

Electronic Supplementary Information

Large Stokes Shifted Quaternary Copper Cadmium Sulfide Selenide Quantum Dots Waveguides

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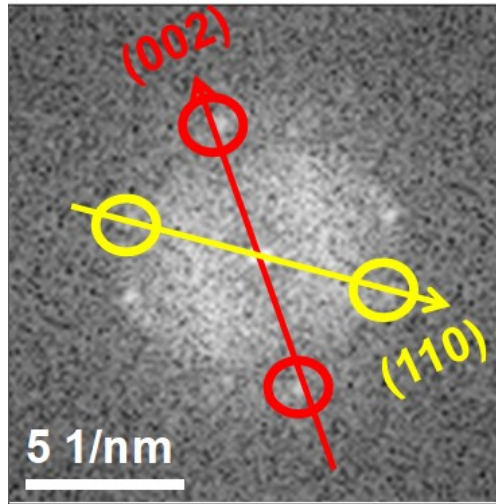


Figure S1. The FFT pattern obtained from the HRTEM showing the single-crystalline nature of CCSS QDs.

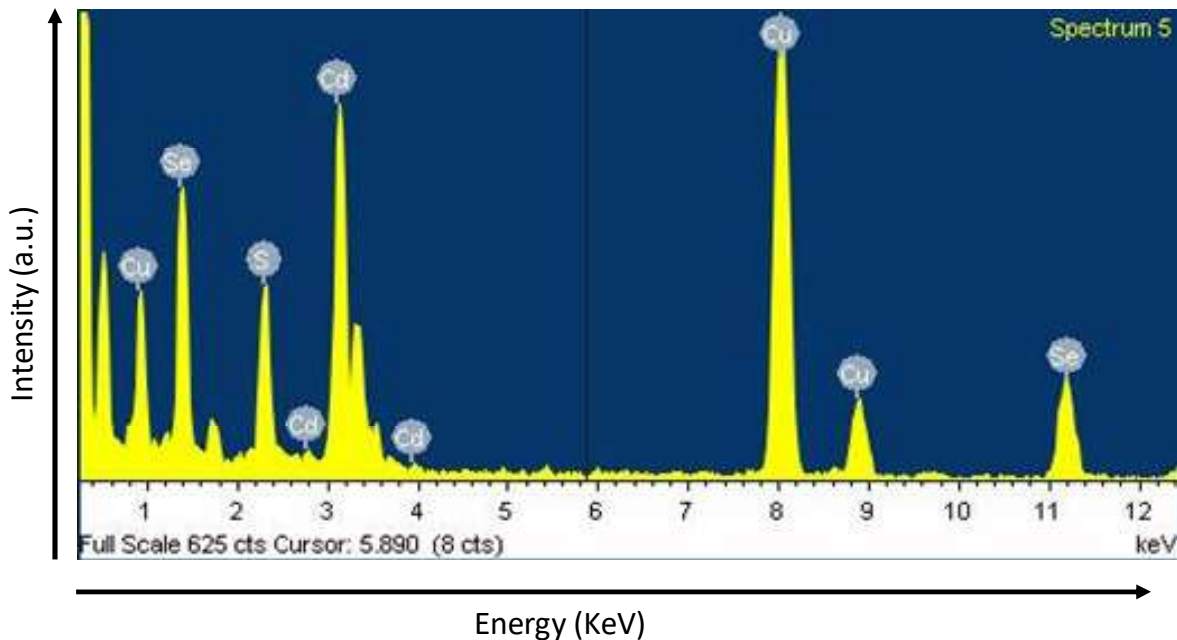


Figure S2. EDX spectrum of CCSS QDs showing the elemental composition of the QDs.

Table S1. Cu/Cd elemental ratio from ICP analysis with increasing annealing time which shows the gradual increase of Cu/Cd ratio with annealing time. The Cu/Cd ratio reaches the maximum value at 90 min annealing and the decreases upon increasing the annealing time. EDX analyses show the atomic percentage in the CCSS QDs synthesized at 90 min. The EDX reveals Cu/Cd elemental ratio of 1.67, which is close to ICP analysis at 90 min. Elemental analyses from XPS showing Cu/Cd elemental ratio of 1.55 at 90 min, which is close to ICP and EDX analyses.

| ICP | | EDX | | XPS | | | |
|-----------------------------|--------------------|----------------|-----------------|--------------------|----------------|-----------------|--------------------|
| Annealing Time (min) | Cu/Cd ratio | Element | Atomic % | Cu/Cd ratio | Element | Atomic % | Cu/Cd ratio |
| 10 | 0.37 | Cu | 45 | | Cu | 43 | |
| 20 | 0.43 | | | | | | |
| 40 | 0.81 | Cd | 27 | | Cd | 27 | |
| 60 | 0.94 | | | 1.67 | | | 1.55 |
| 90 | 1.56 | S | 16 | | S | 17 | |
| 120 | 1.31 | | | | | | |
| 150 | 1.02 | Se | 12 | | Se | 14 | |
| 180 | 1.02 | | | | | | |

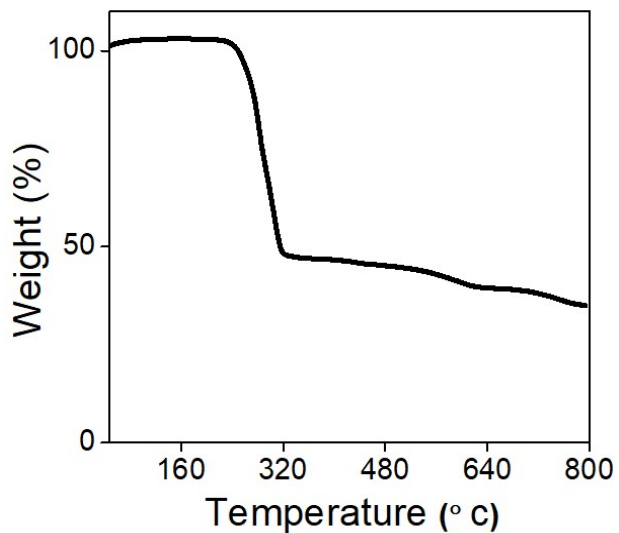


Figure S3. Thermogravimetric analysis showing the thermal stability of CCSS QDs.

Table S2. Cathodic and anodic peaks for CCSS and CSS QDs obtained from CV plots.

| Material | Anodic Peak (A1) | Cathodic Peak (C1) | Anodic Peak for Cu (A2') | Cathodic Peak for Cu (C2') |
|----------|------------------|--------------------|--------------------------|----------------------------|
| CCSS QDs | -5.67 eV | -3.0 eV | -4.94 eV | -3.01 eV |
| CSS QDs | -5.97 eV | -3.11 eV | Absent | Absent |

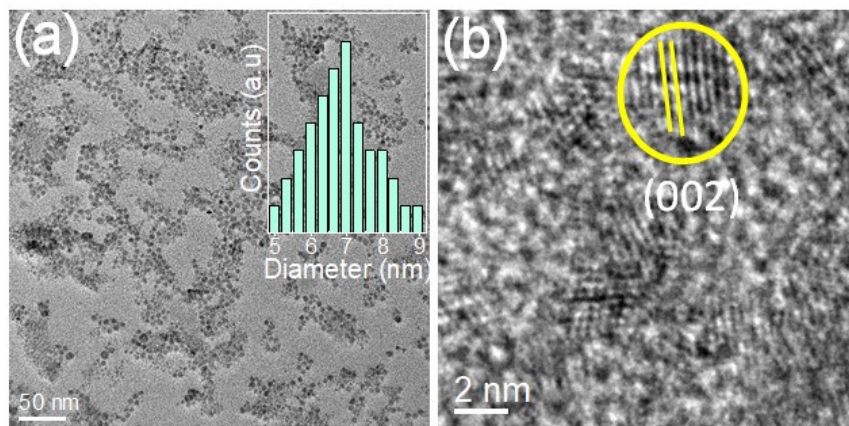


Figure S4. (a) TEM images of 180 min annealed QDs. The inset shows size distribution histogram. (b) HRTEM image shows lattice spacing's of 0.36 ± 0.02 nm which matches with (002) planes.

Table S3: PLQYs at different annealing time showing the maximum for the 90 min annealed QDs.

| Annealing Time (min) | PLQY (%) |
|----------------------|----------|
| 10 | 12.03 |
| 20 | 17.4 |
| 40 | 26.2 |
| 60 | 39 |
| 90 | 62 |
| 120 | 20 |
| 150 | 10 |
| 180 | 2 |

Table S4: TCSPC lifetime components of CCSS QDs along with the fitting parameters at different annealing time.

| Annealing time (min) | τ_1 (ns) | τ_2 (ns) | τ_3 (ns) | A ₁ | A ₂ | A ₃ | τ_{avg} (ns) |
|----------------------|---------------|---------------|---------------|----------------|----------------|----------------|-------------------|
| 20 | 14.09 | 91.3 | 265 | 0.44 | 0.42 | 0.137 | 80 |
| 60 | 16.5 | 115.7 | 333.6 | 0.37 | 0.46 | 0.17 | 115.3 |
| 90 | 6.74 | 45.2 | 136.6 | 0.49 | 0.38 | 0.12 | 37.5 |
| 150 | 28.6 | 146.3 | 435.5 | 0.25 | 0.5 | 0.24 | 187 |
| 180 | 106.8 | 396.5 | - | 0.54 | 0.46 | - | 237 |

Table S5. Rate of radiative and non-radiative relaxation of CCSS QDs with annealing time.

| Annealing time (min) | Radiative rate (k_{rad}) $10^6 \times S^{-1}$ | Non-radiative rate (k_{nrad}) $10^6 \times S^{-1}$ |
|----------------------|---|--|
| 20 | 2.18 | 10.32 |
| 60 | 3.4 | 5.3 |
| 90 | 16.5 | 10.1 |
| 150 | 0.534 | 4.8 |
| 180 | 0.084 | 4.1 |

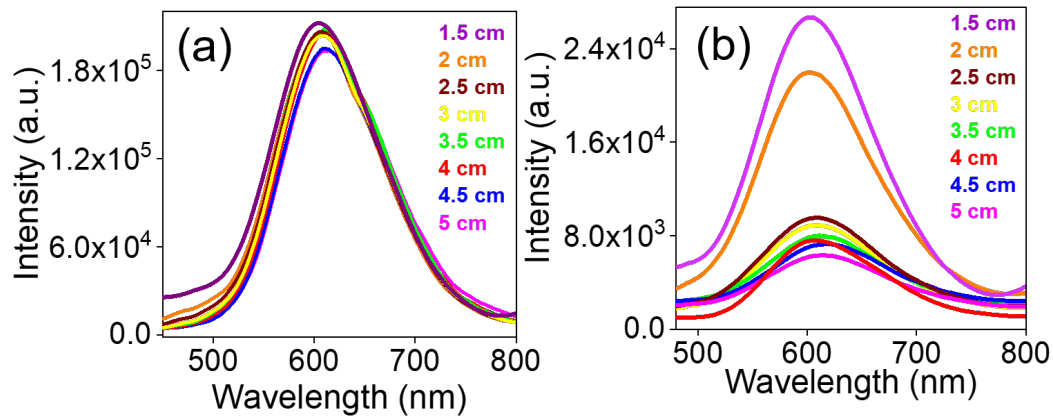


Figure S5. PL spectra of the waveguide slab at different distances from the excitation source collected at (a) edge and (b) face of the slab.