Measurement Method for Flexoelectric Coefficients of Nematic Liquid Crystals by means of Symmetrically Oblique Incidence Transmission Ellipsometry

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Recently, the study of the flexoelectric effect has attracted the attention of many researchers because of its applicability to fast response liquid crystal displays.[1] Furthermore, flexoelectric effect is considered to be the cause of the image sticking problem.[2] However, accurate measurement method for the flexoelectric coefficients has not been well established yet. As is summarized in the literature,[3] the sign and/or the absolute value of the measured flexoelectric coefficients with regards to a common nematic liquid crystal (NLC) differs for every published paper. In this study, improved measurement method for the flexoelectric coefficients of NLCs based on the renormalized transmission ellipsometry is demonstrated. For eliminating the inaccuracy in the measurement of retardation caused by multiple-beam interference (MBI) in anisotropic multilayer-structured thin films, symmetrically oblique incidence transmission Ellipsometry[4] (SOITE) has proposed and applied to the determination of the LCD's device parameters such as the cell gap, surface anchoring energy, reduced dielectric anisotropy and reduced elastic constant. We applied the SOITE technique to determine the flexoelectric coefficients (e_{11} and e_{33}) for the splay and bend distortion.

First, we discuss the director distortion inside a simple hybrid aligned nematic (HAN) cell. The bulk free energy density can be expressed by the prototypical equation as follows;[5]

$$W = \frac{1}{2} f_{\mathrm{elas}}(\theta)\left(\frac{\partial\theta}{\partial z}\right)^2 - \frac{1}{2} f_{\mathrm{diel}}(\theta)\left(\frac{\partial V_\varphi}{\partial z}\right)^2 + f_{\mathrm{flex}}(\theta)\cos\theta\left(\frac{\partial\theta}{\partial z}\right)\left(\frac{\partial V_\varphi}{\partial z}\right), \qquad (1)$$

Where $\theta(z)$ is the polar angle with respect to the x-y plane, V_φ is the electric scalar potential, $f_{\mathrm{elas}}(\theta)=K_{11}\cos^2\theta+K_{33}\sin^2\theta$, $f_{\mathrm{diel}}(\theta)=\varepsilon_0(\varepsilon_p\sin^2\theta+\varepsilon_n\cos^2\theta)$, and $f_{\mathrm{flex}}(\theta)=(e_{11}+e_{33})\sin\theta\cos\theta$, respectively. The planar anchoring energy is given in the usual Rapini-Papoular form;

$$W_s = \frac{1}{2} A_\theta \sin^2\left(\theta_{[0]} - \theta_0\right). \qquad (2)$$

The director distribution throughout the cell $\theta(z)$ can be numerically solved by the Euler-Lagrange equation, and resultant optical retardation for $+\beta$ and $-\beta$ incidences (say R^+ and R^-) can be obtained. Second, experimentally measured the optical phase differences between the p- and s-polarized light for $+\beta$ and $-\beta$ incidences (say Δ^+ and Δ^-) hold $\Delta^- - \Delta^+ = R^- - R^+$, therefore $e_{11}+e_{33}$ can be determined by the numerical fitting procedure. $e_{11}-e_{33}$ can be determined by similar procedure with horizontal electric filed.

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