Omni-directional band edge lasing emission from a dye-doped cholesteric liquid crystal infiltrated photonic crystal fiber

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This work demonstrates an omni-directional lasing emission in a photonic crystal fiber (PCF) which is selectively injected with dye-doped cholesteric liquid crystal (DDCLC) and azo-CLC into the hollow core and the cladding holes, respectively. Experimental results indicate that the helical axis of the DDCLC will align perpendicularly to the fiber wall and thus the band edge lasing emission of the DDCLC within the PCF can be pumped by a pulse laser and measured in radial direction. This work also demonstrates that the direction of the lasing emission of the PCF can be controlled optically.

Introduction

Fig. 1. Broadband fluorescence can be produced in the cell via spontaneous emission, at the short- and long-wavelength edges (SWE & LWE) of cholesteric liquid crystal reflection band (CLCRB). fluorescence can propagate via multiple reflection, which results in a very small group velocity and a very large density of photon state (DOS) for the fluorescence. Due to the distributed feedback of the active multilayer in the multilayer reflection process, a high gain can be achieved for a low-threshold lasing emission.

Sample preparation

Fig. 2. (a) Schematic of the process for selectively injecting materials in the PCF. DDCLC and azo-CLC are injected into the core and the cladding of the PCF as the lasing source and the light valve, respectively. (b) Cross section of the PCF and the prescriptions of the injected materials in the core and cladding, respectively. (c) The POM images of the selectively injected DDCLC PCF. The top and bottom images are the sample before and after the exposure of UV light, respectively.

Experiments

Results & Discussion

Fig. 4. (a) Reflection spectrum and lasing spectrum of the DDCLC infiltrated PCF. (b) Polarization investigation of the lasing emission. Variations in (c) the lasing emission spectrum of the DDCLC injected PCF and (d) its peak intensity and corresponding full-width at the half maximum (FWHM) with various pumped energy.

Optically controllable lasing direction

Fig. 5. The lasing spectra of the DDCLC injected PCF measured at 0° and 180°, (a) before UV irradiation or after 442 nm laser irradiation, (b) after UV irradiation, and (c) after UV irradiation on 0° only. The corresponding pictures of lasing pattern for (a), (b), and (c) are shown in (d), (e), and (f), respectively.

Mechanism

Fig. 6. Schematic of the mechanism for the optically controllable lasing emission. The azo-CLC in the cladding of the PCF can transform between scattering focal cone state and transparent isotropic state isothermally via the photo induced isomerization of the azo LC.

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