Inverse Twisted Nematic Mode Using Photo-Alignment Method

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ABSTRACT

We propose an inverse twisted nematic mode using photo-alignment method with two stacked alignment layers. By stacking the planar and vertical alignment layers, we can increase the azimuthal surface anchoring energy, and thus the stable twist structure is obtained under an electric field.

1. INTRODUCTION

Liquid crystal display (LCD) is the most popular flat panel display (FPD) due to its intrinsic advantages such as high definition and mass-productivity. Many LC modes have been demonstrated such as twisted nematic (TN), patterned vertical alignment (PVA), in-plane switching (IPS) modes [1-3]. Among them, the TN mode is most widely used with high transmittance, fast response time, and low fabrication cost. However, the TN mode exhibits poor black level because the LC molecules near the surface are strongly attached on the surface. But the vertical alignment (VA) mode has excellent contrast ratio due to their initially vertical alignment of the LCs. To overcome the problem of the poor black level in the TN mode, an inverse TN mode using initially vertical alignment state was developed which has both advantaged high contrast ratio and high transmittance due to the completely dark level in the initial state and the twisted configuration under an applied field [4-5]. In general, two methods to generate the ITN mode have been demonstrated such as adding chiral dopant to maintain twist structure under an applying voltage [4] and enhancing azimuthal anchoring energy by stacking two alignment layers without chiral dopant [5]. In the ITN mode, the LC molecules which have negative dielectric anisotropy are initially vertical aligned and they are arranged perpendicular to the applied voltage. However, in those two methods, they use the rubbing method to the surface and rubbing method can cause the disadvantages such as contamination on polyimide layer or image sticking with residual DC voltage by electrostatic charge. So currently, rubbing-free techniques for LC alignment are needed and photo-alignment method has been proposed to improve alignment condition and achieve high resolution.

In this paper, we attempt to obtain the enhanced azimuthal anchoring energy of the surface using photo-alignment method which is non-contact technique by stacking two photo-alignment layers. In the stacked alignment layer system, the planar alignment layer coated below the diluted vertical alignment layer has a decisive effect on the LC layer to be arranged parallel to the surface anisotropic direction due to enhanced surface azimuthal anchoring energy under an applying voltage. In this paper, we propose the ITN mode by photo-alignment method which maintains stable twist structure using the stacked alignment system.

2. EXPERIMENTAL

Figure 1 shows the fabrication process of the ITN mode using photo-alignment method. At first, the planar photo-alignment material (Chisso Inc.) was spin-coated onto the indium-thin-oxide (ITO) glass. The coated substrate was treated by O_2 plasma to enhance the coating property between two photo-alignment materials. The diluted vertical photo-alignment material (Chisso Inc.) was spin-coated onto the first layer. After full imidization, the substrate coated with two photo-alignment materials was exposed to non-polarized ultra-violet (NPUV) shown as Fig. 1. The intensity of NPUV was about 18 mW/cm^2. The substrate was tilted 45 degree from the horizon surface to generate the pretilt angle on the substrate. The UV light source with a wavelength of 365nm was used to generate pretilt angle shown as Fig. 2(a). After UV exposure, two substrates were assembled perpendicularly and maintained by glass spacers about 5 μm. The MLC-6608 (E. Merck) which has negative dielectric anisotropy was injected into the sandwiched cell at isotropic phase.

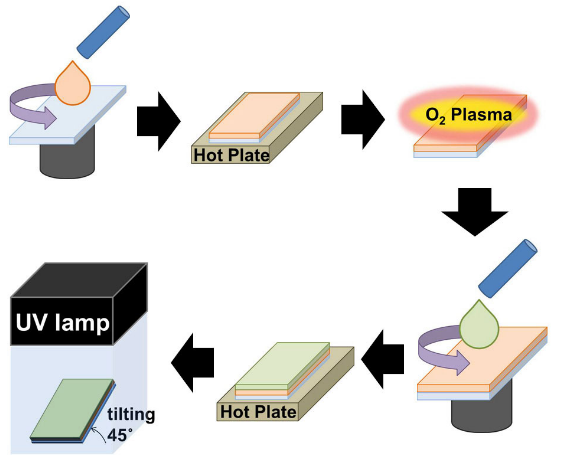


Fig. 1 The schematic diagrams of fabrication process.

3. RESULT

As shown in Fig. 2(a), the substrate by stacking two photo-alignment materials induced surface anisotropic direction toward the NPUV exposure direction. As we expected, we can achieve the relative strong surface azimuthal anchoring energy.

Figure 3 shows the microscopic textures under crossed polarizers for various conditions of the ITN mode. Compared to the vertical photo-alignment layer case as shown in Fig. 2(a), the stacked photo-alignment layer exhibits high transmittance, which reflects the twisted configuration under the applied voltage, in the rotation the sample by 45 degree under crossed polarizers shown as Figs. 3(b) and (c).

We measured the azimuthal anchoring energy by measuring the twist angle of the LC molecule with different chiralities [6] for the NPUV exposed alignment layer for 60 min. As shown in Table 1, the surface azimuthal anchoring energy of the stacked photo-alignment system is about 9 times larger than that of the vertical photo-alignment layer because the planar photo-alignment layer under vertical photo-alignment layer contributes to LCs layer of being maintained to the surface.

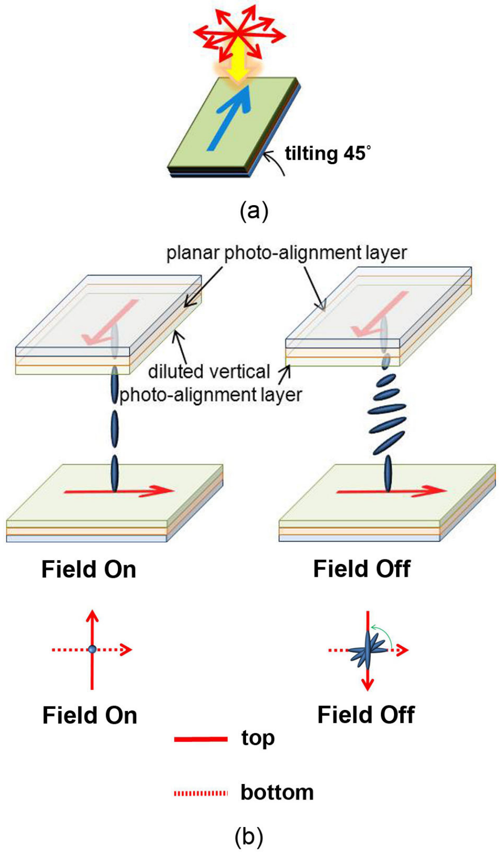


Fig. 2 The schematic diagrams of (a) our UV exposure condition and (b) the ITN mode with applying voltage.

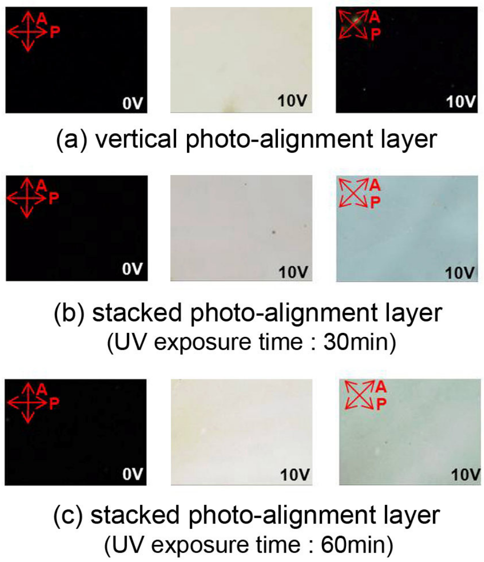
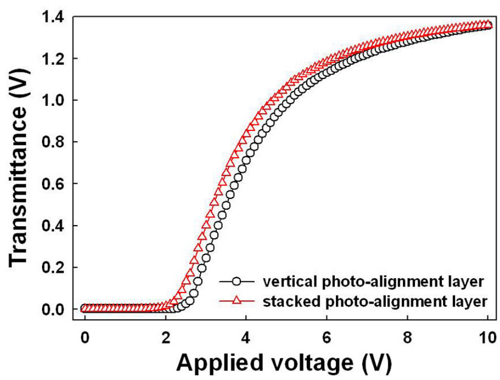


Fig. 3 Microscopic textures of the ITN mode using photo-alignment method with (a) the only vertical photo-alignment layer, (b) the stacked photo-alignment layers exposed to NPUV for (b) 30 min and 60 min under crossed polarizers, respectively.

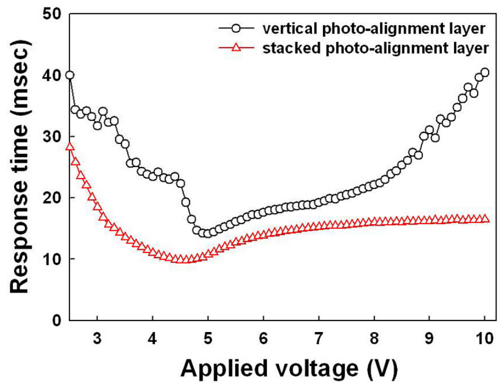
Table 1. Measured surface anchoring energy.

layer system	surface azimuthal anchoring energy
vertical photo-alignment layer	1.23×10^{-6} N/m
planar photo-alignment layer	1.54×10^{-5} N/m
stacked photo-alignment system	1.08×10^{-5} N/m

Figure 4 shows the voltage-transmittance characteristics of the fabricated samples. The screen effect of the planar alignment material decreases the threshold voltage about 0.5 V than that of the only vertical PI case. However, the response time is about 5 ms faster at 6 V and 24 ms faster at 10 V than those of the only vertical PI sample. In a high voltage, the reorientation process is reduced and LCs are directly fall down to the surface due to relatively strong surface anchoring energy in stacked PI system than conventional method.



(a)



(b)

Fig. 4 (a) The voltage-transmittance curve and (b) response time curve of two different layer systems with NPUV exposure for 60 min.

4. CONCLUSION

We proposed the ITN mode using the photo-alignment method by stacking two different photo-alignment materials. By stacking the planar and vertical alignment layers, we can enhance the surface azimuthal anchoring energy, and thus obtain twist structure without chiral dopant. In addition, our proposed method is expected to expand to the mass-production with multi-domain devices to compensate the viewing angle using mask shifting method.

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