Electronic Supplementary Information (ESI)

Observation of polarized gain from aligned colloidal nanorods

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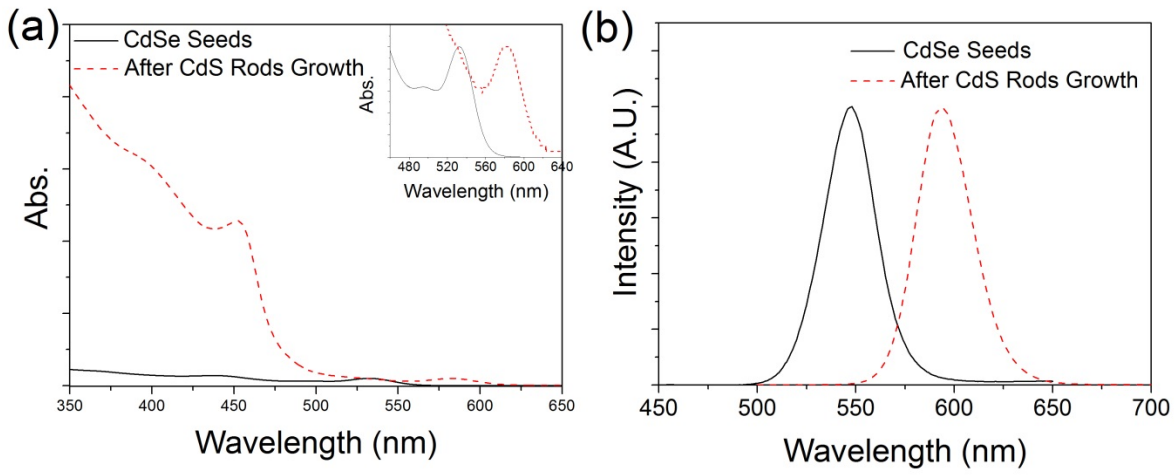


Figure S1. (a) Absorption spectra of CdSe seed and CdSe/CdS dot-in-rod solutions. The inset shows the zoom-in of the first absorption peaks. (b) Photoluminescence spectra of CdSe seed and CdSe/CdS dot-in-rod solutions.

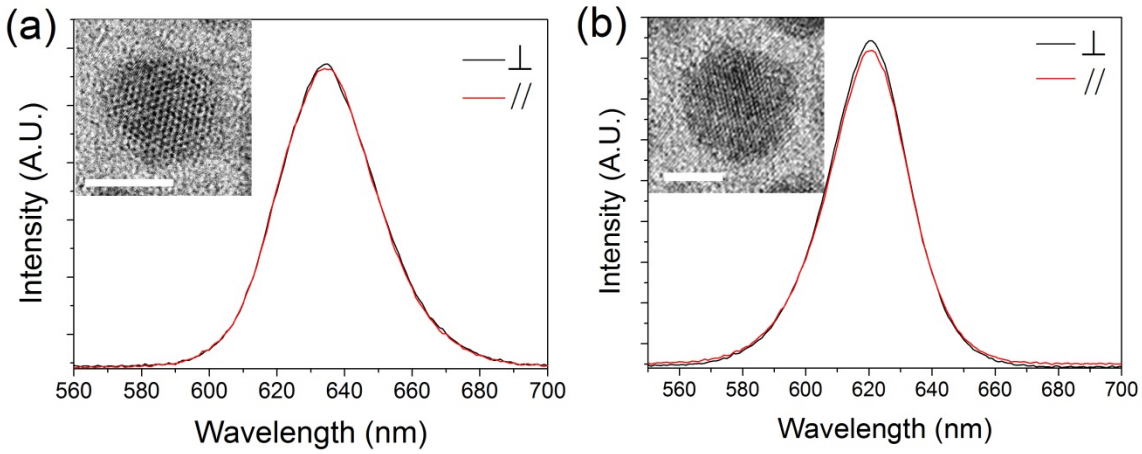


Figure S2. Spectra of emission from diluted (a) wurtzite CdSeS/ZnS spherical nanocrystals (b) zinc blende CdSe/CdS/ZnS spherical nanocrystals, which were detected with polarization parallel and perpendicular to the excitation polarization, respectively. The insets show high resolution TEM images for (a) wurtzite CdSeS/ZnS spherical nanocrystal and (b) zinc blende CdSe/CdS/ZnS spherical nanocrystal, and the scale bar is 5 nm.

Calculation of Fluorescent Anisotropy for Ensemble of DR Structure

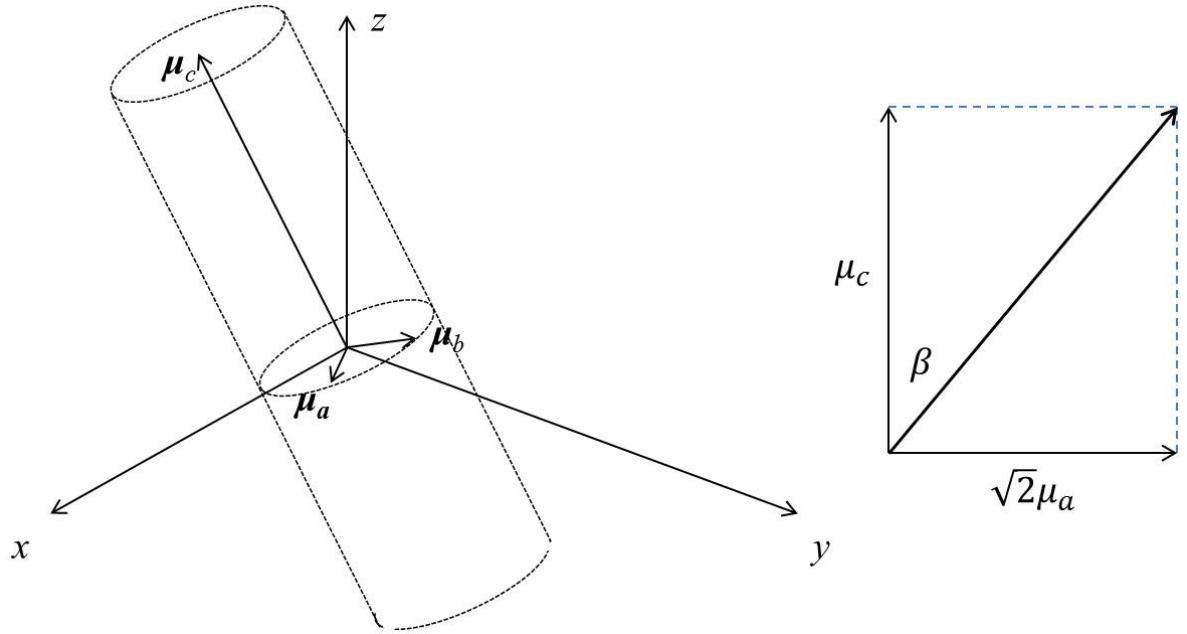
The fluorescence anisotropy is defined as

$$r = \frac{I_{//} - I_{\perp}}{I_{//} + 2I_{\perp}} \tag{S1}$$

For molecules, whose absorption and emission dipole is collinear, the maximum anisotropy is 0.4. If there is a displacement between absorption and emission dipole by β, the anisotropy can be written as [1]

$$r_0 = 0.4\left(\frac{3\cos^2\beta - 1}{2}\right) \tag{S2}$$

In our case, there are more than three dipoles, as shown in the following figure, contribute to the transitions. Thus we corrected the fundamental anisotropy.



$$r = 0.4\frac{1}{1+2x^2}\cdot\frac{3\cos^2\left(\arctan\left(\sqrt{2}x\right)\right)-1}{2} + 2\cdot 0.4\cdot\frac{x^2}{1+2x^2}\cdot\frac{3\cos^2\left(\arctan\left(\frac{\sqrt{1+x^2}}{x}\right)\right)-1}{2},$$

where $x = \frac{\mu_a}{\mu_c}$, $\beta = \arctan\left(\sqrt{2}x\right)$. (S3)

This equation is plotted in Figure 1d.

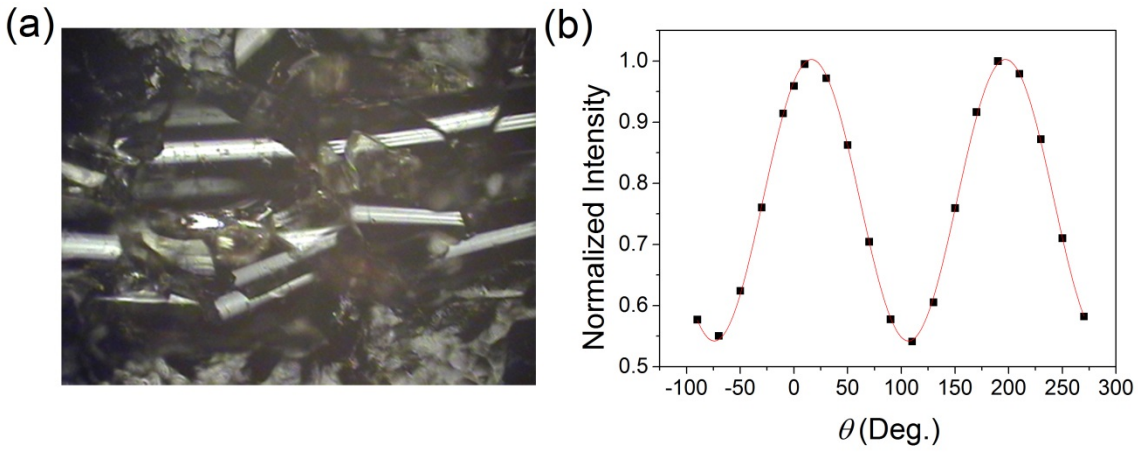


Figure S3. (a) Fragments of capillary tube with dried CdSe/CdS DRs in its inner wall. The capillary tube

was affixed on adhesive tape to maintain the orientation of fragment. (b) Normalized emission from cracked capillary tubes with CdSe/CdS DRs as a function of excitation polarization angle with respect to tube axis. The sample is excited by a linear polarized laser.

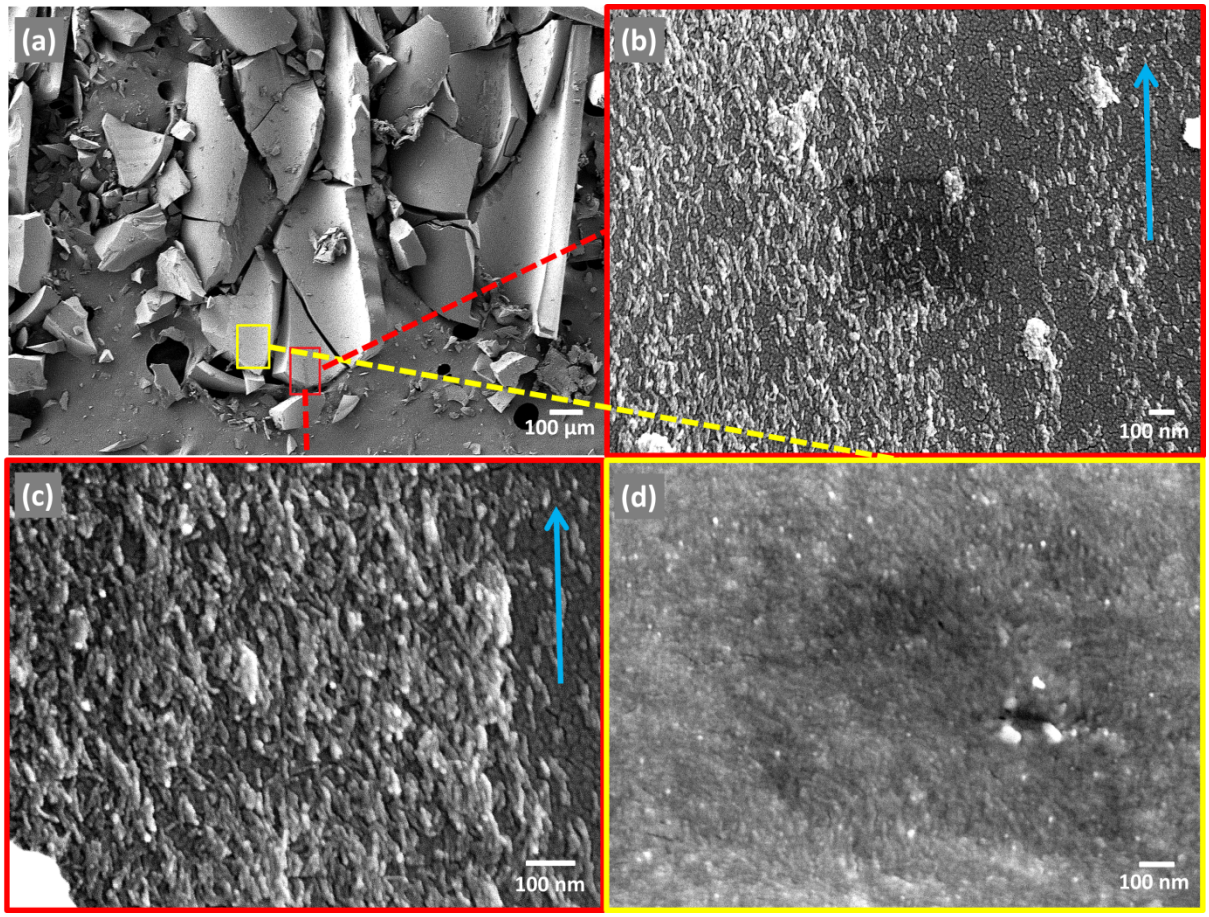


Figure S4. SEM images of CdSe/CdS dot-in-rod (DR) layer on the inner wall of a capillary tube. (a) The capillary tube with dried CdSe/CdS DRs was cracked and affixed to the SEM sample holder with conductive carbon tape. The sample was covered by 5-10 nm gold to improve electrical conductivity. (b), (c) A small peel-off region shown in the red frame of (a) illustrates that DRs are statistically oriented along the capillary tube. The arrows indicate the orientation of the capillary tube. (d) Area in the yellow frame of (a) where DR film is flat and smooth. The finite grain size of the gold coating layer together with smoothness and non-conducting nature of the glass capillary limited us to take high quality SEM images. The black region in (b) and (c) is caused by the charging effect in our sample which is not very conductive.

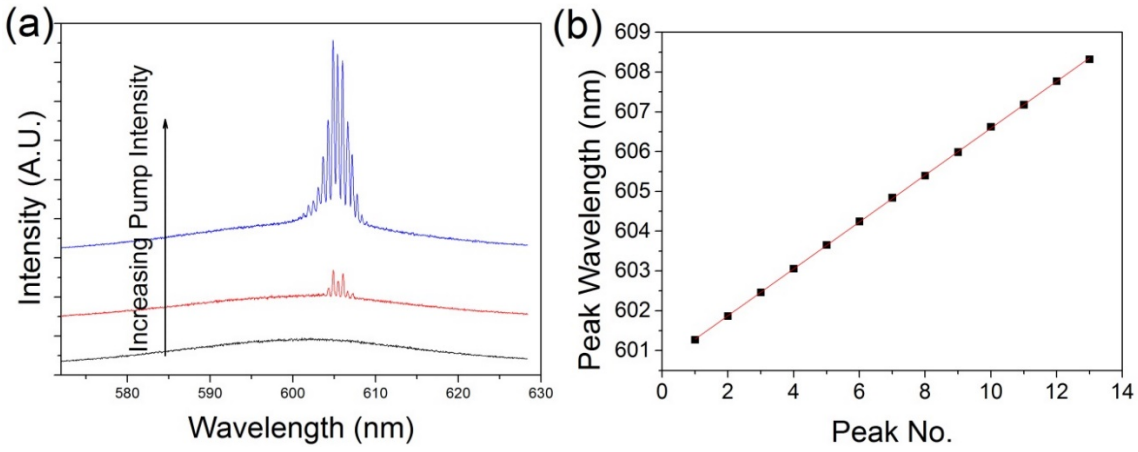


Figure S5. WGM lasing from dried CdSe/CdS DRs in capillary tube with diameter of 100 μm. (a) Evolution of spectra as increasing pump energy (from the lower to the upper). (b) Plot of wavelength of each peak versus the peak number with linear fitting.

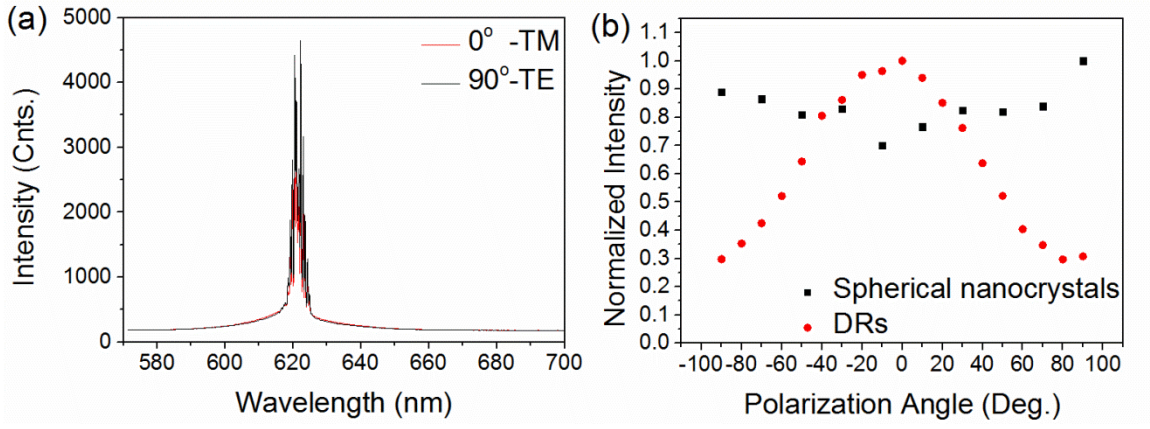


Figure S6. Stimulated emission characterization from CdSeS/ZnS spherical nanocrystals in the capillary tube. (a) Lasing spectra from CdSeS/ZnS spherical nanocrystals in the capillary when pumped by a circularly polarized laser and the detected polarization is set along the tube (0°, TM mode) and then perpendicular (90°, TE mode). (b) Lasing intensity from CdSeS/ZnS spherical nanocrystals (black square) and DRs (red dot) in the capillary tube as a function of the detection angle with respect to the capillary tube.

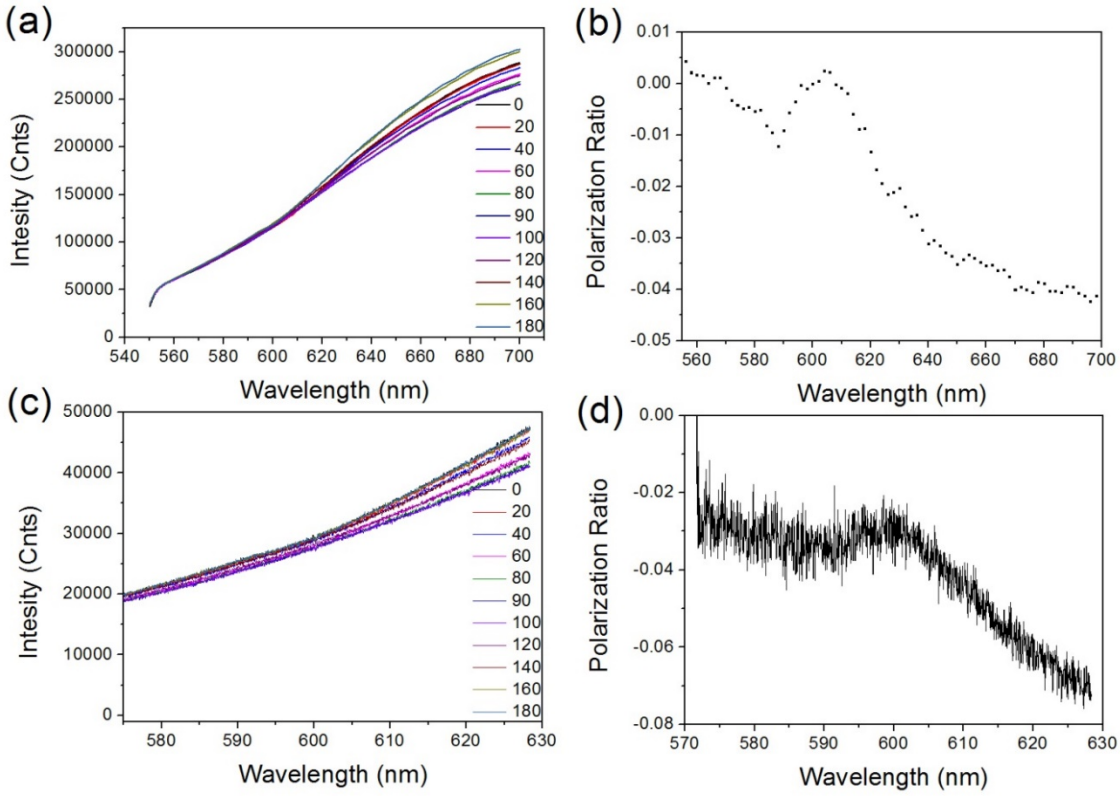


Figure S7. Polarization response of the detector within the wavelength range of interest under iodine-tungsten lamp illumination. Monochromator plus PMT: (a) The evolution of spectra of the lamp during varying the polarization angle of detection; (b) the corresponding polarization ratio. Monochromator plus CCD: (c) The evolution of spectra of the lamp during varying the polarization angle of detection; (d) the corresponding polarization ratio.

References

1. J. R. Lakowicz, *Principles of Fluorescence Spectroscopy*, Springer, 2007, 353-381.