Pretilt Angle Control of the Liquid Crystal by using the Reactive Mesogen

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We proposed a method to control the pretilt angle of liquid crystal (LC) by using the mixture of conventional vertical polyimide (PI) and UV curable reactive mesogen (RM). In this paper, the pretilt angle of LC can be controlled at the intermediate range by polymerization of the RM. The RMs inside the alignment layer memorizes the LC tilting direction during the UV exposure process in the presence of different applied voltage. Therefore we can control the pretilt angle in whole ranges with conventional polyimide and RM by varying the applied voltage.

1. Introduction

In liquid crystal displays (LCDs), the pretilt angle of LC is an important factor because the electro-optic characteristics of LCDs such as the driving voltage, transmittance, and response time strongly depend on the pretilt angle of the LC. Most LCDs are based on either planar alignment or vertical alignment of the liquid crystal director by using alignment materials such as polyimide, photopolymers, surfactants, silicon oxide, and so on. Therefore, many methods to control the pretilt angle have been proposed and developed such as stacked alignment layers [1], mixture of homogeneous and homeotropic alignment material [2], oblique evaporation of silicon oxide [3], the competition of the van der Waals interaction between crest region and trough region of the upper alignment layer in a dual alignment layer [4], controlling the groove depth by atomic force microscopy [5], and double layer with different rubbing strength [6]. Those methods have some problems such as high cost of manufacturing process, long term stability and reproducibility. To endure those problems, we propose a method to control the intermediate pretilt angle using the mixture of conventional vertical PI and RM as alignment layer. The intermediate range of pertilt angle is controlled by anchoring competition between vertical PI and the polymerized RM by UV exposure. And RM forms the certain direction followed by the LC molecules tilting direction with the various applied voltage.

2. Experimental

Figure 1 shows the schematic diagrams of pretilt angle control processes. The vertical alignment (VA) material (from JSR), the RM monomers and the photo initiator were mixed sufficiently in the stirrer with magnetic bar. The mixtures of those materials were spin-coated on the indium tin oxide (ITO) substrate. And it is pre-baked to remove the solvent of alignment material, hard-baked to imidize the alignment material on the hot plate. Then the surface of each substrate was rubbed in anti-parallel direction and cell gap was maintained about 3 μm by glass spacer.

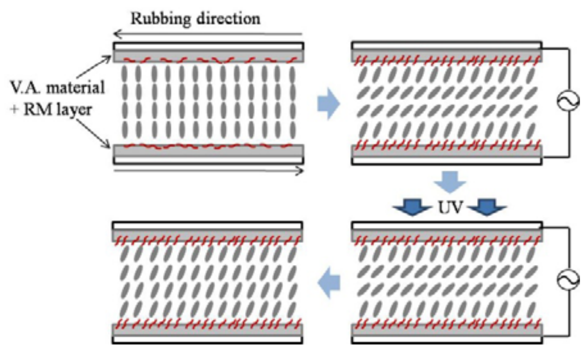

Figure 1 Schematic diagram of pretilt angle control processes

The nematic LC with negative dielectric anisotropy was injected in the sample. This sample was exposed to the UV light with the applied voltage.

3. Result and Discussion

At an initial state, the LC molecules were aligned vertically on the alignment layer (see Fig. 1(a)). When the voltage applied to the sample, the LC molecules were falling to the substrate by electric field and the RM monomers were aligned along direction of the lied LC molecules. At this state, the sample was exposed to the UV light. Then the RM monomers were polymerized in the alignment layer. The polymerized RMs inside the alignment layer memorizes the tilting direction of LC during the UV exposure process even after the applied voltage was removed. At this process, pretilt angle can be controlled by applied voltage during the UPV exposed process.

To measure the pretilt angle, we used the polarizer rotation method [7]. The crystal rotation method was widely used the measurement due to accuracy and convenience, however it has originally problems that are hard to determine the symmetric point in the intermediate range of pretilt angle. Therefore two polarizers are rotated and the sample is fixed with oblique angle between two polarizers. By using this method we can measure the whole range of the pretilt angle.

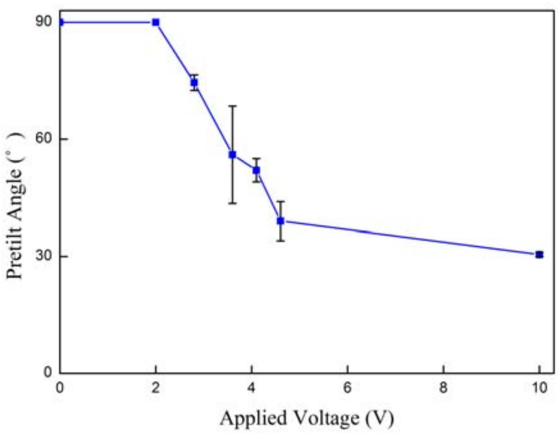

Figure 2 the measured the pretilt angles as the applied voltage during the UV curing process

Figure 2 shows the measured the pretilt angles according to the applied voltage during the UV curing process. The pretilt angles were controlled at the intermediate range (30˚~ 90˚). When the applied voltage is lower than threshold voltage (V_{th}), pretilt angle were not changed due to the LCs maintained vertically aligned the initial state. When voltage is larger than V_{th}, the pretilt angles were changed continuously according to the applied voltage.

Figure 3 shows the polarized microscopic image of the sample under crossed polarizers. At the Fig. 3(a), the light cannot pass through crossed polarizer because the optical retardation of the sample is zero due to vertically aligned LC. However, when the UV exposure with the applied voltage larger than threshold voltage, intermediate range of pretilt angle can generate the optical retardation, then the light can pass through the crossed polarizer (see Fig. 3(b), (c), and (d)).

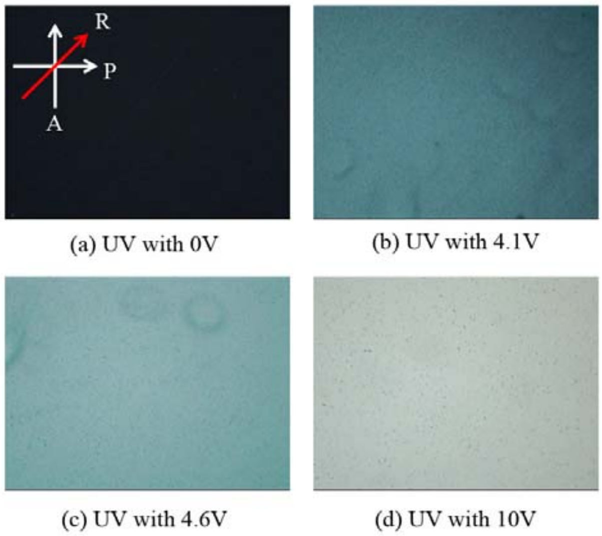

Figure 3 Textures of the produced LC samples under crossed polarizer according to the applied voltage. The arrows indicate polarizer (P), analyzer (A) and rubbing (R) direction.

From this result, we think the intermediate range of pretilt angle was produced the polymerized the RMs by anchoring competition between vertical PI and the RM.

4. Conclusion

We proposed the new method to control the intermediate range pretilt angles of LC using the polymerized RM by UV curable. The proposed method has very simple process as compared with the conventional method of pretilt angle control using the alignment material and the RM.

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