Polymer films with elongated droplets of nematic liquid crystal: light transmission, scattering, and polarization

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Polymer-dispersed liquid crystal (PDLC) technology provides the possibility of creating of effective electrically or magnetically controlled non-absorptive light polarizers, which are attractive for use in high-power laser applications when the conventional film polarizers based on the absorption anisotropy are unstable. The operating principal of PDLC polarizers is based on the effect of anisotropic light scattering by the uniaxially stretched PDLC films with at most uniform orientation structure of liquid crystal (LC) droplets optical axes.

Recently it was realized the new combined technique of light polarization [1] caused by both the mechanical deformation of PDLC film and the modification of the interphase surface anchoring by ionic surfactants. These factors lead to a formation of the ensemble of elongated ellipsoidal LC droplets with monodomain internal structure of LC director and therefore allow obtaining the PDLC films with extreme polarizing characteristics.

In here the analytical optical-mechanics model to analyze spectral transmittance and spectral polarizing ability of the PDLC films is proposed. It is based on the Foldy-Twersky approximation, anomalous diffraction and Wentzel–Kramers–Brillouin approaches [2,3]. The spectral dependences of transmittances and polarizing ability of the polymer dispersed liquid crystal films have been analyzed as well as the small-angle intensity distribution and the polarization degree of scattered light depending on the film thicknesses, the refractive index of polymer matrix, the sizes of droplets, their anisometry parameters, concentration, polydispersity, and optical axes orientation. The optical characteristics of PDLC films with homogeneous and inhomogeneous interfacial anchoring at the surface of liquid crystal droplets have been considered. The transmittance and polarizing ability of the films have been studied as functions of the angular aperture of the system recording scattered light.

The model makes it possible to determine the extreme polarizing characteristics of PDLC films at mechanical stretching (transmittance equals 0.5 and polarizing ability equals ±1) depending on the: light wavelength, film thickness and order parameter, refractive indices of the nematic liquid crystal and polymer matrix, sizes, concentration, polydispersity, and anisometry parameters of LC droplets. The appropriate numerical data are presented and discussed. We have verified the model by comparison with experiment under the ionic modification of the LC–polymer interphase anchoring [1].

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[2] V. A. Loiko, V. Ya. Zyryanov, A. V. Konkolovich, A. A. Miskevich Light Transmission of Polymer-Dispersed Liquid Crystal Layer Composed of Droplets with Inhomogeneous Surface Anchoring. Optics and Spectroscopy, 2016, Vol. 120, No. 1, pp. 143–152.
[3] V. A. Loiko, A. V. Konkolovich, and A. A. Miskevich Light Scattering by a Nematic Liquid Crystal Droplet: Wentzel–Kramers–Brillouin Approximation. Journal of Experimental and Theoretical Physics, 2016, Vol. 122, No. 1, pp. 176–192.