

Liquid Crystal Deflectors of LaserRadiation as the Display Devices Elements

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Abstract

The investigations of the laser radiation deflectors on the basis of liquid crystal were carried out. Two deflectors types were studied—the deflector on diffraction structures and deflector on wedge-shaped deformation. The possibility to stabilize the diffraction structure by means of introducing a small concentration of cholesteric dopant to liquid crystal matrix. A new system of electrodes for deflectors on wedge-shaped deformation has been suggested.

Introduction

It is known that the main number of works were dedicated to application of liquid crystals (LC) as an active medium for optical information processing devices (OIPD) and separate elements of its. The interest to LC as an active medium of OIPD is explained in a different LC electrooptical effects, which quantity is greater than in traditional crystals. The peculiarities of LC devices are the absence of mechanic movable details, small construction sizes, lengthy period of employment (above 1000 hours), etc. On account of these properties the LC OIPD may replace analogical systems which have been made on the basis of usual crystals.

Two principal types of deflectors attracts attention among the various constructions of LC ones: the deflectors on a wedge-shaped deformation (analogic) and the deflectors on diffraction structure (discrete).

This work is dedicated to studying of possibility of LC deflectors on the diffraction structure.

Theory

It is easy to form the phase and amplitude gratings in LC which may be used for deflectors on the diffraction structure construction thanks to their considerable sensibility to the influence of electric field. The radiation will diffract if periodic structure in LC layer with wavelength is not under when pencil of rays has been directed. One part of radiation will pass straight, another - at an angle of:

$$\text{Sin } \theta = (m \lambda)\ 1/2\ d \quad (1)$$

where l - light wave length λ; d - diffraction structure period: m - diffraction maximum order, m = 1, 2, 3 ... n.

The periodic grating in LC layer may be directed by different methods: narrow striped electrodes system, Vilson omains with invariable period (the cross structure, which has been created in LC under the certain influences of perpendicular direction of deflector); flexoelectric static domains; excitation of supersonic waves in LC layer.[1]

The possible angles of deflection are appraising. It is known that diffraction grating with 500 line/mm is real in the structure photoconductor-LC. Supposedly, the electrodes system with the same period (2 mkm) can be done on the LC'-layer. In accordance with expression (1) the deflection angle approximates to 9° in the first of diffraction order for 1=0,63. It being now that the cross domain period is invariable and equal to LC layer thickness. This domain type was investigated in a cell with more than 5 mkm thickness. In order to receive the regular structure of cross domains and to obtain accurate diffraction picture it was proposed to use minimum concentration of cholesteric dopant which allow to stabilize the formation centers of cross domains and place it round the cholesteric helix axis. The ratio of LC thickness to cholesteric helix pitch is sure to equal ~1.

The longitudinal domains were studied in cells with small thickness of LC layer (less than 5 mkm). Minimum period should be 0,5-0,6 mkm^2 in order to obtain the deflection angle approximates to 30°. Due to diffraction orders has been formed there are uncomfortably to using thus cells as a deflector. According to Bragg condition, if an input radiation will direct at certain angles towards graiting and will form the phase difference between rays which pass excited and unexcited equal πLC part, only one diffraction order of theoretic effectivity 100% will obtain.

This condition takes place for LC layer thickness

$$1 = 1/2\Delta n \quad (2)$$

and falling angle:

$$\theta_f = 2\arcsin(\lambda / 2d) \quad (3)$$

LC layer thickness is 1 = 1,57 mkm for period d=2 mkm and usual for refraction index of LC An = 0,2. It is difficult to obtain so small LC layer thickness and keep unvariability during the exploiting process. Due to this deflectors type it is necessary to carry out LC with small Δn no more than 0,02-0,03, and LC layer thickness no less than 10-15 mkm. The acids of cyclohexancarbon are used as LC materials with so refraction index (Δn=0,0 1-0,02).

There is shown the construction of deflectors on wedge-shaped deformation which consists of 4 strip electrodes has been layed on a glass plates. The space thickness between plates is filled up of LC nematic (Figure 1). We discuss the configuration of electric field was created in 3 electrodes system and voltage made to it.

The electric field voltage between 1-3 electrodes is equal El=U/dl . At the same time the electric field voltage between 32 electrodes is equal E2=U/d2; d2>>d 1 and El>>E2 in consequence of constructive peculiarities of wedge-shaped deflector. A heterogeneity of the electric field taking place between the electrodes (Figure 1). On the lower packing between the electrodes 1-2 is a zone without electric field. The surface powers interact with LC and form planar orientation which led to the rays selection.

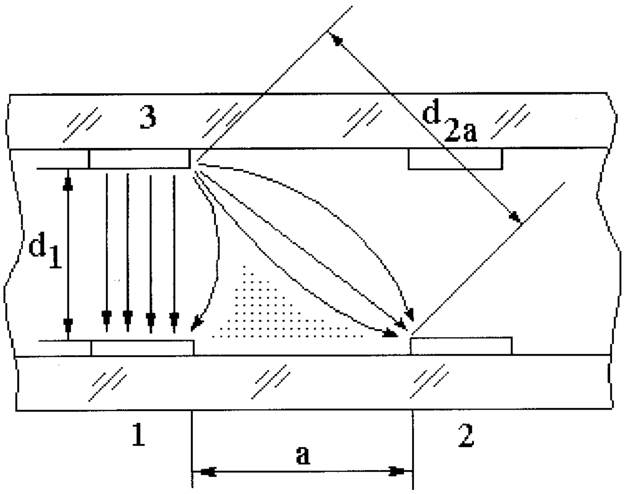

Figure 1. The construction of deflector on wedge-shaped deformation with system 4 electrodes.

So we may speak about the such defect as the violently rays selection because of sharp heterogeneity Δn in LC.

We replaced the electrodes (1-2) by solid electrode 1 (Figure 2) to deliver this defects. In this electrodes system the electric field voltage lines take up the whole electrode 1. Due to limier decreasing of the electric field orientation powers Δn change limier accordingly. The peculiarity of this electrodes system is so that if the voltages between the electrodes change there is change the input laser rays position in "prism" has been formed. The root of "prism" moves smoothnessly towards electrode 1. It is explained by Frederick transition in LC under the electric field influence.[3] If the voltage influence U increases the distance d3 grows. Along this distance the electric field voltage is equal critical voltage which is necessary to realize the Frederick transition in LC and contrary.

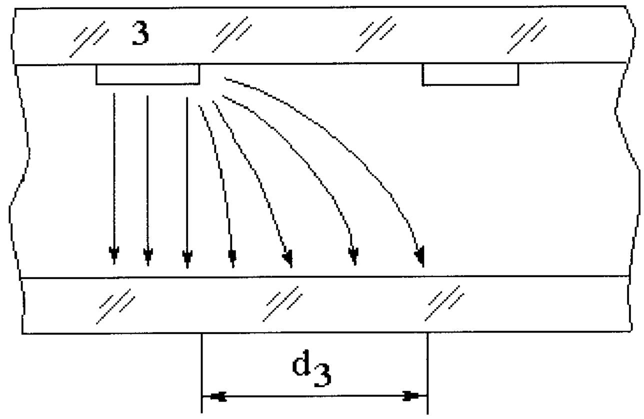

Figure 2. The construction of deflector on wedge-shaped deformation with system 3 electrodes.

Experiment

The objects of our study were the mixture of azoxy-components and the mixture of azoxy components with small concentration of cholesterine ester dopant of mono-basis carbone acids. This choice enable us to investigate the cholesteric dopant influence on the diffraction properties of LC. Two deflector types were used: the deflector on the diffraction structure (the longitudinal domains) and deflector on wedge-shape deformation with our electrode system.

For realization our experiments we used the equipment consist of He-Ne laser, LC cell and screen. The LC cell and screen were in the light protected frame. The specimens were placed in an electrooptic cells with 25 mkm thickness for deflector on diffraction structures and with 100 mkm for wedge-shaped deflector. The SnO_2 conductor was layed on glass plates.

The distance between electrodes 3-4 in wedge-shaped deflector was 3 mm. For studying the deflector on diffraction structure we used the generator of electric sinusoidal signal with the output amplitude 20V, the frequency diapasone of experiments was 0,1-1 Hz. For studying the deflector on wedge-shape deformation we used the steady voltages with maximum in output 200V.

The dependence between angle deflection of laser rays and frequency of signal for asoxy-component mixture (1) and for this mixture with small concentration of cholesterine ester dopant (1) are shown (Figure 3) The relations shows that the angle deflection maximum is equal with 5 Hz in frequency diapasone 2-9 Hz. The same maximum for mixture (2) is lower, stretched and gently. It may be explained that under the electric field duration the cholesteric helixs comes right and then the domains forms.

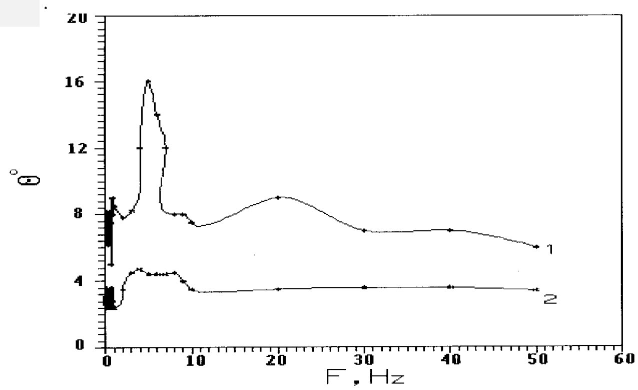

Figure 3. The frequency dependence of angle deflection for a deflector on diffraction structure.

The relation between the angle deflection of laser rays and voltage in system 4 (curve 1) and 3 (curve 2) electrodes for mixture I is shown on Figure 4. We may speak that for 3 electrode system the angle deflection of laser rays is bigger than for 4 electrode system (voltage 60V). These results corroborates our theory. The voltage increasing on the electrodes insignificantly decreases the angle deflection of laser rays for system 3 electrodes in consequence of "prism" position changing. For system 3 electrodes the laser rays selection is decreasing.

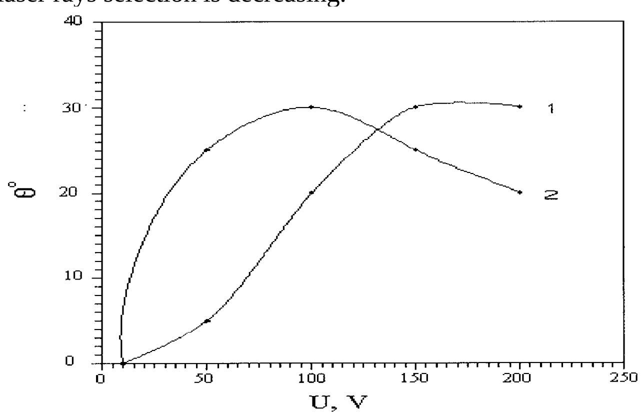

Figure 4. The angle deflection and applied voltage dependence for the deflectors on diffraction structures

Conclusions

1. The using LC materials with small concentration of cholesteric dopant for deflectors on diffraction structure allowed to stabilize the deflection angle value of laser rays and made the maximum of the frequency diapasone widely.
2. The using LC materials with small concentration of cholesteric dopant for deflectors on diffraction structure demands to keep to the certain correlation between LC layer thickness and cholesteric helix pitch.
3. The replacing system 4 electrodes by system 3 electrodes made possible to decrease work voltage and laser rays selection in wedge-shaped deflectors.

References

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