Enhanced Electro-optic Characteristics for Homeotropic Alignment of Nematic Liquid Crystals by Photo-Alignment

A Ra Yoon[1], Young-Ki Kim[1], You-Jin Lee[1], Soo In Jo[2], Sang-Woong Choi[2], Jin Seog Gwag[3] and Jae-Hoon Kim[1, 2*]

[1] Department of Information Display Engineering, Hanyang University, Seoul 133-791, Korea,
[2] Department of Electronics and Computer Engineering, Hanyang University, Seoul 133-791, Korea,
[3] Department of Physics, Yeungnam University, Kyeongsan 712-749, Korea,
e-mail: jhoon@hanyang.ac.kr

This study proposed the photo alignment method in a liquid-crystal (LC) cell fabricated with a general homeotropic polyimide alignment material mixed with reactive mesogen (RM) monomer. In this work, we can obtain uniform alignment of LC molecular as well as enhanced electro–optic characteristics by polymerized RMs on the surface. The polymerized RMs generate pretilt angle through doubly exposed to linearly polarized UV (LPUV). The 1st UV irradiation led to anisotropic alignment of nematic LC molecules along perpendicular direction of LPUV due to photodecomposition. And then, from the 2nd UV irradiation, we carry out polymerizing of RMs to increase the pretilt angle with applied voltage.

1. Introduction

The control of the uniform orientation of liquid crystalline molecules is essential in liquid crystal displays (LCDs). Rubbing method is the most widely used because of the simplicity of making them and their good thermal stability [1, 2]. However, this process has serious problems such as impurities from working process and contamination of electrons and/or ions on polyimide (PI) layer or inducing electrostatic charge which can cause residual DC voltage [3]. The photo alignment (PA) technique, as one promising alternative to the conventional rubbing technique, has attracted great merit for its contact free. It can be also high reproducibility due to no static charge and clean process without defect. It is great advantage to the large area fabrication of multi-domain LC displays for wide viewing angle. However, PA is also difficult to obtain strong anchoring [4] and stable pretilt angle [5]. Thus, it has slow response time, and reverses tilt or twist domains [6].

In previous work, some polyimide (PI) has known sensitivity to UV [7, 8]. It means that anisotropic chemical reactions induced by linearly polarized UV (LPUV) light cause changes in the alignment of LC molecules [9, 10].

Recently, we demonstrated that the surface controlled patterned vertical alignment (SC-PVA) mode with enhanced response time using PI-RM alignment layer [11]. In this sample, RM monomers are polymerized and anchor LC molecules to generate pretilt angle on alignment surface.

Therefore, we are focusing on a PA method using general homeotropic polyimide alignment material containing the RMs. Through two-step UV exposure processes, we can obtain the enhanced electro-optic characteristics for stable performance.

2. Experiment

Figure 1 shows schematic diagram of the proposed PA sample. To fabricate the sample, we conducted double step UV process.

At first, we mixed the general homeotropic polyimide alignment material (AL60101, JSR), proper amount of RM monomer (BASF), and photo initiator (IRGACURE 651, Ciba chemical) which can enhance the photo reactivity for a long time. After that, ITO glass was spin-coated with the mixed alignment material. It was pre-baked at 100°C for 10 minutes, hard-baked at 180°C for 1 hour to completely imidize on the surface.

The sample was obliquely situated about 30 degree from the bottom. If LPUV exposure is not tilted, polar direction of LC directors could not be defined. Thus, we have the 1st LPUV curing process for 15 min to define the weak in-plane and out-of-plane surface anisotropy.

The PA direction between top and bottom substrates is antiparallel.

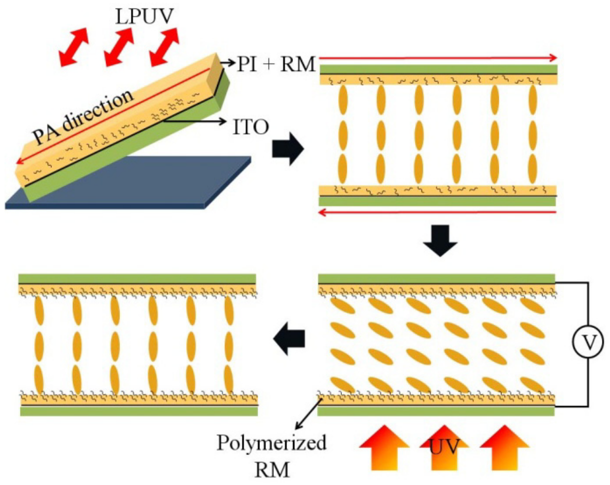

Figure 1 Schematic diagrams of the fabricated sample by photo alignment.

The cell gap of the assembled two ITO glass substrates was maintained under 3μm, which can obtain the maximum transmittance. We use the nematic LC (MLC-6610, Δε = -3.1, Δn = 0.0996, Merck). After the assembly of fabricated sample, we exposed the 2nd step UV with applied voltage for 30 min to enhance the pretilt angle on the surface.

3. Result and Discussion

For the 1st UV process, alignment polymer chain is selectively destroyed to induce anisotropic orientation of LC molecular along perpendicular direction of LPUV. At this time, it takes the long reorientation time due to low pretilt angle. Therefore, we can find defect lines during the reorientation time.

Figure2 shows microscopic textures of the proposed method after 1st UV process and 2nd UV process under crossed polarizer when applying the static voltage each 0V and 10V.

After enough stabilization of LC directors with applied voltage, we have the 2nd UV process to polymerize RM monomers contained homeotropic PI layer. At this time, the orientation of LC molecular is faster than the 1st UV process because the generated pretilt angle on the surface. And anchoring energy is increased at the same time. These effects are confirmed in textures, as shown in Fig. 2(b). We could obtain uniform texture without any disclination lines and reverse tilt domains. Namely, the reorientation time for stabilization of LC molecules was definitely enhanced. In the study, the measured response time of the sample before and after 2nd UV exposure was several hundred (ms) and several tens (ms), respectively. The measured pretilt angle was 87 °. From this result, the pretilt angle can be controlled up to 1.5° by polymerized RMs on the surface.

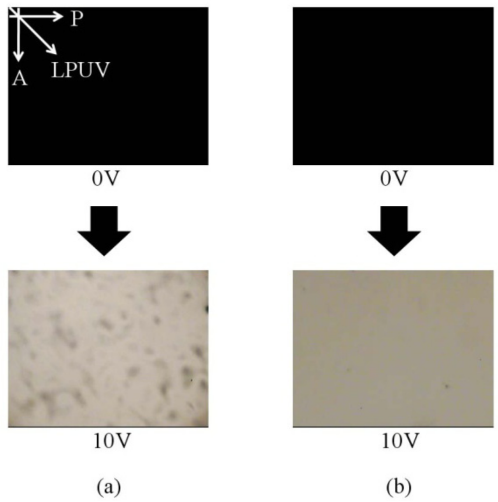

Figure 2 Microscopic textures for photo aligned VA mode sample (a) before 2nd UV process and (b) after 2nd UV process with applied voltage.

4. Conclusion

In summary, we proposed the photo alignment method in a liquid-crystal (LC) cell fabricated with a mixed general homeotropic polyimide alignment material with reactive mesogen (RM) monomer. In this study, we can obtain uniform alignment of LC molecular as well as enhanced electro–optic characteristics. At this results, we can be achieved enough pretilt angle for uniform alignment of LCs by polymerized RMs on surface. Moreover, our fabricated cell is shown that strong anchoring strength for fast response time by the additional UV process with applied voltage.

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