

## Supporting information

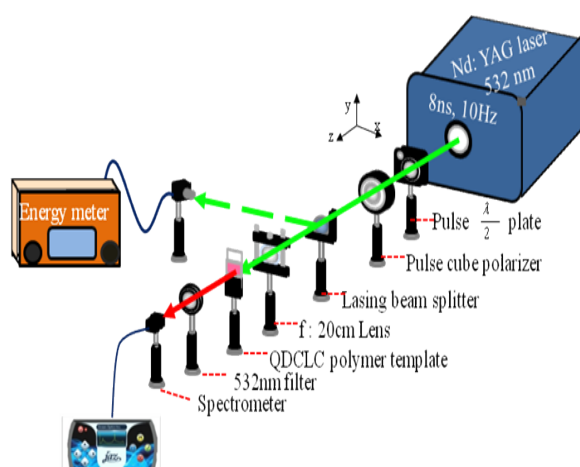
### Experimental Section

The blended CLC-monomer materials used to fabricate the CLC polymer template (“template” for short in later content) in this study include 69.8 wt% E7 (NLC, from ECHO CHEMICAL CO.), 12 wt% R811 (right-handed chiral dopant, from Fusol-Material), 15.5 wt% RMM691 (chiral monomer, from Merck), 2.5 wt% RMM257 (achiral diacrylate monomer, from Merck), and 0.2 wt% Irg184 (photoinitiator, from Pufeng). In E7 host, the HTP values of R811 and RMM691 are about 11.24 and 3.73  $\mu\text{m}^{-1}$ . The photoinitiators can absorb UV light to generate free radicals which may trigger the chain polymerization process of RMM691 and RMM257, where the function of RMM257 is to strengthen the crosslinking polymerization. Each empty cell is pre-fabricated by assembling two cleaning glass slides which are pre-coated with anti-parallel alignment layers. Two narrow plastic spacers with variable thicknesses are placed between the two glass slides to control the cell gap ( $d$ ). Four stages in fabricating each refilling CLC template sample. The uniformly blended CLC-monomer materials are injected into empty cells, and then diffuse throughout the cells via capillary effect to form the CLC-monomer composite cells (before curing). Each CLC-monomer composite cell is cured with one UV beam of 1.2 mW/cm<sup>2</sup> for 45 minutes to complete the photopolymerization of the cell (after curing). The UV-cured cell is then immersed in cyclohexane in dark for about five days for washing out the residual fluids of CLC (E7 and R811) and nonreactive monomers in the cell (after washing). In this stage, the transparent template cell can be obtained after completely removing the residual fluids and drying out in an oven at 80°C for 6 hrs by vaporizing the remnant cyclohexane. A QDNLC (QDs and MDA3970) is then refilled into the template cell to form a QDNLC-refilling template sample (after refilling).

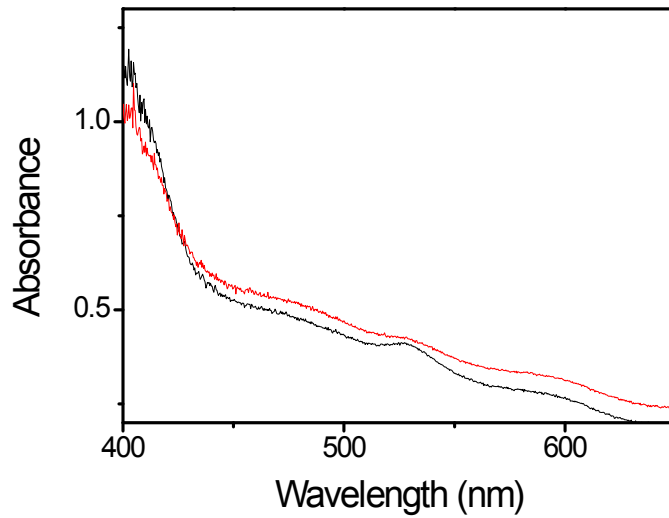
Details of the passivation procedure are presented in a typical reaction, thiol ( $\text{C}_6\text{H}_{14}\text{S}$ , 110 mg, 0.43 mmol, from Alfa Aesar) was mixed with an QDs (11.5 mg, 0.1 mmol) sample, and the mixture was heated to 120 °C for 72 h. After the reaction, the mixture was cooled to room temperature and dispersed in ethanol, followed by centrifuging for 30 min. The QDNLC mixtures with weight ratios of nematics and QDs dopant with surface passivation of 95:5 was prepared according to the previous procedure [1]. CdSe/ZnS QDs with a CdSe core and a ZnS shell (quantum yield=80%, average diameter = 3 nm, from PlasmaChem) was mixed in NLCs to produce QD-embedded NLC mixtures.

The lasing output from the QDCLC polymer template cell was measured after the

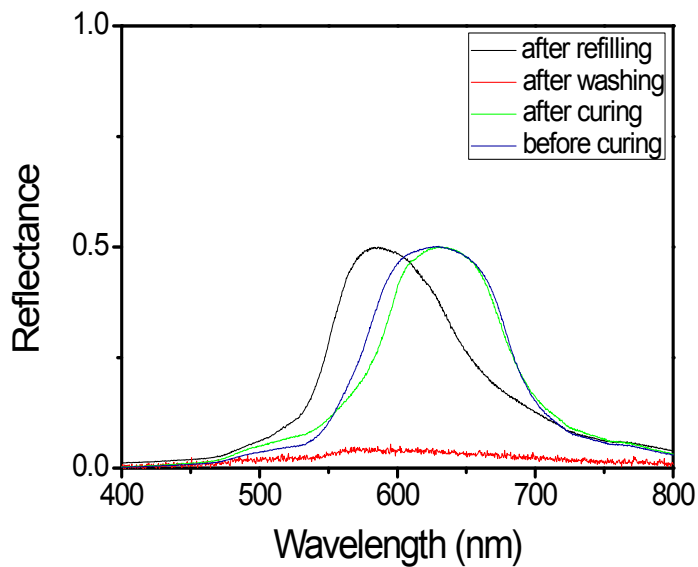
excitation of the pumped-pulse laser beam based on the experimental setup presented in **Figure S1**. A second harmonic-generated pumped-pulse laser beam from a Q-switch Nd:YAG laser (LAB-130, from Quanta-Ray), with a wavelength, pulse width, and pulse repetition frequency of 532 nm, 8 ns, and 10 Hz, respectively, was used to pump the QDCLC polymer template cell. The incident beam was focused on the sample by a lens (focal length: 20 cm) at an incident angle of  $0^\circ$  from the normal of the cell. The induced lasing emission along the normal direction of the cell was measured behind the cell by using a fiber-based spectrometer with an optical resolution of  $\sim 1.0$  nm (Jaz-combo-2, Ocean Optics). A notch filter (for 532 nm) was placed behind the cell to block the strong transmitted light of the pumped pulses from directly hitting the spectrometer. A half-wave plate (for 532 nm) and a polarizing polarizer were placed behind the exit of the laser to adjust the incident pumped energy (E) of the pumped-pulse laser beam on the cell. The reflection spectrum of the incident white light that was illuminated at normal incidence on the QDCLC polymer template cell was also obtained using a fiber-based spectrometer (USB2000, Ocean Optics; optical resolution = 1.4 nm) to identify the corresponding PBG structure of the cell.



**Figure S1** Experimental setup for measuring the fluorescence (or lasing) emission spectra of the QDCLC polymer template cells.



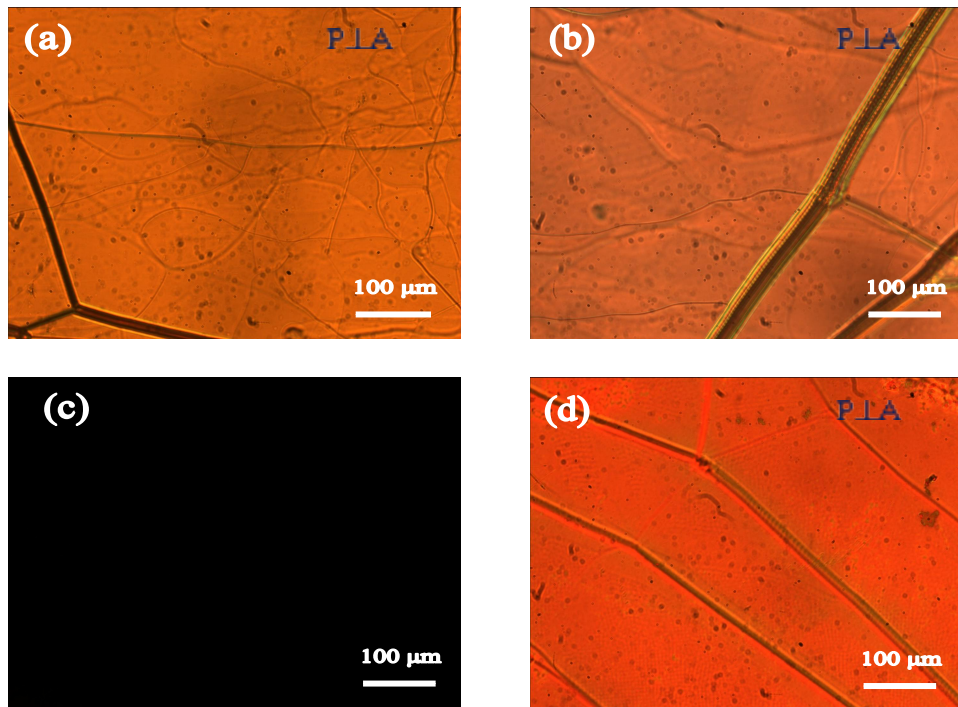
**Figure S2** Measured absorption spectra of the of CdSe/ZnSe QDs (before surface passivation is black line, after surface passivation is red line) dispersed in toluene.



**Figure S3** Measured reflection spectra of the sample, presented by the black, green, red, and blue curves, at before-curing, after-curing, after-washing, and after-refilling stages of fabrication of the QDNLC-refilling CLC template sample, respectively.

Also, the increase of the optical efficiency is due to a decrease in the number of surface defects or an increase in the density of emissive surface states. It should be noted that, after the surface passivation process, the lasing intensity of the sample increased slightly with QDs emission matching the band edge of the CLC polymer template. Therefore, the contribution of a template component to the interactions between CLC and the surface of the QDs cannot be completely ruled out. At after-washing and after-refilling stages, the PBG of the sample disappears and then reforms, respectively. These results reflect that a spiral structure inside the sample is just temporally hidden at after-washing stage and reappears at after-refilling stage.

However, in the samples with 5 % or higher QDs content, serious aggregate in the devices were observed after refilling was applied. Thus, as the dark image of POM shows, a nonuniform alignment with defect and with increased liquid crystal disturbance was observed in the devices with higher QDs concentration ( $>5\%$ ). In this case with more than 5 % QDs concentration, more substantial, but also uniform, changes in the alignment – moving from the initial planar to isotropic – were detected. A change to isotropic phase is consistent with the results observed by other groups in liquid crystal structure with polymer template. Their detailed analysis of the template mode suggested that some QDs aggregation were excluded from the effect to the polymer–LC interfaces as a result of decreased QDs emission efficiency in the ordered nematic liquid crystal bulk. QDs aggregation accumulated at the polymer template affecting the alignment of the liquid crystal molecules. In our experiment, the process of polymerization toward substrates could have been accelerated by the rise UV irradiation intensity. Consequently, we decreased the QDs content to find the critical concentration at which the majority of nanoparticles remained in the liquid crystal bulk and therefore did not affect the initial, planar cell alignment. These concentrations were found to be 5 % by weight for MDA3970. Samples without surface passivation of QDs and also without polymer template assisted were selected for further optical experiments. The further characterization of the interesting QDCLC polymer template and investigation of their electrooptical properties are in progress. With formation of QDCLC polymer template after refilling, the stop band enhances systematically and the corresponding reflectance intensity increased about 5 times (Figure S3). The enhancement of the stop band position in the progress of QDCLC polymer template indicates further incorporation of the CLC structure into the order orientation, resulting in an increase of the multi-reflect resonance.



**Figure S4.** Polarizing optical microscopy images of the devices with: a) before curing, b) after curing, c) after washing, d) after refilling, respectively.

Initially, the device demonstrated planar phase at the conditions (before curing, after curing and after refilling) except washing process. These corresponded to the bright and dark POM images, which depended on the nematic liquid crystal alignment direction with respect to polarizer axes. UV irradiation at 365 nm was contributed by a UV lamp ( $1 \text{ mW/cm}^2$ , for polymer curing purpose) at the sample. Within 1 day under irradiation this sample conservation of the planar phase as evidenced as shown in Figure S4 (b). Removal of residual fluids under washing process leads to the isotropic phase appearing (Figure S4c). It is shown by this experiment that the conversion from the isotropic to the planar (Figure S4(d)) phase of the QDCLC leads to refilling QDs doped nematic liquid crystals. The reversion to the original planar texture was reached within approximately 3 h at room temperature.

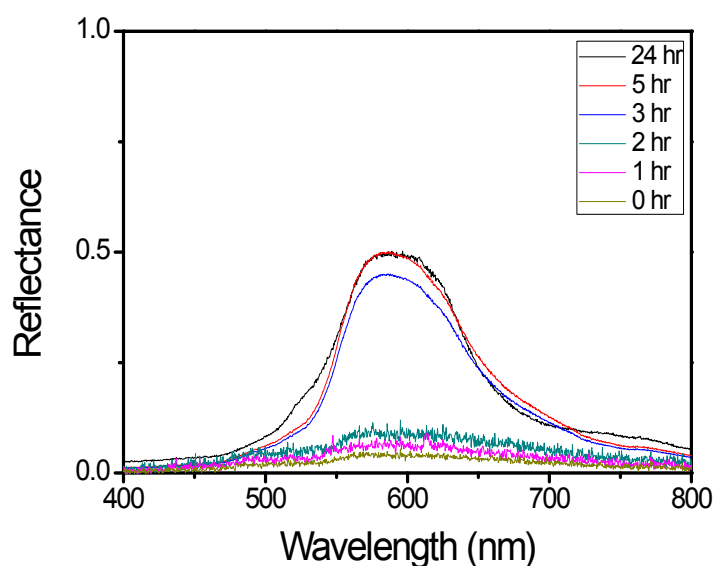
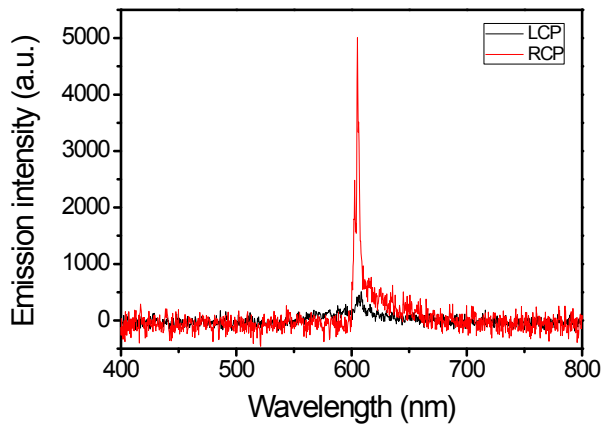
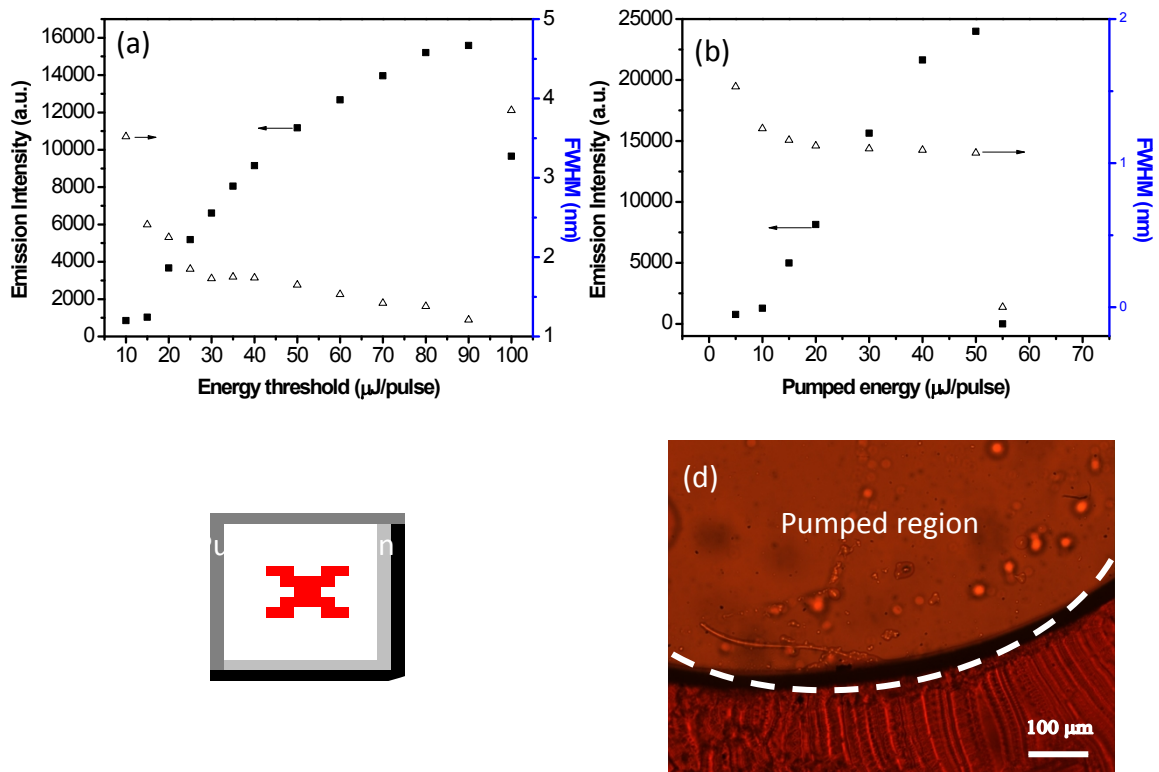


Figure S5. Dependence of reflectance spectra of QDCLC polymer template after static time for 0 h, 1 h, 2 h, 3 h, 5 h, and 24 h, respectively.

The reflect intensity increases with the increasing static time of the underlying polymer template manifold for the same experimental conditions (4 times for the static time 3 hr). Similarly, adding the polymer template on top of QDCLC leads to an increase of photoemission intensity with a further, 1/2-fold increase as compared to QDCLC without polymer template (Figure 1b). The stop band of QDCLC polymer template formed with increasing static time. Over a broad range of static time (3hr), we observed complete stop band or no change in the characteristics of the band-edge for QDCLC polymer template. Over the static time of 2 hr, the complete stop band of QDCLC polymer template was obtained. This indicated that the polymer crosslink was a good template agent for the QDs doped CLC cells. Polymer crosslink template seemed more sensitive to basic static time. At static time above 2 hr, the stop band of QDCLC appeared. Compared with the various conditions, the expanded surface passivation of QDs combined with the increased PL intensity of the CLC polymer template made them good candidates for realizing optical gain enhancement of light emitters.



**Figure S6.** The measured lasing emission spectra of QDCLC polymer template if the pre-made CLC right- and left-circular polarizers (LCP and RCP, respectively) are individually inserted between the cell and the spectrometer.



**Figure S7.** (a),(b) Peak intensities of fluorescence emission and corresponding full-widths at half-maximum (FWHM) of the QDCLC and DDCLC polymer template as functions of pumped energy, respectively. (c),(d) Images of the pumped area for the QDCLC and DDCLC polymer template cells observed under the polarizing optical microscope (POM) with crossed polarizers, respectively, after the two cells are pumped at high pumped energies of  $E = 100 \mu\text{J}/\text{pulse}$  and  $E = 55 \mu\text{J}/\text{pulse}$ , respectively.

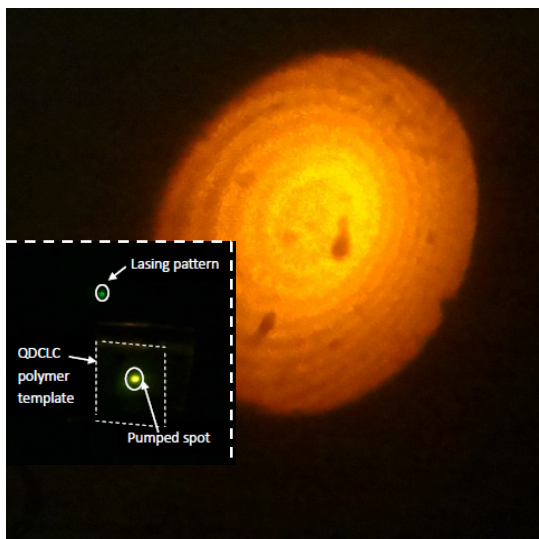


Figure S8. Recorded emission patterns of the QDCLC polymer template cell on the screen placed behind the cell when the QDCLC cell is excited by the pumped pulses beam. The inset indicates the lasing pattern of QDCLC polymer template.

The PL modes observed in the luminescence spectrum below the lasing threshold (Figure 3 (a)) and the lasing modes show that the QDCLC polymer template forms an optical cavity, caused by the refractive index difference between and the QDCLC and the surrounding. We remark that the polymer template did not have a significant influence on the laser emission; lasing was also observed when the resonator source was replaced by polymer template. This indicates that the polymer template to the enhancement optical efficiency is rather strong. The image of the QDCLC polymer template shows characteristic similarities with a diffraction pattern of a round aperture generated by polymer template sources at the QDCLC cells, which are sufficiently far apart such that hardly any interference is observed. Furthermore, one can see weak emission intensity from the QDCLC without polymer template due to incoherent emission at  $E=11 \mu\text{J}/\text{pulse}$ . The QDCLC with polymer template, in contrast, shows strong interference between the lasing emission sources, leading to a ray-like pattern due to the formation of interference maxima and minima.