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Rubbing-less planar alignment method of liquid crystal with liquid crystalline polymer by electric field

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We propose a planar alignment method of the liquid crystal (LC) involving no conventional alignment layer and rubbing process. Horizontal electric field and ultra-violet irradiation to liquid crystalline polymer (LCP) produce a uniform alignment of the LC. Using the treated substrates, the planar and twisted nematic LC modes were demonstrated.

1. Introduction

The liquid crystal displays (LCDs) are most widely used flat panel display devices due to its simple process, mass-producibility and high definition. In the LCD devices, the uniform alignment of the LC molecules is important to obtain the excellent image quality. The polyimides with thermal and chemical stability are widely used as an alignment layer. However, additional treatments such as rubbing and photo-alignment methods are required in the polyimide layer to obtain a uniform alignment of LC molecules.

The alignment-layer-free technologies were achieved in many ways such as optically isotropic LC mode, nano-particle doped LC system, and reactive mesogen with different reactive wavelength [1-3]. Those kinds of methods have a critical limitation because they require the high operating voltage and residues in the LC layer.

In this work, we proposed a planar alignment method of the LC without conventional alignment layer and rubbing process using the liquid crystalline polymer (LCP). The horizontal electric field and the ultra-violet (UV) exposure to the LCP layer coated on substrates were used to obtain a uniform planar alignment. The LCP were aligned by the electric field and polymerized by the UV irradiation. The planar alignment characteristics of the polymerized LCP layer were confirmed by fabricating the planar, hybrid, and twisted nematic (TN) cells.

2. Experiments

To fabricate the LC cell, we used the conventional fringe field switching (FFS) electrode. The substrate was cleaned by detergent (MUCASOL) in ultra-sonicator for 1 h and washed by the de-ionized water. The

KLCC 2013, Vol. 15

LCP (RMS03-013C, E. Merck) was spin-coated onto the cleaned substrate. At first, the reactive mesogen (RM) monomers in the LCP layer are randomly distributed due to the spin coating process [Fig. 1(a)]. Next, to align the RM molecules, the horizontal electric field was applied as shown in Fig. 1(b). The RM molecules with positive dielectric anisotropy are aligned parallel to the field direction. In such situation, the RM molecules in LCP layer are exposed to UV light for 30 min (2 mW/cm^2 at 365 nm).

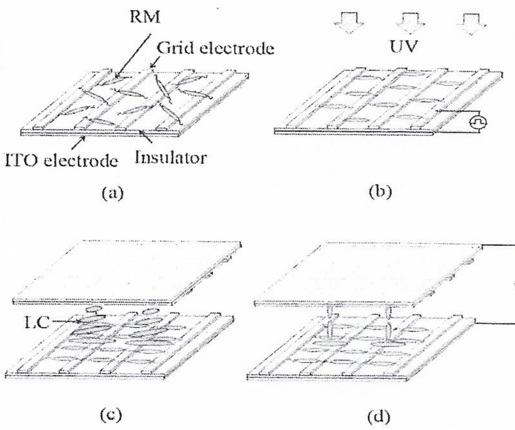

Figure 1 The schematic diagrams of the proposed aligning method: (a) randomly distributed RM on the FFS electrode and (b) uniformly aligned RM by the electric field and UV exposure. (c) White state and (d) black state in the TN cell.

The terminal groups of the RM molecule are cross-linked and produce the uniform alignment. Two substrates with the aligned LCP layer were assembled to form the planar and the TN cells, and the LCs were injected by capillary action in the isotropic phase. To operating the cells, a vertical field in the FFS electrode was applied similar to the conventional planar or TN mode.

3. Results and Discussion

To confirm the alignment characteristics of the surface, we observe the polarizing optical microscopic (POM) textures in the planar alignment cell as shown Figs. 2(a) and (b). When the aligned direction is parallel to one of crossed polarizers, the incident light is blocked in the planar cell under crossed polarizer [Fig. 2(a)]. Rotating the planar cell, the incident light experiences the phase retardation and thus the bright state is obtained. Here, the dark lines represent the black matrix of the FFS electrode.

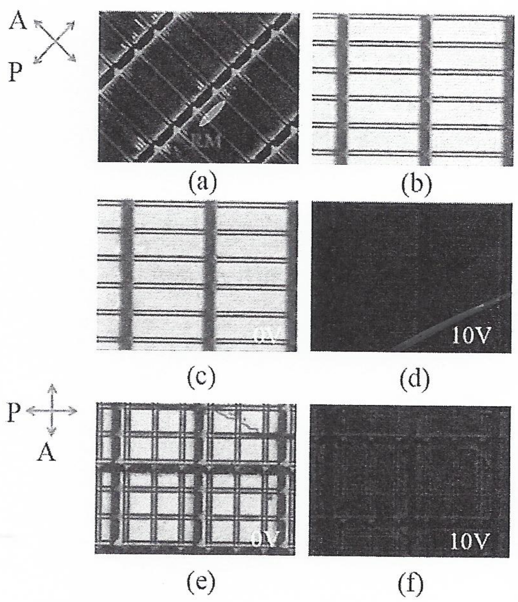

Figure 2. The microscopic textures of the planar cell (a) parallel and (b) rotated by 45° to the polarizer, the hybrid aligned cell (c) under no applied voltage and (d) under 10 V, and the TN cell (e) under no applied voltage and (f) under 10 V.

Also, to confirm the polar anchoring characteristics, we fabricated a hybrid aligned LC cell using conventional vertical alignment

KLCC 2013, Vol. 15
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layer at opposite substrate. Because the substrate did not rubbed, the alignment of the LC in bulk layer are only depend on the electrically aligned RM layer. We observe the uniform alignment of the LC by the POM textures as shown in Fig. 2(c) at the white state.

Now, we fabricate the TN cell to confirm the azimuthal anchoring features as shown in Figs. 2(e) and (f). In the TN cell, the bright state was obtained under no applied electric field as shown in Fig. 2(e) and the dark state was observed under the applied field as shown in Fig. 2(f). As a result, the electrically aligned LCP layer gives rise to a uniform planar alignment of the LC with enough polar and azimuthal anchoring strengths

4.Conclusion

We proposed the planar aligning method without the conventional alignment layer and rubbing process using the LCP layer. The planar aligning direction was controlled by the electric field and the UV exposure to the LCP layer. The electrically aligned LCPs gave rise to uniform LC alignment. The polar and azimuthal anchoring characteristics were confirmed by fabricating the various nematic modes such as the planar, hybrid, and TN modes.

5. Acknowledgements

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