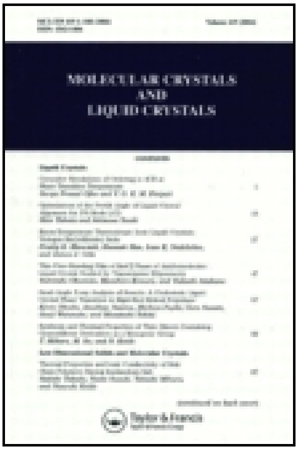

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

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

Transient Periodical Structure at Polarization Reversal in Ferroelectric Liquid Crystals

Hiroshi Moritake [a] , Susumu Kinoda [a] & Kohji Toda [a]

[a] Department of Electronic Engineering, National Defense Academy, 1-10-20 Hashirimizu, Yokosuka, 239-8686, Japan

Version of record first published: 24 Sep 2006

Mol. Cryst. Liq. Cryst., 1999, Vol. 328, pp. 341-348
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Transient Periodical Structure at Polarization Reversal in Ferroelectric Liquid Crystals

HIROSHI MORITAKE, SUSUMU KINODA and KOHJI TODA

Department of Electronic Engineering, National Defense Academy, 1–10–20 Hashirimizu, Yokosuka 239–8686, Japan

Switching mechanism of thick cell of ferroelectric liquid crystals has been studied by means of light scattering measurement and polarizing microscope observation adopting stroboscopic technique. The transmitted light through the cell at the instant of polarity reversal of applied voltage has been diffracted by the formation of periodical stripe texture. This transient stripe texture has a tilt from the smectic layer. The period of the transient stripe texture is independent of temperature and depends on applied voltage. The oblique angle from smectic layer depends on applied voltage.

Keywords: ferroelectric liquid crystal; transient stripe texture; light scattering; transient scattering mode; TSM

INTRODUCTION

Ferroelectric Liquid Crystals (FLCs) have attracted considerable attention from fundamental and practical points of view[1]. From practical points of view, various types of electrooptic effects have been reported. Among them, the surface stabilized ferroelectric liquid crystal (SSFLC) has been studied most extensively[2]. The switching mechanism for thin cell in which surface stabilized state indicates has been reported[3-5].

On the other hand, other electrooptic effects using light scattering such as transient scattering mode (TSM) have been reported[6,7]. These effects requires thick cell in which the helicoidal structure is formed. In this paper, we report transient periodical structure which is observed at the instant of polarization reversal in thick cell of FLCs.

EXPERIMENTAL

Ferroelectric liquid crystals used in this study are mixture samples CS-1014, CS-1016 and CS-1017 (Chisso) which show the Sm C* phase in room temperature. The sample was sandwiched between indium-tin-oxide (ITO)-coated glass plates whose surfaces were coated with polyimide and rubbed. Both the glass plates were fixed with the rubbing directions antiparallel using polyethyleneterephthalate (PET) sheets as spacers. The cell gap was typically 20 μm.

For electrooptic measurement, a He-Ne laser (632.8 nm) was used as a light source and no optical polarizer was used. The incident light was perpendicular to the cell and the transmitted light intensity through the cell was monitored with a photodiode. The experimental setup is shown in Fig. 1. The direction of transmitted light was specified by the angles θ and ϕ. The switching process was observed using a polarizing microscope (Nikon, OPTIOHOT2-POL) attaching stroboscopic lamp (Sugawara, MS230) and digital camera (Minolta, RD-175).

RESULTS AND DISCUSSION

Figure 2 shows a waveform of transmission intensity response to polarity reversal of applied voltage in CS-1014 sample. A dip of transmission intensity was observed at the instant of polarity reversal of applied voltage. This dip is due to the light scattering which is caused by the transition between two ferroelectric uniform states and this electrooptic effect is called the transient scattering mode (TSM)[6]. Figure 3 shows light scattering profile at 3 ms after the polarity reversal

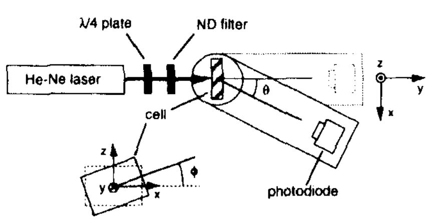

FIGURE 1 Experimental setup for the measurement of light scattering.

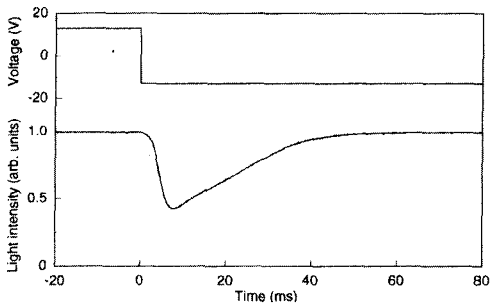

FIGURE 2 Applied voltage waveform and waveform of transmission intensity response to polarity reversal of applied voltage in CS-1014 sample.

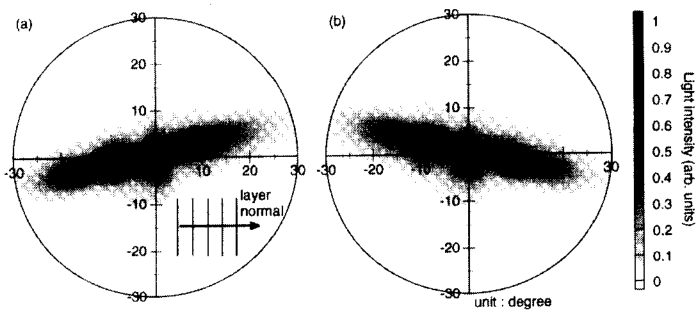

FIGURE 3 Scattering profiles in 3 ms after polarity reversal of applied voltage in CS-1014 sample.

of applied voltage in CS-1014 sample. The transmitted light was scattered along $\phi=\pm14°$ direction and the oblique direction was decided by the polarity of applied voltage waveform. The peaks of transmission intensity existed at $\theta=\pm10°$ in $\phi=\pm14°$ direction. This result indicates that this light scattering was not uniform scattering. Figure 4 shows the polarizing micrographs at 4 ms after the polarity reversal of applied voltage in CS-1014 sample. The periodical stripe texture which had a tilt from the smectic layer was observed, as shown in Fig. 4. The oblique angle was ±14° and corresponded to the azimuth to which the transmitted light was strongly scattered. From these results, this phenomenon was not scattering but diffraction which was caused by the formation of the

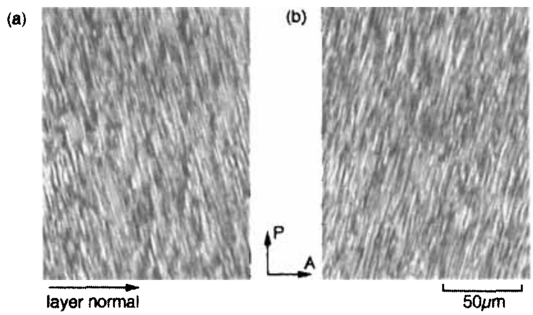

FIGURE 4 Polarizing micrographs of transient strupe texture. (a) + to - and (b) - to + of applied voltage in CS-1014 sample.

See color plate XVII at the back of this issue.

transient periodical structure.

Figure 5 shows θ and time dependencies of transmission intensity after polarity reversal of applied voltage under the condition of ϕ=14° in CS-1014 sample. A peak of transmission intensity was observed at θ=10°. This peak did not shift and decreased with time elapse. Figure 6 shows temperature dependence of period of transient stripe texture in CS-1014 sample. The pitch of helicoidal structure is also shown in this figure. The helicoidal pitch increased as temperature increased. While, the period of transient stripe texture did not depend on temperature and was constant. Therefore, the period of transient stripe texture was not directly concerned with the helicoidal pitch. Figure 7

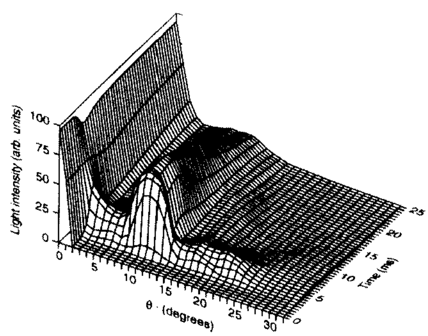

FIGURE 5 θ and time dependencies of transmitted light intensity after polarity reversal of applied voltage under the condition of ϕ=14° in CS-1014 sample.

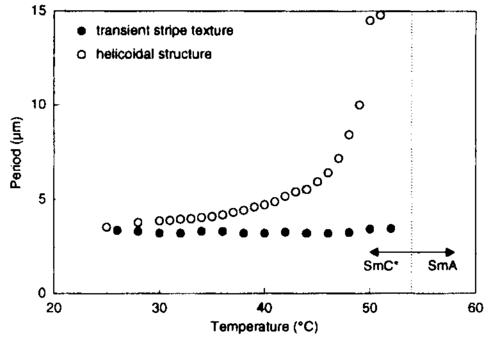

FIGURE 6 Temperature dependencies of periods of transient stripe texture and helicoidal pitch in CS-1014 sample.

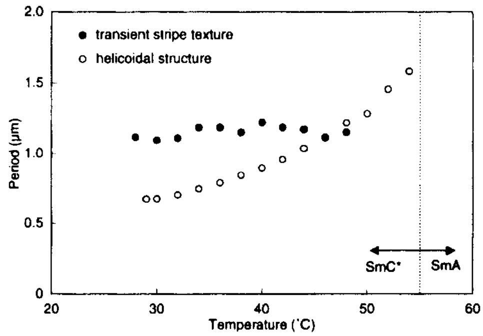

FIGURE 7 Temperature dependencies of periods of transient stripe texture and helicoidal pitch in CS-1017 sample.

shows temperature dependencies of periods of transient stripe texture and helicoidal structure in CS-1017 sample. The period of transient stripe texture was constant and the helicoidal pitch increased as temperature increased. Both the periods of transient stripe texture and helicoidal structure in CS-1017 sample was shorter than those in CS-1014 sample. Therefore, the period of transient stripe texture may originate from the force of helicoidal structure.

Figure 8 shows applied voltage dependence of period of transient stripe texture in CS-1014 sample. The period of transient stripe texture decreased with applied voltage. Under applying voltage above 60 V, the diffraction peak of transmitted light could not be observed. Polarizing micrographs of transient

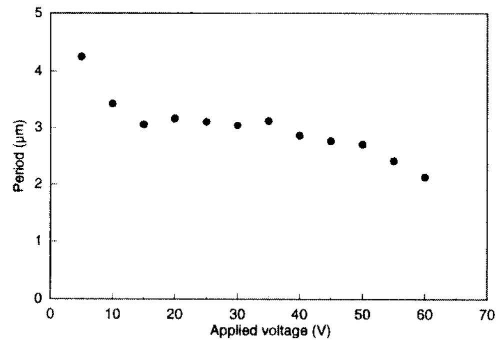

FIGURE 8 Applied voltage dependence of period of transient stripe texture in CS-1014 sample.

stripe texture under various applied voltages in CS-1014 sample are shown in Fig. 9. The transient stripe texture was observed under applying not only below 60 V but also above 60 V, as shown in Fig. 9(c) and 9(d). The length of each stripe in texture became short with applied voltage. This result shows that the periodicity of transient stripe texture was disordered under high applied voltage. Therefore, the diffraction peak of transmitted light disappeared under high applied voltage. The oblique angle from smectic layer of transient stripe texture

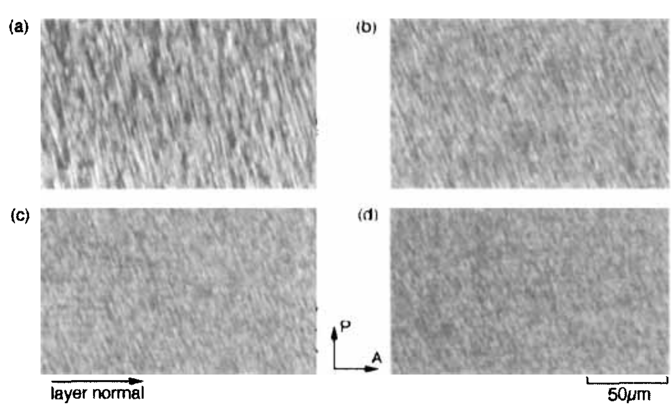

FIGURE 9 Polarizing micrographs of transient stripe texture under applying various voltages in CS-1014 sample. (a) 20 V, (b) 60V, (c) 100 V and (d) 160V. See color plate XVIII at the back of this issue.

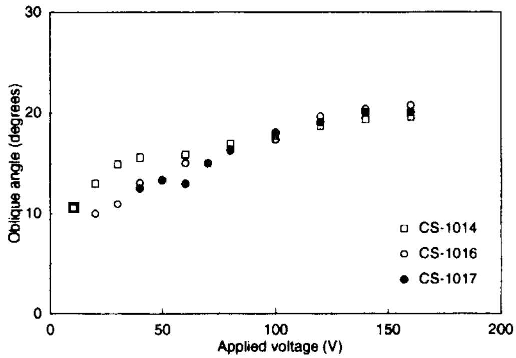

FIGURE 10 Applied voltage dependence of oblique angle from smectic layer.

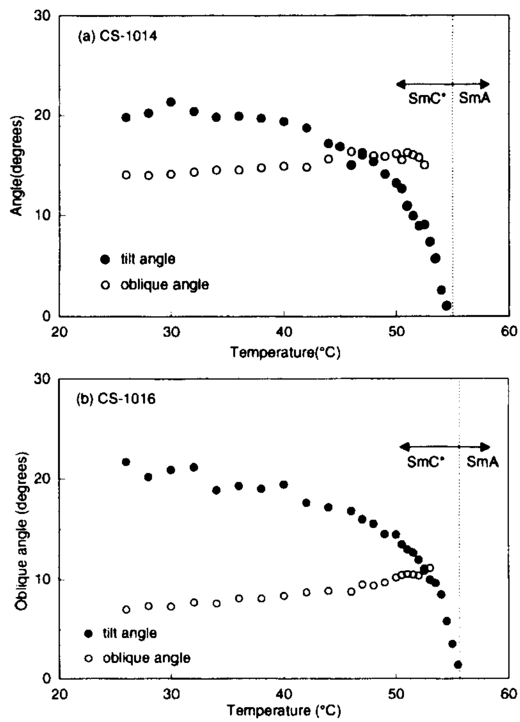

FIGURE 11 Temperature dependencies of oblique angle and tilt angle in (a) CS-1014 sample and (b) CS-1016 sample.

also depended on applied voltage.

The oblique angle became larger with applied voltage, as shown in Fig. 9. Figure 10 shows applied voltage dependence of the oblique angle in CS-1014, CS-1016 and CS-1017 sample. The oblique angle increased with applied voltage in all samples. The oblique angle under applying high voltage became twice as large as that under applying low voltage. The temperature dependence of the oblique angle in CS-1014 and CS-1016 samples are shown in Fig. 11. The tilt angle is also shown in these figures. The tilt angle decreased toward the transition temperature between Sm A phase and Sm C* phase. On the other hand, the oblique angle increased slowly with temperature in both samples. Therefore, the oblique angle is not concerned with the tilt angle.

CONCLUSIONS

We have clarified that the transmitted light through the cell at the instant of polarity reversal of applied voltage was diffracted by the formation of periodical stripe texture. This transient stripe texture had a tilt from the smectic layer. The period of the transient stripe texture was independent of temperature and depended on applied voltage. The oblique angle from smectic layer depended on applied voltage. The origin of transient stripe texture has not been clarified at this stage, but this stripe texture may be caused by the formation of transient helicoidal structure.

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