Absorption Characteristics on Triazine Based Hyperbranched Polymer

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1 Introduction

Microcavities can be expected for various applications, such as biosensor [1,2] and optical frequency comb [3] due to their high Q-factor and small mode volume. Above all, microdisk cavities have attracted owing to its superior mode selectivity and ease of implementation. Although microdisks were traditionally fabricated by lithography method, we proposed the ink-jet printing method. However, optical property of ink-jet printed microdisks and its materials have not been investigated in detail. In this study, we experimentally investigated on the Q-factor of ink-jet printed microdisk laser by cavity ringdown method and the theoretical Q-factor estimated with absorption coefficient.

2 Experiment and Result

Figure 1(a) shows the experimental setup of cavity ringdown method. Microdisks were fabricated using an ink solution dissolved in triazine-based hyperbranched polymer TZ-001, cyclohexanone and laser dyes which are Rhodamine6G or LDS798. Then, microdisks were excited by second harmonic generation of Q-switched Nd:YAG laser (PNG-002025-040, Nanolase Corp.). The lasing signal from microdisks were collected to photomultiplier tube (PMT, H10720-01, Hamamatsu, response time 0.57 ns) and damping curve was obtained as shown in Fig. 1(b). Q-factors were estimated by the formula $Q = \omega\tau$ [4], where ω is angular frequency of the propagating light in the cavity and τ is its time constant which is obtained by exponential fitting of damping curve. As a result, Q-factor of Rhodamine6G and LDS798 are 1.4×10^7 and 3.8×10^7, respectively. Here, we discuss the measured Q-factor by the theoretical formula $Q^{-1} = Q^{-1}_{rad} + Q^{-1}_{s.s.} + Q^{-1}_{cont} + Q^{-1}_{mat}$, where Q^{-1}_{rad} is intrinsic radiative losses, $Q^{-1}_{s.s.}$ is scattering losses, Q^{-1}_{cont} is losses introduced by surface contaminants and Q^{-1}_{mat} is material losses [5]. In the case of ink-jet printed microdisks, Q^{-1}_{mat} is dominant. As a reason, radiative losses vanishes exponentially due to the large size in the case of diameter of 100 μm, and the RMS of ink-jet printed microdisk surface is 0.583 nm. Therefore the influences of Q^{-1}_{rad}, $Q^{-1}_{s.s.}$ and Q^{-1}_{cont} can be ignorable, and Q-factor of ink-jet printed microdisks can approach to the theoretical value of Q_{mat}. To investigate the Q_{mat} we measured the absorption coefficient of TZ-001 with spectrophotometer (V-630, JASCO Corporation). Figure 2 shows the measured absorption coefficient α of TZ-001. α of Rhodamine6G and LDS798 are 0.27 cm^{-1} at 600 nm and 0.036 cm^{-1} at 810 nm. Therefore, Q_{mat} were estimated 3.5×10^5 and 1.9×10^6 from these α, respectively. However, measured Q-factors are larger than Q_{mat}. In this experiment, ink-jet printed microdisks operated as a laser. In other words, propagating laser light in the cavity was amplified by stimulated emission, and the amount of light was increased. Consequently, measured Q-factor was obtained larger than Q_{mat}, and narrow line width of lasing mode was also confirmed.

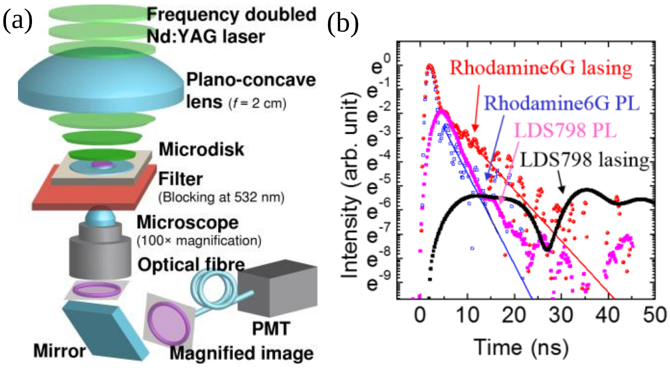

Fig. 1. (a) Experimental setup and (b) damping curve of microdisks.

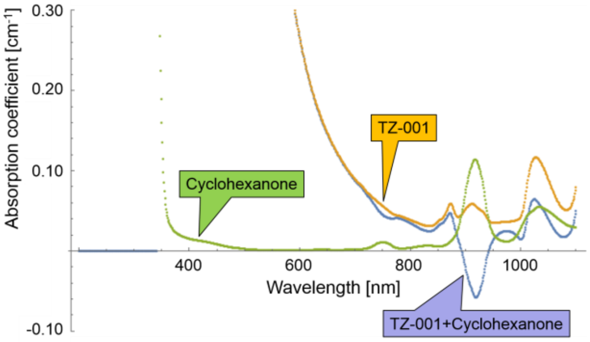

Fig. 2. Absorption coefficient.

3 Conclusion

We measured the Q-factor of ink-jet printed microdisks and compared its Q-factor with Q_{mat} which is estimated with absorption coefficient of TZ-001. Therefore Q_{mat} of Rhodamine6G and LDS798 are 3.5×10^5 and 1.9×10^6, respectively.

4 References

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