Control of Pre-tilt Angle and Evaluation of Azimuthal Anchoring Strength Considering the Pre-tilt Angle on the Alignment Film Formed by the ESD Method

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The Electro-Spray Deposition (ESD) is one of the film forming methods by which pure electric field and electric charges has been proposed by V. N. Morozov et al. [1] And, a hybrid method which is the combination of spin-coat and ESD has been proposed by our group [2] for the control of pre-tilt angle in the LC cell. The special alignment film consisted of innumerable tiny multi-domains with the horizontal and vertical alignment materials can be formed by this method. Furthermore, the improved method which is sprayed simultaneously two solutions of the alignment materials has been proposed [3] due to forming tinier domains of alignment materials. The purpose of this study is to control the pre-tilt angle by this technique. In this paper, we propose an improved measurement method of azimuthal anchoring strength considering the pre-tilt angle. Generally, the azimuthal anchoring energy $W_A$ was defined as $(1/2)\sin^2\Delta \Phi_0$. [See Fig. 1 (a)] However, this expression is defined under the zero pre-tilt condition. Thus, this definition shows irrationality if the azimuthal anchoring with a large pre-tilt angle LC cell is discussed. Therefore, an improved azimuthal anchoring energy $W'_A$ was proposed [4]; that has been defined as $(1/2)\sin^2\Delta \Phi_0$. [See Fig. 1 (a)] Then, the torque balance method [5] for LC cells with a large pre-tilt angle is redefined. The anchoring strength $A'_\phi$ can be obtained as follows when the LC director and easy axis are defined as shown in Fig.1 (c);

$$A'_\phi = \frac{(K_{22} \cos^2 \theta_{00} + K_{33} \sin^2 \theta_{00}) (\phi_d - \Delta \phi_0)}{2 d (1 - 2 \cos^2 \theta_{00} \sin^2 \Delta \phi_0) \cos \theta_{00} \sin \Delta \phi_0}$$

where $K_{22}$ and $K_{33}$ are the twist and bend elastic constants, $d$ is the cell thickness. Fig. 2 shows the calculation results of the $A'_\phi$ based on the angle formed by crossing directors and the pre-tilt angle. In the case of the large pre-tilt angle which was close to the vertical alignment, $A'_\phi$ was different more than an order of magnitude from those of conventional method.

In the experiment, the azimuthal anchoring strength was controlled by spaying time of the ESD. Alignment materials PI-A and SE-1211 (4 wt% Nissan chem. Ind.) were used. The solvent was mixed of the THF and ACN, the weight ratio was 6:4. Fig.3 shows the measurement results of the pre-tilt angle and the azimuthal anchoring strength. The following tendency was shown; the low value of anchoring energies were obtained when the pre-tilt angle was increased. The value of $A'_\phi$ ($A_\phi$) decreased with increasing the pre-tilt angle, however, a large value of $A'_\phi$ compared with $A_\phi$ was obtained. It was considered that the large factor was a difference of anchoring forces by each material. Our ESD method will be able to control the azimuthal anchoring energy and pre-tilt angle.

References:

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