## Supporting Information

## Ligand Exchange-Ready $\mathrm{CuInS}_{2} / \mathrm{ZnS}$ Quantum

# Dots via Surface Ligand Composition Control for 

 Film Type Display DevicesJinyoung Choi, Wonseok Choi, and Duk Young Jeon*

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Figure S1. Photograph of the samples QDs dispersed in ethanol. (a) DDT:DDA = 1:2 sample QDs dispersed in ethanol without ligand exchange, (b) DDT:DDA = 1:2 with ligand exchange. (c) Ligand exchanged DDT:DDA = 1:2 QDs attached to $\mathrm{TiO}_{2}$ film under UV light. (d) DDT only QD after ligand exchange attempt dispersed in ethanol.


Figure S2 TEM image of the QDs. (a) CulnS $2_{2}$ core, and (b) CulnS $_{2} / \mathrm{ZnS}$ core - shell QD.


Figure S3. FT-IR spectroscopy of the QDs without the ligand exchange. (a) Overall spectrum, (b) N$H$ bending signal region for DDT only QD, and (c) DDT:DDA=1:2 QD.


Figure S4 XRD measurement result of the sample QDs. Top graph shows the result for DDT only QD, center graph shows the result for DDT/DDA combined ligand QD without ligand exchange, and the bottom graph shows the result after ligand exchange. Standard XRD peaks of Zinc Blende ZnS and tetragonal CulnS ${ }_{2}$ crystals from ICSD are shown in top and bottom of the graph.


Figure S5. XPS survey scan of the DDT:DDA = 1:2 sample QD. Element peaks from the QD are marked written by blue text, and the peaks from the SiO 2 substrate are written in black text.


Figure S6. XPS signal peak of the N 1s. (a) Normalized N 1s peaks for the DDT/DDA ligand QDs with synthesis ligand ratio of 1:1, 1:2, and 1:4. (b) Area of the corresponding peaks in (a)

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\tau_{\mathrm{avg}}=\frac{\left(\tau_{1} \times B_{1}\right)+\left(\tau_{2} \times B_{2}\right)+\left(\tau_{3} \times B_{3}\right)+\cdots}{100}
$$

Equation S1. Equation to calculate the average life time ( $\tau_{\mathrm{avg}}$ ) from the TCSPC. $\tau_{\mathrm{x}}$ indicate the lifetime of each component, and $B_{x}$ indicate the portion of the each component in percent.


Figure S7. TCSPC result of the DDT/DDA QDs with and without ligand exchange, alongside with the DDT only QD.

|  | DDT/DDA W/O ligand exchange | DDT/DDA W/ ligand exchange | DDT only |
| :---: | :---: | :---: | :---: |
| $\tau_{1}(\mathrm{~ns})$ | 50.49 | 136.8 | 109.76 |
| $\mathrm{B}_{1}$ (\%) | 8.5 | 16.2 | 8.58 |
| $\tau_{2}(\mathrm{~ns})$ | 213.03 | 322.3 | 291.47 |
| $\mathrm{B}_{2}$ (\%) | 64.14 | 70.19 | 70.85 |
| $\mathrm{t}_{3}(\mathrm{~ns})$ | 524.78 | 828.68 | 711.15 |
| $\mathrm{B}_{3}$ (\%) | 27.36 | 13.6 | 20.57 |
| $\tau_{\text {avg }}(\mathrm{ns})$ | 284.51 | 361.09 | 362.21 |

Table S1. Numerical value of the components in sample QDs derived by the TCSPC measurement. $\mathrm{T}_{1}, \mathrm{~T}_{2}$, and $\mathrm{T}_{3}$ are lifetime for each component, and B1, B2, B3 are component ratio of each.

