Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary information for:

High brightness blue light-emitting diodes based on $CsPb(Cl/Br)_3$ perovskite QDs with phenethylamine chloridesynonym passivation.

He Shao,[a,b] Yue Zhai,[b] Xiufeng Wu,[b] Wen Xu,[b] Lin Xu,[b] Biao Dong,[b] Xue Bai,*[b] Haining Cui,*[a] Hongwei Song*[b]

a. College of Physics, Jilin University, Changchun 130012, China

b. State Key Laboratory of Integrated Optoelectronics, College of Electronic Science and Engineering, Jilin University, Changchun 130012, China

Corresponding Authors:

*E-mail: baix@jlu.edu.cn, cuihaining2009@126.com, songhw@jlu.edu.cn

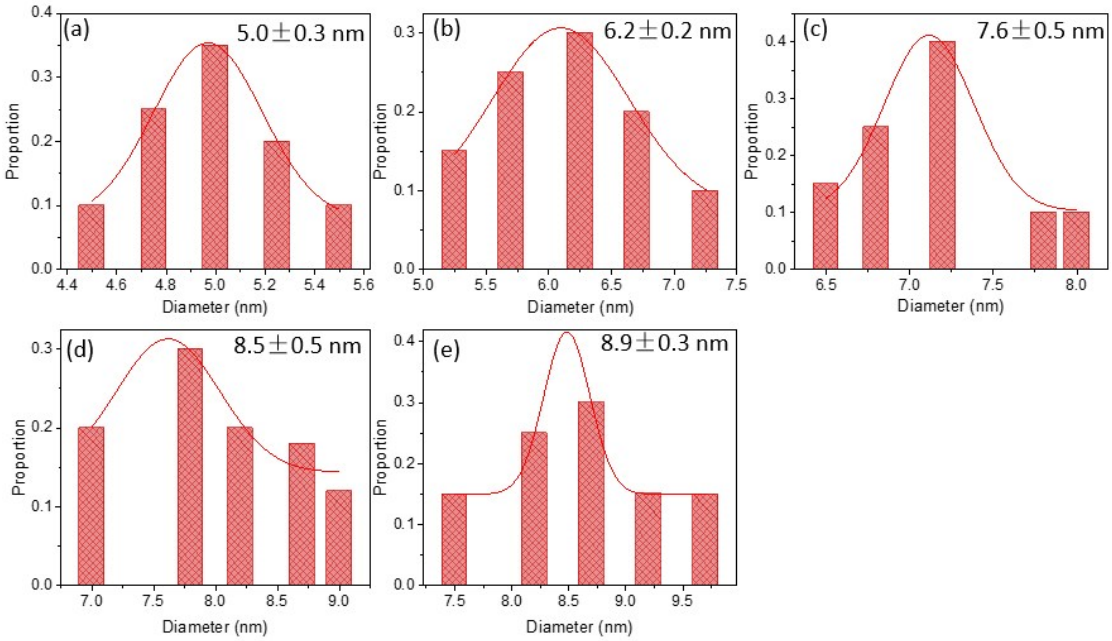

Fig. S1 Log normal distributions of the bare $CsPbCl_3$ QDs and PEA-$CsPbCl_3$ QDs synthesized by adding 1 mL PEACl ethanol solution with different concentrations in the reaction medium (a) 0, (b) 0.2, (c) 0.4, (d) 0.6 and (e) 0.8 M measured from TEM images.

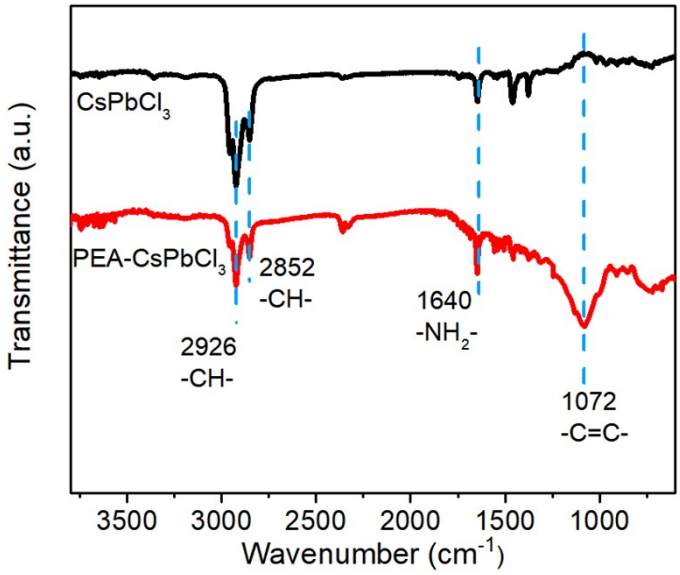

Fig S2 FTIR spectra of pure $CsPbCl_3$ QDs and PEA-$CsPbCl_3$ QDs synthesized by adding 1 mL PEACl ethanol solution with concentration of 0.6 M in the reaction medium.

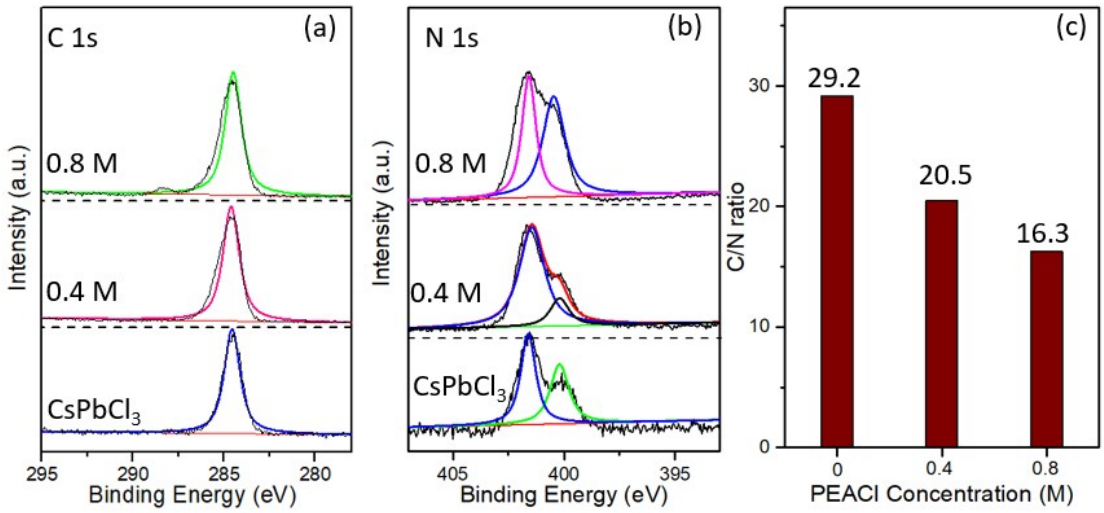

Fig. S3 The XPS spectra of (a) C 1s; (b) N 1s and (c) the corresponding C/N atom ratio in the $CsPbCl_3$ QDs and PEA-$CsPbCl_3$ QDs synthesized by adding 1 mL PEACl ethanol solution with concentration of 0.4 and 0.8 M, respectively.

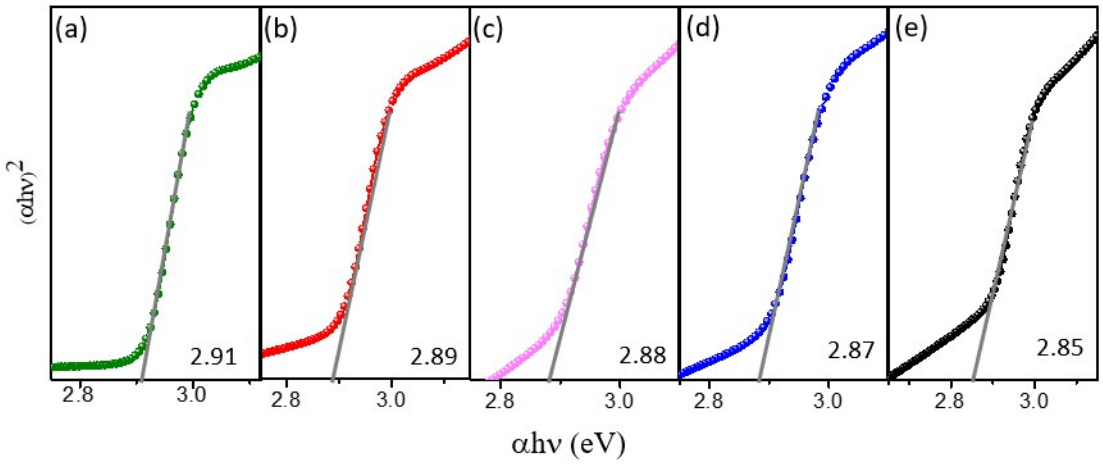

Fig. S4 Tauc plots of the (a) $CsPbCl_3$ QDs and (b-e) PEA-$CsPbCl_3$ QDs synthesized by adding 1 mL PEACl ethanol solution with different concentrations in the reaction medium (b) 0.2, (c) 0.4, (d) 0.6 and (e) 0.8M.

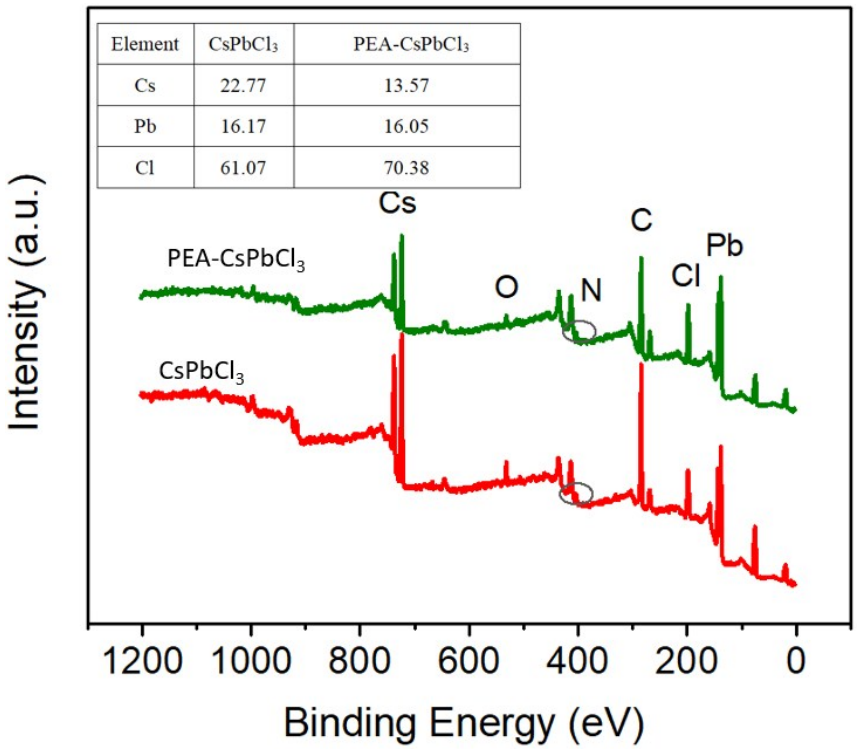

Fig. S5 XPS data of pure $CsPbCl_3$ QDs and PEA-$CsPbCl_3$ QDs synthesized by adding 1 mL PEACl ethanol solution with concentration of 0.6 M.

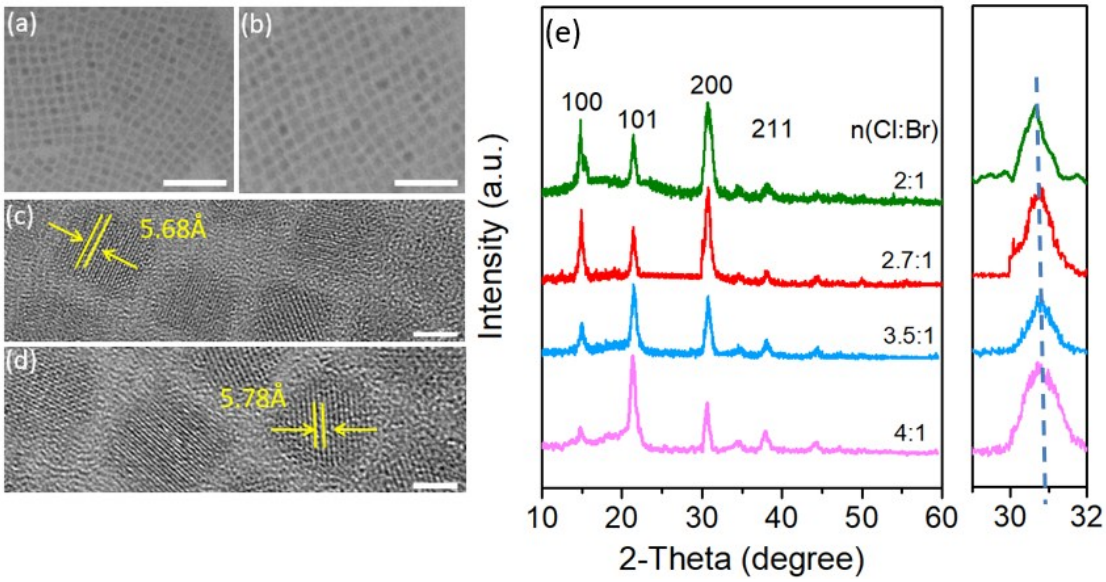

Fig. S6 TEM images of PEA-CsPb(Cl/Br)$_3$ QDs with different molar feed ratios of Cl-to-Br (a) 4:1 and (b) 2:1 and (c)-(d) their corresponding HR-TEM images. Scale bars are 50 nm in TEM images and 5 nm in HRTEM images, respectively; (e) XRD patterns of PEA-CsPb(Cl/Br)$_3$ QDs with different molar feed ratios of Cl-to-Br.

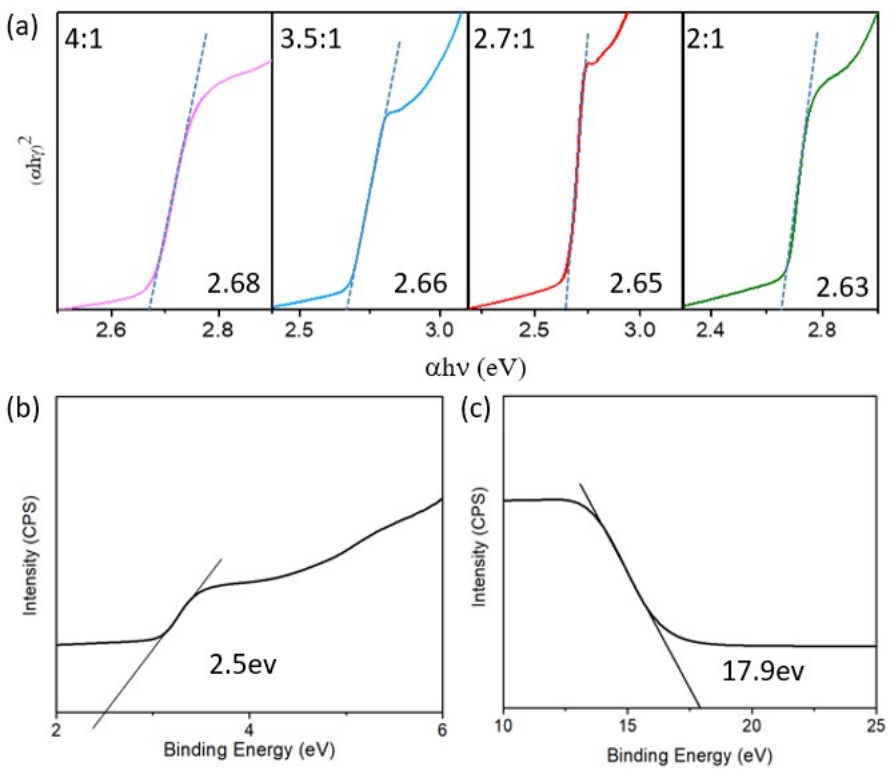

Fig. S7 (a) Tauc plots of films produced from PEA-CsPb(Cl/Br)$_3$ QDs with different Cl-to-Br ratios. (b) UPS spectra of PEA-CsPb(Cl/Br)$_3$ QDs with Cl-to-Br moral feed ratio of 2:1.

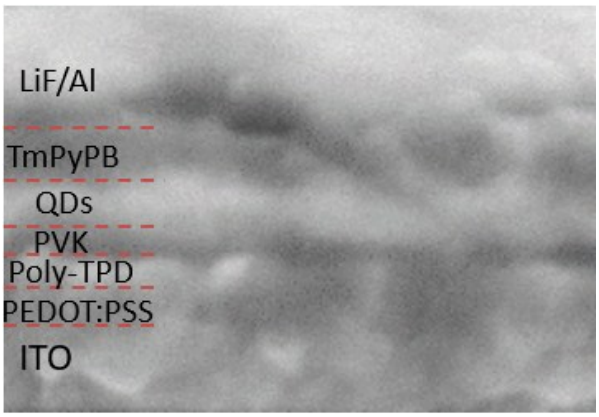

Fig. S8 The cross-sectional SEM image of the PQD-LED device structure.

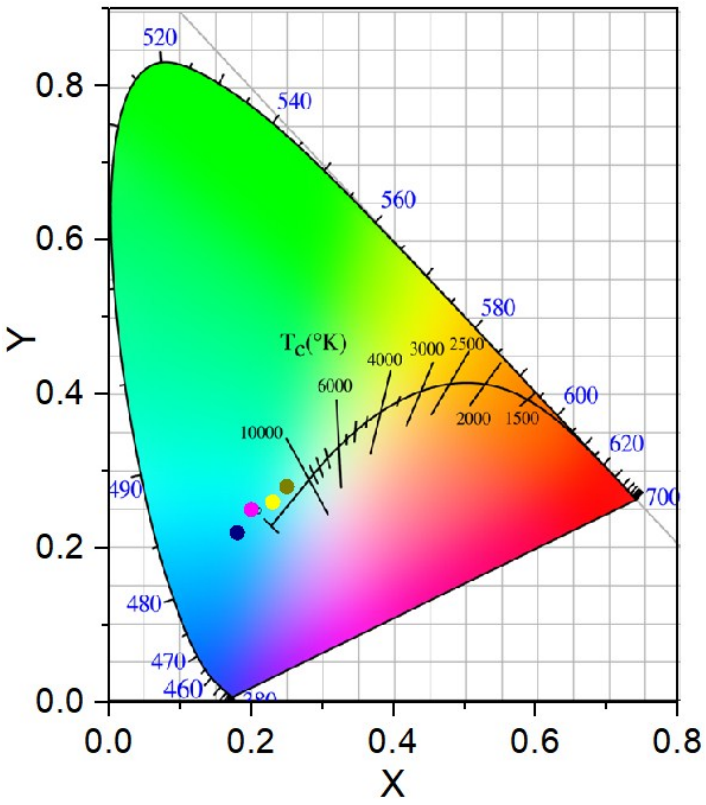

Fig.S9 The corresponding CIE coordinates for the EL spectra of PQD-LEDs based on PEA-$CsPb(Cl/Br)_3$ QDs synthesized with different Cl-to-Br ratios.

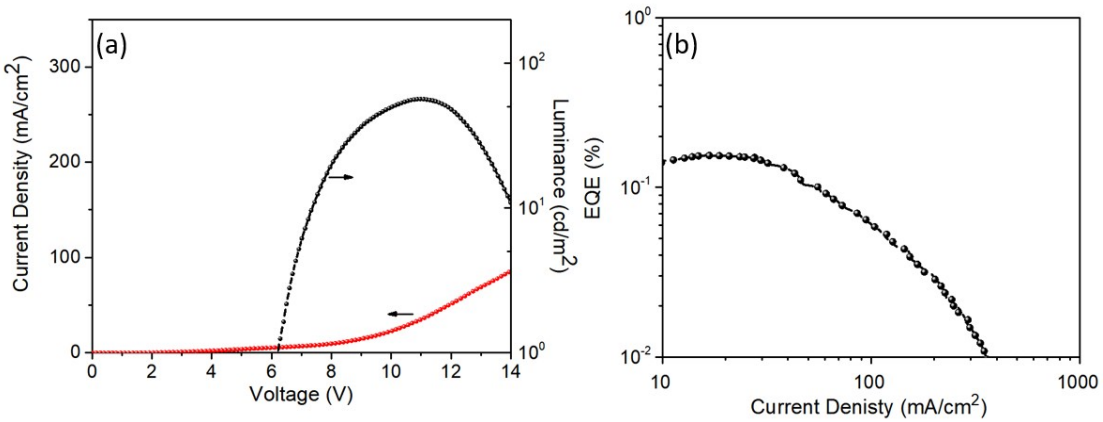

Fig. S10 (a) The *J-V-L* curves and (b) EQE of the PQD-LED based on the $CsPb(Cl/Br)_3$ QDs synthesized with Cl-to-Br moral feed ratio of 2:1.

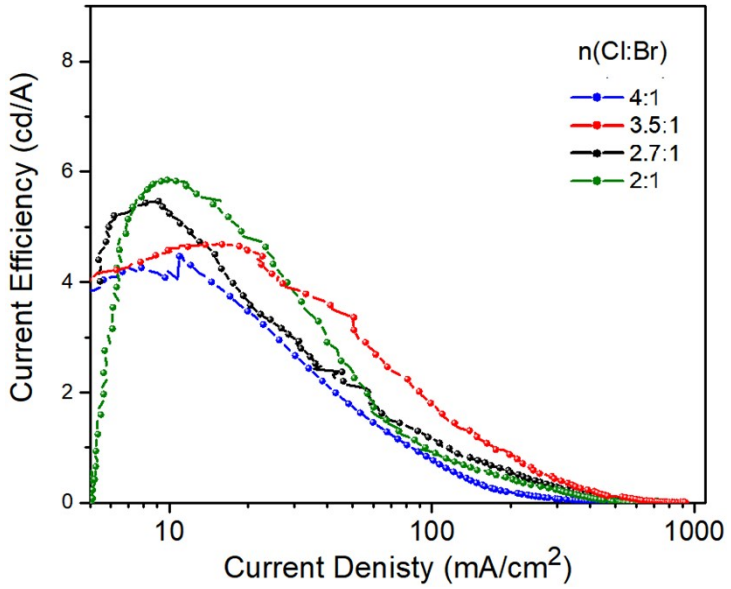

Fig. S11 Current efficiency of the devices as a function of current density.

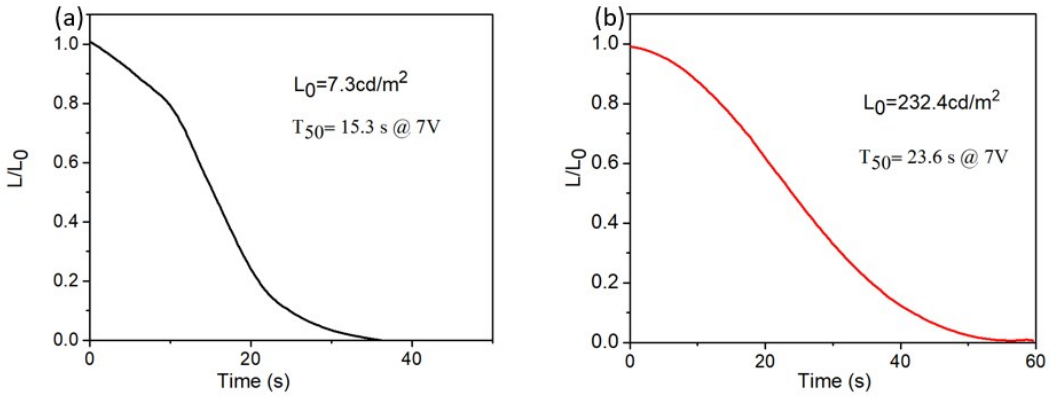

Fig. S12 Lifetime measurement (T50) of PQD-LED based on the (a) $CsPb(Cl/Br)_3$ QDs; (b) PEA-$CsPb(Cl/Br)_3$ QDs synthesized with Cl-to-Br moral feed ratio of 2:1 at a voltage of 7V.

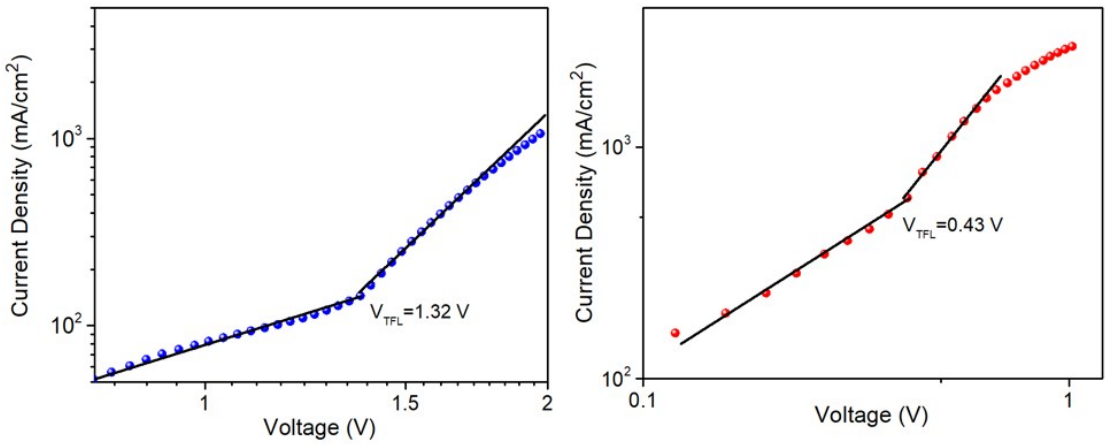

Fig. S13 Current density–voltage characteristics of devices for estimating the defect density of $CsPb(Cl/Br)_3$ and PEA-$CsPb(Cl/Br)_3$ QDs films with Cl-to-Br moral feed ratio is 2:1.

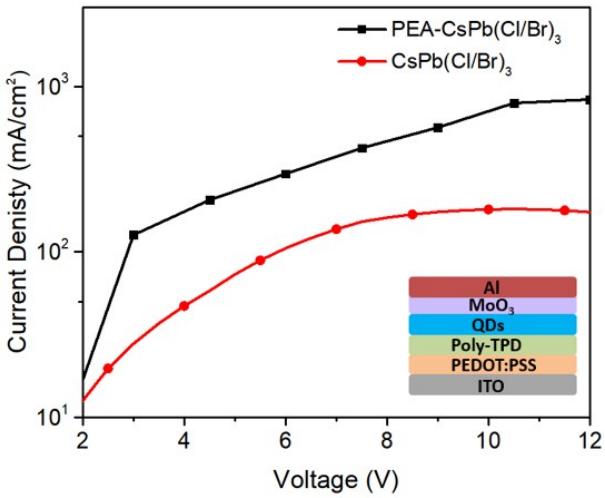

Fig. S14 *J-V* curves of "hole-only" devices based on the $CsPb(Cl/Br)_3$ and PEA-$CsPb(Cl/Br)_3$ QDs synthesized with Cl-to-Br moral feed ratio of 2:1.

Table S1. The measurement and calculated particle sizes of $CsPbCl_3$ QDs and PEA-$CsPbCl_3$ QDs synthesized by adding 1 mL PEACl ethanol solution with different concentrations.

PEACl ethanol solution concentrations (M)	0	0.2	0.4	0.6	0.8
Measured from TEM images (nm)	5.2	6.8	7.6	8.5	9.3
Calculated by XRD patterns (nm)	5.3	6.7	7.8	8.4	9.4

Table S2. Emission decay of excitonic transitions monitored at 408 nm for $CsPbCl_3$ QDs and PEA-$CsPbCl_3$ QDs synthesized by adding 1 mL PEACl ethanol solution with different concentrations.

PEACl ethanol solution concentrations (M)	A_1	τ_1 (ns)	A_2	τ_2 (ns)	τ_{avg} (ns)	k_{nr} ($\times 10^{-2}$ ns^{-1})	k_r ($\times 10^{-2}$ ns^{-1})
0	72%	3.5	28%	7.8	5.4	17.5	1.0
0.2	42%	4.7	58%	11.5	9.9	9.3	9.5
0.4	32%	6.0	68%	12.0	10.8	6.3	8.7
0.6	22%	7.2	78%	12.3	11.5	3.5	8.2
0.8	33%	6.2	67%	12.3	11.1	5.6	8.2

The time-resolved PL decay curves can be well fitted by a bi- exponential function as

$$A(t) = A_1 e^{(-\frac{t}{\tau_1})} + A_2 e^{(-\frac{t}{\tau_2})}$$

The average lifetimes are calculated by a formula as

$\tau_{avg} = (A_1\tau_1^2 + A_2\tau_2^2)/ (A_1\tau_1 + A_2\tau_2)$

The calculated non-radiative and radiative recombination rates from the formula:

$k_{nr} = (1 - PLQY)/\tau_{avg}$ and $k_r = PLQY/\tau_{avg.}$