Electrically controllable random laser with dye-doped liquid crystals inside the capillary fiber

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Owing to the intrinsic birefringence of LCs, the characteristic of random lasers (RLs) have attracted considerable attention by infilling the nematics LCs (NLCs) or polymer dispersed LCs (PDLCs), as a scattering materials, inside the glass cell, capillary tube and the hollow core fiber to produce multiple light scattering [1-3]. Unlike other scattering materials, LCs can be easily modulation through the external signals, like electric filed, magnetic field, stress, temperature and so on. Through the modulation of LCs by the temperature, the manipulation of output characteristic of RLs has been investigated previously [1-3]. In this work, the alternative characteristics from RL produced by infilling the NLC inside the single core capillary was demonstrated through the applied sinusoidal voltage and analyzed by the applied sinusoidal voltage.

The preparation of dye-doped LCs (DD-LCs) inside the capillary fiber was reported previously [2]. First, the dye-dope LC mixtures were produced by doping 0.5 wt% of laser dye Pyrromethene 597 (PM597) into 99.5 wt% nematic liquid crystal (E7). Then, we infilled the admixture into the holey holes of a single core capillary (Polymicro Technologies Inc.) with diameter around 30 μm by the capillary effect. The produced DD-LCs infilling capillary fiber was clipped between two ITO-glasses and connected to a sinusoidal AC voltage (V_{AC}) with 1 KHz repetition rate to make sure uniform distribution of the electric field inside the cell as shown in Fig.1 (a).

Schematic setup for the RL generation from the produced capillary fiber is shown in the Fig. 1(b). A frequency doubling Q-switched Nd:YAG laser with the central wavelength at 532 nm was used as an excitation source. By using the cylindrical lens (CL) with focal length f_1 about 5 cm, the pump beam was focus into a long line strip onto the side of capillary fiber. In order to optimize the pump area onto the capillary fiber, the produced cell was mounted on a 3-axis translation stage.

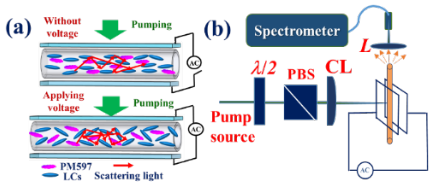

Fig.1 (a) Schematic setup for the alignment of DDLCs inside the capillary fiber without and with the AC voltage. (b) Experimental setup for the RL generation from the produced DD-NLCs inside capillary fiber through the pump of a Q-switched Nd:YAG laser..

As pump pulse energy was fixed, the emission spectra from single capillary fibre were shown in Figs. 2(a) and 2(b). It is obvious to see the multiple emission spikes on the top of broad emission spectrum that is one characteristic of random laser with coherent feedback. As applied voltage V_{AC} increase, the numbers of emission spikes increase because the disordering of LCs alignment increase (Fig. 1(a)). In order to quantitatively define the threshold of RLs, the econophysical function, termed α-stable distribution, was proposed by Uppu et al [4, 5]. By a statistic measurement of intensity fluctuation from dynamic system, Levy fluctuations (power-law tailed) has been produced to represent the Gaussian (α=2) or Levy statistics (α<2). Thus, 1000 spectrum slots from output plate of each sample were grabbed. After fitting by the equation from α-stable distribution (blue solid curves in Figs. 2(c) and 2(d)), the obtained value of α from DD-LCs in capillary fibre are 1.71 and 1.37 with V_{AC}= 0V and 15 V, respectively. It demonstrates the stronger Levey fluctuation was obtained as V_{AC} increases.

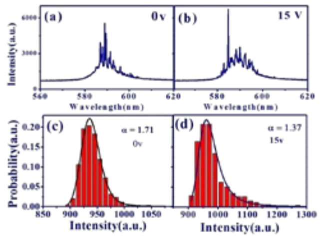

Fig.2 The output emission spectrum of DD-LC RL with (a) VAC=0V and (b) VAC=15V, as well as the corresponded intensity distribution with (c) VAC=0V and (d) VAC=15V.

In this work, we demonstrated the electric modulation of RL from DD-LCs within the single core capillary fiber through the excitation of the Q-switched laser. As applied voltage increases, the estimated Levy exponent α from RLs was reduced from 1.71 to 1.37 to show the stronger Levy intensity fluctuation because of the enhancement of light scattering within DD-LC mixtures.

Acknowledgement

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Reference

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