Fabrication of Twisted Nematic Structure in Phase Separated Composite Films

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Abstract

We investigated the effect of the liquid crystal (LC) anchoring in phase-separated composite films (PSCOF). It was found that the azimuthal anchoring strength on the interface phase-separated in nematic phase was much higher than that in isotropic phase. Using such anchoring effect that was induced by imprinting of NLC ordering on the polymer layer, we demonstrated a twisted nematic structure in PSCOF by application of in-plane electric fields during phase separation.

1. Introduction

Electro-optic (EO) properties using liquid crystal (LC) devices depend highly on the LC configuration in bulk. To manipulate birefringent LC layer, several types of alignment techniques have been proposed. According to conventional alignment method, the LC cell should be prepared by a pair of alignment layer in general. Recently, a new type of fabrication method requiring only single alignment treatment was reported, which is referred to as phase-separated composite film (PSCOF) method. [1,2] The PSCOF structure is composed of a stack of a thin LC layer and a thin polymer layer, prepared by an anisotropic phase separation of LC from its solution in a prepolymer. It is known that such properties of PSCOF cell as the good mechanical stability and the flexibility of polymer layer itself have advantages in fabricating flexible LCDs. [3,4,5] Using these features, we have demonstrated a flexible LCD with a single substrate. [6] However, the LC geometry produced by the conventional PSCOF method is limited to a uniform homogeneous structure since the LC orientation is determined by a single alignment layer and the phase separation process is executed in isotropic phase of LC, which is existing problem of the PSCOF to be solved.

In this work, we proposed a method for fabricating the PSCOF structure in nematic phase. The anchoring effect induced by imprinting of Nematic LC (NLC) ordering on the polymer layer was sufficient for competing with the elastic energy in the bulk. We demonstrated a twisted nematic (TN) structure in PSCOF by application of in-plane electric fields during phase separation in nematic phase.

2. Experimental

Fabrication of PSCOF cell with a twisted namtic structure. A schematic diagram of our cell structure is demonstrated in Fig.1. The cell was made using two glass substrates. One of the substrates has in-plane electrodes prepared by etching ITO in chevron pattern with 100 μm wide and 100 μm separation. Then, the patterned substrate was spin-coated by 1 wt% of a Nylon6 in trichloroethanol and unidiredtionally rubbed in a direction as shown in Fig.1. The other substrate has no electrode and no alignment layer. The cell gap between the substrates was maintained by 5 μm glass spacers. The material used were E48 (E. Merck) for NLC and UV curable epoxy NOA65 (Norland. Inc.) for prepolymer. The mixture of NLC and prepolymer in a ratio of 50:50 was introduced into the cell 100°C.

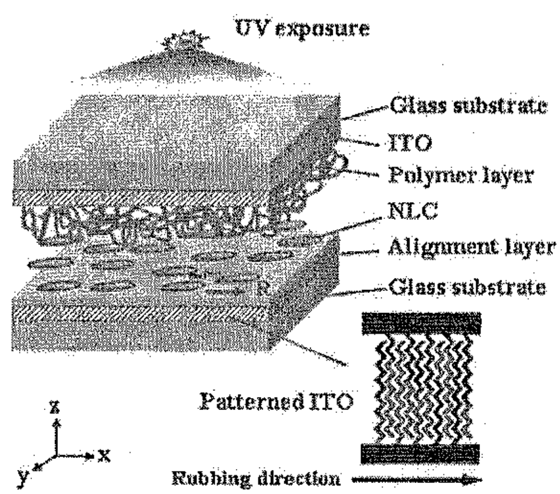

Figure 1. Schematic diagram of PSCOF cell with TN structure.

In the conventional fabrication method of PSCOF, the phase separation was executed in single step of UV exposure in isotropic state of the NLC. In this work, two steps of UV exposure were executed. First, the cell was exposed to UV for 10 min in isotropic phase of 100°C without a bias field. Then, the cell was cooled down to 40°C and then further exposed to UV for 30 min in nematic phase with bias field. The UV lamp was operated in an electrical power of 400 W and the bias voltage applied during second UV exposure was 200 V (1kHz, square wave). The first UV exposure promotes uniform anisotropic phase separation and the second UV exposure creates an anisotropic anchoring at the phase-separated interface between the NLC and the polymer layer.

3. Results and Discussion

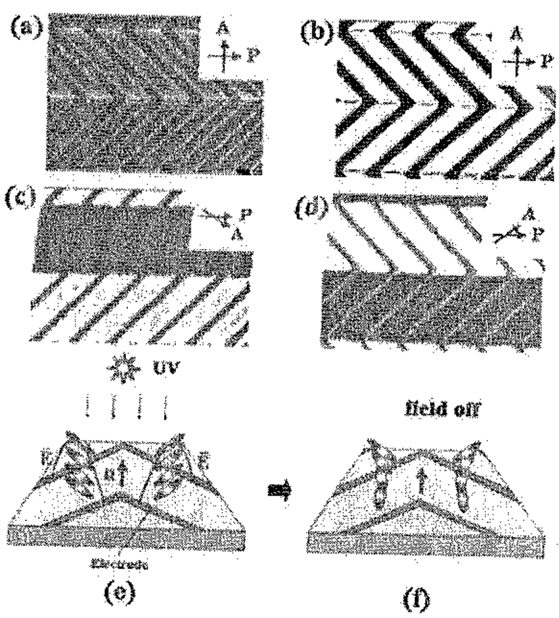

Figure 2. Polarizing microscopic images of the cell obtained ; (a) in the absence of an applied voltage and (b), (c), and (d) in the presence of an applied voltage, 2 V/μm in different geometries of polarizers. (e) and (f) shows the NLC orientation during phase separation in the presence of an applied voltage and after UV exposure in the absence of an applied voltage, respectively.

Figure 2(a)-(d) shows the polarizing microscopic images of the cell. Figure a(a) and (b) are images obtained between the crossed polarizers in the absence of applied voltage and in the presence of an applied voltage, 1 V/μm, respectively. Waveguiding effect of the twisted structure could be observed by a light leakage in Fig. 2(a). The NLC geometry between the alignment layer and the phase-separated polymer layer was more clarified by rotating the transmission axis of the analyzer in the absence of an applied voltage. From Fig. 2(c) and (d), it was confirmed that the NLCs in the two domains of the chevron were aligned in 45°C twisted and -45°C twisted structure, which coincided with the direction of the electric field at second UV exposure.

Figure 2(e) and (f) shows the NLC orientation during phase separation in the presence of an applied voltage and after UV exposure in the absence of an applied voltage, respectively. Experimetal results showed that the field-induced bulk nematic ordering was imprinted to the phase-separated polymer layer and the anchoring strength at the interface generated during phase separation in nematic phase was strong enough to compete with the elastic energy of LC at filed off even in the very thin cell gap of 2.5 μm.

4. Conclusions

We proposed the phase separation method for fabricating the PSCOF structure in nematic phase. The PSCOF cell based on our method show an anisotropic anchoring at the phase separated polymer interface , which is originated by imprinting of the bulk nematic ordering to the polymer layer. With this feature, TN structure of PSCOF cell was demonstrated with in-plane electric field application during phase separation.

5. References

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Program : October 21, 2005 (Fri.)

Chairman : Seiji Kurihara

10:20~10:40 : Invited Paper

"Development and Industrialization of Liquid Crystal Materials"

Haruyoshi Takatsu

DAINIPPON INK & CHEMICALS INC.

10:40~10:50 : Coffee Break

10:50~11:20 : Invited Paper

"Synthesis and Electroluminescent Properties of Fully Substituted Ethylene Moieties"

Jong Wook Park

Department of Chemistry/Display Research Center, The Catholic University of Korea Catholic University

Chairman : Keun-Byoung Yoon

11:20~11:40 : Invited Paper

"Numerical simulation study of cell gap dependence on anisotropic phase separation"

Min-Young Jin

Department of Electronics and Computer Engineering, Hanyang University

11:40~12:00 : Invited Paper

"Fabrication of Twisted Nematic Structure in Phase Separated Composite Films"

Hak-Rin Kim

Department of Electronics and Computer Engineering, Hanyang University

12:00~13:30 : Lunch