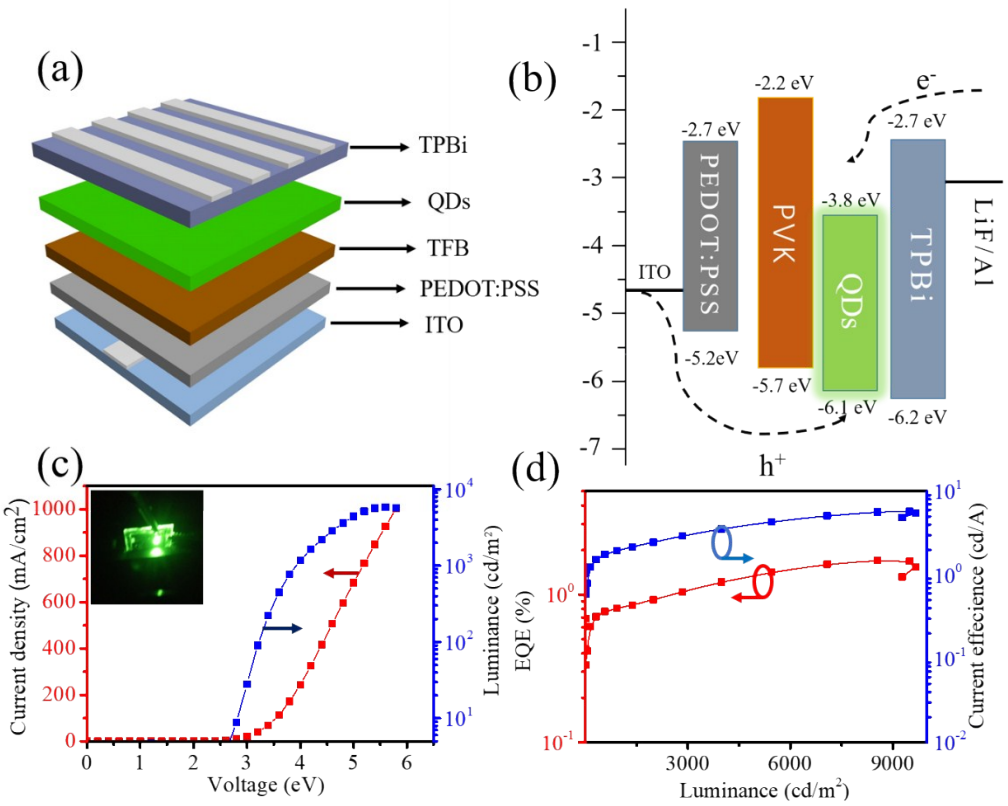

Figure S10 (a) LED device structure. (b) Flat band energy level diagram. (c) Current density (left) and luminance as a function of voltage (right). (d) Current efficiency (left) and external quantum efficiency (right) as a function of luminance.