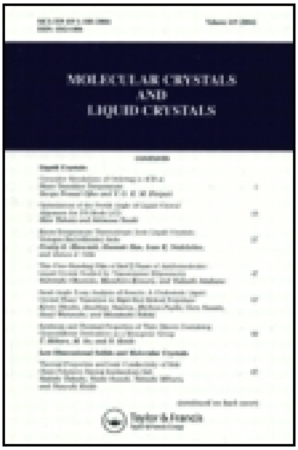


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# High Contrast Light Modulator Based on PDNLC Monolayer

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# High Contrast Light Modulator Based on PDNLC Monolayer

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Interference effects in polymer dispersed nematic liquid crystals (PDNLC) films with monolayer arrangement of the LC droplets are investigated. Transmittance characteristics were measured both in dependence on the collection angle and incidence angle. The method of increasing of contrast of light modulators based on such films is discussed.

*Keywords:* polymer dispersed liquid crystals; nematic; light modulator

## INTRODUCTION

The traditional way to produce high contrast light modulator based on polymer dispersed nematic liquid crystals (PDNLC) is to use thick composite films [1]. Transmittance of the films in off state is low due to the multiple scattering of the light beam by the droplets arranged in several layers across the sample. But this way inevitably results in the growth of driving voltage. Another method utilized an interference effect in the monolayer PDNLC film will be considered in this paper.

Earlier it has been shown experimentally that the dependence of the light transmission of PDNLC monolayer on applied voltage reveals oscillation behavior [2-4]. The interference of light beams passing trough the nematic droplets and polymer is a cause of the oscillations. A number of the oscillations and its amplitude depend on the wavelength of incident light, morphology of the sample and refractive indices of the film component [5]. The opportunity of the quenching of coherent transmittance in a monolayer film of polymer dispersed ferroelectric liquid crystal has been theoretically predicted in [6]. To observe this effect it is necessary to meet rigid requirements concerned the film parameters. This problem can be solved easier by using polymer dispersed nematics. In the latter case one of the parameters, namely refractive index of the nematic, is varied by electric field. The detailed theoretical consideration and experimental observation of the interference quenching effect in PDNLC monolayer was carried out in [7].

In this paper, we present the light modulation characteristics of PDNLC monolayer films measured both in dependence on the collection angle and incidence angle.

## EXPERIMENTAL

PDNLC films were prepared by a method of solvent-induced phase separation (SIPS) [1]. To form a homogeneous solution we dissolved the composition of polyvinylbutyral and nematic liquid crystal 5CB (in ratio

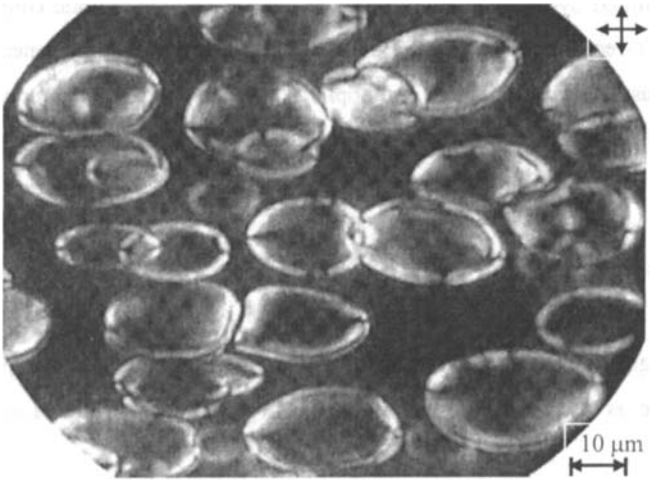


FIGURE 1 Optical microscope image of the stretched PDNLC film. The arrows show the orientation of the cross polarizers.

1:1) in ethanol. The solution was poured on polytetrafluoroethylene plate. The solvent evaporated resulting in formation of the composite film with monolayer arrangement of LC droplets. Then the film was separated from plate, uniaxially stretched and placed between two glass substrates with indium-tin oxide (ITO) electrodes.

A size of the droplets was varied by the rate of evaporation. On the Figure 1 a typical texture of the samples under study is presented. The PDNLC film morphology was investigated by using the polarized microscope POLAM-P113.

The dependencies of the light transmission of PDNLC films upon applied voltage (volt-contrast curves) were measured using the experimental setup constructed as follows. Linearly-polarized light of He-Ne laser ($\lambda$=0.633 μm) passed through the sample. Transmitted light was limited by the diaphragm and was detected by photodiode coupled to a XY-recorder. An ac electric field of 1kHz was provided by generator of sinusoidal electric signal and applied to the transparent electrodes of the cell. All measurements were performed at room temperature.

## RESULTS AND DISCUSSION

The light transmission curve of PDNLC monolayer film versus applied voltage is presented on the Figure 2. Average sizes of the axes of

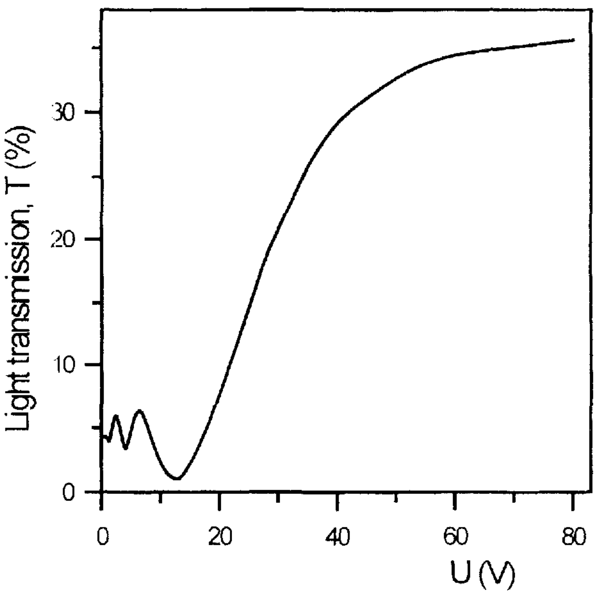


FIGURE 2. Light transmission of the PDNLC monolayer film as a function of the applied voltage. Film thickness is 14 μm.

ellipsoidal droplets are 44x30 μm in the plane of film and 12 μm in lateral plane. Average deviation of long axes of droplets from a direction of their preferable orientation is 7.5 degrees. The overlap coefficient equal to the ratio of the projection area of the whole droplets on the film plane to the area where they are distributed – 0.6. In unpowered state, the light transmission of the sample is equal 4%. As can see, volt-contrast curve reveals the oscillation behavior due to interference effect. At the voltage U=13.2V the light quenching is observed (transmission is 1.1%). At saturation field the transmittance grows up to 36%. The switching of the cell between the initial state (U=0) and saturation one (U=80V) gives a contrast ratio 9:1. Utilization of the light quenching state (switching voltage between 13.2V and 80V) permit us to increase contrast ratio up to 33:1.

As was shown in [8] theoretically, the quenching of light passed through the film strongly depends on the collection angle of transmitted radiation. In the measurements, we changed the collection angle $\alpha$ in the range from 0.2 degree to 2 degree. The dependencies of the minimal transmittance $T_{min}$ (in the state of light quenching) and maximal one $T_{sat}$ (in saturation state) on the angle $\alpha$ are presented on Figure 3. Really, the $T_{min}$ increases from 0.78% to 7.4% in the range of the variation of angle $\alpha$. As a consequence the contrast ratio of the PDNLC cell also strongly depends on $\alpha$. It should be noted, that the behavior of $T_{min}(\alpha)$ curve is determined by transmission of incoherent light component only and corresponds to the theoretical dependence [8].

We have investigated also a dependence of contrast ratio on the angle deviation of light beam from normal incidence (see Figure 4). The angle $\beta$ of deviation was within the limits of $35^0$. As can see, the contrast

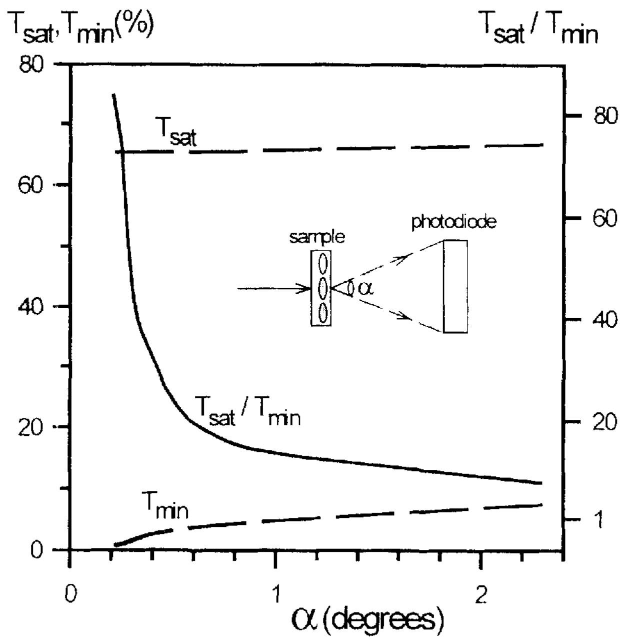


FIGURE 3. Light transmission of the PDNLC film in the quenching state ($T_{min}$) and saturating one ($T_{sat}$) and contrast ratio ($T_{sat}/T_{min}$) versus the collection angle $\alpha$.

ratio abruptly decreases under deviation from normal, but is more than 40:1 in the range $|\beta|<12^0$.

## CONCLUSION

Thus, the results of this paper show a promising way to increase contrast ratio of the light modulators based on the PDNLC monolayer. High contrast due to the light quenching effect can be achieved at the small

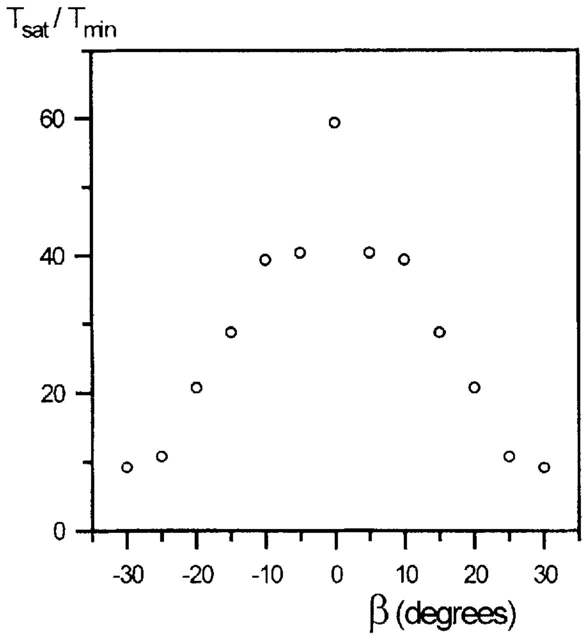


FIGURE 4. The contrast ratio of the light modulator based on PDNLC monolayer film versus the incidence angle β.

collection angle only. It means the PDNLC modulators with interference increasing of the contrast are especially convenient for various laser devices and light projection systems.

**Acknowledgements**

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