Chiral Hybrid In-Plane Switching Liquid Crystal Mode with Stable Domain by the Stacked Alignment Layers

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Abstract

We propose an improved chiral hybrid in-plane switching (CH-IPS) liquid crystal mode with a stable domain for high brightness. The stable mono-domain in the CH-IPS mode was obtained by the alignment layer stacked with the planar and vertical alignment layers. The stable CH-IPS mode with high brightness was obtained by the improved azimuthal anchoring energy with the stacked alignment layer.

1. Introduction

Liquid crystal displays (LCDs), such as twisted nematic (TN)[1], vertically aligned[2], in-plane switching (IPS)[3], and fringe-field switching[4] modes, have attracted great interest and have been widely developed since their excellent display performances. Especially, the IPS mode has widely used in LCDs due to their wide viewing angle characteristics and uniform gray/color levels. However, since the LC directors on the electrodes are aligned vertically by field direction, the brightness on the electrode becomes almost dark even in bright state, which gives rise to reduction of the transmittance of the LCD.

The chiral hybrid in-plane switching (CH-IPS) LC mode, adopted a twisted configuration and a hybrid alignment of the LCs, was proposed to improve the transmittance of the LCDs[5]. In the CH-IPS, the bright state was obtained under no applied voltage similar to that in the normally white TN mode. Therefore, the whole pixel region even on the in-plane electrodes was acted as the bright state, thus high transmittance was obtained. When the electric field on interdigitated electrodes for in-plane switching is applied to LC layer, the LCs are rearranged to the direction of electric field which is the same as the optic axis of polarizer. However, conventional CH-IPS LC mode has reverse domains due to the weak azimuthal anchoring energy of the vertical alignment layer[5].

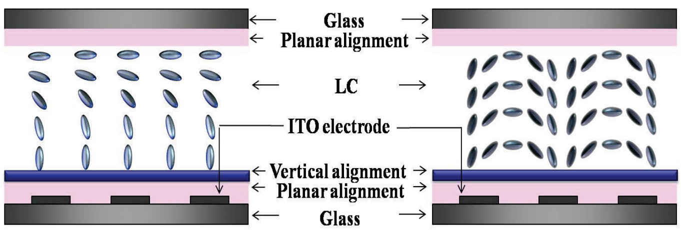
In this paper, we proposed an advanced method for improving the alignment stability of the CH-IPS mode through the surface modification using the stacked alignment layer of the planar and vertical alignment layers. By introducing the planar alignment layer beneath the vertical alignment layer, the stacked alignment layer of the CH-IPS mode proposed in this work was enhanced the azimuthal anchoring energy[6]. Finally, we achieved the improved CH-IPS mode with the high transmittance by eliminating the reverse domains.

2. Experiment

Figure 1 shows the schematic diagram of the CH-IPS LC mode proposed in this work. As shown in Fig. 1(a) the hybrid alignment can be realized by using planar and stacked alignment layers on the top and bottom substrates, respectively. The CH-IPS mode is operated by normally white mode which achieves a high transmittance in the initial state. We make the in-plane direction of the field the same as the rubbing direction of the top and bottom substrates, as shown in Fig. 1(b).

We fabricated interdigitated indium-tin-oxide (ITO) electrodes by using photo-lithography process. After that, a planar alignment material (SE7492, Japan Synthetic Rubber) was spin-coated on the patterned ITO glass bottom and top substrate. The spin-coated alignment layer of the bottom and top substrate layer was pre-baking at 100 °C for 10 minutes to evaporate the solvent in alignment material, and the cured at 210 °C for 2 h to have complete imidization. The only bottom substrate was spin-coated the diluted vertical alignment layer which consists of 7 wt.% vertical alignment layer (AL1H659, Japan Synthetic Rubber) and 93 wt.% solvent (n-methyl-pyrrolidon:buthyrolactone:butoxyethanol = 3:4:3).

The second layer on the bottom substrate was pre-baking at 100 °C for 10 min and the cured at 180 °C for 2 h. The bottom substrate was rubbed in perpendicular to the direction



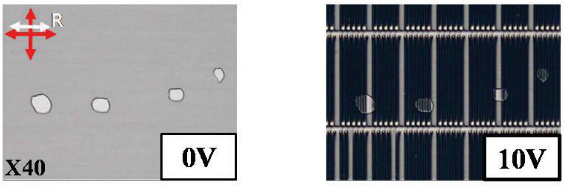
(a) Field off **(b) Field on**

Fig.1. The schematic diagrams of proposed CH-IPS mode in (a) bright state without the electric field and (b) dark state with the electric field.

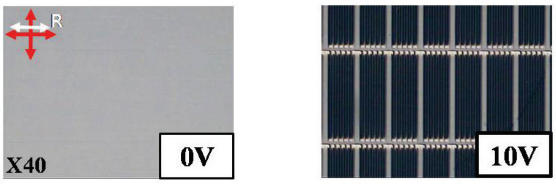
of the interdigitated electrodes. The top and bottom substrates were assembled anti-parallel. The cell gap (*d*) was maintained using glass spacers of 4.5 μm and the cell gap to pitch (*p*) ratio, *d/p* was 0.33. In this case, the LC molecules were twisted 120° from the bottom to the top substrates, and its transmittance was over 90%. The LCs and chiral dopant which were used in this work were MLC-6875 (Δn = 0.114, $\Delta\varepsilon$ = 7.8, Merck Co.) and S-811(HTP = 10^3/μm, Merck Co.). The LC was injected by capillary action at isotropic phase (T_{ni} = 91 °C)

3. Results and discussion

Figure 2 shows the change of alignment texture in CH-IPS mode depending on the applied voltages. As shown in Fig. 2(a), without the external voltage, you can see that the discilination lines are formed between reverse domains which have the transmittance difference between domains. When the voltage is applied to the conventional cell, it is difficult to maintain the gray level and get the dark state immediately due to the different behavior of reverse domain. This is the most essential issue to have to overcome difficulty in CH-IPS mode for LCD application.



(a) Conventional CH-IPS



(b) Stacked layer CH-IPS

Fig.2. Microscopic images of CH-IPS sample: (a) Conventional CH-IPS, (b) CH-IPS with the stacked layer.

To remove these reverse domains, we fabricated the improved CH-IPS LC cell using by the surface modification using stacked alignment layer. By using the double layer structure with the vertical and planar alignment layers, CH-IPS LC cell proposed in this work can be obtain the initially vertical alignment state and the enhanced azimuthal anchoring energy by the lower planar alignment layer. As a result, by the elimination of reverse domains, our CH-IPS LC cell could be acquired a stable LC alignment characteristic and higher transmittance compared with the conventional CH-IPS as shown in Fig. 2(b).

4. Summary

We proposed the improved CH-IPS LC mode with the enhanced transmittance by removing the reverse domains. The LC mode with the uniform domain which was removed the reverse domains could be obtained through the enhanced azimuthal anchoring energy of vertical alignment layer introducing the planar alignment layer beneath the vertical alignment layer. Consequently, our CH-IPS LC mode was obtained the higher transmittance compared with the conventional that.

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