Investigation of parameters of LC cell with modified conoscopic technique

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\textbf{Introduction}

Being a basic element of majority of LC devices LC cell consists, in the simplest case, of two glass substrates, which inner surfaces are covered with the aligning layers. The angle of orientation of an LC director on the aligning surface (tilt angle) is a basic characteristic parameter of LC devices [1]. View angle and voltage-contrast characteristics of LCD’s strongly depend on the value of the tilt angle. Deviations from the needed director surface orientation result in the changes of LCD performance known as flickering and image-sticking effects. Development of advanced LCD, e.g. fast nematic bistable devices imposes even more strict demands onto the surface director stability.

Most popular up-to-date method of the tilt angle measurement is a ‘crystal rotation’ technique [2]. In this technique the LC cell is rotated between crossed polarizers with the fixed probe beam’s pass and the tilt angle is determined by measuring the light transmission with respect to the angle of the cell rotation. This method is not appropriate of studying the temporal and temperature dependences. An experimental set up based on a modified conoscopic technique and the results of investigations of the dynamics and temperature dependences of the tilt angle values for a number of photoaligning polymers are presented. The technique has been also employed for precise measurements of the refractive indices of LC compounds and colloids.

\textbf{Experiment}

The elaborated arrangement was used for the studies of polar gliding and memory of LC director on several synthesized photoaligning polymer surfaces. Application of a strong electric field across the cell during some period of time causes the deviation of LC director from its initial (almost planar) orientation and, in turn, the change of the easy axis orientation. After the field removal not only the director comes back to the easy axis but the latter relaxes towards its initial direction. This evolution in time of an easy axis lasting for many hours has been investigated. The measurements of the gliding relaxation for different durations of elastic torque application at the areas subjected to different UV-light exposures have been carried out.

It was shown that under the application of the electric field (\( E = 1 \div 3 V/\mu m \)) the substantial gliding and memory effect were observed for the fluorinated poly-vinyl-cinnamate-based orienting polymer materials. On the contrary, the poly-celulose-cinnamate-based orienting materials (PG’s) reveal lower easy axis gliding, which was accompanied with no residual memory effect.

In addition, investigations of the tilt angle temperature dependences were carried out for a number of liquid crystalline mixtures. These measurements allowed for a deeper understanding of the mechanisms of LC – surface interaction and, potentially, distinguish the role of the adsorption/desorption process and that of the polymer surface modification such as the orientation mobility of the flexible fragments of polymer chains.
In homeotropically aligned cells the temperature dependences of the effective refractive indices and the birefringence of some nematic LC systems including mono- and multi-component mixtures and LC colloids were measured in the temperature range up to the clearing point. Thorough studies have shown an important contribution of the ferroelectric nanoparticles into the increase of the effective refractive index of LC colloid and its birefringence.

Conclusions
With the use of developed technique and set up the time- and temperature-resolved measurements of the tilt angle in liquid crystal cells have been carried out. It allows studying temperature and electric field dependences of the LC director tilt angle, anchoring energy and polar director gliding. The developed software facilitates measurements of temperature dependences of refractive indices of LC. The technique is believed to be useful for precise, express and easy, time- and spatially-resolving characterization of parameters of LC cells.

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References