Optical Characteristics and Lasing Spectra of CLC with Defects of Different Types

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Annotation

The transmission and lasing spectra in a CLC in the presence in its helical structure defects of two types have been studied. Defects in the helical structure of the CLC were created by unfolding the orienting glass substrates by 90 ° relative to each other (the first type) and by introducing an isotropic layer 0.5 mm thick (the second type). In this type of defect, the orientation of the directors on the substrates in each layer was in one direction. The directors of the layers of the CLC formed an angle of 90°.

It is established that a local dip in the center of the selective reflection (SR) band for linear polarization of light appears in the transmission spectra of both types of defective CLC structures. Studies of lasing spectra in defective structures of both types in CLC have shown that lasing is located within the dip in the transmission spectrum, which allows us to interpret these defects as a phase jump in the helical structure. A comparison of experimental data obtained from laser and optical spectra with existing theoretical models of laser generation, including defective modes in CLC also presents .

Introduction

Dye-doped CLC with natural periodic structure are suitable structures for lasing. On the basis of such materials had been created mirorrless micro lasers [1-2]. Absence of the external cavity, arbitrary cross-section of the active media at low lasing thresholds specify of their use in systems of high brightness information display. In recent years, CLC lasers with defects in the helical structure, which lead to the appearance of defective modes in the band gap, have been actively studied [3]. We have recently shown [4] that the creation of a defect in steroidal CLCs formed by substrates can significantly reduce the width of the lasing spectrum. which is of great practical importance. In the development of these studies in this work we present the results of studies the optical and spectral characteristics of lasing in dye-doped CLC of a steroidal-type for two types of defects in their helical structure; isotropic layer in the thickness of the CLC and the defect is due to the orientation of the directors on the substrates .

Materials

As the matrix of the steroidal CLC 3-component mixture of oleate, pelargonate and cholesterol chloride with temperature alteration of spiral pitch ~ 3 nm /° C was used. CLC was doped with the phenolenone dyes F 490 at weight concentration of 0,3%.

A planar texture was created using transparent orienting substrates with rubbed in the same direction polymer layers and shift of substrates in the rubbing direction.

Experimental techniques

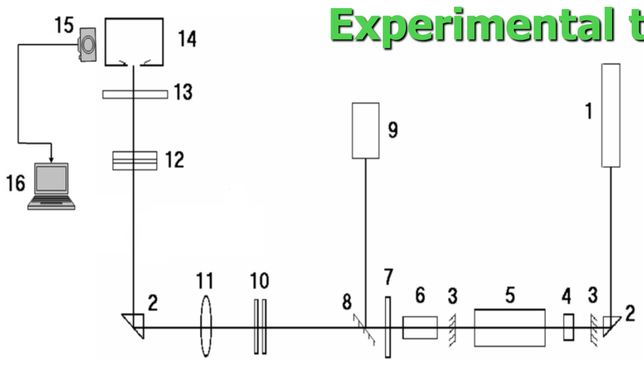

Fig.1. Scheme of laser setup: 1 – He-Ne laser, 2 – rotating prism, 3 –resonator mirrors, 4 –Q modulator, 5 – active element solid-state laser , 6 – frequency doublers , 7 – filter, 8 –half mirror, 9 – calorimeter, 10 –neutral filters, 11 – lens, 12 – dye-doped CLC, 13- filter, 14 – spectrograph, 15 – video camera, 16 –computer.

Laser setup

Optical pumping of the doped CLC was carried out by the second harmonic (λ=530nm) of a Q-switched Nd $^{3+}$ laser operating in a slow pulse repetition rate mode with the pulse duration ≈20 nsec. The second harmonic radiation focused by a lens with focal distance of 21 cm on the sample of doped CLC in a spot with a diameter ≈0,5 mm. A maximal power density of the second harmonic radiation was ≈ 27 MWt/cm^2 and attenuated by neutral filters. The lasing spectra of the dyed CLC corresponding to each pumping pulse were optically imaged in a focal plane of a spectrograph with an inverse dispersion 0.6nm/mm and then displayed by the video camera on a PC monitor (Fig.1).

The UV-vis absorption spectra of the CLC were measured at room temperature by spectrophotometer SF-20 (LOMO, St. Petersburg). The fluorescence spectra of dye in CLC were measured by spectrometer MPF-4 "Hitachi".

Results and Discussion

Optical characteristics of the defect texture of CLC

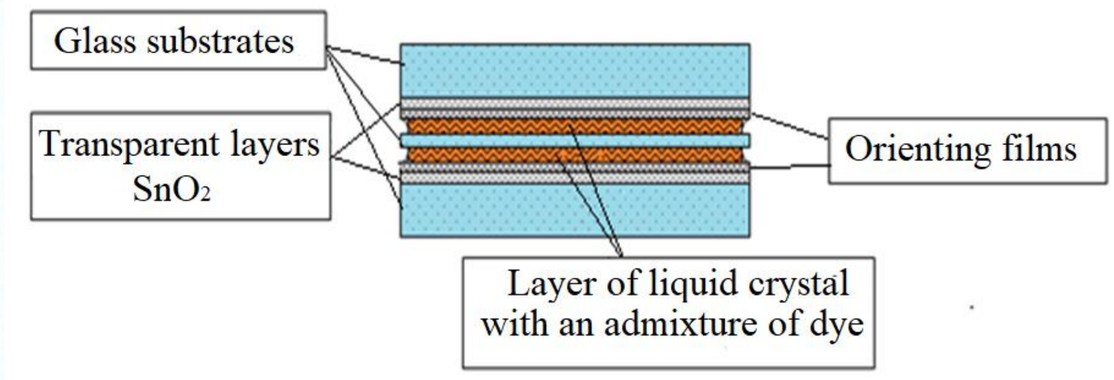

Fig. 2. Scheme of the active element of the CLC laser based on impurity CLC with an isotropic defect in the form of a glass plate.

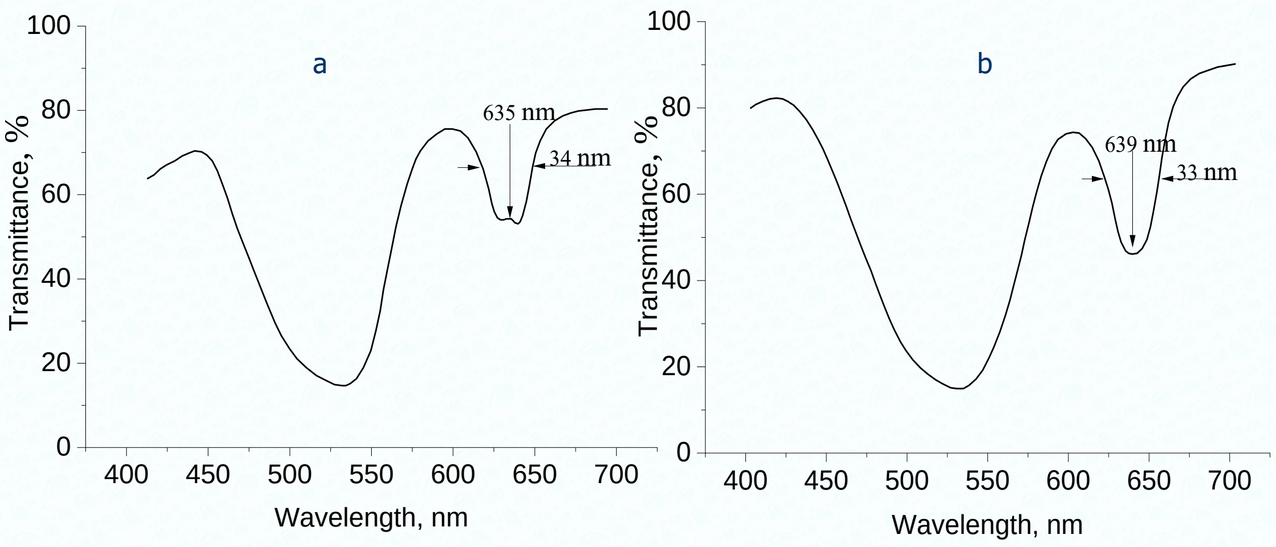

Fig. 3. The transmission spectra of dye-doped CLC : a -with an isotropic defective layer with mutually orthogonal orientations of the directors in the CLC layers; b - with parallel orientation of the surface layers on the substrates. Mixture: 38% cholesterol oleate; 33% - cholesterol pelargonate; 29% cholesterol chloride. The layer thickness is 45 μm. The arrows in both figures indicates the position of the lasing wavelength with respect to the selective reflection (SR) band of the CLC. In the SR band, a dip is clearly observed (indicated by an arrow), the presence of which, according to the theory of [3], indicates the existence of a defect in the helical structure of the CLC.

Spectral characteristics of lasing in the CLC

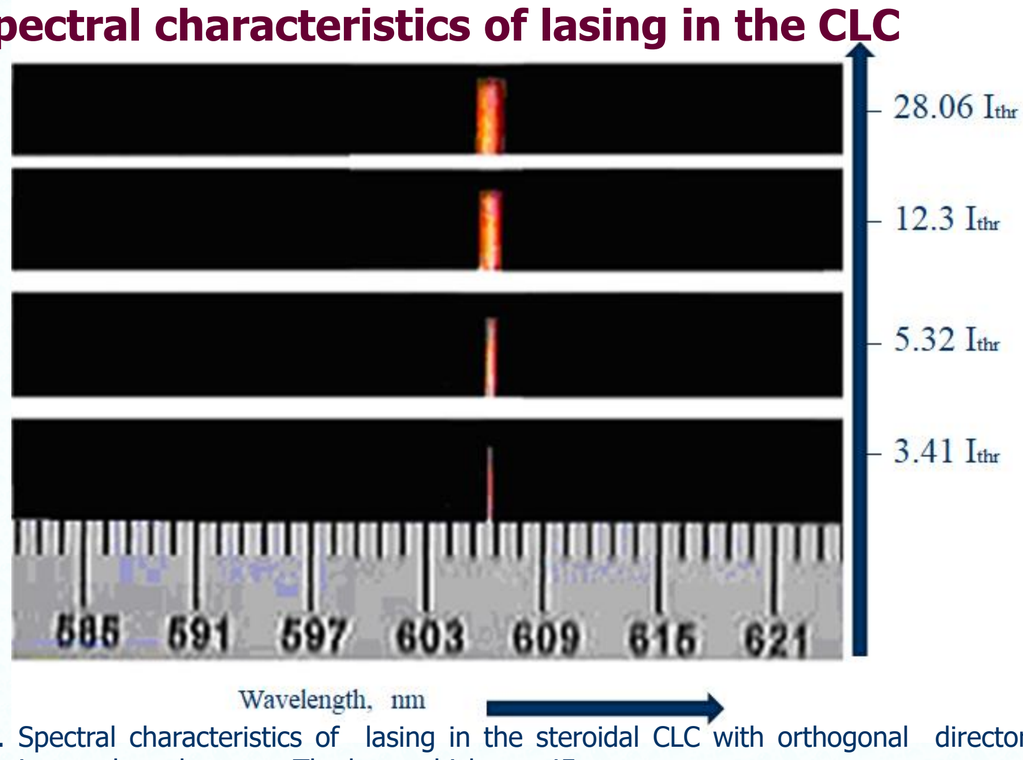

Fig. 4. Spectral characteristics of lasing in the steroidal CLC with orthogonal director orientation on the substrates. The layer thickness 45 μm

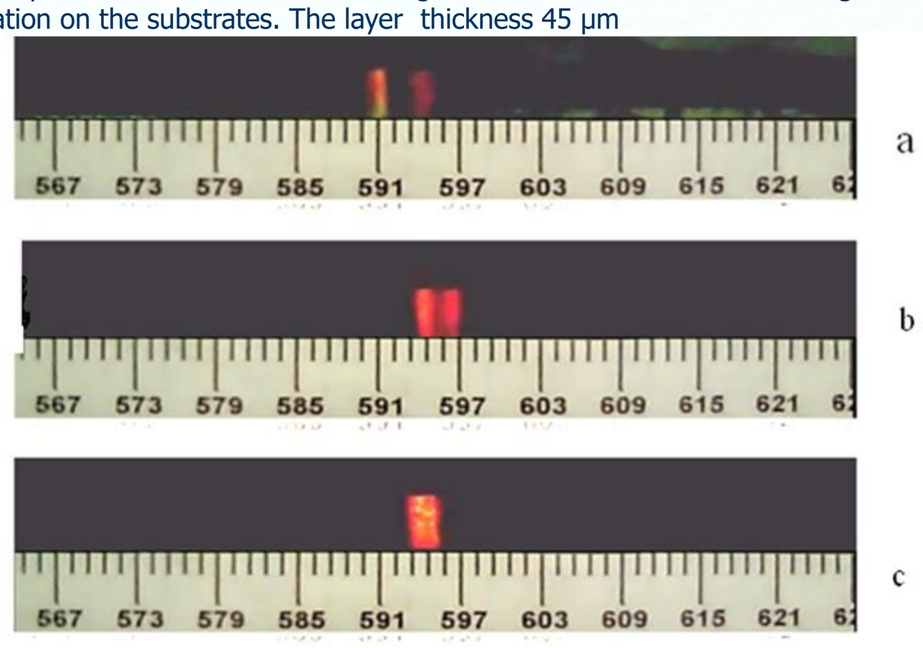

Fig.5. The lasing spectra in steroid CLC activated by phenalenone dye F 490 at: parallel orientation with a layer thickness of 25 μm (a): parallel orientation with a layer thickness of 50 μm (b): introduction into the texture of theisotropic glass layer (c) .

Conclusions

1. A defect can arise in the helix of CLCs created by viscous mixture of cholesterol esters at the mutually orthogonal director orientations at the orienting substrates. The defect manifests itself as a characteristic dip in the SR band (Fig.3, a)

2. The single-mode lasing can be invoked and maintained, if the lasing threshold is exceeded several times, and the CLC directors are oriented mutually orthogonal at the orienting substrates. This method considerably improves the spectral purity of radiation emitted by a CLC laser (Fig.4).

3. As can be seen from Fig. 3, and with the introduction of the isotropic layer into the helical structure of the CLC (isotropic defect) there is a similar dip in the SR band , as well as dip. which is registered at the defect created by substrates in [4]. It testifies to their identical nature and allows to interpret it. as a phase jump in a helical structure. From Fig. 5, c it is seen that in the presence of an isotropic defect, one mode is also observed, as in the case of a defect created by substrates.

References

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