Electronic Supplementary Material (ESI) for Nanoscale.

Highly Luminescent Red-Emitting In(Zn)P Quantum Dots Using Zinc Oxo Cluster: Synthesis and Application to Light-Emitting Diodes...

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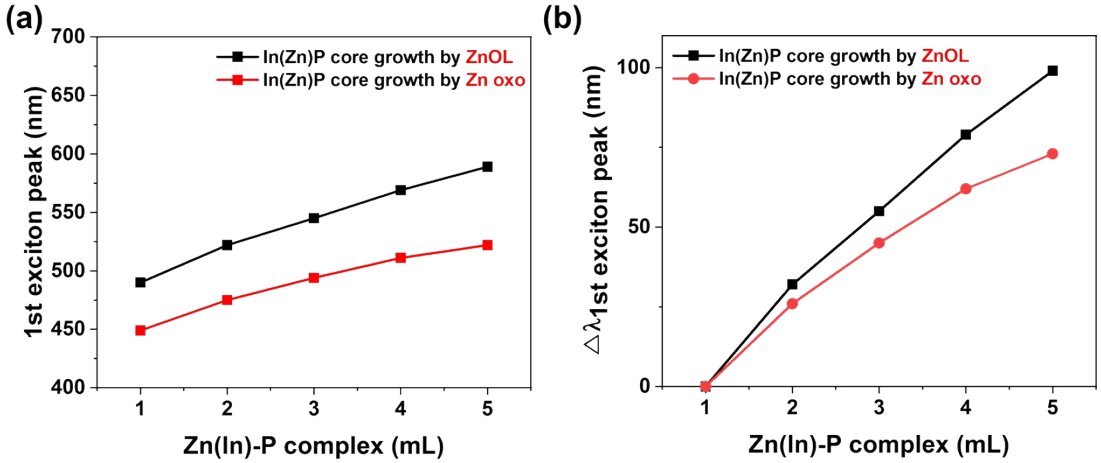

Figure S1. Effects of Zn precursor and the amount of added Zn(In)-P complex on the (a) position and (b) position change of the first exciton peaks of In(Zn)P cores.

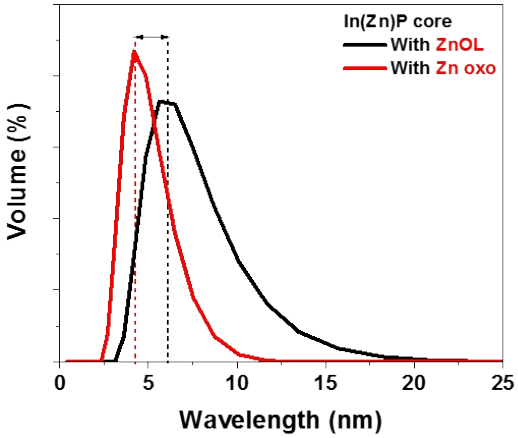

Figure S2. Dynamic light scattering measurements: Results obtained for In(Zn)P cores synthesized from ZnOL and the Zn oxo cluster.

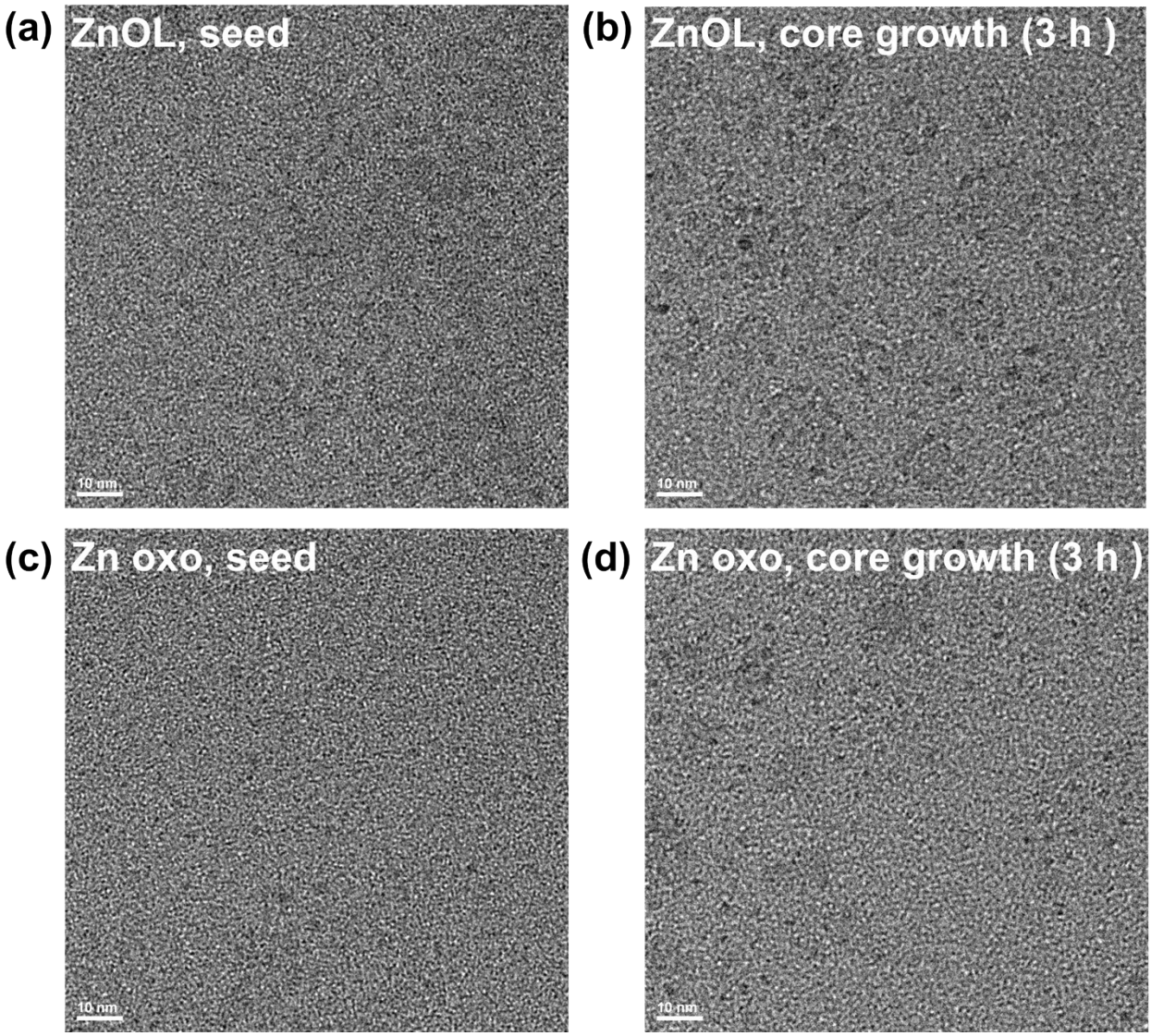

Fig. S3. TEM images of In(Zn)P seeds and 3 h-growth In(Zn)P cores. (a) In(Zn)P seeds by ZnOL, (b) 3 h-growth In(Zn)P cores by ZnOL, (c) In(Zn)P seeds by Zn oxo cluster, (d) 3 h-growth In(Zn)P cores by Zn oxo cluster.

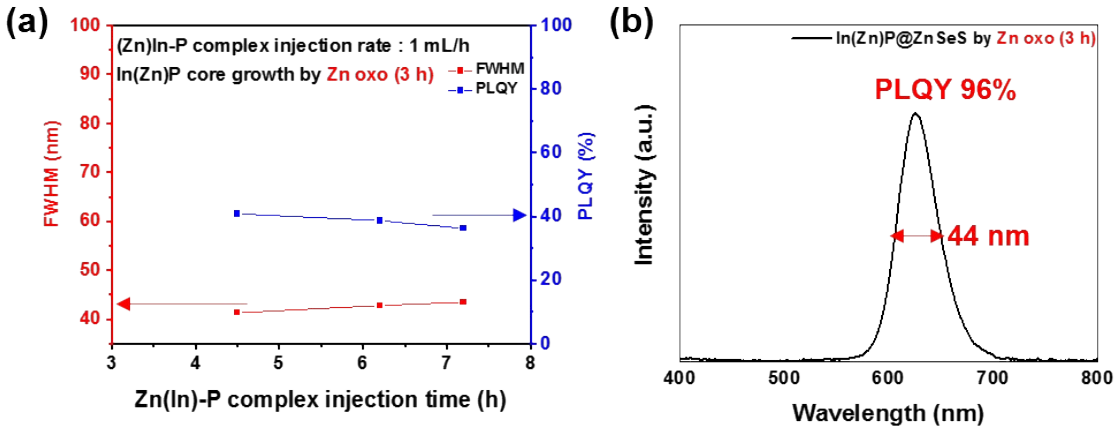

Figure S4. (a) Effect of growth time on the FWHM and PLQY of In(Zn)P cores prepared from thermally over-decomposed Zn oxo cluster and (b) the PL spectrum of the resulting In(Zn)P@ZnSeS QDs using 10 mL of Zn(In)-P complex

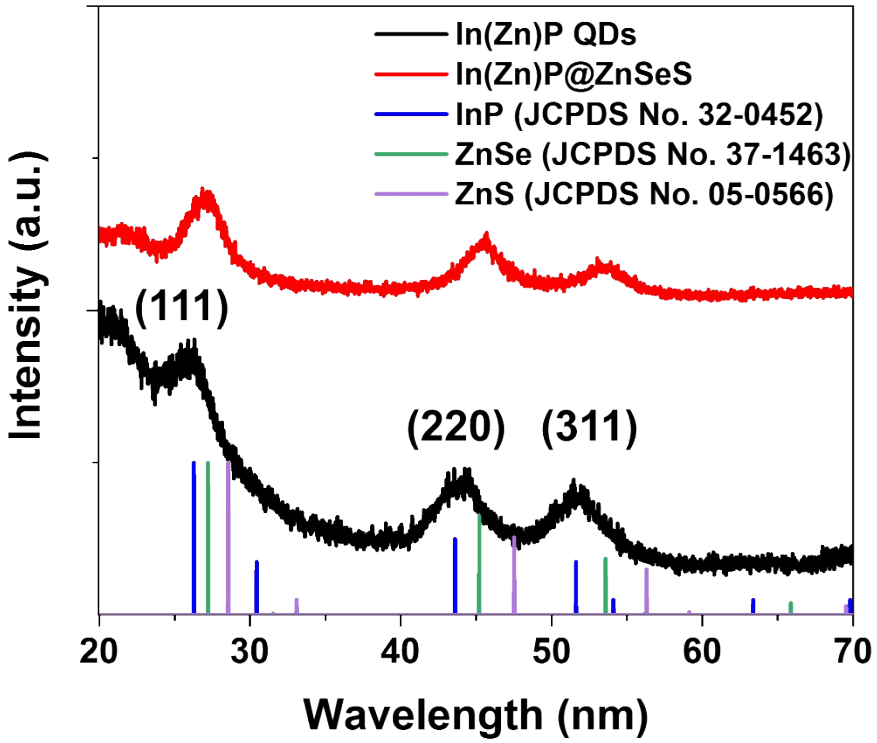

Figure S5. XRD patterns of In(Zn)P cores and In(Zn)P@ZnSeS core@shell QDs.

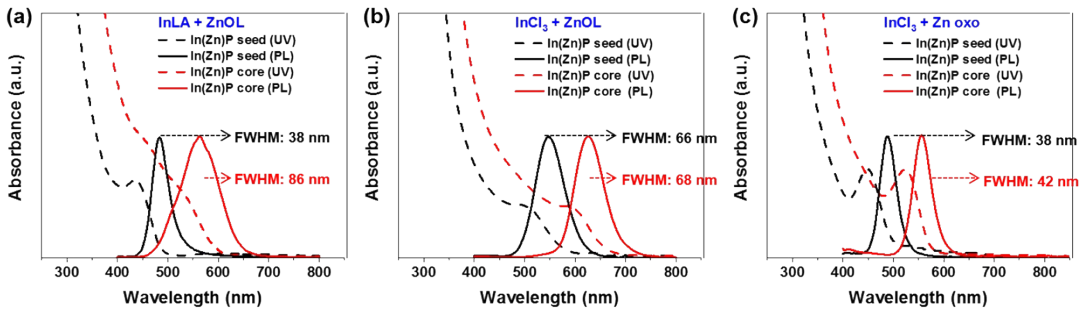

Figure S6. UV-vis and PL spectra of In(Zn)P seeds and In(Zn)P cores prepared using (a) In laurate + ZnOL, (b) $InCl_3$ + ZnOL, (c) $InCl_3$ + Zn oxo cluster. The reaction condition is same except the types of In and Zn precursors. The growth was conducted until the emission wavelength of In(Zn)P cores reached around 560 nm.

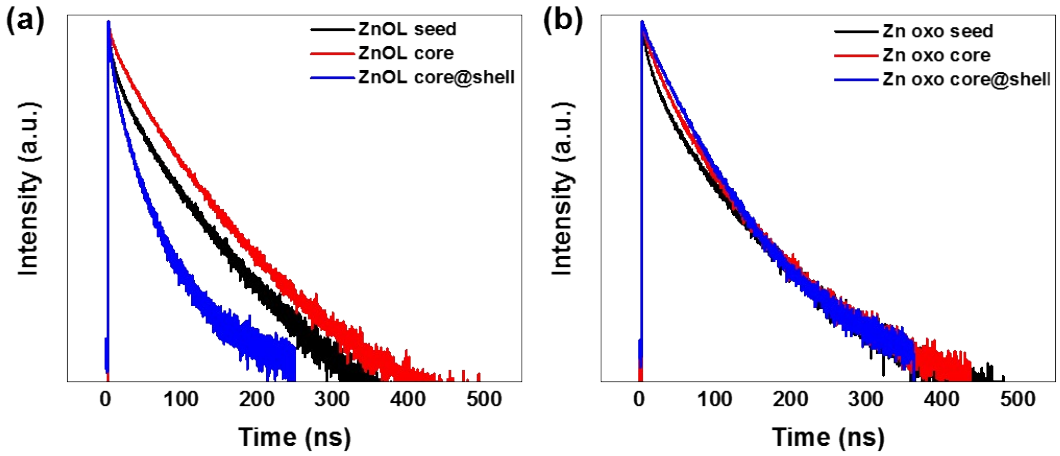

Figure S7. TRPL results for In(Zn)P QDs synthesized using (a) ZnOL and (b) Zn oxo cluster as precursors.

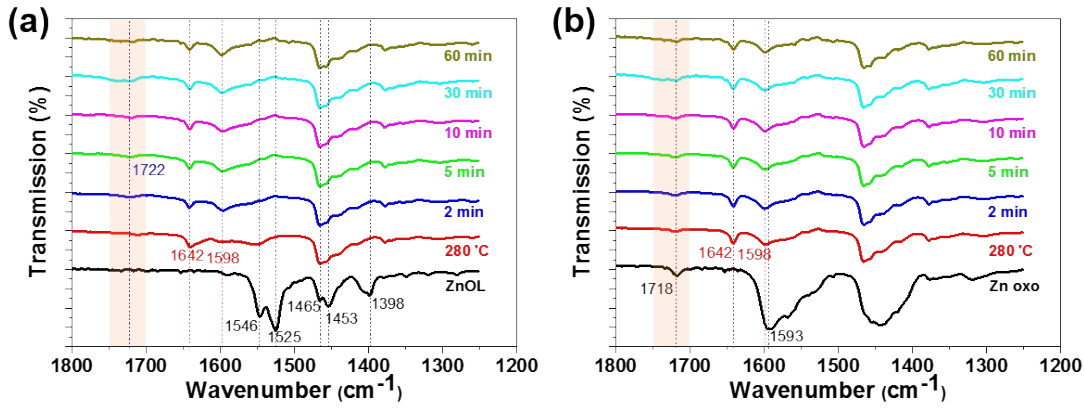

Figure S8. Full FT-IR spectra of aliquots sampled during In(Zn)P core synthesis from (b) ZnOL and (c) the Zn oxo cluster as precursors.

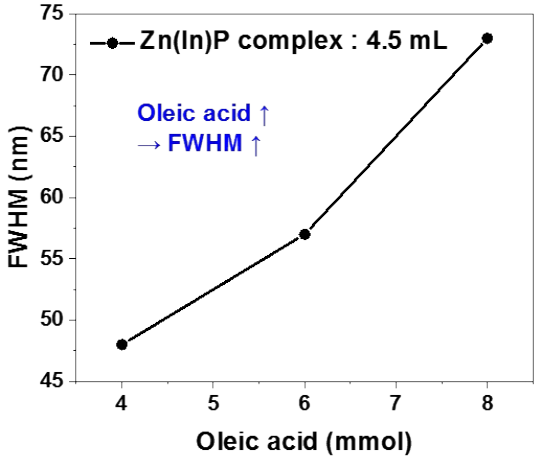

Figure S9. Effect of excess OA on the FWHM of In(Zn)P cores.

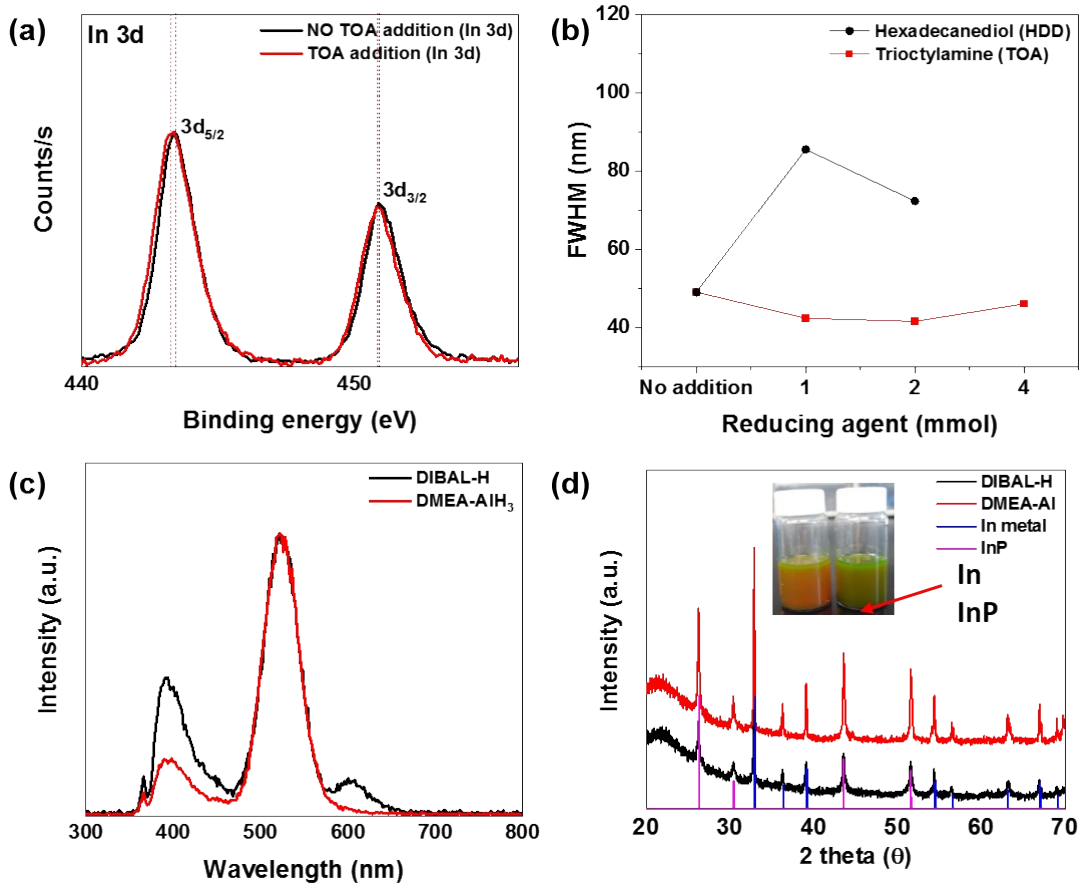

Figure S10. (a) X-ray photoelectron spectra of In(Zn)P cores synthesized using the Zn oxo cluster with and without TOA. (b) Effect of mild reducing agents on the FWHM of In(Zn)P cores (c) PL spectrum and (d) XRD patterns of In(Zn)P cores prepared using strong reducing agents (inset: Photograph of as-synthesized In(Zn)P core solutions).

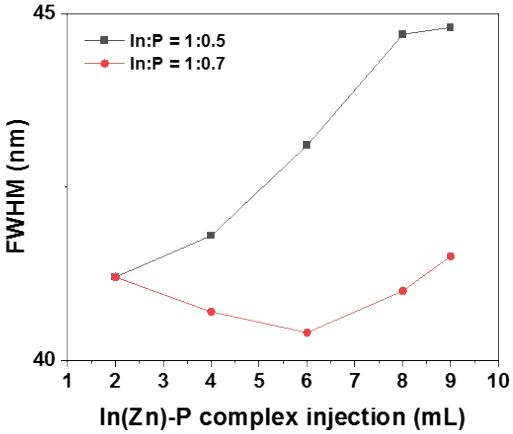

Figure S11. Effect of the $InCl_3$:TMS_3P ratio and the amount of injected In(Zn)-P complex on the FWHM of In(Zn)P cores.

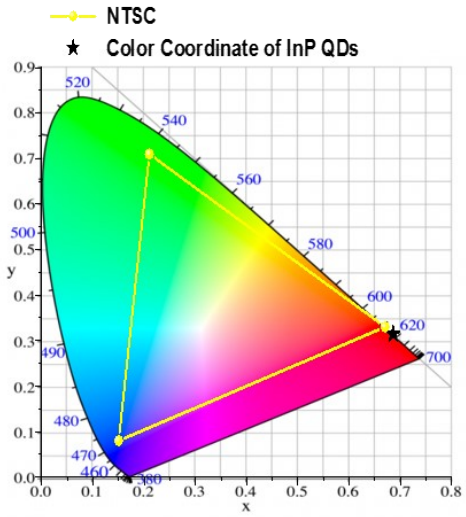

Figure S12. CIE 1931 chromatic coordinates of InP QDs at a certain applied voltage for an ITO/PEDOT:PSS/PTAA/InP QDs/ZnO NPs/Al device structure.

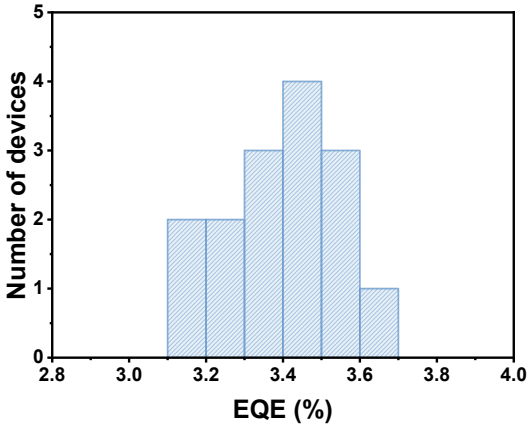

Figure S13. Histograms of peak EQEs for 15 devices

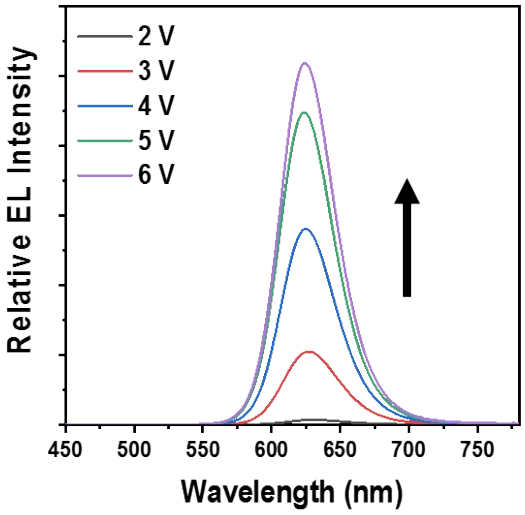

Figure S14. Electroluminescence spectra of InP QD–based LEDs at different operating voltages.

Table S1. PL decay time components and amplitudes of triexponential fit curves. ((Table Caption.

Type of QDs (Zn precursor)	τ_1 [ns]	A1	τ_1 [ns]	A2	τ_3 [ns]	A3	τ_{avg} [ns]	$\chi 2$
In(Zn)P seed (**ZnOL**)	3.27	0.39	22.89	0.34	70.54	0.17	28.2	1.04
In(Zn)P cores (**ZnOL**)	3.62	0.18	23.97	0.34	63.16	0.48	39.15	1.02
In(Zn)P@ZnSeS (**ZnOL**)	6.34	0.26	26.72	0.64	74.52	0.10	26.45	1.09
In(Zn)P seed (**Zn oxo**)	4.42	0.28	22.49	0.43	74.62	0.29	32.4	1.04
In(Zn)P cores (**Zn oxo**)	6.13	0.18	31.42	0.61	83.95	0.21	37.83	1.00
In(Zn)P@ZnSeS (**Zn oxo**)	6.99	0.09	35.59	0.71	74.87	0.20	40.61	1.02

Table S2. Performances of optimized InP QD–based LEDs with a structure of ITO/PEDOT:PSS/PTAA/InP QDs/ZnO NPs/Al. EQE stands for external quantum efficiency, CE stands for current efficiency *L* stands for luminance.

Emitting layer	L_{max} **[cd m^{-2}] @ bias**	CE_{max} **[cd A^{-1}] @ bias**	EQE_{max} **[%] @ bias**	**Turn-on voltage [V] @ 0.1 cd m^{-2}**
InP QDs	1164.6@5.8	4.17@2.6	3.61@2.4	2.0