Electronic Supplementary Material (ESI) for Materials Chemistry Frontiers.

Supporting information

Zinc non-halide dopant strategy enables efficient perovskite $CsPbI_3$ quantum dot-based light-emitting diodes

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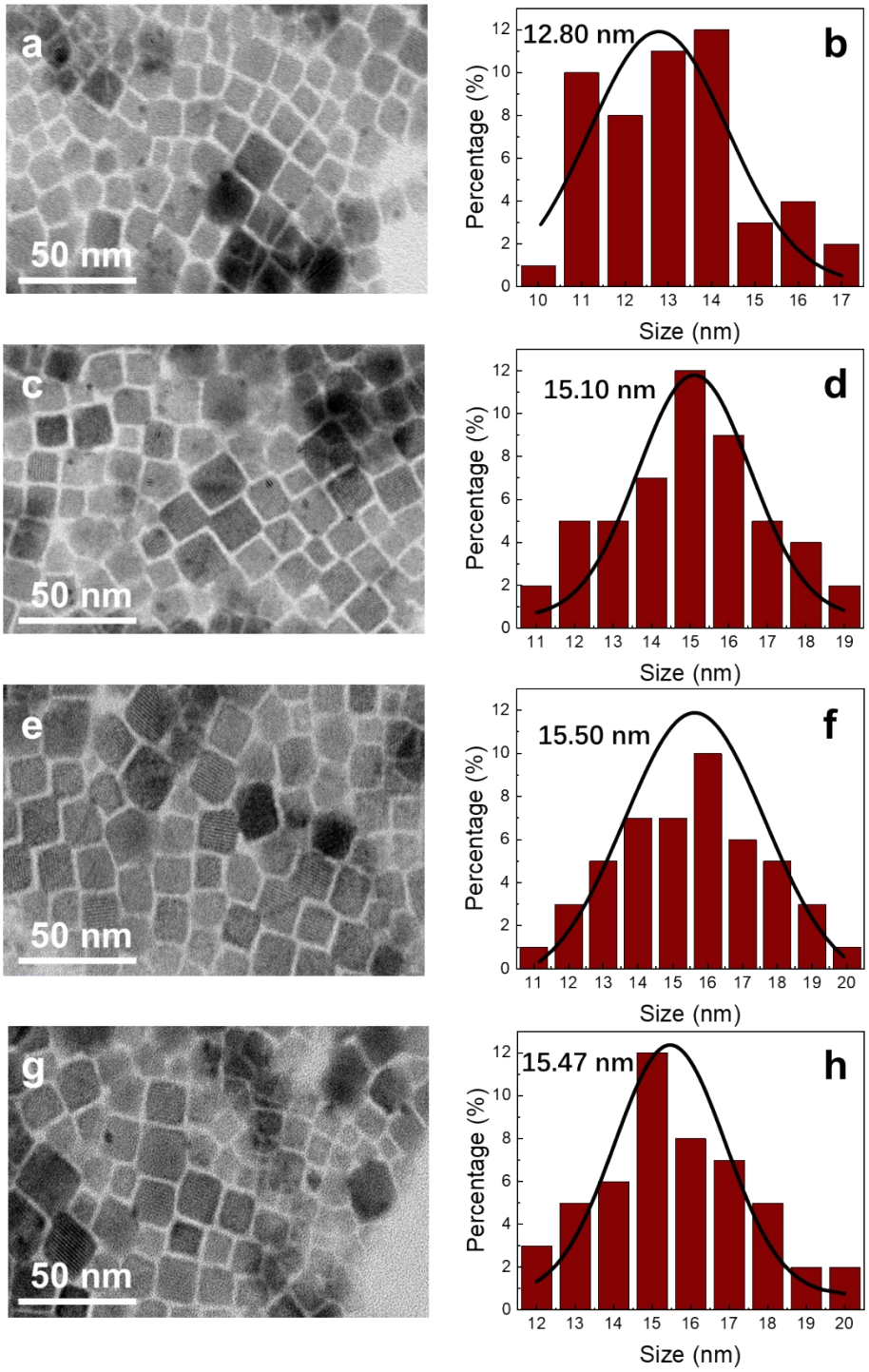

Figure S1. TEM images and corresponding log normal distributions of (a-b) pristine, (c-d) ZnAc doped, (e-f) ZnAcAc doped, (g-h) ZnSt doped $CsPbI_3$ QDs.

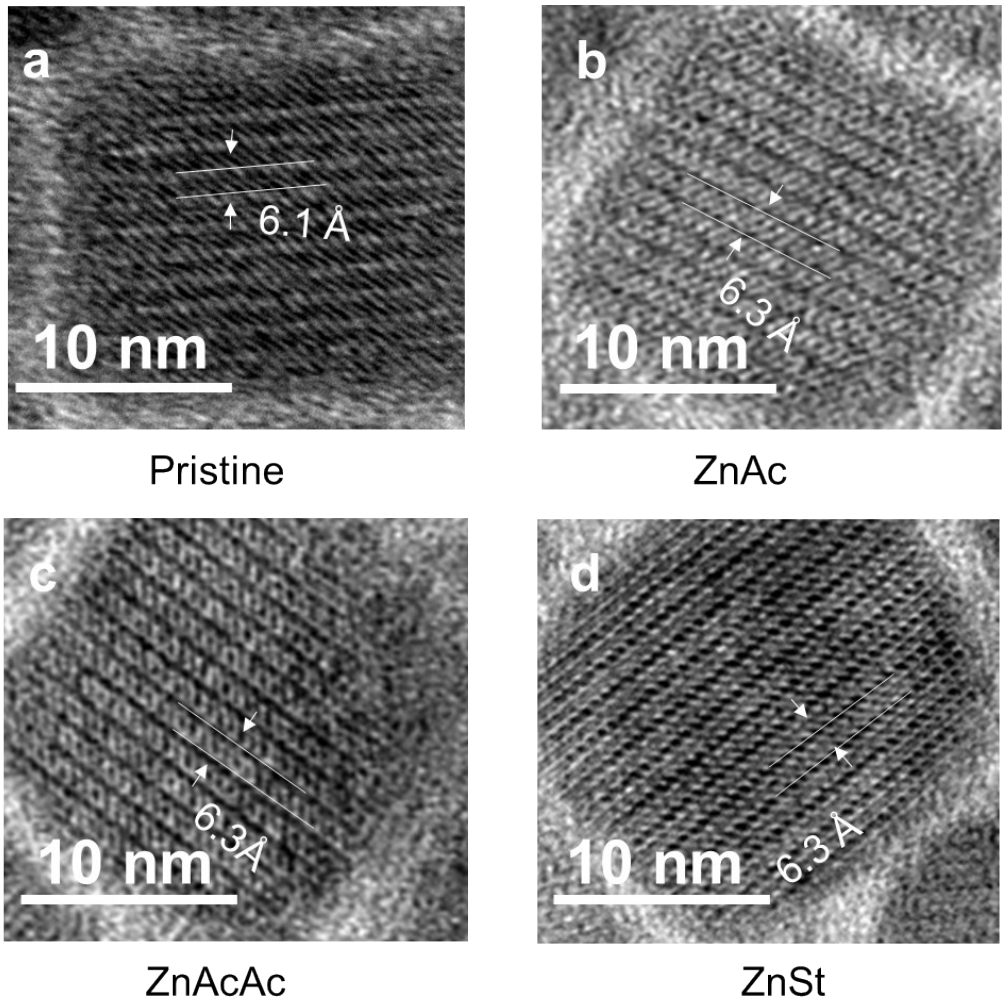

Figure S2. HRTEM images of $CsPbI_3$ QDs doped with different Zn^{2+} salts (a) pristine $CsPbI_3$, (b) ZnAc, (c) ZnAcAc, (d) ZnSt.

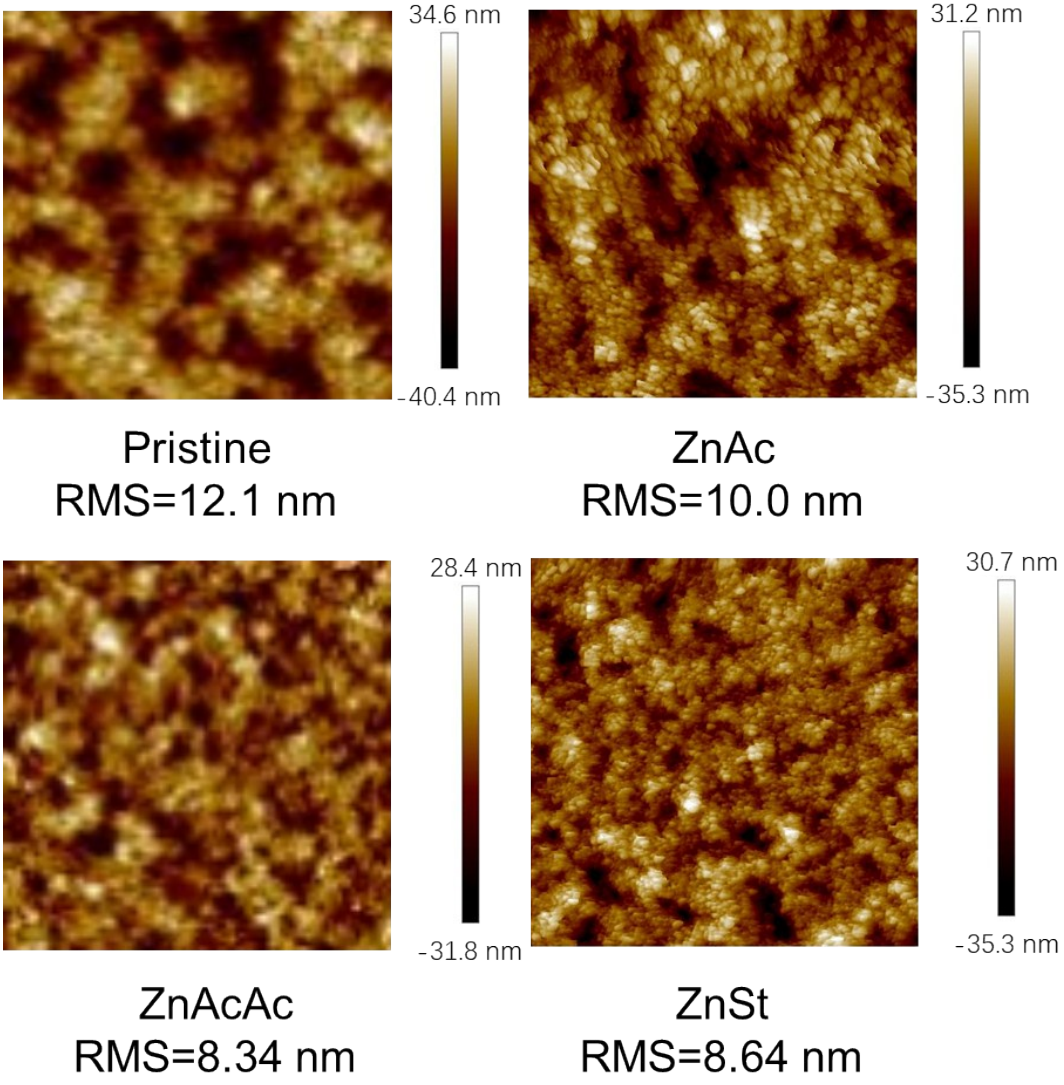

Figure S3. AFM images $CsPbI_3$ QDs doped with different Zn^{2+} salts (a) pristine $CsPbI_3$, (b) ZnAc, (c) ZnAcAc, (d) ZnSt, the scan area is 5 μm × 5 μm.

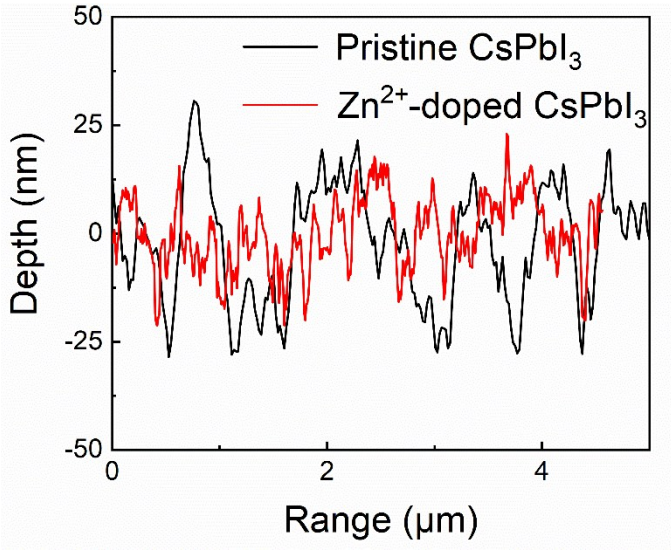

Figure S4. Film roughness of pristine and Zn^{2+}-doped $CsPbI_3$ QDs.

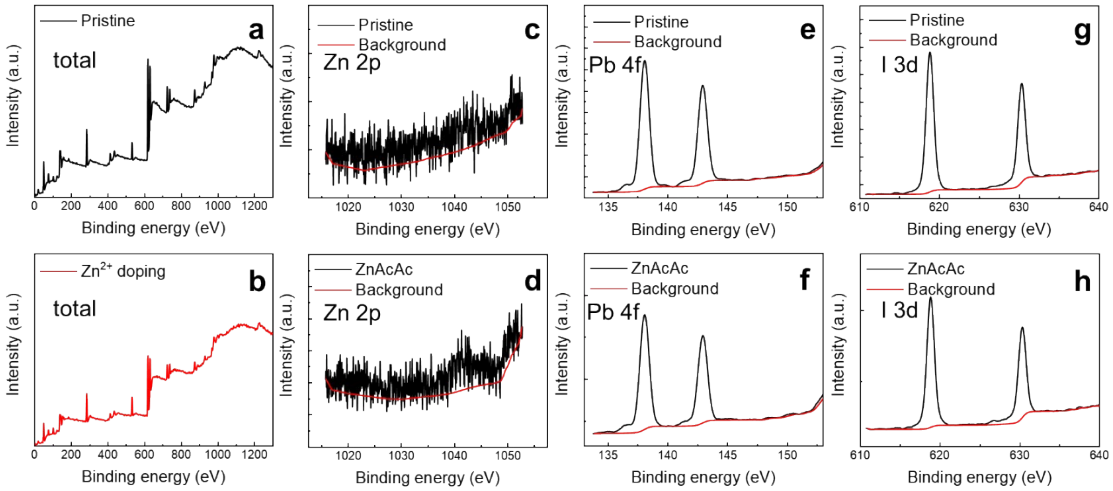

Figure S5. (a, b) XPS spectra of $CsPbI_3$ QDs synthesized with and without Zn^{2+} doping. (c, d) High-resolution XPS spectrum of Zn, (e, f) Pb ($4f_{5/2}$ and $4f_{7/2}$), and (g, h) I ($3d_{3/2}$ and $3d_{5/2}$) of $CsPbI_3$ QDs synthesized with and without Zn ion.

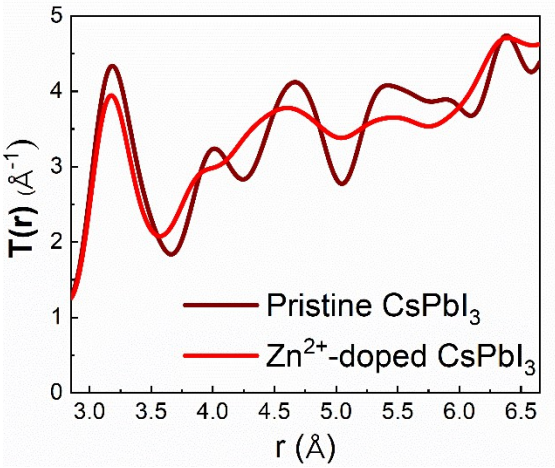

Figure S6. The pair distribution function G(r) of pristine $CsPbI_3$ QDs and Zn^{2+}-doped $CsPbI_3$ QDs, respectively.

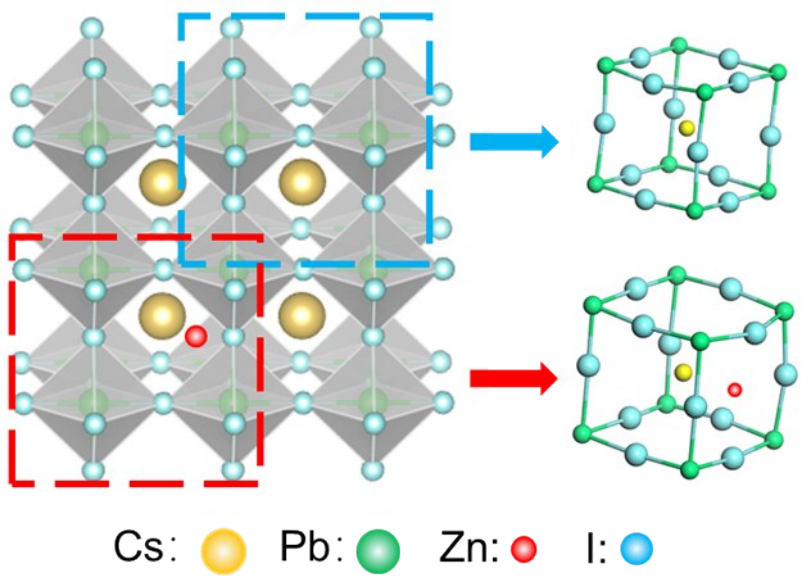

Figure S7. Schematic figure of Zn^{2+}-doped $CsPbI_3$ QDs.

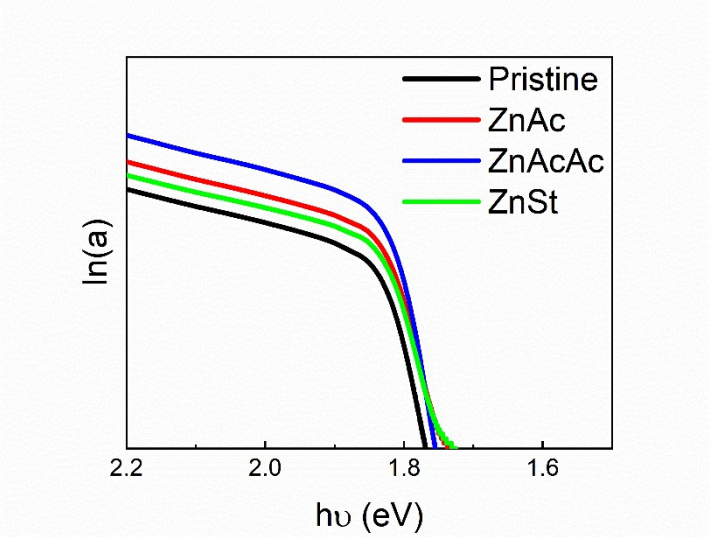

Figure S8. (a) Relationship of ln(α) versus energy for calculation of Urbach energy curves of $CsPbI_3$ QDs with different Zn^{2+} salts of ZnAc, ZnAcAc, and ZnSt.

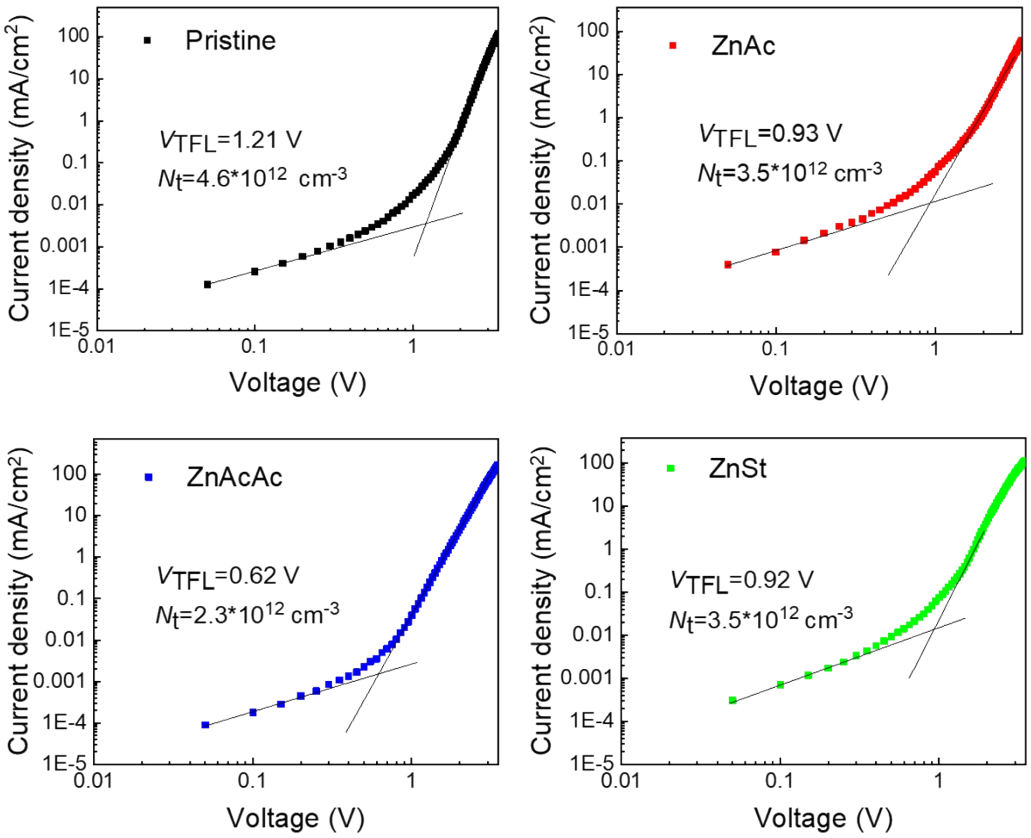

Figure S9. Current-voltage characteristics of hole-only device of pristine and Zn^{2+}-doped $CsPbI_3$ QDs with different Zn^{2+} salts of ZnAc, ZnAcAc, and ZnSt.

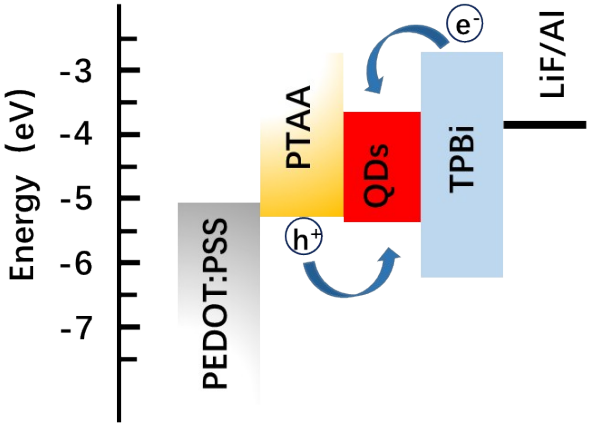

Figure S10. Device energy-level diagrams for each functional layer in the LEDs.

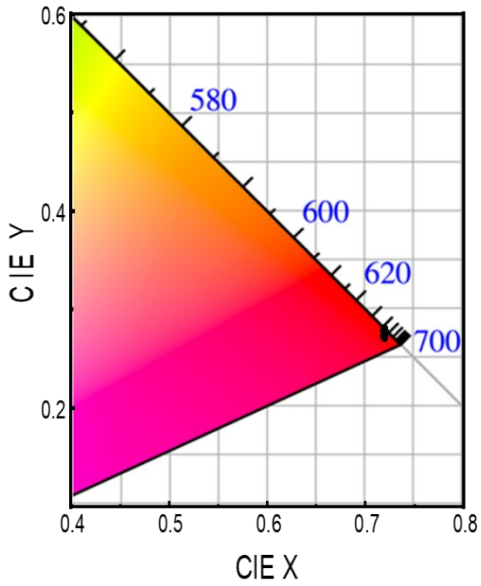

Figure S11. CIE coordinates of $CsPbI_3$ and Zn^{2+}-doped $CsPbI_3$ QD films.

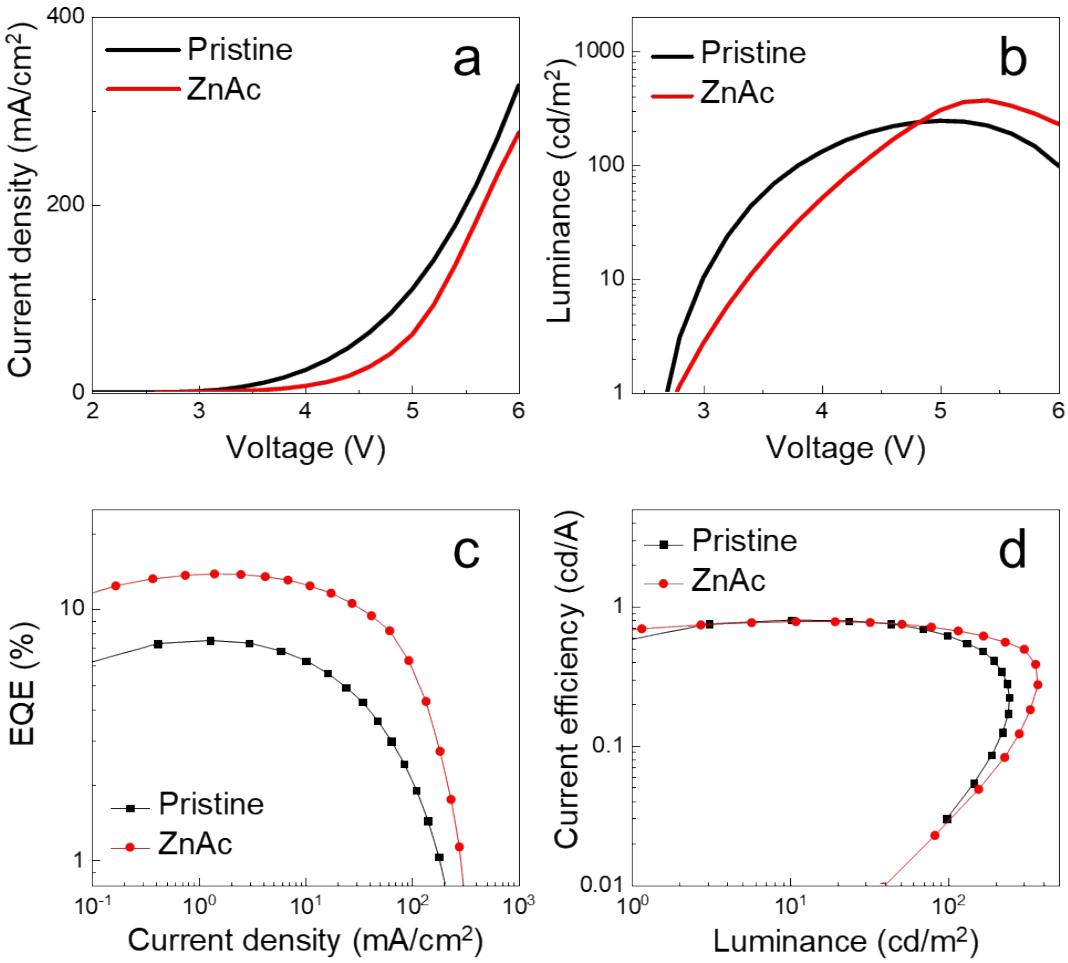

Figure S12. (a) Electrical transportation demonstrated by current density vs. voltage curves of pristine and ZnAc doped LEDs. (b) The luminance-voltage characteristics. (c) EQE of the devices as a function of current density. (d) Current e□ciency of pure and doped $CsPbI_3$ QLEDs as a function of luminance.

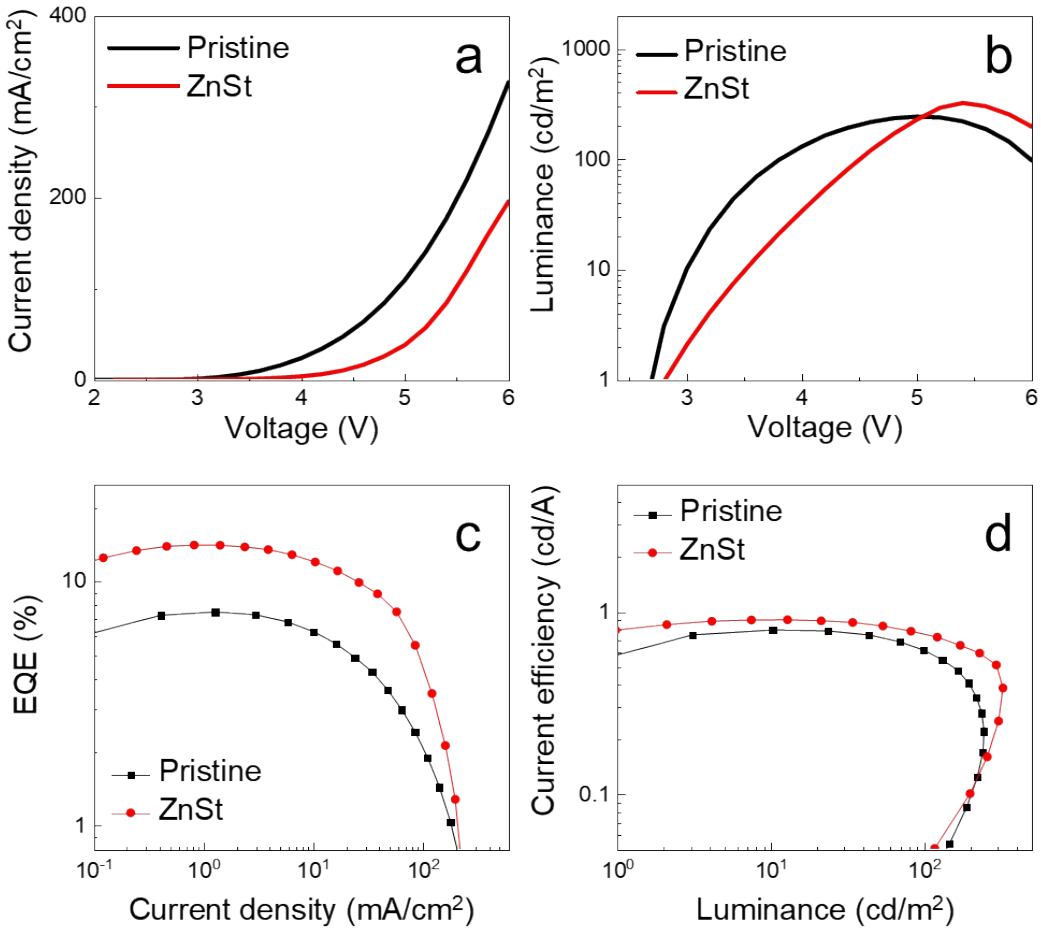

Figure S13. (a) Electrical transportation demonstrated by current density vs. voltage curves of pristine and ZnSt doped LEDs. (b) The luminance-voltage characteristics. (c) EQE of the devices as a function of current density. (d) Current e□ciency of pure and doped $CsPbI_3$ QLEDs as a function of luminance.

Figure S14. The EQE progress of $CsPbI_3$ QLEDs[1-8].

Table S1. Summary of PL delay time for $CsPbI_3$ and Zn^{2+}-doped $CsPbI_3$ QD films.

	τ_1 (ns)	τ_2 (ns)	τ_3 (ns)	τ_{avg} (ns)
Pristine $CsPbI_3$	1.36(0.219)	5.38(0.5684)	18.17(0.2127)	7.22
ZnAC doped	1.56(0.1832)	6.05(0.5517)	19.35(0.2651)	8.75
ZnACAC doped	1.99(0.1839)	8.17(0.5403)	25.14(0.2759)	11.71
ZnST doped	1.57(0.1889)	6.60(0.5439)	22.70(0.2672)	9.95

Table S2. Reported EQE of $CsPbI_3$ QLEDs and EQE in our work.

Luminescent materials	Employed strategy	EQE	Publishing date
$CsPbI_3$ QD	——	0.21%	2017[1]
$CsPbI_3$ QD	Bidentate ligand passivation	5.02%	2018[2]
$CsPbI_3$ QD	——	8.2%	2019[3]
$CsPbI_3$ QD	Silver doping & surface passivation	11.2%	2018[4]
$CsPbI_3$ QD	PbS surface passivation & device designing	11.8%	2018[5]
$CsPbI_3$ QD	Sr doping & Cl surface passivation	13.5%	2018[6]
$CsPbI_3$ QD	PEAI surface ligand passivation	14.04%	2018[7]
$CsPbI_3$ QD	Zn alloying treatment	15.1%	2019[8]
$CsPbI_3$ QD	Zinc non-halide dopant strategy	14..6%	Our work

References

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