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Two color bandedge lasing from cholesteric liquid crystals in capillary

Kuan-Cheng Liao, Chun-Hao Chen, Li-Hao Jian, Ja-Hon Lin*, Shwu-Yun Tsay, Yao-Hui Chen
Department of Electro-optical Engineering, National Taipei University of Technology, Taipei, Taiwan
Email: jhlin@ntut.edu.tw

Nowadays, mirrorless lasing from dye-doped cholesteric liquid crystals (CLCs) have attracted much attention. To produce the CLCs, chiral materials are mixed into the nematic LCs and thus the rod-like LC molecules self-assembly aligned and rotated regularly along the helical axis to produce the one-dimensional photonic bandgap. The wavelength at long- and short-photonic band edges (λ_{LWE} and λ_{SWE}) are characterized by the relation $\lambda_{LWE} = n_e p$ and $\lambda_{SWE} = n_o p$ [1] in which p is helical pitch, where n_e and n_o are extraordinary and ordinary refractive index. For the CLC lasers, the photon density will be enhanced at two bandedge so as to lower the lasing threshold [2]. Traditionally, the dye-doped CLC was infill into the cell constructed by the glass plate [3, 4]. In this work, we filled the dye-doped CLCs into the capillary tube to investigate the occurrence two lasing emission mode at bandedge of the photonics bandgap.

Liquid crystal mixtures used in this work consist of 0.5 wt% of laser dye Pyrromethene 597 (Exciton inc.) as gain medium, 25.5 wt% left hand chiral S811(Helical Twisting Power of CLC, HTP = 10.8um^{-1}), and 74 wt% nematic liquid crystal (MDA-04-606, Merck inc. with n_e=1.7153, n_o=1.5086 and clear point 96.5°). The CLC mixtures are infill into 3 cm long capillary tube with 110mm inner diameter by the capillary effect. The transmission spectrum from capillary tube is measured by the white light source and spectrum meter (Ocean optics Inc). Besides, the schematic setup for the bandedge laser generation is shown in Fig. 1 and the corresponding photography is shown in Fig. 2. Then, we fixed dye-doped CLC infilling capillary tube onto the three-dimensional translation stage. The capillary tube was radially pumped by a frequency doubling Q-switched Nd:YAG laser with central wavelength at 532 nm as well as 10 Hz repetition rate and 5.8 ns pulse duration. The pumping beam was focused into the capillary tube by the spherical lens with focal length of 5cm. The axial and radial emission spectra from capillary tube were measured by the optical Spectrometer.

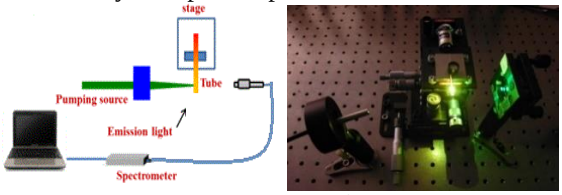

Fig. 1 Schematic illustration of the experimental set-up.

The room temperature transmission spectrum of the CLC infilling capillary tube (blue curve) is shown in Fig. 2(a) in which a long and short photonic band-edge are approximately located at 620 nm and 560 nm, respectively. Besides, a dip occurred with wavelength around 530 nm is due to absorption of the fluorescent molecule. After pump by the Q-switched laser, we measured the band edge lasing from capillary tube in both axial and radial direction (Fig. 2(a)). Obviously, two emission peaks were generated at 567.9 and 627.9 nm around the two edge of photonic bnadgap in axial direction. Inset of Fig. 2(a) shows the emission peaks in radial direction that illustrates slightly shift relative to the axial direction. In addition, a small emission peak with central wavelength at 580 nm could be seen due to defect modes lasing. In Fig. 2 (b), two slope were revealed from in-out characteristics of DD-CLCs (blue squares) to show the spontaneous and stimulated emission, respectively. By the linear fitting (red line), the lasing threshold of pulse energy (E_{th}) is estimated to be 3.35 J /pulse.

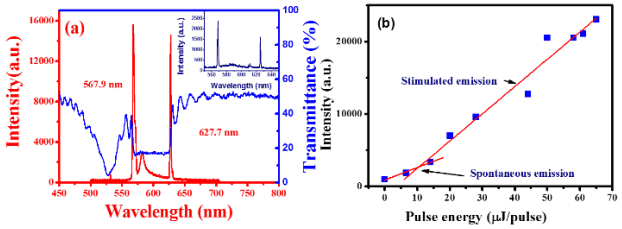

Fig. 2(a) Emission spectra from capillary tube infilling CLC with (red curve) and transmission spectrum of CLC (blue curve). Fig. 2(b) In-out characteristics measured from dye-doped CLCs in capillary tube .

Mirrorless lasing behavior was investigated in this work by filling up dye-doped cholesteric liquid crystal (CLC) into capillary tube. After excitation by the Q-switched laser, two lasing peaks were experimentally demonstrated to occur around the band-edge of photonic bandgap in both axial and radial direction. Besides, the in-out characteristics of laser were measured to reveal the lasing threshold around 3.35 J/pulse. These temperature tuning two bandedge lasing peaks will be reported in near future.

Acknowledgement

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