Accurate Measurement of Twist Angle for Analysis of Azimuthal Anchoring Energy and Rubbing Direction of LC Panels of IPS Mode

S.H.Baek(1), B. G. Rho(1), J.M.Oh(2), W.S.Dong(2) , B.K.Yang(3), and J.S.Kim(3)

[1]Sesim Photonics Technology Co., 196-5, Ojeon-Dong, Euiwang-Shi, Kyunggi, Korea

+82-19-256-7658, E-mail: bgrho@sesimlcd.co.kr

[2]Jeil Textile Co., 332-2 Gochun-Dong, Euiwang-Shi, Kyunggi-Do, Korea

[3]Chonbuk National University, Chonju-Shi, Chonbuk, Korea

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Abstract

A new method is developed for the measurement of twist angles of LC molecules in an LC panel with angular resolution of 0.01degree, which allows measurement of LC panels with small twist angles. The method is based on the analysis of the change in polarization state of a light beam as it passes through the LC panel in test is rotated in-plane. Compared to other traditional method, including the analysis of transmittance change, our method is more sensitive and more precise. This method allows accurate determination of anchoring energy and close analysis of the rubbing process in the fabrication of IPS mode LC panels.

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1. Objectives and Background

Azimuthal anchoring energy is one of the important parameters for development of a new rubbing layer or optimization of a rubbing process. Up to now azimuthal anchoring energy (*A*) of an LC cell was determined by measuring the twist angle of the cell doped with a chiral dopant and then using the following formula [1].

$$A = \frac{2K_{22}}{\sin 2\phi_s}\left(\frac{2\pi}{P_0} - \frac{\theta}{d}\right) \qquad (1)$$

Where K_{22} is the elastic constant for twist deformation, $2\phi_s$ is the angle between the LC director and the rubbing direction. P_0, d, and θ are the pitch, cell gap, and the twist angle, respectively.

For accurate determination of anchoring energy, precise measurement of twist angle is necessary [2]. Up to now measurement of twist angle was based on the measurement of transmittance variation with respect to the variation of incidence angle. However, such measurement is in general not so accurate because of the fluctuation of the intensity of incident light itself and the multiple reflections from the interfaces of the components comprising the LC panels. In addition, the smaller the twist angle, the lower becomes the accuracy and the lower bound of the twist angle that can be reliably measured is limited to around 10 degrees [2]. In our new method, a linearly polarized light beam is sent to the LC panel to be tested and the polarization state of the transmitted beam is measured. When the direction of polarization of the incident beam is changed, the polarization state of the transmitted beam is changed accordingly. Such polarization transmission property of the LC panel is determined by the orientation as well as the optical properties of the LC molecules within the panel. The experimental data are compared with the simulated result based on the Jones matrix of the panel and the twist angle and other parameters of the LC panel are determined from the best fit simulation condition.

2. Experimental

Figure 1 is the photograph of the experimental system and Figure 2 is its schematic diagram. The light source is a He-Ne laser with wavelength of 632.8nm and the polarization direction of the incident beam is controlled by rotating the polarizer, situated next to the laser.

Fig.1. Photograph of the experimental system

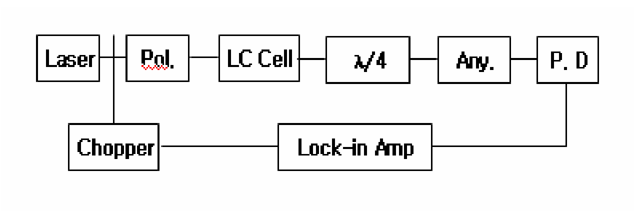

Fig. 2. Schematic diagram of the experimental system

The quarter-wave plate between the LC cell and the analyzer can convert an arbitrary elliptically polarized light into a linearly polarized light which can be completely extinguished by properly adjusting the transmission axis of the analyzer. The orientation of the quarter-wave plate and the analyzer in this condition of complete extinction determines the polarization state of the light transmitted though the LC panel [3]. The Fabry-Perot effect originating from the multiple reflections at the surfaces of glass plates forming the LC panel is the most detrimental for accurate measurement. Such effect can be successfully suppressed by using index-matching technique. The process of measurement is the following:

1) Adjust the polarizer and the analyzer in cross state and the optic axis of the quarter-wave plate in parallel with the transmission axis of the analyzer.

2) Insert an LC cell to be tested into the liquid gate of the measurement system and rotate it to find the orientation where the transmittance becomes a minimum. In this condition the transmission axis of the polarizer is in parallel with the central direction of the twist

3) Rotate the polarizer by -5 degrees and measure the polarization state of the light transmitted through the LC cell. Rotate the polarizer by 1 degree and repeat the measurement. Repeat such process to produce eleven data corresponding to the direction of the polarizer from -5 to +5 degrees with steps of 1 degree.

4) In the simulation, adjust the thickness of the LC layer and the twist angle of the LC cell to find the best fit with the experimentally obtained data.

3. Results and discussion

Figure 3 shows the traces of the Stokes vectors in the Poincare sphere representation of the light transmitted through three types of LC cells. All the LC cells have the same values of K_{22}, Δn, and the pitch which are 7.6×10^{-12}dyne, 0.1043, and 15 um, respectively. Trace (a) is from an LC cell without chiral dopant, traces (b) and (c) are from LC cells with right- and left-handed chiral dopants, respectively. The polarization characteristics of an LC cell can be described as a rotational transformation in the Poincare sphere representation: the rotation angle mainly depends on Δnd of the LC filling the cell. The twist angle of the cell mainly influences the position of the intercept of the latitude by the trace. Table 1 shows the twist angle, the cell gap, and the anchoring energy determined from the best fit of the simulation with the experimental data.

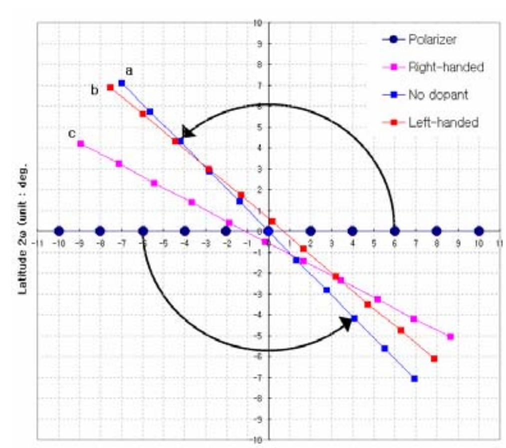

Fig. 3. Plot of measured data on the surface of the Poincare sphere

TABLE 1. Measured data

Sample	Cell gap (um)	Twist angle (deg.)	Anchoring energy (J/m^2)
A	2.468	0.004	-
B	2.588	0.523	6.909×10^{-4}
C	2.797	-0.528	6.975×10^{-4}

4. Summary

The method of measurement described here shows the highest precision reported in the measurement of twist angle of LC cells and can be applied to determine the anchoring energy of LC molecules in the LC cells as well as the accurate orientation of rubbing directionsof LC panels for IPS and TN modes

5. References

1. Y. Sato, K. Sato and T. Uchida, Jpn. J. Appl. Phys.31, **L579** (1992).

2. Y. Saitoh and A. Lien, Jpn. J. Appl. Phys. **39**, 1743 (2000).

3. J. S. Kim, B. G. Rho, and G. S. Kim, Asia Display'95, 173 (1995).