Liquid Crystals

Surface Guiding Optical Anisotropy in Nematic Liquid Crystal Cells

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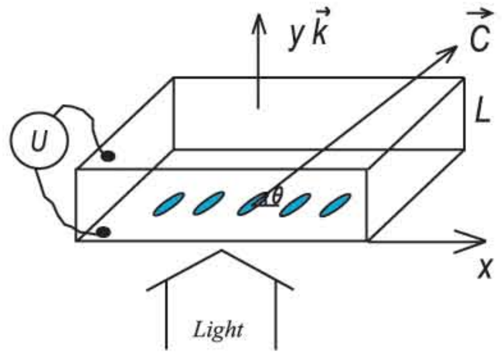
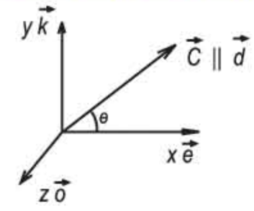
The creation of dynamic electro-optical elements based on liquid crystals with an ultra-fast switching time (less than 10 μs) has great prospects for the development of image-oriented optical information systems. Spatial reorientation of the LC director under the simultaneous action of electric voltage and light beams is the main mechanism for modulation of the refractive index in LC cells [1, 2]. Experiments prove that composite LC cells containing a nano-sized film on one substrate lead to a decreasing in the time constant and an increasing in the efficiency of the optical response [3, 4]. We have developed a mathematical model of the photorefractive effect in the composite cells for the case of a two-wave mixing. Computer experiments were performed on the basis of the Comsol package.



θ – tilted angle of LC molecules

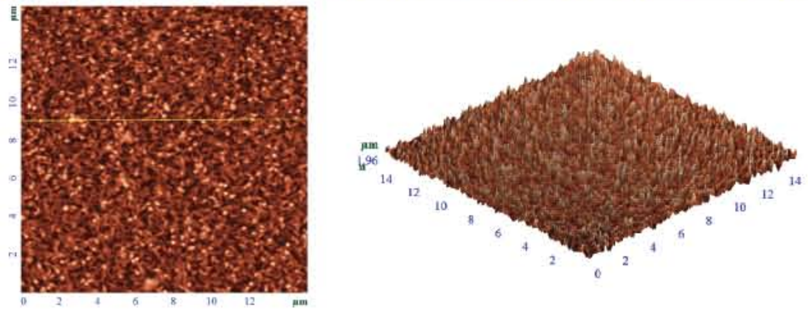


d – director LCs

C – optical axis

k – wave-vector of light

o, e – polarization of light



Experiments of two-wave mixing show a temporary quickening of reorientation of liquid crystal molecules, when a gold nano-island film is deposited on a substrate of LC cell (see Figs.).

$$(K_{11}\cos^2\theta + K_{33}\sin^2\theta)\frac{\partial^2\theta}{\partial z^2}(K_{33}-K_{11})\sin\theta\cos\theta\left(\frac{\partial\theta}{\partial z}\right)^2 + \varepsilon_0\Delta\varepsilon E^2\sin\theta\cos\theta = \gamma_1\frac{\partial\theta}{\partial t}$$

- Ericksen-Leslie Model

$$\frac{\partial\theta}{\partial t} = \frac{K_{33}}{\gamma_1}\frac{\partial^2\theta}{\partial z^2} + \frac{\varepsilon_0\Delta\varepsilon}{\gamma_1}\sin\theta\cos\theta\cdot E^2$$

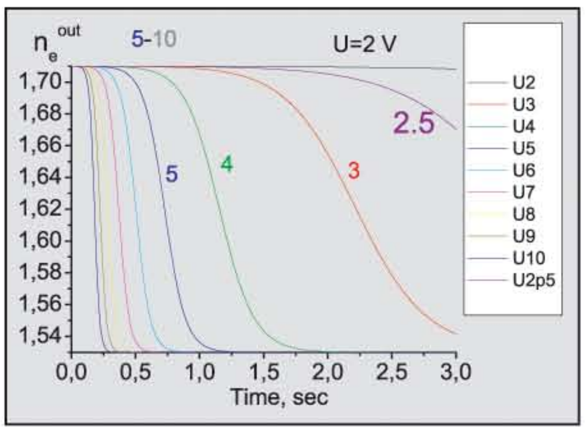
- Changes of the tilt angle for the case $K_{33} = K_{11}$

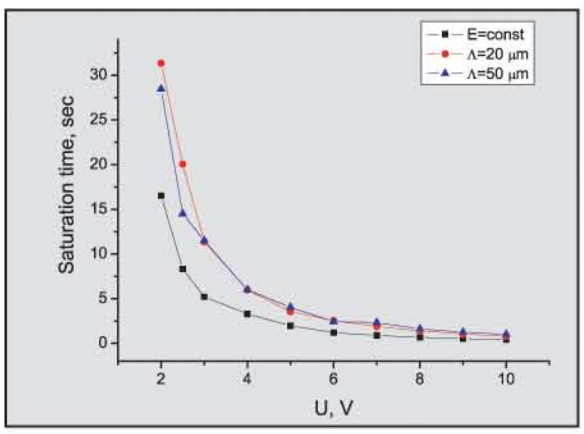
Changes of the refractive index:

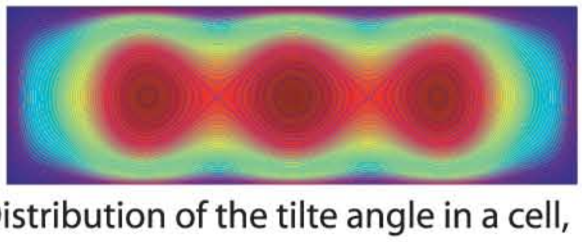
$$n_e(t,z) = \frac{n_{\parallel}n_{\perp}}{\left[n_{\parallel}^2\sin^2\theta(t,z) + n_{\perp}^2\cos^2\theta(t,z)\right]^{1/2}}$$

N_{grat} - Modulation of the refractive index in the dynamic grating

We study kinetics of phase dynamic grating N_{grat}.

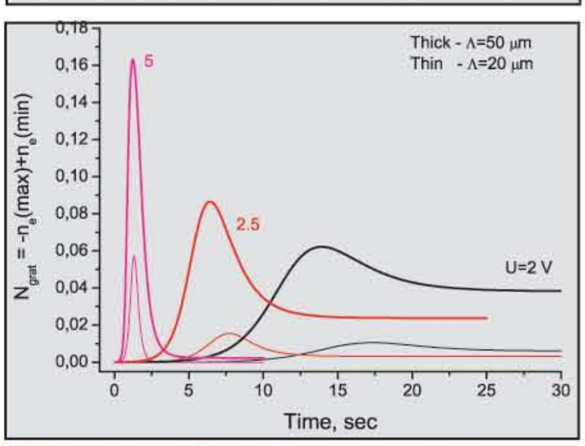


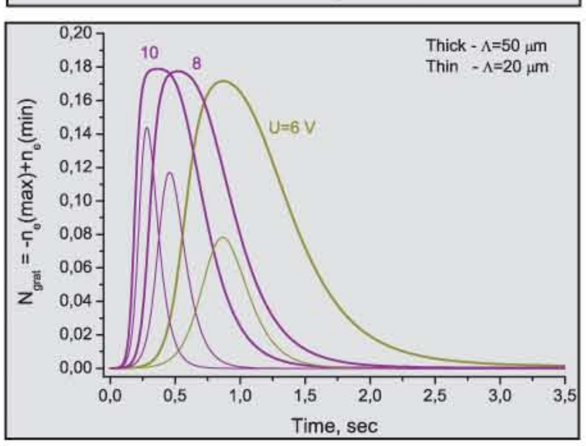




Distribution of the tilte angle in a cell, sinusoidal distribution of electric field, Λ=50 μm.

The thikcness of a cell L=30 μm; LC is 5CB.





1. F. Simoni, L. Lucchetti, Photorefractive Effects in Liquid Crystals, in Photorefractive Materials & Their Applications 2, (2007).

2. L.M. Blinov, Structure and Properties of Liquid Crystals (2011).

3. S. Bugaychuk, et.al., Appl.Nanosci., 10:4965 4970, (2020).

4. S. Bugaychuk, et.al., Nanoscale Res. Lett., 12:449, 1 9 (2017).