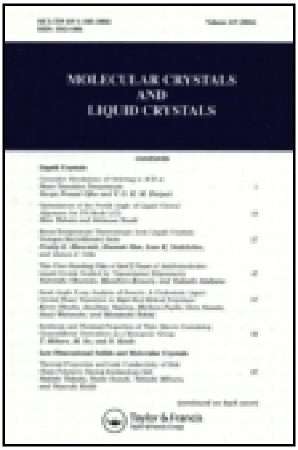

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Liquid Crystal Modulator of Laser Radiation for High-Power Lasers of Infra-Red Range of Spectrum

Zenon Mikityuk [a], Julia Semenova [a], Michael Nutskovsky [a] & Orest Sushinsky [a]

[a] State University “Lvivska Polytechnika”, Lviv, Ukraine

Version of record first published: 04 Oct 2006

To cite this article: Zenon Mikityuk, Julia Semenova, Michael Nutskovsky & Orest Sushinsky (1998): Liquid Crystal Modulator of Laser Radiation for High-Power Lasers of Infra-Red Range of Spectrum, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 317:1, 93-97

To link to this article: http://dx.doi.org/10.1080/10587259808047108

Mol. Cryst. Liq. Cryst., Vol. 317, pp. 93-97
Reprints available directly from the publisher
Photocopying permitted by license only

Liquid Crystal Modulator of Laser Radiation for High-Power Lasers of Infra-Red Range of Spectrum*

ZENON MIKITYUK**, JULIA SEMENOVA, MICHAEL NUTSKOVSKY and OREST SUSHINSKY

State University "Lvivska Polytechnika", Lviv, Ukraine

The possibility of high-power IR-radiation modulation by cholesteric-nematic phase transition in LC is discussed.

Keywords: Modulation; liquid crystal; cholesteric-nematic transition effect

INTRODUCTION

It is known that a considerable number of works are dedicated to liquid crystals (LC) using in optical information processing devices (modulators, deflectors, scanning devices, etc.) as an active medium of such devices [1-4].

The studying of laser radiation influence on LC in infra-red (IR) spectrum range gives a great number of possibilities for creation of modulators. The majority IR-range radiation modulators are created for low-power radiation modulation. It is explained by the fact that the guaranteeing of minimum IR-radiation absorption is a matter of some difficulty. This work is dedicated to studying of possibility of high-power IR-radiation modulation by LC.

*Presented at the XVI International Liquid Crystal Conference, 24-28 June, 1996, Kent, OH, USA.

**Corresponding author.

IR-RADIATION MODULATION BY SCATTERING EFFECTS

Among all electrooptical effects in LC the scattering effects ("guest-host" effect and the effect of cholesteric-nematic phase transition (CNPT)) are the most prospective for IR-radiation modulation [5, 6]. The application the "guest-host" effect allows to achieve the modulation depth of approximately 80% and to observe the modulation depth to 10% at the frequencies up to 1 kHz. But "LC-dye" systems have essential disadvantages: the complexity of "LC-dichroic dye" pair selection; the necessity of a high degree of dichroizm achievement; the complexity of LC-cell optical density increasing, the maximum anisotropy of dyes selection and a high degree of dye molecules regulating in LC-matrix guaranteeing [7]. That is why, the application of the "guest-host" effect for IR-radiation modulation is connected with essential difficulties of both the "guest-host" pair selection and a minimum absorption of radiation guaranteeing.

The problem of the optical active medium selection can be partially solved by using of CNPT-effect in induced cholesterics. This effect consists in the change from scattering cholesteric texture to transparent homeotropic nematic under the action of electric field. The scattering of IR-radiation by induced cholesterics is caused by the cholesteric helix existence. The radiation, that passes through such a helix, is scattered by Bragg diffraction on the "fingerprints" texture. This diffraction will be maximum, when the cholesteric helix pitch is connected with a wavelength of radiation by the ratio:

$$\lambda = Pn, \tag{1}$$

where P – a helix pitch; n – a refraction index [8].

The possibility of induced cholesteric with a necessary pitch value creation (by addition of a certain quantity of a cholesteric to nematic matrix) allows to achieve a maximum of scattering. So, the application of the cholesteric-nematic phase transition effect gives a possibility of making an effective IR-radiation modulator. However, the modulation of IR-radiation is connected with a guaranteeing of minimum absorption capacity of a modulator, because the absorbed heat is capable of changing the electrooptical properties of LC and even transforming LC mixture to the isotropic state. It requires using as windows the materials, that are transparent for IR-radiation; cooling of modulator for guaranteeing of a certain temperature conditions. It's not possible to use a LC with a mesophase existence room temperature as a modulating medium for high-power IR-radiation.

EXPERIMENT

For high-power IR-radiation modulation realization we used the absorbed by the modulator material heat for providing the LC-mixture transition into the mesophase state without changes in modulator construction. This modulator functions by two stages: 1) IR-radiation absorption by LC-mixture and its transition to mesophase state; 2) subsequent IR-radiation modulation by CNPT. This modulation method may be classified as thermoelectrooptical one.

By such a way the modulator for $\lambda = 1.06\,\mu m$ and a power $W = 10.20$ Wt was created. It consists from two glass windows with transparent conducting coatings of SnO_2, LC-mixture, dielectric spacers, that determine the thickness of LC-layer. Total absorption of the cell at $\lambda = 1{,}06\,\mu m$ (without LC) is equal to 5%, when the glass thickness is 5 mm and 6% when – 7 mm. The LC-layer thickness is equal to 25 μm.

We used the laser with $\lambda = 1.06\,\mu m$ and $P = 30$ Wt as a source of radiation. The control of the modulator was realized by the square-wave-pulse generator. The laser beam, passed through the dissipative attenuator and the diaphragm, was registered by the photodiod. A signal from the photodiod was observed by the double oscillograph.

On the base of CNPT time parameters studying we used a square pulse with $T/t = 2$ (T–pulse period, t–pulse duration) for modulator control [9].

The modulation depth was calculated by the formula:

$$m = (1 - I\min / I\max)100\%, \tag{2}$$

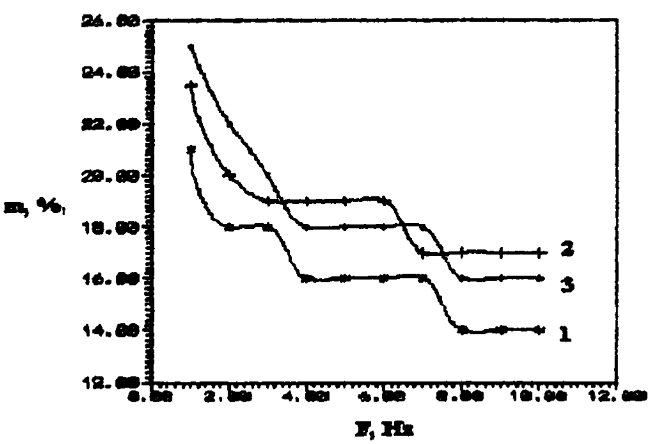

FIGURE 1 Frequency modulation characteristics at 400 K for LC mixture 1–3.

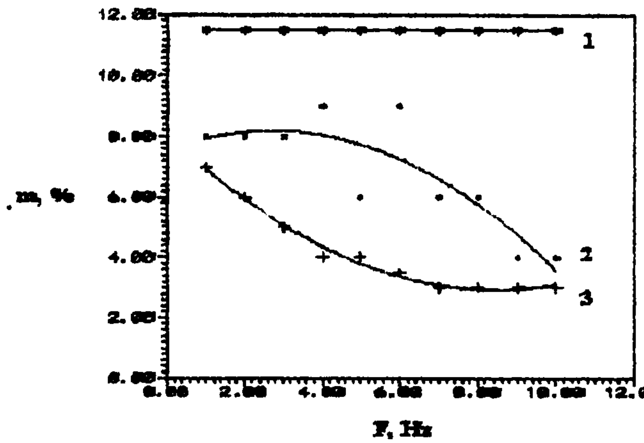

FIGURE 2 Frequency modulation characteristics at 410 K for LC mixture 1 – 3.

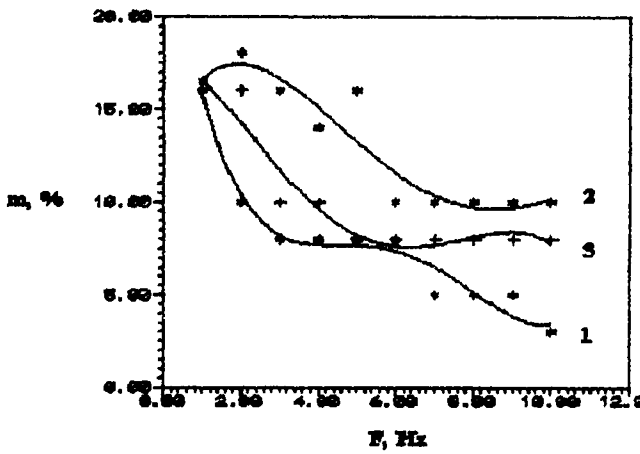

FIGURE 3 Frequency modulation characteristics at 430 K for LC mixture 1 – 3.

where I min, I max – minimum and maximum intensities of laser radiation, that passes through the modulator.

On the first stage a mesophase existence temperature served as a criterion for LC selection. Proceeding from this 9 LC-mixtures were synthesized: 3 homologous of hydrochynon-bis-*n*-iloxybenzoate and 3 dopants of cholesterine esters of palmitine(1), propione(2), miristine(3) acids (the dopants in nematic matrices were equal to 2 weight %). The studies showed, that the maximum of modulation depth is observed for the 3 mixtures of cholesterine esters dopants (1, 2, 3) in the matrix with a minimum homologous number. The modulation more than 4% is observed up to frequencies 1 kHz. On the Figures (1 – 3) the frequency modulation characteristics are shown for different temperature (1 – 400 K, 2 – 410 K, 3 – 430 K) ranges for LC-mixture 1 – 3.

CONCLUSIONS

On the base of our studies it is possible to draw the following conclusions:

(1) The scattering thermo-electrooptical effects should be used for a modulation of IR-radiation, because such effects don't require the application of the polarization optic;
(2) The proposed method allows to use LC as an active medium for high-power laser IR-radiation;
(3) The nematic matrices from homologous row of hydrochynon-bis-*n*-iloxybenzoate with a minimum number should be used;
(4) The thickness of LC should be more than 50 mm in view of high power of laser radiation.

References

[1] N. G. Basov, Yu. M. Popov and I. N. Kompanets, *The studies of possibilities of new optoelectronic systems creation* (M.-Precinct, 1973), p. 221.
[2] G. P. Katis, *Optoelectronic information processing* (M.-Mashinostroenie, 1973), p. 447.
[3] K. Presto, *The coherent optical calculating devices* (M.-Air, 1974), p. 339.
[4] Yu. R. Nosov, *Optoelectronics* (M.-So. Radio, 1977), p. 232.
[5] F. L. Vladimirov, I. E. Morichev and N. I. Pletneva, *Optico-mechanicheskaya promishlennost*, **3**, 54 – 64 (1984).
[6] V. I. Vashchuk, K. F. Gorot, Yu. G. Kozak, S. F. Luksutov and E. A. Tichnov, *Kvantovaya electronika*, **4**(21), 337 – 340 (1994).
[7] V. V. Danilov and D. A. Savelyev, *Trudy GOI*, **194**(60), 81 – 91 (1986).
[8] L. N. Lisetskiy, V. D. Panikarskaya and T. P. Antonyan, *Kristallographiya*, **6**(36), 1533 – 1536 (1991).
[9] Z. Mikityuk, A. Fechan and J. Semenova, *Opto-Electr. Rev.*, **5**(1), 47 – 53 (1997).