Supporting Information

Laser mode control based on chiral liquid crystal microcavities

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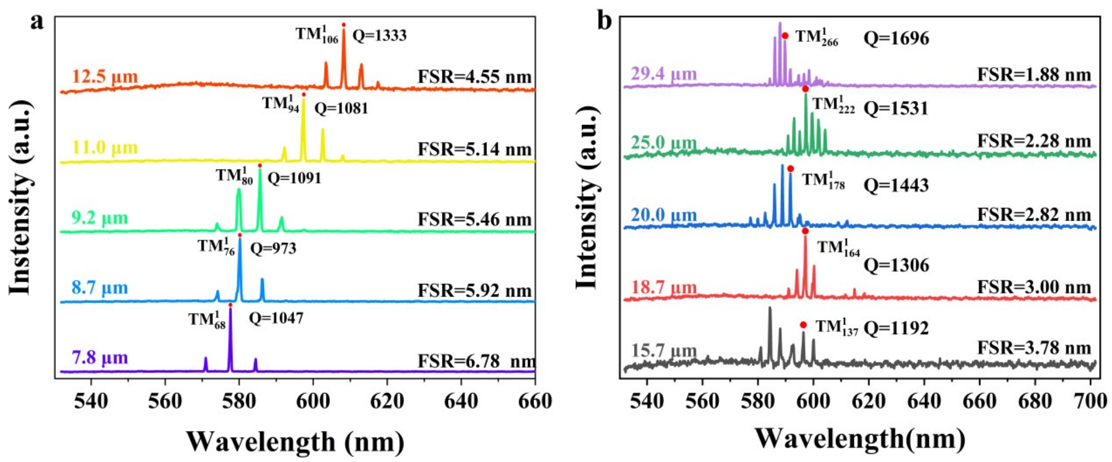

Fig. S1. The WGM spectra of CLC/PM597 droplets at different sizes. (a) WGM spectra of CLC/PM597 microdroplets at relatively small sizes (7.8-12.5 μm). (b) WGM spectra of CLC/PM597 microdroplets at sizes 15.7-29.4 μm.

The wavelength shift can be explained by the WGM mode calculation formula

$$\lambda^{-1} = \frac{1}{\pi D n_{cav}} \left[\mathrm{m} + \frac{1}{2} + 2^{-\frac{1}{3}} a(r) \left(m+\frac{1}{2}\right)^{\frac{1}{3}} - \frac{N}{\sqrt{n_r^2-1}} + \frac{3}{10} 2^{-\frac{2}{3}} a^2(r) \left(m+\frac{1}{2}\right)^{-\frac{1}{3}} - 2^{-\frac{1}{3}} N \left(n_r^2 - \frac{2}{3}N^2\right) \frac{a(r)\left(m+\frac{1}{2}\right)^{-\frac{2}{3}}}{\left(n_r^2-1\right)^{\frac{3}{2}}} \right]$$

* MERGEFORMAT (1)

where λ is the resonant wavelength, n_{cav} is the refractive index of the cavity, n_{env} is the surrounding refractive index, *D* is the radius of the circular microcavity, $n_r = \frac{n_{cav}}{n_{env}}$, $N = \frac{1}{\mathrm{n}_r}$ for transverse magnetic (TM) mode, $N = n_r$ for transverse electric (TE) mode, $a(r)$ is the root of the Airy function, where r is the radial mode number and m is the mode number.

We calculate the corresponding TM patterns using formula (1) and annotated them in the figure. Fig. S1a shows that as the droplet size increases from 7.8 to 12.5 μm, the lasing wavelength of WGM shifts, and the corresponding mode also shifts. In Fig. S1b, when the size is large, the lasing wavelength of WGM is mainly concentrated between

580 and 610 nm. However, for different size droplets, the TM modes of the WGM laser peak at the same wavelength are different. And the quality factor (Q) at this time is marked in the graph.

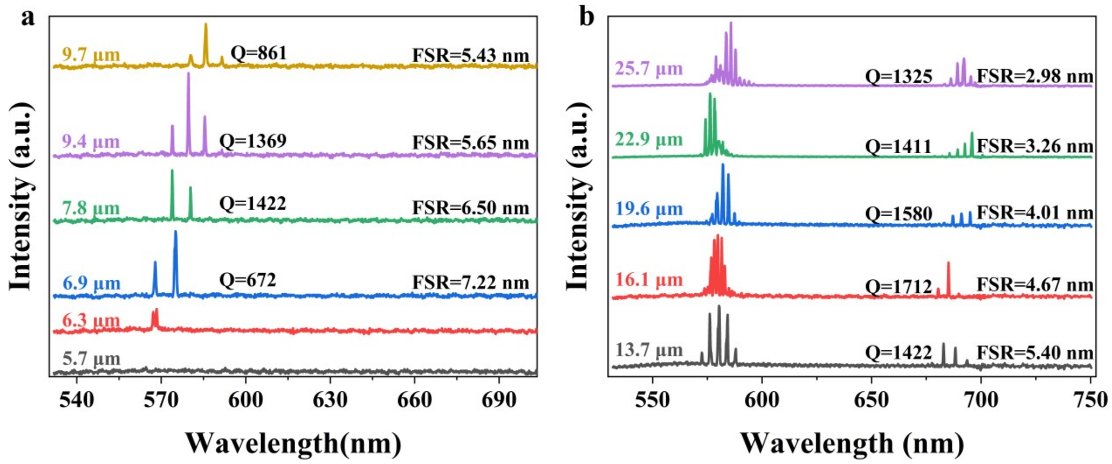

Fig. S2 WGM spectra of sample 2 at different sizes.

The quality factor for the sizes between 13.7-25.7 µm is calculated using the WGM at 680-710 nm.

We compare the quality factor in this paper with that of other liquid crystal droplet lasers. The specific results are shown in Table S1 below.

Table S1: Comparison of quality factors among liquid crystal droplet lasers

Type	Quality factor	References
Nematic liquid crystal droplet	770	1
Cholesteric liquid crystal droplets	694	2
Cholesteric liquid crystal droplet	4300	3
Nematic liquid crystal droplet	12,000	4
Cholesteric liquid crystal droplet	1607	This work

Table S2: FSR of sample 1 with different sizes

Size (µm)	λ_1 (nm)	λ_2 (nm)	FSR_2 (nm)	FSR_1 (nm)
7.8	577.70	570.92	7.65	6.78

8.7	580.18	574.26	6.94	5.92
9.2	585.39	579.93	6.69	5.46
11.0	597.33	592.19	5.83	5.14
12.5	608.15	603.60	5.33	4.55
15.7	596.47	592.71	4.09	3.78
18.7	597.05	594.05	3.45	3.00
20.0	591.74	588.92	3.17	2.82
25.0	599.58	597.30	2.61	2.28
29.4	588.02	586.14	2.14	1.88

According to the experimental results, calculate FSR_1 using the following formula:

$$FSR_1 = \lambda_1 - \lambda_2 \qquad \text{* MERGEFORMAT (2)}$$

where λ_1、λ_2 represents the two adjacent wavelengths used to calculate FSR_1. To calculate the theoretical value of FSR_2, we use the following formula:

$$FSR_2 = \frac{\lambda_2^{\ 2}}{\pi n D} \qquad \text{* MERGEFORMAT (3)}$$

where λ_2 is the emission wavelength, D represents the diameter of the droplet, and n represents the refractive index of the microcavity. In this experiment, due to the parallel surface orientation of the liquid crystal molecules to the droplets, it is assumed that $n \approx n_e = 1.74$, where n_e represents the extraordinary refractive index of the liquid crystal.

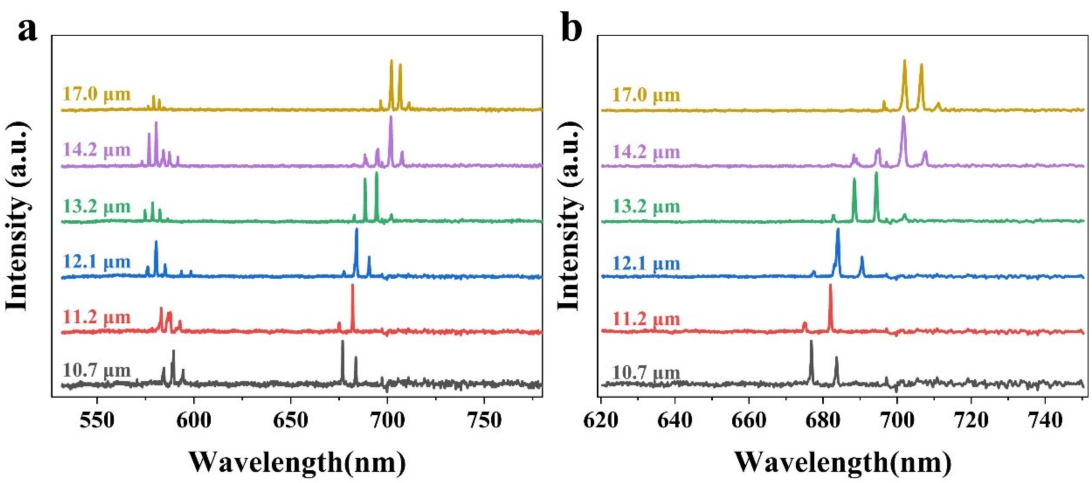

Fig. S3. Laser spectra of sample 2 droplets at different sizes by end pumping. (a) Sample 2: CLC microcavity WGM laser at different sizes. (b) The energy transfer part in (b) is extracted and enlarged.

During the process of size increasing from 10.7-17 μm, the WGM of energy transfer (between 680 nm and 710 nm) also shows a red shift in wavelength as the droplet size increases.

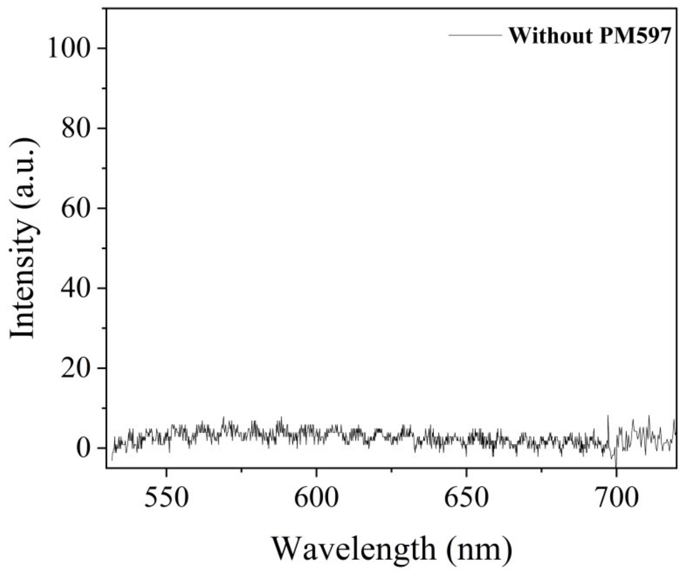

Fig. S4. There is no PM597 inside the droplet, and NB is presence in the external solution.

Fig. S4 shows that no laser output is shown whether the excitation light (532 nm) is applied to pump the edge or the center of the droplet. When there is only NB dye in our experiment, there cannot be laser emission. The excitation of NB is due to energy transfer.

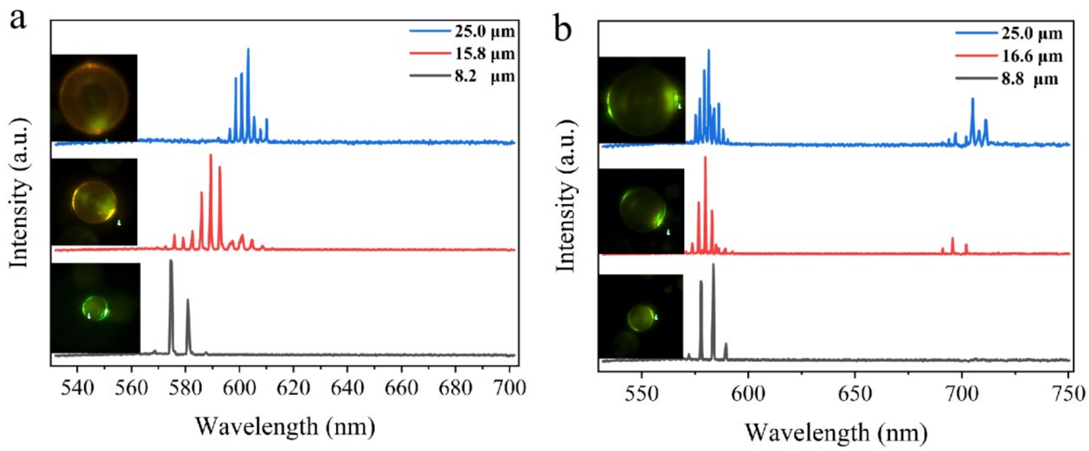

Fig. S5. Microscope photograph and spectrogram of a droplet with excitation light applied to pump the end face of the droplet. (a) Photographs and spectra of droplets from Sample 1. (b) Photographs and spectra of droplets from Sample 2.

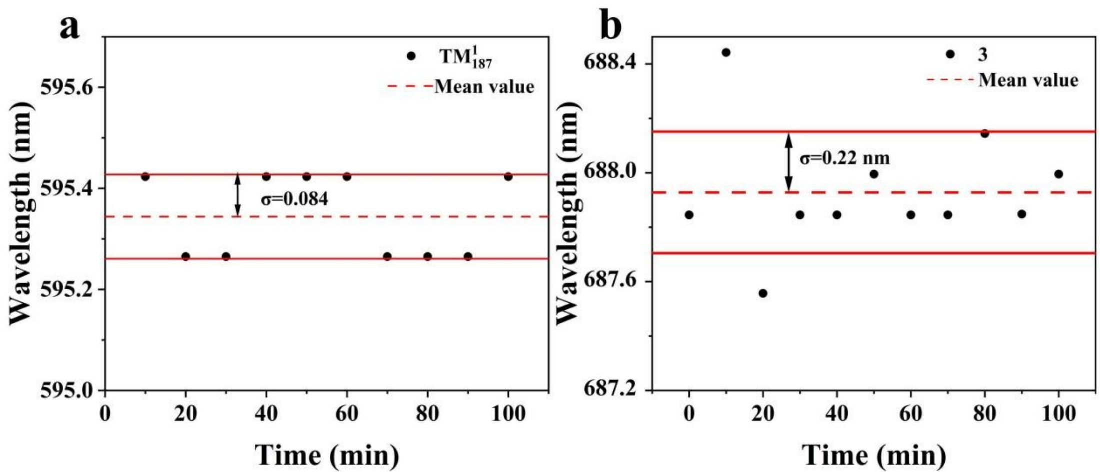

Fig. S6 (a) Temperature standard deviation of WGM laser generated by CLC droplets in sample 1, (b) Temperature standard deviation of WGM laser generated by CLC droplets in sample 2.

Calculate LOD according to the following formula:

$$DOL = \frac{3\sigma}{S} \qquad \text{* MERGEFORMAT (4)}$$

where σ is the standard deviation, S is the sensitivity. From Fig. S6 and Fig. 6, it can be seen that σ= 0.084, S=3.08 for Sample 1; σ= 0.22, S=2.17 for Sample 2. The LOD of Sample 1 is 0.08 °C. The LOD of Sample 2 is 0.30 °C.

References

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