Domain-Divided Twisted Nematic Liquid Crystal Mode using Homeotropic Reactive Mesogen Mixture

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Abstract

We proposed the domain-divided twisted nematic liquid crystal (DDTN-LC) mode induced by four splayed TN structures in each sub-pixel. The four splayed TNs were simply obtained by the perpendicular assemble of the rubbed substrates with different pre-tilt angles. For the control of pre-tilt angles, reactive mesogen mixture was used to control the pre-tilt angles.

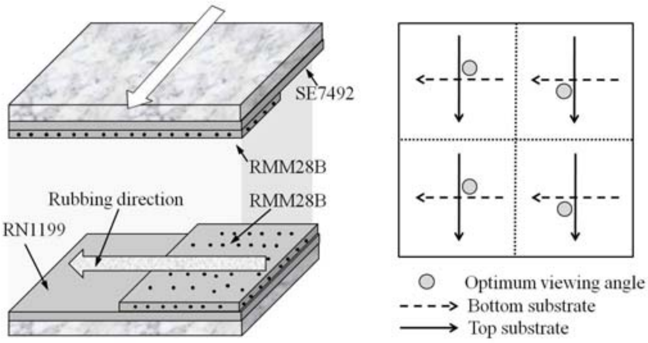
1. Introduction

Conventional single domain twisted nematic displays (TN-LCDs) have been the most widely used due to their simple fabrication and high transmittance[1]. With increasing the size of panel, the non-symmetric and narrow viewing angle characteristics of the TN-LCD might be a serious problem for the application of display devices with good optical qualities. The main reasons for these problems are that the optic axis in the mid-plane of the cell is uniformly tilted in one direction. To improve the viewing angle characteristics of the TN mode, the optical compensation was widely used[2,3]. Also, various multi-domained TN modes have been proposed such as 4D TN mode and DDTN mode[4,5]. In the DDTN mode, the aligning issue of the top and bottom substrates is a crucial problem for fabricating the DDTN mode.

In this paper, we proposed a novel fabrication method of a DDTN LC mode induced by four splayed TN structures in each sub-pixel for the wide viewing angle characteristics. To induce the asymmetric different pre-tilt angles in sub-pixels, we formed the homogeneous alignment layers with the difference in pre-tilt angles on both substrates and assembled perpendicular two substrates. The different pre-tilt angles were achieved by the patterned reactive mesogen mixture (RMM). The DDTN LC mode was simply fabricated without assembling problem in the conventional DDTN mode.

2. Experimental

Figure 1 (a) shows the schematic diagram of DDTN LC mode proposed in this work. The solid arrows and dashed arrows in each sub-pixel indicate the direction of the pre-tilt angle on the top and bottom substrates, respectively. Like the conventional DDTN LC mode, each sub-pixel in our cell has a splayed TN LC structure induced by asymmetric pre-tilt angles and twist sense opposite to the direction of pre-tilt angles[6,7]. Each pixel of our DDTN LC cell is divided into four regions with the different pre-tilt angles. To produce the different pre-tilt angles, our LC cell was patterned using UV curable RMM material with the homeotropically aligning properties with different pre-tilt angles. Although all of sub-pixels have the same chirality by chiral dopant, arranged direction of the LC molecules at a mid-plane of the LC cell is determined by the surface condition with the higher pre-tilt angle. For this reason, the optimum viewing angle only exists in two directions as shown in Fig. 1 (b). Thus, our DDTN LC cell has the symmetric viewing angle characteristics due to the sub-pixels to spatially averaged optical characteristics.



(a) (b)

Fig. 1. Schematic diagram of DDTN LC cell proposed in this work: (a) the cross-section and (b) direction of pre-tilt angle and optimum viewing angle in respective sub-pixels

Figure 2 shows a schematic diagram of fabrication process for the DDTN LC mode proposed in this work. For gap of 2° pre-tilt angle between both substrates, two kinds of PI (polyimide) alignment layers (RN1199, Nissan Chem.) and the SE7492 (Nissan Chem., Japan) which induce a pre-tilt angle of about 2° first were spin-coated at 1000 rpm for 10 sec and 3000 rpm for 20 sec on top and bottom substrates deposited with indium-tin-oxide (ITO), respectively. Two substrates were pre-baked at 100 °C for 10 min in order to remove solvent followed by hard-baking at 210 °C for 1 h. After thermally curing process, the two substrates were rubbed by using a rubbing machine. The mixture in the optimized ratio of the solvent (PGMEA: propylene glycol monomethyl ether acetate) and homeotropic RMM was spin-coated through the two-step process at 1000 rpm for 5 sec and 5000 rpm for 20 sec on the rubbed PI alignment layers. Baking was carried out for removing solvent at the condition of 60 °C for 90 sec. The substrates with RMM layer were exposed to UV light (λ=365 nm, 17 mW/cm^2) for 1 sec through a photo-mask with striped pattern (500 μm) under the nitrogen environment. The residual RM monomers at the non-irradiated regions were removed by dipping the cell in PGMEA for 30 sec. Two substrates were assembled maintaining the cell gap of 4.5 μm. Finally, the nematic LC mixture of MLC-6875 (n_e=1.601, n_o=1.4896, Merck Co.) and S811 (left-handed chiral dopant, Merck Co.) was injected by capillary action at isotropic phase.

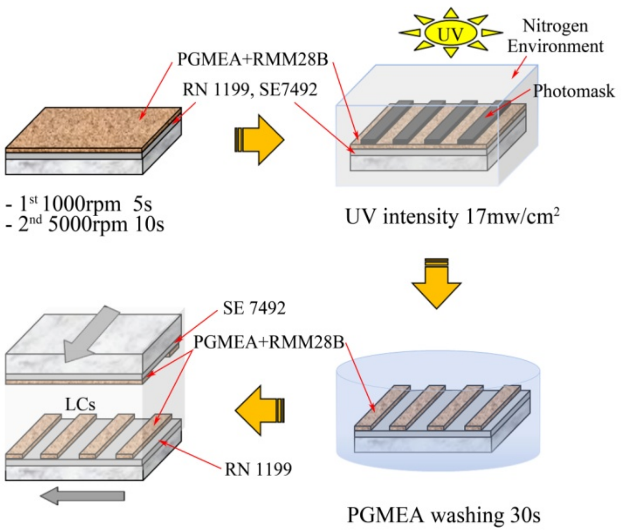
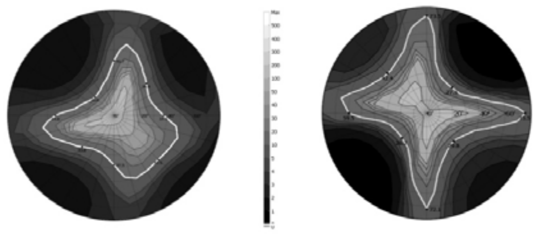


Fig. 2. The schematic diagram of fabrication progress for DDTN LC cell proposed in this work.

3. Results and Discussion

Figure 3 shows the experimental results of viewing angle characteristics under crossed polarizers of (a) conventional single-domain TN mode and (b) DDTN mode proposed in this work. The conventional single-domain TN mode has non-symmetric viewing angle characteristics at various polar and azimuthal angles. However, in case of proposed DDTN mode, viewing angle is symmetric and wide, relatively. Because LC molecules in our DDTN mode is aligned at only two directions at the mid-plane, optically compensated viewing angle characteristics is relative symmetric and wide as shown in Fig. 3 (b).



(a) (b)

Fig. 3. Viewing angle characteristics of (a) single-domain TN mode and (b) DDTN mode proposed in this work.

4. Summary

We proposed the novel method for fabricating DDTN LC mode with symmetric and wide viewing angle characteristics, based on two domains which induced by different pre-tilt angles on the top and bottom substrates. Our fabrication process is simple in comparison to conventional DDTN LC cell due to UV curable RMM with vertically alignment properties which can control the pre-tilt angle with no need for aligning process.

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5. References

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