A Study on Electro-optical Characteristics of the UV Aligned FFS Cell on the Organic Layer

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In this study, we investigated the electro-optical (EO) characteristic of fringe-field switching (FFS) mode cell by the two kinds of ultraviolet (UV) alignment method on the organic thin film (polyimide: PI). The suitable organic layers for FFS cell and the aligning capabilities of nematic liquid crystal (NLC) using the *in-situ* photoalignment method were studied; Disclination is observed after conventional photoalignment method for 1h, and *in-situ* photoalignment method for 1h. Monodomain alignment of the NLC can be observed via *in-situ* photoalignment method for 2 h and 3 h. It is considered that NLC alignment is due to photo-depolymerization of the polymer with oblique non-polarized UV irradiation on PI surface. An unstable V-T curve of UV-aligned FFS-LCD with conventional photoalignment method can be achieved. However, a stable V-T curve of UV-aligned FFS-LCD with *in-situ* photoalignment method (1 h), and V-T curve of UV-aligned FFS-LCD with *in-situ* photoalignment method was much stable comparing with that of other UV-aligned FFS-LCD's. As a result, more stable EO performance of UV-aligned FFS-LCD with *in-situ* photoalignment method for 3h is obtained than that of the other UV-aligned FFS-LCD's.

Keywords : Fringe-field switching(FFS) mode, Polyimide(PI), In-situ photoalignment method, Liquid crystal, EO characteristics

1. INTRODUCTION

Liquid crystal displays (LCDs) are gaining more popularity in larger display, such as monitors and large sized TVs. Recently; the market is expected to grow rapidly, especially for large sized LCD-TV's. However, LCD's have basically two kinds of problems such as narrow-viewing angle, and slow optical response speed. In order to improve these problems, in-plane switching (IPS)-LCD's[1], multi-domain vertical alignment (VA)-LCD's[2], and FFS-LCD's[3] were developed. Among them proposed, FFS and IPS-LCD's are original only liquid crystal (LC) mode without an additional optical compensating film. In this study, we have used FFS-LCD because of superior readability and good transmittances[3].

Currently, a rubbing aligning method for LC alignment at FFS-LCD has been used. However, the rubbing method has some drawbacks, such as the generation of electrostatic charges, the creation of contaminating particles, rubbing scratch and rubbing track[4,5].

Thus, rubbing-less techniques for LC alignment are strongly needed in LCD technology. Thus, the LC alignment effects by using the photodimerization[6-8] and photodissociation[9-11] have been reported. Also, the LC alignment and pretilt angle generation using the *in-situ* photoalignment method have been reported[12]. We reported NLC alignment by non-polarized UV method[13]. This alignment method with non-polarized UV light has the advantage such as applying large sized display panel because linearly polarized UV light needs polarizor equipment.

Therefore, this article reports the electro-optical EO characteristics of the UV-aligned FFS-LCD with *in-situ* photoalignment method using non-polarized UV exposure on the PI surface.

2. EXPERIMENTAL

The chemical structure of the PI material is shown in Fig. 1. The PI films were coated on indium tin oxide (ITO)

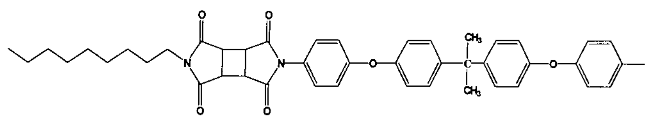


Fig. 1. Chemical structure of the polymer.

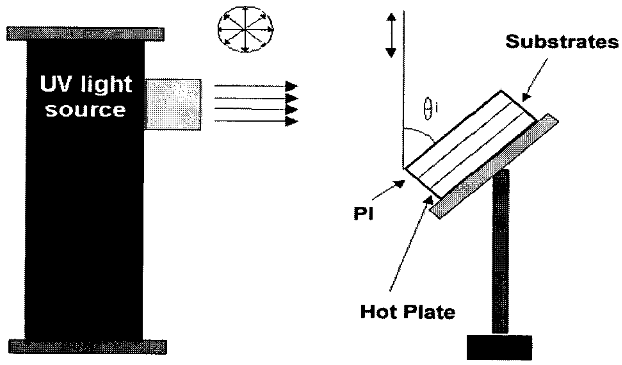


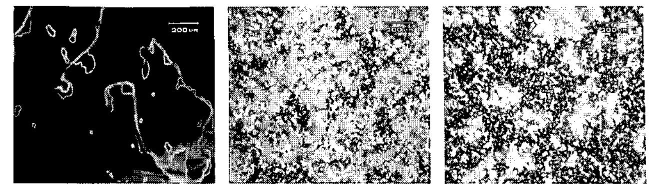
Fig. 2. Schematic diagrams UV light irradiation system.

coated glass substrates by spin coating. In the conventional photoalignment method, the polymers were soft-baked at 80 ℃ for 10 min and baked at 250 ℃ for 1 h, 2 h, and 3 h. The thickness of the PI layer was set at 500 Å. The UV exposure system is shown in Fig. 2. The UV source was a 1000 W Mercury lamp. In the *in-situ* photoalignment method, polymers were exposed to obliquely polarized UV during imidization of polyimide at 140 ℃ for 1 h, 2 h, and 3 h.

The LC cell was assembled in an anti-parallel structure to measure the pretilt angle. The thickness of the LC layer was 60 μm. The LC cell was filled with a fluorinated mixture type of NLC without a chiral dopant ($\Delta\varepsilon$=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's that were assembled by anti-parallel structure, the cell thickness was a 4.0 μm. LCs used were positive dielectric anisotropy. 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 UV-aligned FFS-LCD's were measured by the LCD-700 (LCD Evaluation System, from Otsuka Electronics Co.).

3. RESULTS AND DISCUSSION

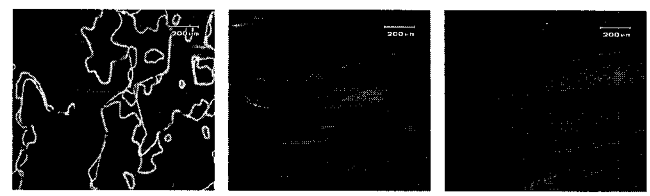
Figure 3 shows microphotographs of the NLC in a cell aligned using two kinds of photoalignment method (in crossed Nicols). In the conventional potoalignemnt method, Disclination is observed after oblique non- polarized UV



(a) (b) (c)

(a) Exposure time for 1 h (b) Exposure time for 2 h
(c) Exposure time for 3 h

(a) Conventional photoalignment method



(a) (b) (c)

(a) Exposure time for 1 h (b) Exposure time for 2 h
(c) Exposure time for 3 h

(b) *In-situ* photoalignment method

Fig. 3. Microphotographs of aligned NLC in cell with two kinds of photoalignment method using oblique non-polarized UV light irradiation on PI surfaces (in crossed Nicols).

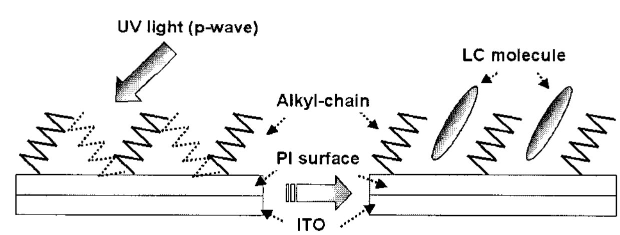


Fig. 4. Liquid crystal alignment principles with oblique non-polarized UV light irradiation on PI surfaces.

exposure for 1 h, and LC alignment is destroyed after oblique non-polarized UV exposure for 2 h and 3 h. But, In the *In-situ* photoalignment method, Disclination in LC alignment is obtained after oblique non-polarized UV exposure for 1h. Monodomain alignment of the NLC can be observed via oblique non-polarized UV exposure for 2 h and 3 h. However, perfect date state in aligned NLC cell is not shown.

We suggested that aligned NLC is parallel to incident direction (p-wave) of UV irradiation as shown Fig. 4. It is considered that NLC alignment is due to photo-depolymerization of the polymer with oblique non-polarized UV irradiation on PI surface[13].

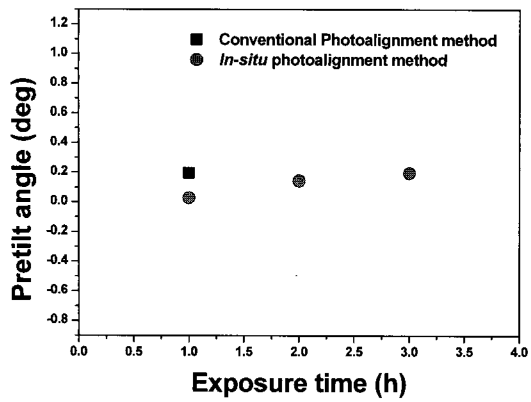


Fig. 5. Generation of pretilt angles in NLC with UV exposure on a PI surfaces.

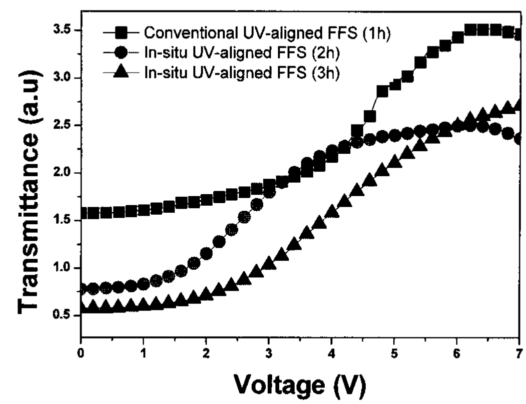


Fig. 6. Voltage-transmittances curve of three kinds of UV-aligned FFS-LCD on PI surfaces.

The LC pre-tilt angles observed with oblique non-polarized UV exposures on the PI surface as a function of two kinds of photoalignment method angle are shown in Fig. 5. It is shown that the LC pretilt angle generated was below 1.0 ° with the two kinds of photoalignment methods.

Figure 6 shows voltage-transmittance (V-T) curve of UV-aligned FFS-LCD's on the PI surface using conventional and *in-situ* photalignment method. An unstable V-T curve of UV-aligned FFS-LCD with conventional photoalignment method can be achieved. However, a stable V-T curve of UV-aligned FFS-LCD with *in-situ* photoalignment method (1h), and V-T curve of UV-aligned FFS-LCD with *in-situ* photoalignment method was much stable comparing with that of other UV-aligned FFS-LCD's. As a result, more stable V-T curve of UV-aligned FFS-LCD with *in-situ* photo-alignment method for 3h is obtained than that of the other UV-aligned FFS-LCD's. It is consider that better LC aligning capability give rise to better V-T characteristics. Therefore, this indicated that LC aligning capability generated by in-situ photoalignment method is stronger than that by conventional photoalignment method.

Figure 7 shows response time (RT) characteristics of three kinds of UV-aligned FFS-LCD's on the PI surface. An optical bounce characteristic of UV-aligned FFS-LCD with conventional photoalignment method is obtained, and the much light leakage is measured. However, all stable curves on the UV-aligned FFS-LCD's with *in-situ* photoalignment method can be achieved as shown in Fig. 7. Also, the light leakage on UV-aligned FFS-LCD is decreased, as increasing UV exposure time. From these results, it is contended, herein, that the *in-situ* photoalignment method can be to achieve EO characteristics. However, the light leakage indicates that UV-aligned FFS-LCD has weak anchoring. Consequently, to better EO performance of the UV-aligned FFS-LCD, we need study about optimizing condition in the *in-situ* photoalignemnt method.

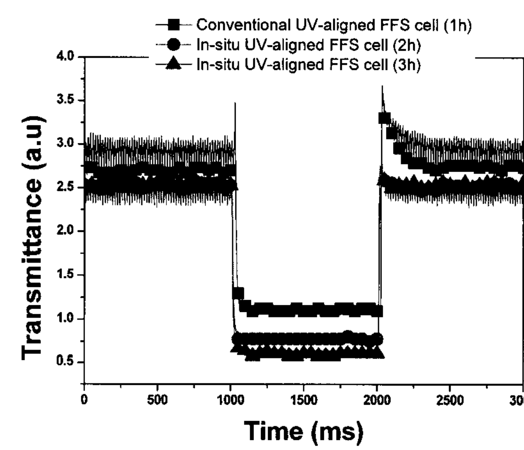


Fig. 7. Response time curve of three kinds of UV-aligned FFS-LCD on PI surfaces.

Table 1. Response time characteristics of UV-aligned FFS-LCD on PI surfaces.

	Rising Time (msec)	Falling Time (msec)
Conventional UV-aligned FFS	15.77	20.65
In-situ UV-aligned FFS (2h)	15.75	21.45
In-situ UV-aligned FFS (3h)	13.59	21.45

4. CONCLUSION

In conclusion, LC alignment capabilities, and the EO characteristics of the UV-aligned FFS-LCD's with conventional photoaligment and *in-situ* photoalignment method using oblique non-polarized UV light on the PI surface were studied. Disclination is obtained after conventional photoalignment method for 1 h. But, monodomain alignment of the NLC can be observed via *in-situ* photoalignment method for 2 h and 3 h. It is considered that NLC alignment is due to photo-depolymerization of the polymer with oblique non-polarized UV irradiation on PI surface. More stable EO performance of UV-aligned FFS-LCD with *in-situ* photoalignment method for 3 h is obtained than that of the other UV-aligned FFS-LCD's. Consequently, to better EO performance of the UV-aligned FFS-LCD, we need study about optimizing condition in the *in-situ* photoalignemnt method.

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