Measurement and LCD application of Flexoelectricity of Nematic Liquid Crystal: Symmetrically Oblique Incidence Transmission Ellipsometry

Munehiro Kimura
Graduate school of Engineering, Nagaoka University of Technology, Nagaoka, Niigata 940-2188, Japan
Tel.:+81-258-47-9540, E-mail: nutkim@vos.nagaokaut.ac.jp

Due to the distribution of molecular orientation in nematic liquid crystal (LC), in general, permanent polarization does not appear regardless of its dipole moment. However, when the symmetry of the molecular arrangement is broken under a certain condition (i.e. applied electric field, hybrid alignment geometry, etc), net polarization can be generated, which was named Flexoelectricity.[1,2] The coefficient of the flexoelectric effect was paid attention after a report on flicker phenomenon on liquid crystal display (LCD).[3] It is required to evaluate device parameters including flexoelectric coefficients for new types of high-speed LCD.[4] There are many reports on evaluation method of flexoelectric coefficient e_{11} and e_{33}, for splay alignment distortion and bend alignment distortion in the nematic liquid crystal phase.[5] In order to elucidate the flexoelectric effect, it is necessary to establish the measurement method for the flexoelectric coefficients. Up to today, however, accurate determination of the flexoelectric coefficients has not been established yet. In this research, a method of determining e_{11} and e_{33} is proposed, where an in-plane twist nematic liquid crystal (TNLC) was evaluated by the transmission ellipsometry. The aim of this study is to estimate the measurement conditions and measurement accuracy.

In the evaluation procedure, firstly, director distribution throughout the TNLC layer is calculated under a set of conditions with supposed flexoelectric coefficients. From this calculation, polar and twist angle of director can be obtained from the NLC continuum theory with free energy minimization principle, these are effected by the conditions of cell gap, pretilt angle, twist angle and the anchoring energy. Secondly, an optical calculation based on Berreman's 4×4 Matrix is performed to obtain the phase difference Δ and the angle of amplitude Ψ at an wavelength. In the optical calculation, the conditions of the incidence angle, rotation angle, the thickness of cell layer, and refractive index are considered.

From the calculation results of typical nematic liquid crystal, several tendencies have been confirmed. Firstly, when an electric field is applied, Δ reflects the polar angle, and Ψ reflects the azimuthal angle. Since the change of Δ is larger than the changes of the Ψ, the evaluation of Δ is preferable for determining the flexoelectric coefficient. Therefore, based on symmetric oblique incidence transmission ellipsometry (SOITE),[6] the tendency of Δ^{-}-Δ^{+} under several conditions is surveyed. As a result, an asymmetric Δ characteristics in the dependency graph of e_n is found. Furthermore, the dependence of various parameters of $\Delta\varepsilon$, cell thickness, twist angle on the flexoelectric coefficient are studied. From all these evaluations, it is concluded that the determination of e_{11}-e_{33} as well as e_{11}+e_{33} can be evaluated by the measurement of Δ^{-}-Δ^{+}.

References

1. R. B. Meyer, Phys. Rev. Lett. **22** (1969) 918.
2. A. Buka and N. Eber, Flexoelectricity in Liquid Crystals, London: World Scientific Publishing (199 2).
3. J. -W. Kim, T. –H. Choi, T. –H. Yoon, E-J. Choi, and J. –H. Lee, Opt.Express, **22** (2014) 30589.
4. D. J. Gardiner, S. M. Morris, F. Castles, M. M. Qasim, W.-S. Kim, S. S. Choi, H.-J. Park, I.-J. Chung, and H. J. Coles, Appl. Phys. Lett., **98** (2011) 263508.
5. T. Takahashi, S. Hashidate, H. Nishijou, M. Usui, M. Kimura and T. Akahane, Jpn. J. Appl. Phys., **37** (1998) 1865.
6. L. H. Trong, M. Kimura, and T. Akahane, Jpn. J. Appl. Phys., **44** (2005) 932.