EO Characteristic of the In-plane Driven VA Cells on a Polymer Layer

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Viewing angle characteristics of a nematic liquid crystal (NLC) using a in-plane driven (IPD) vertical alignment (VA) cell without a negative compensation film on a homeotropic alignment layer were studied. Good voltage-transmittance (V-T) curves were obtained using the rubbingaligned IPD-VA cell. However, instability and low transmittances of V-T characteristics in photoaligned IPD-VA cell was measured. The EO performance of a rubbingaligned IPD-VA cell without a negative compensation film was wider than that of photoaligned IPD-VA cell and conventional VA cell. Also, the fabrication processes using the rubbingaligned IPD-VA cell mode be carried out with only one-sided rubbing.

Keywords : Vertical-alignment mode, Viewing angle, Nematic liquid crystal, IPD-VA cell

1. INTRODUCTION

Recently, active-matrix (AM) liquid-crystal displays (LCDs) have been widely used in information display devices such as notebook computers, desktop monitors, and televisions. However, LCD performance using a twisted-nematic (TN) mode has not been satisfactory due to the narrow viewing angles. To improve the viewing angle characteristics, various techniques have been proposed, such as the addition of birefringence films [1] domain-divided (DD) twisted nematics (TNs) [2] the in-plane-switching (IPS) mode [3] and the multidomain vertical-alignment (MVA) mode [4]. The MVA-LCD is expected to achieve wide viewing angles and high contrast ratios. However, a method of dividing each pixel into multidomains and creating a fringe field are required in the MVA-LCD. Recently, the molecular orientation of positive nematic liquid crystal (NLC) in slit-patterned electrode LC cells has been reported by He and coworkers, in which the LC cells were assembled using a both-sides-rubbed poly (vinyl) alcohol (PVA) surface, and a parallel rubbing structure was used between the indium tin oxide (ITO) slit-patterned electrode and the rubbed PVA surface [5]. Most recently, we reported that wide viewing angle and fast response time characteristics can be realized in negative NLCs using a novel VA-1/4π cell mode on a homeotropic alignment layer[6]. In this study, we report on the electro-optical (EO) characteristics of a negative NLC using a new in-plane driven (IPD) VA without negative compensation film on a homeotropic polyimide (PI) surface.

2. EXPERIMENTAL

In these experiments, we used a patterned ITO electrode coated on a glass substrate for one side. The electrode used for the other side was an ITO layer coated on a glass substrate. For patterned ITO electrodes, the electrode distance was 20 ㎛, and the electrode width was 10 ㎛ as shown in Figure 1. The polymer (JSR Co.) was used as a homeotropic alignment layer and as coated on ITO-coated glass substrates by spin-coatings, which were then imidized at 180℃ for 1 h. The thickness of the PI layers was 500 Å. The rubbing-free

method was adopted for the patterned ITO electrodes. The PI films were rubbed using a machine equipped with a nylon roller (Y_o-15-N, Yoshikawa Chemical Industries Co.). A definition of rubbing strength (RS) has been given in previous papers [7]. The RS used was 187 mm for the medium-rubbing region. The conventional VA cell was used for the both-sides rubbed PI surfaces and a IPD-VA cell was used for the one-side rubbed PI surface. The photoaligned IPD-VA cell was assembled at medium rubbing strength (164 mm) for comparison with rubbingaligned IPD-VA cell. The UV source used was a 500 W mercury lamp (Oriel instruments Co.). We used a UV linear dichroic polarizer (Oriel instruments Co.). UV energy density used was 15.5 mW/cm^2. The photoaligned VA-LCD, the cell was fabricated with an antiparallel structure by polarized UV exposure in the oblique direction of 60° on the photopolymer surface for 3 min. The LC layer thickness of the rubbingaligned IPD-VA, photoaligned IPD-VA, and conventional VA cells was set at 4.0 μm. NLC is used in negative dielectric anisotropy ($\triangle\varepsilon$ = -4, from Merck Co.). The IPD-VA cell fabricated was normally black (NB) mode. The voltage transmittance (V-T) and viewing angle measurements for the IPD-VA and conventional VA cells were performed at room temperature (22℃). The EO characteristics were measured using the LCD evaluation system. (LCD7000, Otsuka Co.)

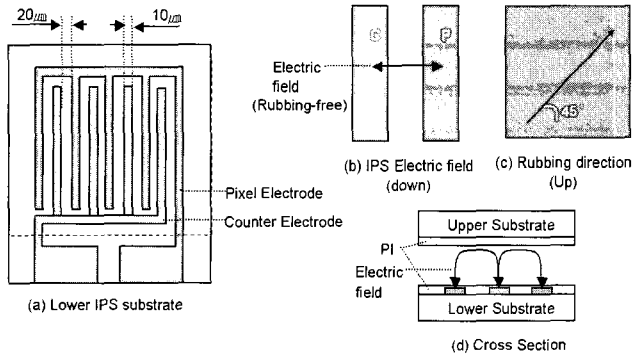

Fig. 1. Structure of the In-plane driven VA.

3. RESULTS AND DISCUSOION

Figure 2 shows a schematic diagram of a IPD-VA cell mode without an optically compensated film, in both the off and on state. In the off-state, the LC directors are aligned vertically to the glass substrates. Under the crossed polarizes, the normal viewing direction indicates no phase retardation. Therefore, the off-state of a new IPD-VA cell is very dark in the normal direction. In the on state, the NLC molecules were moved to the electric fringe field. In the electric fringe field, the stable LC director field was symmetrically aligned, and two domains were achieved. The light was transmitted by the transition of the NLC molecules. The two domains formed by the electric fringe field contribute to an improvement in the viewing angle.

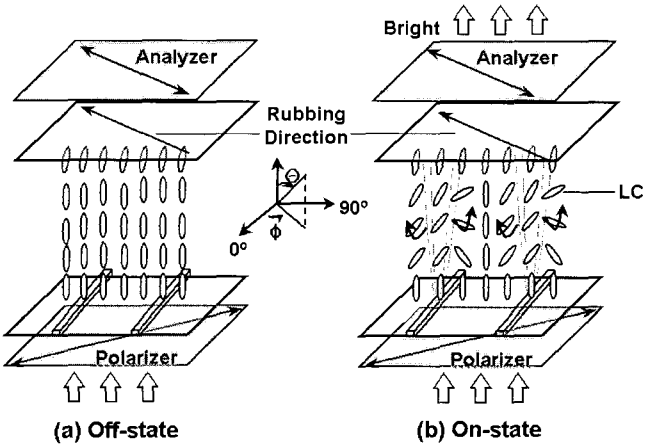

Fig. 2. Schematic diagram of a new IPD-VA cell mode without a negative compensation film in the off and on state.

The transmittance characteristics of a IPD-VA cell were obtained by computer simulation of the DIMOS method (Autronic-Melchers Gmb. Co.) as shown in Fig. 3. Symmetric transmittance by the electric fringe field was obtained.

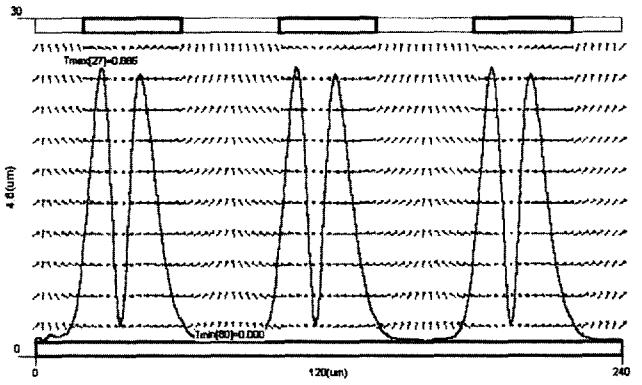

Fig. 3. Transmittance of a IPD-VA cell by computer simulation.

Figure 4 shows the V-T characteristics of a IPD-VA cell without a negative compensation film on a homeotropic PI surface. A good V-T curve for the rubbingaligned IPD-VA cell can be observed. However, poor V-T curves of the photoaligned IPD-VA cell with UV exposure on homeotropic photopolymer surfaces were measured. It is considered that the instability V-T

characteristic is attributable to the weak anchoring surface energy of LC molecules by the photoalignment method in the upper ITO substrate. The V-T characteristics of a conventional VA cell on a homeotropic PI surface are shown in Figure 5. A good V-T curve for a conventional VA cell was obtained. The threshold voltage of the IPD-VA cell was higher than that of the conventional VA cell mode. It is considered that the high threshold voltage can be attributed to the electric fringe field by the patterned IPS electrodes.

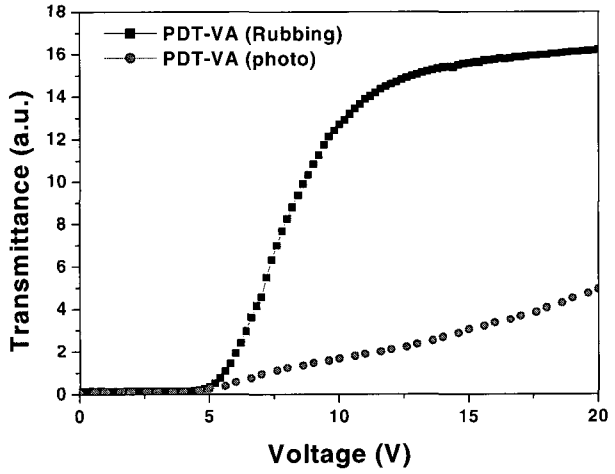

Fig. 4. V-T characteristics of a IPD-VA cell without a negative compensation film on a homeotropic PI surface.

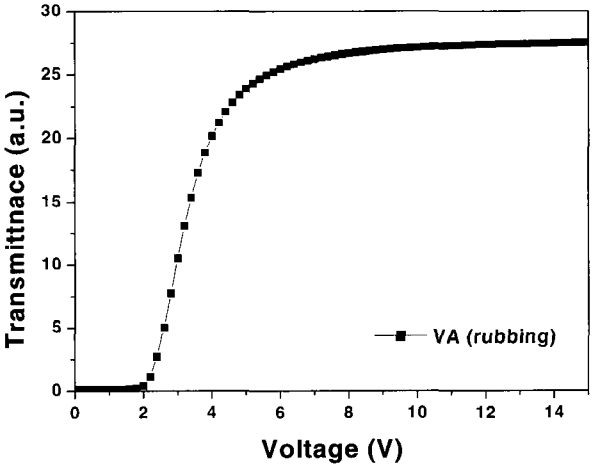

Fig. 5. V-T characteristics of a conventional VA cell without negative compensation film on a homeotropic PI surface.

4. CONCLUSION

In conclusion, we investigated the EO characteristics of a negative NLC using a rubbingaligned and photoaligned PDT-VA cell mode as in-plane driven VA on a homeotropic alignment layer. Good V-T curves were observed using the rubbingaligned IPD-VA cell mode without a negative compensation film. However, instability and low transmittances of V-T characteristics in photoaligned IPD-VA cell was measured. Therefore, fabrication process using a rubbingaligned IPD-VA cell can be achieved with only one-sided rubbing.

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