무기막에서의 수형배향된 액정의 특성에 대한 연구

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Inorganic Thin film for Horizontal Aligned Liquid Crystal with Non-rubbing Technologies

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요 약

본 연구에서는 폴리이미드 박막위에서의 수직 및 수평배향에서 혼합액정의 배향 특성에 대해서 연구하였다. 혼합액정은 러빙을 이용하여 배향처리하였으며, 러빙에 사용된 폴리이미드 박막은 알킬기를 Side Chain으로 가진 수직배향용 배향막과 그렇지 배향막으로 나누어서 프리틸트각 특성을 측정하였다. 실험결과 혼합액정을 사용하여 양호한 배향상태를 얻을 수 있었으며, 고온에서의 열 안정성에서도 우수한 특성을 보이는 것을 알 수 있었다. 또한 프리틸트각의 발생 원리를 이해하기 위해서 접촉각 측정을 실시하였으며, 이 둘이 밀접한 상관관계를 갖고 있음을 알 수 있었다.

Key Words : liquid crystal, liquid crystal alignment, Inorganic alignment layer, Pretilt angle, EO characteristics

ABSTRACT

In this study, we investigated the electro-optical (EO) characteristic of fringe-field switching (FFS) mode cell by the ion beam alignment method on the a-C:H thin film. The suitable inorganic thin films for FFS cell and the aligning capabilities of nematic liquid crystal (NLC) using the new alignment material of a-C:H thin film were studied. An excellent voltage-transmittance (V-T) and response time curve of the ion beam aligned FFS-LCD was observed with oblique ion beam exposure on the a-C:H thin films. Also, the V-T hysteresis characteristics of the ion beam-aligned FFS-LCD with IB exposure on the a-C:H thin films is almost the same as that of the rubbing-aligned FFS cell on a polyimide surface.

I. Introduction

A rubbing method has been widely used to align LC molecules on the PI surface. LCs are aligned due to the induced anisotropy on the substrate surface. Rubbed PI surfaces have suitable characteristics such as uniform alignment and a high pretilt angle. However, the rubbing method has some drawbacks, such as the generation of electrostatic charges and the creation of contaminating particles [1]. Thus, rubbing-less techniques for LC alignment are strongly needed in LCD technology. Recently, the LC alignment effects by using the photodimerization [2-9] and photodissociation [10-15] have been reported. Recently, the representative LCD mode applied to TFT-LCD is normally white (NW) twisted nematic (TN) mode. But, it has narrow viewing angle because it has limitation of asymmetric phase retardation on polar angle. FFS mode [16] has the same phase retardation in every direction of polar angle, so it has wide viewing angle characteristic. But FFS mode has been homogeneous alignment state of normally black (NB) type in initial. Currently, we used rubbing aligning method for LC alignment at FFS-LCD and at TN-LCD. However, the rubbing method has some drawbacks, such as the generation of electrostatic charges, the creation of contaminating particles, rubbing scratch and rubbing track [17, 18]. The FFS mode has more serious problem in rubbing method than that of TN mode because FFS mode

※본 논문은 2013년도 서일대학교 학술연구비에 의해 연구되었음
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접수일자 : 2015년 5월 19일, 수정완료일자 : 2015년 6월 5일, 최종게재확정일자 : 2015년 6월 15일

adopt normally black mode. So FFS mode has demerit of narrow process margin in rubbing process. Most recently, the LC aligning capabilities by IB exposure on the DLC layer have been successfully studied by P. Chaudhari et al [19]. This article will report the electro-optical (EO) characteristics of the IB-aligned FFS-LCD with oblique IB exposure on the DLC thin films.

Ⅱ. Experimental

a-C:H thin films were deposited on various substrates such as indium-tin-oxide (ITO), single crystalline Si, and glass by the remote plasma enhanced chemical vapor deposition (RPECVD). All substrates were cleaned ultrasonically before deposition; ITO and glass were cleaned with trichloroethylene (TCE), acetone and alcohol, and single crystalline Si was cleaned with TCE, acetone, alcohol, buffered oxide etchant (BOE), and DI water. Then the samples were sputter cleaned for 10 min by argon plasma. Under first condition without rf bias, a-C:H thin films were deposited using a mixture of C_2H_2(3sccm) and He(30sccm) as working gases. C_2H_2 and He gases were introduced into the chamber through the separate gas lines and the deposition was performed for 10min at 100W rf power and with a gas pressure of 30 Pa. Under Second condition with 30W rf bias, a-C:H thin films were deposited using a mixture of C_2H_2 (3sccm) and He (30sccm) as working gases at 30W rf bias condition. C_2H_2 and He gases were introduced into the chamber through the separate gas lines and the deposition was performed for 10 min at 100W rf power and with a gas pressure of 30 Pa. The surface properties of a-C:H thin films were controlled by Ar ion beam irradiation. The Kaufman ion gun was used for the irradiation of a-C:H thin films. The argon IB irradiation time was 0,1, and 5 min at 200 eV ion beam energy, respectively. .The IB (Kaufman-type Arion gun) exposure system is shown in Fig.1.

The LC cell was assembled in an anti-parallel structure to measure the pretilt angle. The thickness of the LC layer was 60 mm. The LC cell was filled with a fluorinated mixture type of NLC without a chiral dopant (De=8.4, from Merck Co., Ltd.). Also, the rubbing aligned cell was fabricated. LC alignment ability was observed using a photomicroscope. To measure EO characteristics for FFS-LCD, the IB exposure direction was 83° to the electric field on the a-C:H thin film deposited at rf 30W bias condition as shown in Fig. 1. The FFS-LCDs were assembled by anti-parallel structure. The cell thickness was a 5.0 mm. LCs used were positive dielectric anisotropy. Also, a rubbing-aligned FFS-LCD was fabricated. The cell thickness was a 4.0mm. The FFS-LCD fabricated was NB (normally black) mode. The pretilt angle of the anti-parallel cell was measured by a crystal rotation method. EO characteristics of the IB-aligned FFS-LCD were measured by the LCD-700 (LCD Evaluation System, from Otsuka Electronics Co.) equipment. The residual DC voltage of he IB-aligned FFS-LCD was measured by a capacitance-voltage hysteresis (C-V) method.

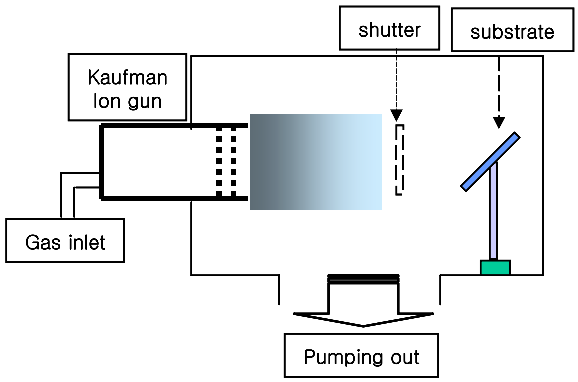


Figure 1. Ion beam exposure system.

Ⅲ. Results and Discussion

The LC pre-tilt angles observed with IB exposure on a-C:H thin film for 1 min as a function of the incident angle are shown in Fig. 2. It is shown that the LC pretilt angle generated was about 5.0º with an IB exposure of 30~65º on the a-C:H thin film deposited at rf bias condition.

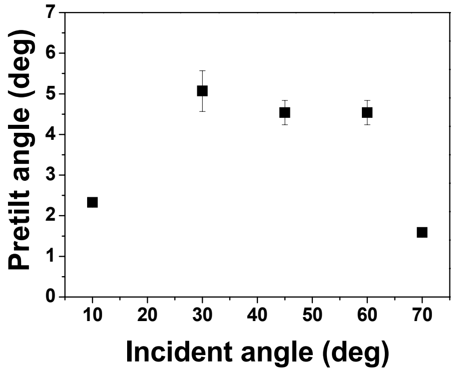
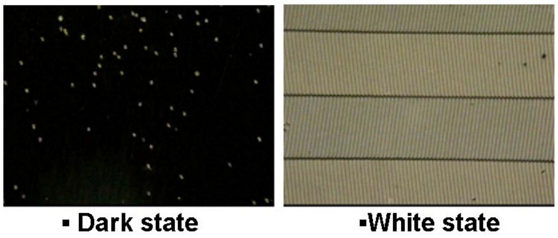
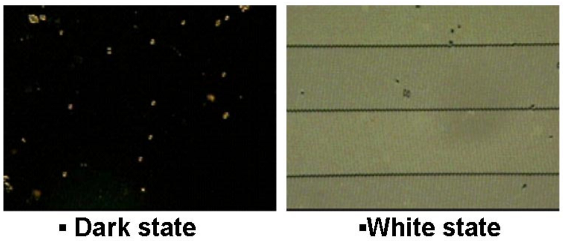


Figure 2. Generation of pretilt angles in NLC with IB exposure on a-C:H thin films.

Figure 3 shows micrographs of rubbing-aligned FFS-LCD on the polyimide surface and the ion-beam-aligned FFS-LCD with oblique ion beam exposure on DLC thin films deposited at rf bias condition (in crossed Nicols). Monodomain alignment of the rubbing-aligned FFS-LCD and ion-beam-aligned FFS-LCD can be observed.



(a) rubbing aligned FFS-LCD



(b) ion beam aligned FFS-LCD

Figure 3. Microphotographs of the dark & the white state of rubbing aligned FFS-LCD cells (in crossed Nicols).

Figure 4 shows voltage-transmittance (V-T) curve of rubbing-aligned FFS-LCD on the PI surface and ion beam aligned FFS-LCD on the a-C:H thin film. All stable V-T curves of rubbing-aligned and ion beam aligned FFS-LCD can be achieved. The light transmittance of ion beam aligned FFS-LCD starts to occur at the saturated at 7 V. Furthermore, the maximum-transmitted in intensity is higher than that of rubbing-aligned FFS-LCD though the transmission-saturation voltage is the same. As a result, more transmittance level of ion beam aligned FFS-LCD was obtained than that of rubbing-aligned FFS-LCD. It is consider that better LC aligning capability give rise to higher transmittance level. Therefore, this indicated that LC aligning capability generated by ion beam treatment is stronger than that by rubbing treatment.

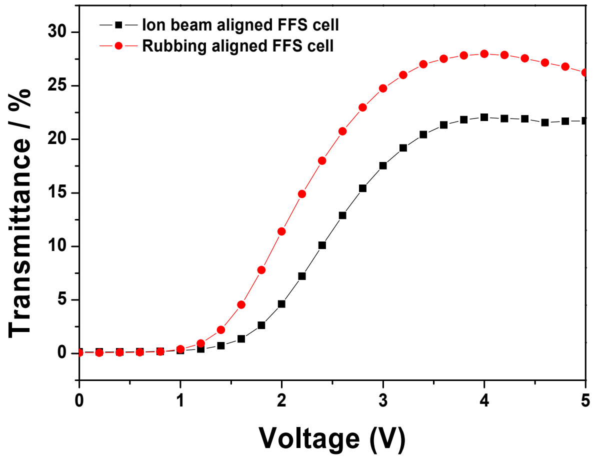


Figure 4. Voltage-transmittances curve of rubbing-aligned FFS-LCD on the PI surface and ion beam aligned FFS-LCD on the a-C:H thin film.

Figure 5 shows response time (RT) characteristics of rubbing-aligned FFS-LCD on the PI surface and ion beam aligned FFS-LCD on the a-C:H thin film. All stable curve on the the rubbing-aligned and ion-beam-aligned FFS-LCD can be achieved as shown in Fig 6. However, the transmittance level of ion-beam-aligned FFS-LCD is higher than that of rubbing-aligned FFS-LCD. From these results, it is contended, herein, that the ion beam alignment method can be to achieve a good V-T curve and good response time characteristics, as shown in Fig. 4 and Fig. 5. Consequently, the VT performance of the ion-beam-aligned FFS-LCD on the DLC thin film surface is almost the same as that of the rubbing-aligned FFS-LCD on the PI surface.

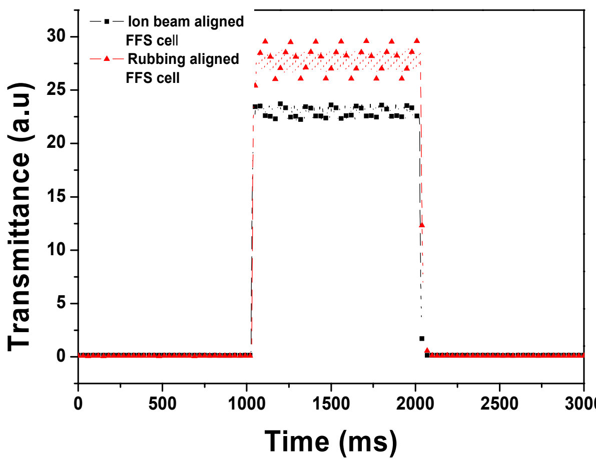


Figure 5. Response time curve of rubbing-aligned FFS-LCD on the PI surface and ion beam aligned FFS-LCD on the a-C:H thin film.

Figure 6 shows the AC V-T hysteresis characteristics of the rubbing-aliged and ion-beam-aligned FFS-LCD.

Few hysteresis characteristics of rubbing-aliged and ion-beam-aligned FFS-LCD were measured. It can be concluded that inner ion in the ion-beam-aligned FFS-LCD can't produce for AC operation. Therefore, the EO characteristics of the ion-beam-aligned FFS-LCD with oblique ion beam exposure on the DLC thin films for 1 min are almost the same as those of the rubbing-aligned FFS-LCD on the PI surface.

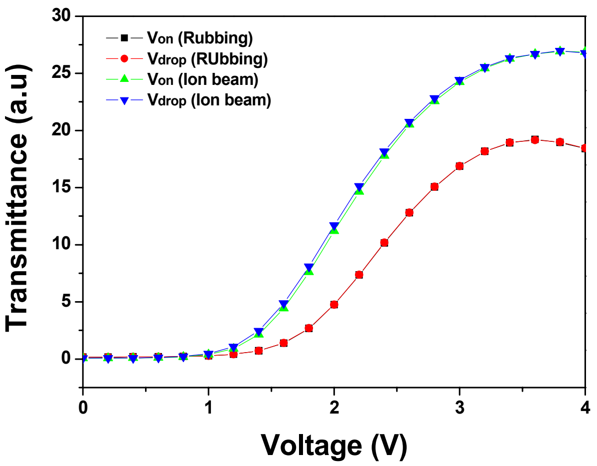


Figure 6. AC V-T hysteresis characteristics of the ion-beam-aligned FFS-LCDs with oblique ion beam exposure on the DLC thin film surface and the rubbing-aligned FFS-LCD on a PI surface.

Ⅳ. Conclusion

In conclusion, LC alignment capabilities and the variation of pretilt angles with ion beam irradiation on the DLC thin films, and the EO characteristics of the ion-beam-aligned FFS-LCD with oblique ion beam exposure on the DLC thin film surface were studied. A high pretilt angle of on the a-C:H thin film deposited at 30W rf bias condition was measured. A good V-T and RT curve was observed for the ion-beam-aligned FFS-LCD with ion beam exposure on the DLC thin films for 1 min. Finally, the AC V-T hysteresis characteristics of the ion-beam-aligned FFS-LCD with ion beam exposure of 1 min on the DLC thin film surface is almost the same as that of the rubbing-aligned FFS-LCD on the PI surface.

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