

Thermo-Recording for The Composite System of (Disk-Like Molecules and Liquid Crystals)

Hwan-Kyeong Jeong*

AMLCD Division Semiconductor, Samsung Electronics Co., LTD.

Chunan, 330-300 Korea

(Received July 24, 2002 ; Accepted August, 30, 2002)

Abstract : A (disk-like liquid crystal (DLC) monomer/liquid crystals(LCs)/chiral dopant/dichroic dye) composite was irradiated with ultraviolet (UV) light. The (DLC network/LCs/chiral dopant/dichroic dye) was formed in the homeotropically oriented smectic A(SA) phase by the surface orientation treatment and the electric field. A focal-conic texture exhibiting strong light scattering appeared in the heat-induced chiral nematic phase(N*) of the composite upon heating. Thermo-recording in the composite system has been realized by using a He-Ne laser. The laser irradiation was induced the phase transitions from SA phase to chiral nematic(N*) phase in the composite system.

Keywords : *Liquid Crystal, Smectic A Phase, Chiral Nematic Phase, Disk-Like Molecules, Light Scattering.*

1. INTRODUCTION

Laser addressing liquid crystal(LC) display modes have attracted much attention because of the unique characteristics such as a high density information display, no cross-talk effect, a rewritable memory effect, no viewing angle problem and a large area projection etc [1-4]. Chiral nematic liquid crystals[1, 2] or smectic A liquid crystals[3, 4] are currently important candidates as the materials of laser addressing LC display modes. The smectic LC is a better candidate concerning with the display of memory effect and the low magnitude of energy necessary for writing and erasing information.

The (side chain type liquid crystalline polymer(LCP)/LC) composites have been studied extensively and intensively [5, 6]. The reversible and bistable electro-optical effect

based on light-scattering was recognized for the (LCP/LC) mixture [6, 7]. It was concluded that the light-scattering state might arise from an electric current effect based on the electro-hydrodynamic motion of the backbones of the LCP. Since the backbones effectively disturb the uniform alignment of the LC and furthermore, can form the randomly oriented small smectic fragments, the light-scattering intensity of the S phase in the (LCP/LC) mixture was much stronger than that of smectic A(SA) LC. Namely, the light-scattering intensity of the LC could be improved remarkably by mixing the LCP. Recently, it was reported that when a (smectic A LCP/nematic LC/chiral dopant) ternary composite was sandwiched between substrates inducing a homeotropic alignment, an extremely sharp change from a transparent state (the homeotropic state of

the SA phase) to a strongly light-scattering one (the focal-conic state of the chiral nematic(N*) phase) was observed with the heat-induced phase transition [8]. Upon rapid cooling, the strongly light-scattering state of the N* phase was frozen in the SA one. It is well known that the latent heat of the phase transition from SA to N* is very small since the phase transition corresponds to the very weak first order transition or the second order one [9, 10]. Then, it is expected that the phase transition, that is, the change from the transparent SA phase to the strongly light-scattering N* one, might be induced by a low power laser. Therefore, in this study, thermo-recording with a high thermal stability based on the phase transition from SA to N* has been investigated for the (disk-like LC(DLC) network/LCs/chiral dopant/ dichroic dye) composite irradiated by a He-Ne laser.

2. EXPERIMENTAL

2.1 MATERIALS

DLC monomer was synthesized by the method of K.Meerholz et al[11] as shown in Figure 1. The purity and the average molecular weight of DLC monomer were

evaluated by GPC, and the block ratio was determined by NMR and FT-IR. The nematic LC (E7), the SA LCs (S7) and the chiral dopant (CB-15) are commercially available (Merck Co., Ltd.), and they were used without further purification. Also, the dichroic dye (SI-497, Mitsui Co., Ltd.) of 2.0 wt% was doped into the (DLC monomer/S7/E7/CB-15) mixture in order to make the efficiency of energy absorption of the laser beam increased when thermo-recording experiments were performed.

2.2 FABRICATION OF THE CELLS

The inner surfaces of ITO substrates were homeotropically treated following the method proposed by F. J. Kahn by using dimethyloctadecyl[3-(trimethoxysilyl)propyl]ammoniumchloride (Fluka Co., Ltd.) [12]. A PET film of 14 μm thick was used as a spacer of the cells and the mixtures were filled into the cells by an capillary action in their isotropic phases. Then the cell was irradiated by UV light (4W, 365 nm) for about 20 minutes. Thus, DLC network was produced in the homeotropically oriented SA phase upon the photo-polymerization of the DLC monomer and the cell of the composite system was prepared.

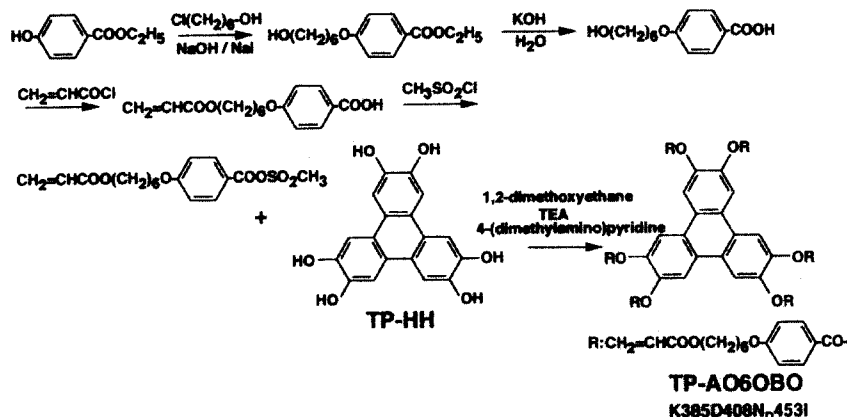


Fig. 1. Synthetic routes to discotic mesogenic monomer.

2.3 MEASUREMENTS

The phase transition temperatures and the aggregation structure of the samples were investigated on the basis of polarizing optical microscopic (POM) observations. POM observations under crossed Nicols were carried out by using Nikon polarizing optical microscope equipped with a hot stage calibrated to an accuracy 0.05 K. The thermo-recording characteristics of the samples were investigated with the home-made instrument schematically shown in Figure 2. The direct beam of a He-Ne laser (2 mW, 632.8 nm) were used as an incident light. The intensity of the transmitted light was recorded with a photodiode. The transmittance of the blank cell was normalized as 100%.

3. RESULTS AND DISCUSSION

It was confirmed from POM observation that a light-scattering focal-conic texture was formed in the N* phase of the (disk-like LC(DLC) network/LCs/chiral dopant/ dichroic

dye=3.0/75/14/6/2 wt%) composite system when it was heated from the SA phase to the N* one as shown in Figure 3(a). Then, when the sample A was cooled very slowly (1 K min⁻¹) to room temperature of about 290 K, the optical axis of the LC molecules in the SA phase aligned along the direction perpendicular to the substrate surfaces due to an anchoring effect of the surface agent. Since the homeotropically oriented SA phase was optically uniform, the slowly cooled the composite system was transparent. On the other hand, if the composite system was cooled rapidly (> 1 K min⁻¹), a focal-conic texture with a light scattering characteristic was formed in the SA phase as shown in Figure 3(b). Therefore, the transparent state or the light scattering one in the SA phase can be selectively obtained by controlling the cooling speed from the N* phase to the SA one. The SI-497 of 2.0 wt% was doped into the composite system in order to increase an energy absorption efficiency of the laser beam. After the irradiation time of 28.4 s the transmittance of the composite system started to decrease, respectively. The drastic decrease

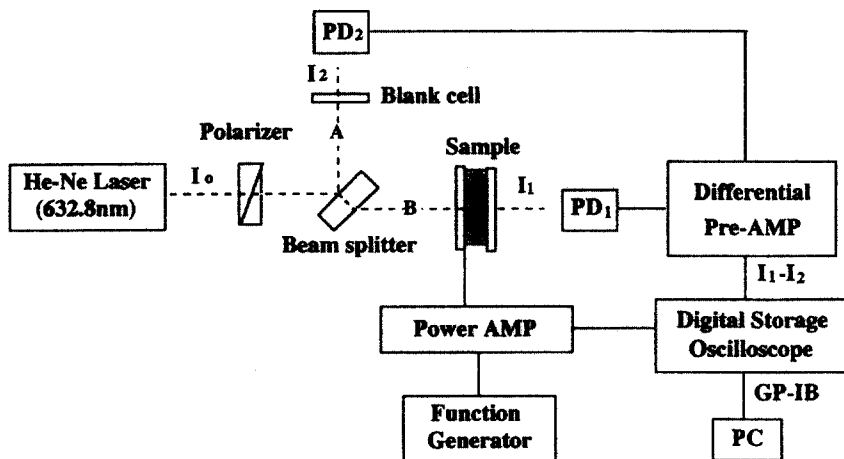


Fig. 2. Schematic diagram of the measuring system for electro-optical properties of the composite system.

in the transmittance might be attributed to the change from the transparent SA phase to the light-scattering N^* of which phase transition was induced by a laser irradiation as shown in Figure 4(X axial is converted into the calculation temperature by the irradiation intensity). A high contrast ratio about 40:1 between the transparent SA phase and the light-scattering N^* one was achieved. After the laser was turned off, the light-scattering state of the N^* phase was frozen in the SA phase due to rapid cooling down to an ambient temperature. Figure 5 shows the POM microphotograph of the frozen focal-conic texture being formed with the direct beam after the irradiation time of 3.5 s. The frozen light-scattering focal-conic texture was so stable that little change in the texture was observed over the time period of one month. Of course, when an enough high electric field of 100 Vrms was applied to the cell directly in the temperature range of the SA phase, the laser-addressed light-scattering texture frozen in the SA phase could also be transformed into the transparently homeotropic texture due to a positive dielectric anisotropy of the composite system. It is seems reasonable conclude that the composite system with the SA- \rightarrow N^* phase transition and containing the DLC network was the premise for a laser-addressing material which had a high contrast and could be addressed with a He-Ne laser. The (disk-like LC(DLC) network/LCs/chiral dopant/ dichroic dye=3.0/75/14/6/2 wt%) composite system was exhibited reversible light scattering-light transmission switching upon the laser irradiation and the electric field

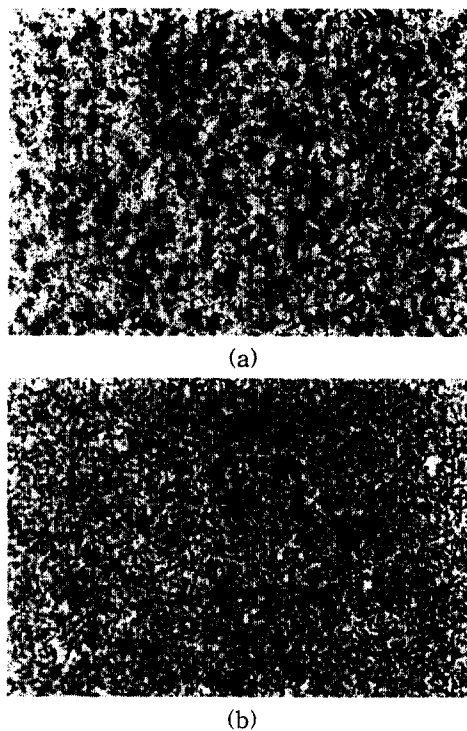


Fig. 3. POM photographs of the composite system.

- (a) The photograph at the temperature of chiral nematic phase
 (b) The photograph at the temperature of smectic A phase

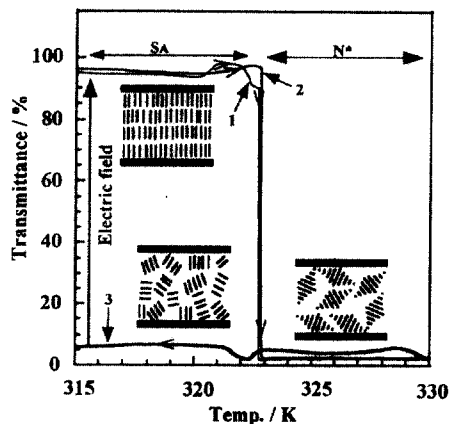


Fig. 4. Thermo and electro-optical switching characteristics of the composite system.

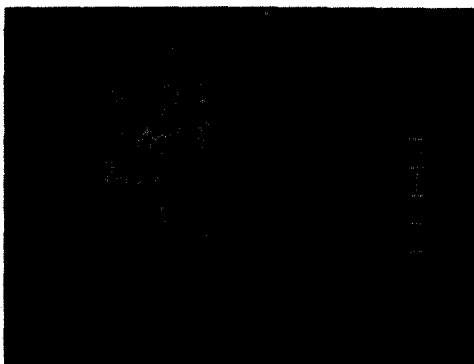


Fig. 5. POM photograph of the composite system (the left photograph showed the composite system after the irradiation time of 3.5 s).

4. CONCLUSIONS

Laser-addressing thermo-recording with high contrast and durable memory effect was realized for the (disk-like LC(DLC) network/LCs/chiral dopant/ dichroic dye) composite system. The thermo-recording could be achieved with a He-Ne laser. The process of a laser-addressing information storage was based on the SA- \rightarrow N* phase transitions. Thus, the composite system was exhibited reversible light scattering-light transmission switching upon the laser irradiation and the electric field and a novel material for laser-addressing memory effect which could be addressed with a low power of laser was developed.

REFERENCES

1. H. Melchior, F. J. Kahn, D. Maydan and D. B. Fraser, *Appl. Phys. Lett.*, **21**, 392 (1972).
2. T. Ueno, T. Nakamura, and C. Tani, *Proc. Japan Display*, **86**, 290 (1986).
3. R. C. Tsai, *Opt. Eng.*, **21**, 565 (1982).
4. H. Hatoh, *Mol. Cryst. Liq. Cryst.*, **250**, 1 (1994).
5. T. Kajiyama, H. Kikuchi, A. Miyamoto, S. Moritomi and J. C. Hwang, *Chem. Lett.*, 817 (1989).
6. H. Kikuchi, S. Moritomi, J. C. Hwang and T. Kajiyama, *Polym. Adv. Technol.*, **1**, 297 (1991).
7. J. C. Hwang, H. Kikuchi, and T. Kajiyama, *Polym. J.*, **27**, 292 (1995).
8. H. Yang, H. Yamane, H. Kikuchi and T. Kajiyama, *Polym. Prepr. Jpn.*, **45**, 480 (1996).
9. P. deGennes, *Solid St. Commun.*, **10**, 753 (1972).
10. T. C. Lubensky and S. R. Renn, *Phys. Rev.*, **A41**, 4392 (1990).
11. K. Meerholz, Y. D. Nardin, R. Bittner, R. Wortmann and F. Wurthner, *Appl. Phys. Lett.*, **73**, 4 (1998).
12. F. J. Kahn, *Appl. Phys. Lett.*, **22**, 386 (1973).