Supporting Information

Highly Luminescent Blue-Emitting In_{1-x}Ga_xP@ZnS Quantum Dots and their Application in QLEDs with Inverted Structure

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Fig. S1. ³¹P NMR spectra of various (a) indium and (b) gallium complexes synthesized using TOP in molar ratio of metal to TOP (M:TOP). Trioctylphosphine peak at -30 ppm is marked. Other peaks are assigned to relevant complex structures by comparing relative peak positions.



Fig. S2. Bandgap energy (black) and lattice constant (gray) vs. $In_{1-x}Ga_xP$ composition. Data are earned from references.¹⁻⁵ The plotted data are fitted using the polynomial function, an order of 2, with Origin program. Fitted graphs are plotted in lines. (Direct band gap energy: black solid line, indirect band gap energy: black dotted line, lattice constant: gray solid line) At about x = 0.72, there is transition from direct to indirect band gap energy.



Fig. S3. Absorbance spectra of aliquots taken at different growth time (0 min of growth: black, 30 min of growth: gray) using different primary amines: (a) tert-butylamine, (b) octylamine, and (c) oleylamine



Fig. S4. ³¹P NMR spectrum of $P(TMS)_3$ in the middle. The second spectrum from the top is new P precursor used in the synthesis. The spectrum of the mixture of $P(TMS)_3$ with OLA left for 9 days is shown at the top. To compare the peaks detected, two spectra of tris(dimethylamino)phosphine, $P(NMe_2)_3$, and its mixture with OLA are shown in the bottom part.



Fig. S5. (a) Absorption spectra, (b) XRD patterns, and (c~h) TEM images of QDs at different reaction times (c: at 0.05 min, d: at 0.5 min, e: at 1.5 min, f: at 2.5 min, g: at 3 min, and h: at 33 min) Each coloured lines are the standard XRD pattern for InP (JCPDF: 032-0452, red-dotted lines), GaP (JCPDF: 032-0397, green-dotted lines), and ZnS (JCPDF: 005-0566, blue-dotted lines).



Fig. S6. Characterization of QLEDs with various thicknesses of emitting layer: (a) EL spectrum, (b) current density-voltageluminance (J-V-L) characteristics, and (c) external quantum efficiency (EQE). Each coloured lines represent various thicknesses: 10nm (orange), 22nm (green), 40nm (blue), 50nm (red), and 59nm (black).

Device	Thickness (nm)	Max. E.Q.E (%)	EL λ_{max} (nm)	Max. Luminance (cd/m²)
# 1	10	0.03	494	82
# 2	22	0.10	495	126
# 3	40	0.20	491	74
# 4	50	0.14	488	36
# 5	59	0.12	491	17

Table S1. Analyzed characteristics of QLEDs with various thicknesses of emitting layer

Reference

- S1. L. Foster and J. Scardefield, *Journal of The Electrochemical Society*, 1970, **117**, 534-536.
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- S3. R. Nelson and N. Holonyak Jr, *Journal of Physics and Chemistry of Solids*, 1976, **37**, 629-637.
- S4. W. T. Masselink and M. Zachau, *Journal of crystal growth*, 1993, **127**, 14-18.
- S5. A. Onton, M. Lorenz and W. Reuter, *Journal of Applied Physics*, 1971, **42**, 3420-3432.