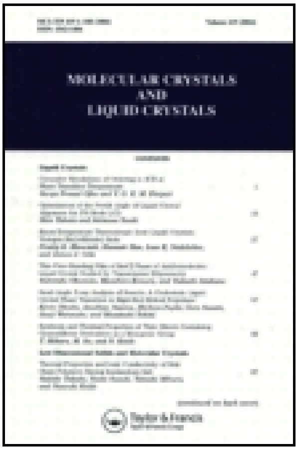

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

ELLIPSOMETRY OF MOLECULAR REORIENTATION IN A FREELY SUSPENDED FERROELECTRIC LIQUID CRYSTAL FILM

Sadahito Uto [a], Yasuaki Matsumoto [a], Masanori Ozaki [b] & Katsumi Yoshino [b]

[a] Department of Electrical Engineering, Osaka Institute of Technology, 5-16-1 Omiya, Asahi-ku, Osaka, 535-8585, JAPAN

[b] Department of Electronic Engineering, Graduate School of Engineering, Osaka University, 2-1 Yamada-oka, Suita, Osaka, 565-0871, JAPAN

Version of record first published: 24 Sep 2006

Mol. Cryst. and Liq. Cryst., 2001, Vol. 366, pp. 565-571
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Ellipsometry of Molecular Reorientation in a Freely Suspended Ferroelectric Liquid Crystal Film

SADAHITO UTO[a], YASUAKI MATSUMOTO[a], MASANORI OZAKI[b] and KATSUMI YOSHINO[b]

[a]*Department of Electrical Engineering, Osaka Institute of Technology, 5–16–1 Omiya, Asahi-ku, Osaka 535–8585, JAPAN and* [b]*Department of Electronic Engineering, Graduate School of Engineering, Osaka University, 2–1 Yamada-oka, Suita, Osaka 565–0871, JAPAN*

Optical measurements of a field induced molecular reorientation process in a freely suspended ferroelectric liquid crystal film (FSFLC) have been studied. In order to measure a direction and a magnitude of a birefringence of the film at the reorientation, a photoelastic modulator has been used. A complicated response that has broad spectrum of the response speed is observed in the thick FSFLC film that has helical structure.

Keywords: ferroelectric liquid crystal; freely suspended film; electrooptic effect; ellipsometry; helical structure

INTRODUCTION

Freely suspended (FS) film of ferroelectric liquid crystal (FLC) has layered structure and thickness of the film can be varied from only two layers to more than several hundreds layers, so that freely suspended ferroelectric liquid crystal film (FSFLC) has recently been investigated as thin two-dimensional liquid crystal system [1-3]. In addition, several interesting electrooptical properties of a thick FS film that is thicker than helical pitch has been reported [4,5]. In this article, ellipsometric study of molecular motion of the thick FS film has been carried out.

EXPERIMENTAL

A ferroelectric liquid crystal (Chisso, CS-1029) was used in this study. The helical pitch of the sample at 25℃ is 2 μ m. Every measurement was carried out at 25℃. The freely suspended film was prepared in a hole of a glass substrate of 150 μ m in thickness. The hole was 1.5 mm in diameter. A thickness of the film used in this study was 7.7 μ m that is thicker than helical pitch of the material. The two electrodes whose gap was 2mm lay in the substrate due to apply electric field.

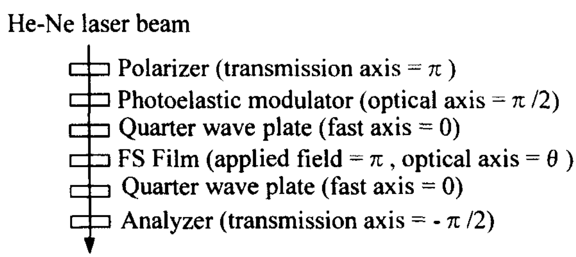


FIGURE 1 Experimental setup.

An optical setup used in the ellipsometry is shown in Fig.1. Both a direction θ and a magnitude Γ of the birefringence of the film can be simultaneously measured by the setup. A He-Ne laser beam was impinged on the film with incident angle of 0. A direction of the applied field was $\pi/2$.

Intensity of the transmission light was detected by a photodiode, and the signal was recorded by a digital oscilloscope and analyzed by FFT. V_{1f} is the first harmonics of the signal at the modulator frequency (f = 50 kHz); V_{2f} is the second harmonics of the signal; J_1 and J_2 are the Bessel function; V_{ref} is the signal of the reference. The θ and the Γ are given by

$$\theta = \frac{1}{2}\tan^{-1}\left(-\frac{V_{2f}\cdot J_1(\pi)}{V_{1f}\cdot J_2(\pi)}\right)$$

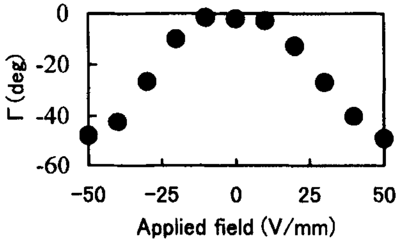
and

$$\Gamma = \sin^{-1}\left(-\frac{V_{1f}}{V_{ref}}\cdot\frac{1}{\cos(2\theta)}\right),$$

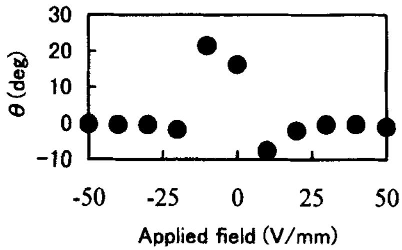
respectively.

RESULTS AND DISCUSSION

Figure 2 shows results of static field applications. The Γ is proportional to the applied field and the θ is constant except around 0 V/mm. Figure 3 shows images of a conoscope observation corresponding to the Fig.2. An optical axis of the film is perpendicular to the film surface around 0 V/mm and inclines with dependence on the applied field. This model of the optical axis can also explain the results shown in Fig.2. The axis parallels the laser beam around 0 V/mm so that the instability of the θ is observed. A reason why the uniaxial optical behavior is observed in the film that has smectic helical structure has been not clarified yet. There is room for further investigation.



(a) Γ



(b) θ

FIGURE 2 Results of ellipsometry for static field.

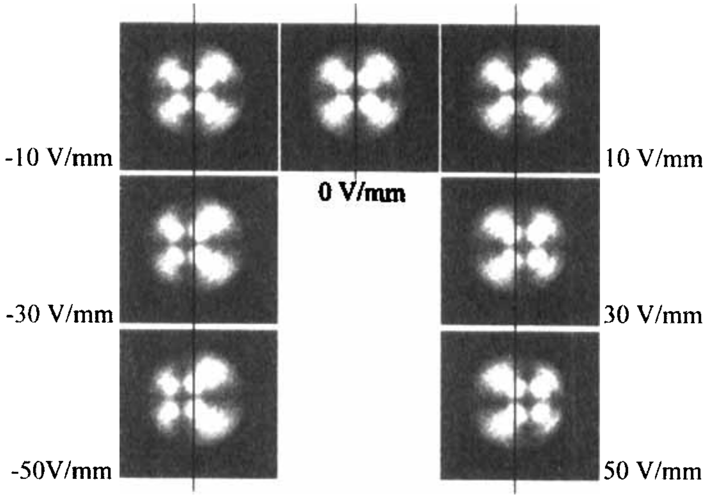


FIGURE 3 Conoscope images. Solid lines indicate center of the image.

Figure 4 and 5 show results of a successive measurement under application of a square alternate field ($\pm$50 V/mm, freq.=0.05 Hz). It must be noted that fast molecular motion with change of the θ is observed by 100μ s, as shown in Fig.4. In addition, slow molecular motion that takes more than 10 s is also observed, as shown in Fig.5. The slow motion is accompanying with the inclination of the optical axis, but the θ is constant. It is interesting to note that such complicated response that has broad spectrum of the response speed is observed in the thick FSFLC film that has helical structure.

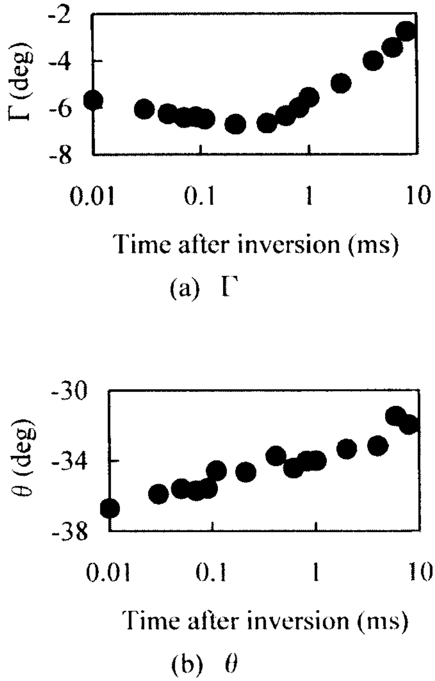


FIGURE 4 Results of ellipsometry after field inversion.

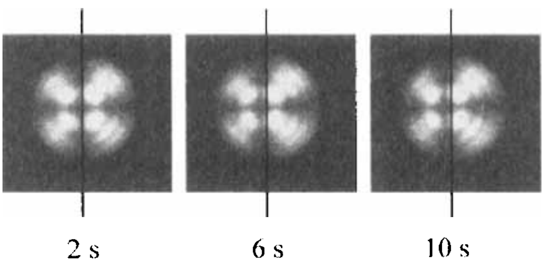


FIGURE 5 Successive image of conoscope after field inversion. Solid lines indicate center of the image.

SUMMARY

This investigation can be summarized as follows. The ellipsometry and conoscope observation of thick freely suspended ferroelectric liquid crystal film that has smectic helical structure was carried out. Uniaxial property was observed in the film. The optical axis was perpendicular to the film surface and inclined depending on the applied field. Slow and fast molecular motions were measured at field inversion.

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