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2013

Dang, C., Lee, J., Roh, K., Kim, H., Ahn, S., Jeon, H., et al. (2013). Highly efficient, spatially coherent distributed feedback lasers from dense colloidal quantum dot films. *Applied Physics Letters*, 103, 171104-.

<https://hdl.handle.net/10356/79635>

<https://doi.org/10.1063/1.4826147>

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SUPPLEMENTAL MATERIAL

Highly Efficient, Spatially Coherent Distributed Feedback Lasers from Dense Colloidal Quantum Dot Films

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1. A Colloidal Quantum Dot Whispering Gallery Mode Laser in a Spherical Micro-Resonator

To show the conformal versatility of the densely packed CdSe/Zn_{0.5}Cd_{0.5}S thin films as laser media we demonstrated of a specific microcavity configuration, namely a spherical micro-resonator in Fig. S1. Here, by spin casting a mixture of 30 μm silica microspheres with the high concentration CQD solution, and following quick evaporation of the solvent, the CQDs were coated on the microspheres (as well as the substrate which anchored microspheres). Lasing under ultrashort pulsed pump with whispering gallery modes (WGM) was clearly demonstrated in Fig. S1, even without any further optimization of the fabrication process. The microphotograph in the inset of Fig. 1 shows how the WGMs were localized inside the microsphere, and how the CQD optical gain media appears to couple into the modes by the evanescent wave modes. The spectral

data which was collected at 90° from incident pump beam showed multi-mode lasing with a threshold of about $150 \mu\text{J}/\text{cm}^2$. Below the threshold, the spectrum of spontaneous emission from CQDs was observed as expected, and above threshold, a multi-mode laser spectrum was emerged from the background spontaneous emission. (The laser lines emerge on strong spontaneous emission background as a result of significant amount of CQD in the planar substrate and under the microsphere, where they did not couple into cavity modes). The mode spacing was $1.4 \pm 0.5 \text{ nm}$ which is corresponding to the resonant modes of $28 \mu\text{m}$ diameter ring cavity (refractive index of 1.5), very good agreement with our microspheres. Our simple fabrication method for this concept demonstration did not include any scheme to optimize targeted coupling of the pump input to the CQDs shell of the microsphere cavity, nor any light output extraction scheme. Nonetheless, we achieved the initial aim of applying the thin films CQD gain media conformally to encourage further work on other micro-resonator geometries.

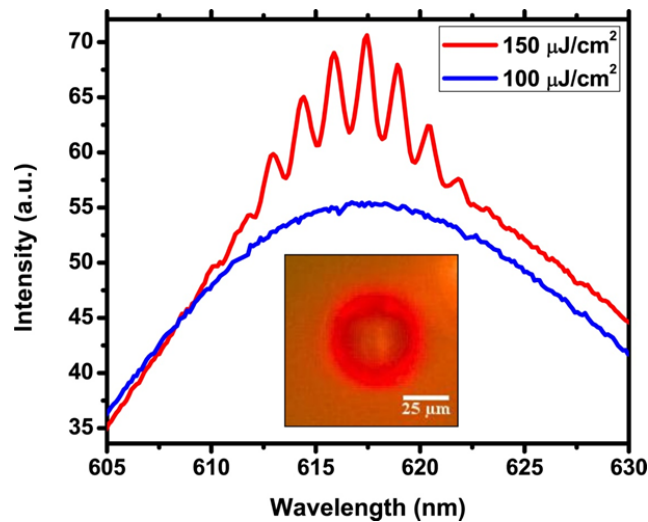


FIG. S1. Spectra analysis of a CQD laser with WGM in a spherical micro-resonator structure presents a threshold behavior and narrow laser lines. The inset shows a clear WGM in a microsphere.

2. Quasi-Continuous Amplified Spontaneous Emission from Dense CQD Films

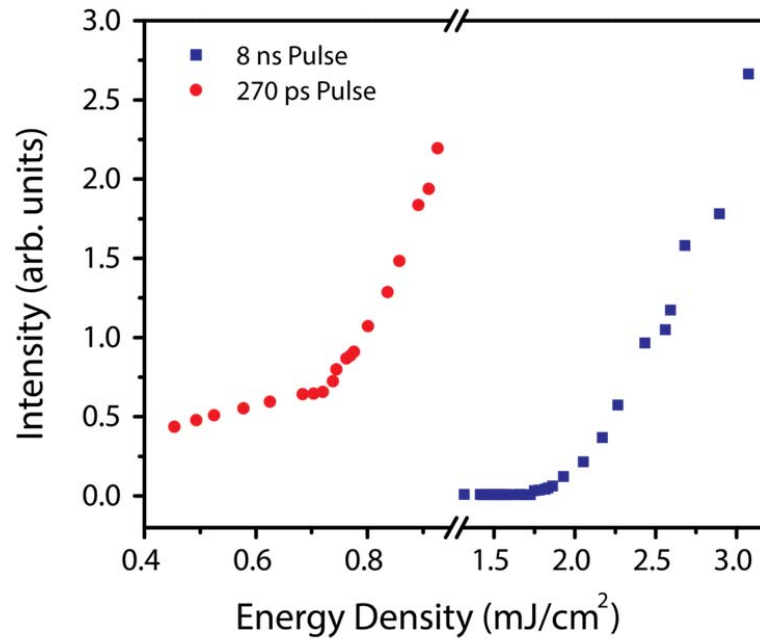


FIG. S2. Quasi-continuous ASE from densely packed red CQD thin film (250 nm) under photo pumping at wavelength of 532 nm. Relative intensity of the measured edge emission is shown as a function of pumping energy density in the stripe excitation geometry. The contrasting pump pulse widths (FWHM) are 270 ps and 8 ns, respectively. Because of single exciton gain mechanism, the Auger loss is significantly reduced and therefore the threshold for ASE only doubles when the pump pulse width increases 30 times.