Chiral hybrid In-Plane Switching Liquid Crystal Mode with Stable Domain by the Reactive Mesogen mixed with Alignment Layers

Young Eun Kang, Kwang-Soo Bae, You-Jin Lee**, Jae-Hoon Kim*, **, Jeong Wook Heo**, ***, Kyeong-Hyeon Kim***, and Chang-Jae Yu*, ****

* Department of Electronic Engineering, Hanyang University, Seoul 133-791, Korea
** Department of Information Display Engineering, Hanyang University, Seoul 133-791, Korea
*** Advanced Development Team, LCD business, Samsung Electronics, Asan, Chungnam 366-741, Korea
*cjyu@hanyang.ac.kr

ABSTRACT

We report an advanced chiral hybrid in-plane switching (CH-IPS) liquid crystal mode using the mixed vertical alignment layer with ultraviolet curable reactive mesogen (RM). The stable CH-IPS mode was obtained by the improved azimuthal anchoring energy due to the polymerized RM on the layer.

1. INTRODUCTION

The liquid crystal displays (LCDs) have been studied and used for a wide range of display application. To increase display performances various approaches have been taken for controlling the alignment and orientation of LC molecules because they play an important role in electro-optic characteristics of LC displays. Many kind of LCD modes such as twisted nematic [1], vertically aligned [2], in-plane switching (IPS) [3] have been developed for wide viewing angle, high contrast ratio and fast response characteristics by controlling alignment and orientation of LC molecules. Among them, the IPS mode has widely used in the LCDs due to its wide viewing angle and uniform gray color levels.

However, since the LC directors on the directors on the electrodes are aligned vertically by field direction, which gives rise to reduction of the transmittance of the LCD. This mode is also difficult to optimize the dark state because of the difference between the rubbing direction and the easy axis of LC, and the misalignment between the easy axis of top and bottom LC alignment layers generated by the rubbing.

To overcome these problems, we reported a chiral hybrid in-plane switching (CH-IPS) [4] to minimize loss of transmittance in the white state, and to reduce misalignment of the easy axes on the top and bottom substrate in the dark state. In the CH-IPS mode, the hybrid configuration of the LC was combined with the twisted structure produced by the chiral dopant. The high transmittance was obtained by the twisted structure in the normally white mode and the excellent dark state was achieved by reducing misalignment problem through the hybrid alignment.

However, this CH-IPS mode exhibited the reverse domains due to the weak azimuthal anchoring energy in the vertical alignment layer. In this work, we reported the optimization of cell condition in CH-IPS mode to remove the reverse domain introducing the reactive mesogen to the vertical alignment layer to enhance the azimuthal anchoring energy.

2. EXPERIMENTS

Figure 1 shows the fabrication procedure of Proposed CH-IPS mode. We fabricated interdigitated indium-tin-oxide (ITO) electrodes by using photo-lithography process. After that, a planar alignment material (SE7492 from Japan Synthetic Rubber) was spin-coated on the top substrate. The spin-coated alignment layer of the top substrate layer was pre-baking at 100 ^{o}C for 10 minutes to evaporate the solvent in alignment material and the cured at 210 ^{o}C for 1 hours to have complete imidization. The RM monomer and photo-initiator (Ciba Chemical IRGACURE651) was mixed in vertical alignment material (AL60702 from Japan Synthetic Rubber). The mixed alignment layer was spin-coated on the bottom substrate and pre-baking at 100 ^{o}C for 10 minutes and cured at 180^{o}C for 1 hour as shown in Fig. 1(a). Bottom was rubbed in perpendicular to the direction of the electrodes. Top and bottom

substrates were assembled anti-parallel.

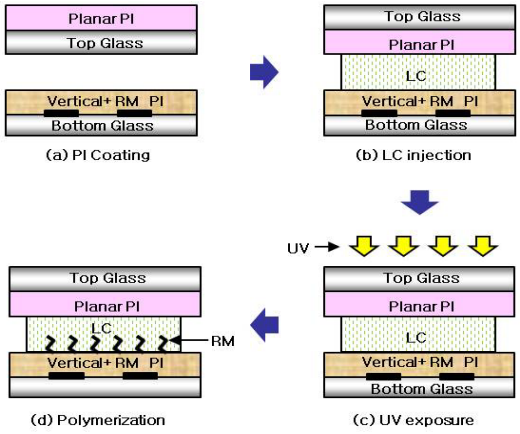

Fig. 1 The fabrication procedure of the CH-IPS

The *d*/*p* and cell gap were maintained to 0.33 and 4.5 μm, respectively. The LCs and chiral dopant which were used in this work were MLC-6875 (Δn = 0.1114, Δε = 7.8, from Merck Co.) and S-811 (HTP= 10.3 μm^{-1}, from E. Merck Co.). The LC was injected by capillary action at isotropic phase (T_{ni} = 91 °C) as shown in Fig. 1(b). The RM monomers on the bottom layer were exposed to the UV light (λ=365 nm) for 30 min [Fig. 1(c)]. Through UV exposure, the RM monomers were polymerized along the LC alignment [Fig. 1(d)].

3. RESULT AND DISCCUSION

Figure 2 shows the schematic diagram of the advanced CH-IPS mode. The white state is obtained by the wave-guiding of the polarized light due to the twist configuration of LC molecules like as the TN mode. In this case, the LC molecules are twisted 120 °C from top and bottom substrate, where the transmittance was 90 %. In our proposed CH-IPS mode, maximum transmittance is obtained under LC mode with *d*/*p*= 0.33. When the voltage was applied, the LC molecules are aligned to the direction of field which is parallel to the top polarizer as shown in Fig. 2(b). Therefore, we obtain the good dark state under the applied voltage.

The Figure 3 shows the microscopic images of the CH-IPS samples. As shown in Fig. 3(a), we can see that the reverse domains. When the voltage was applied, it is difficult to uniform the gray level and get the dark state due to the reverse domain. To remove reverse domain, we proposed the advanced CH-IPS using the RM mixed with alignment layer. The polymerized RMs on the surfaced with the vertical alignment layer enhanced the azimuthal anchoring strength. We can obtain uniform domain which removed the reverse domain as shown in Fig. 3(b).

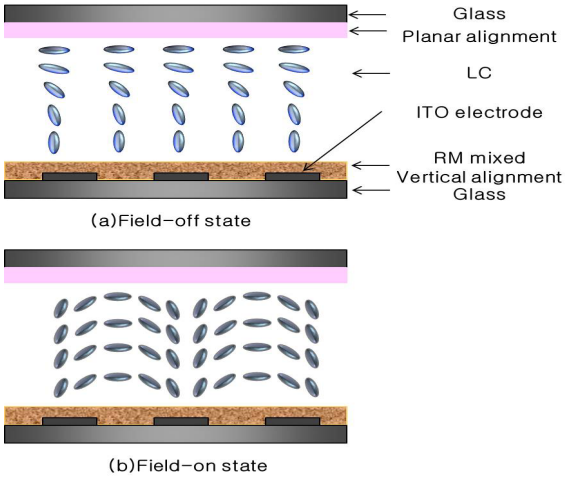

Fig. 2 Schematic diagrams of CH-IPS mode in bright and dark state

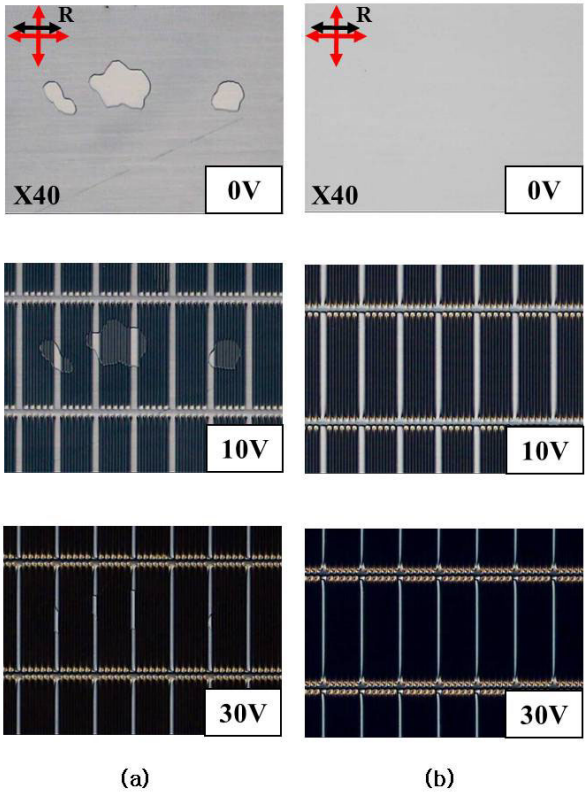

Fig. 3 Microscopic images of CH-IPS sample: (a) Conventional CH-IPS and (b) CH-IPS with the RM mixed with alignment layer

As a result, our proposed CH-IPS mode has a high transmittance and good dark state than those of the conventional CH-IPS mode. Figure 4 shows the measured electro-optic (EO) characteristics of the conventional IPS, the conventional CH-IPS, and proposed CH-IPS modes. The transmittance of the CH-IPS mode is about 30% higher than that of conventional IPS mode. Also, the advanced Ch-IPS mode exhibits the better EO performances than the conventional CH-IPS mode.

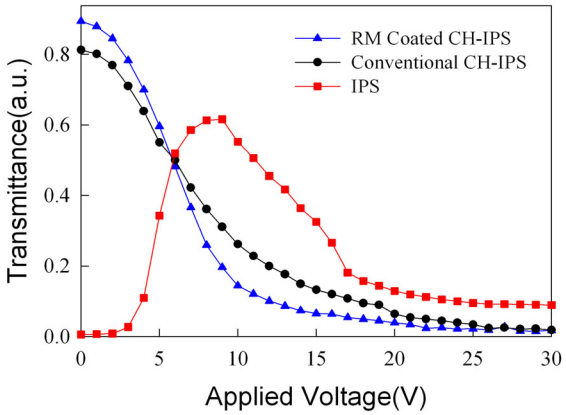

Fig. 4 The measured E-O characteristics of the conventional IPS, the conventional CH-IPS and the RM coated CH-IPS

4. CONCLUSION

We suggested the advanced CH-IPS mode with the stable uniform domain through the surface control by coating UV curable RMs mixed with vertical alignment material. The polymerized RMs on the surfaced of the vertical alignment layer enhanced the azimuthal anchoring strength. The strong anchoring energy removes the reverse domain and thus enhance the transmittance.

5. ACKNOWLEDGMENT

This research was supported by a grant (F0004121-2011-32) from information Display R&D Center, one of the Knowledge Economy Frontier R&D Programs funded by the Ministry of Knowledge Economy of Korean Government and Samsung Electronics, Ltd. (LCD).

REFERENCES

[1] M. Schadt and W. Helfrich, “Voltage-dependent optical activity of a twisted nematic liquid crystal,” *Appl. Phys. Lett*, pp. 127-128, Vol. 18 (2003).

[2] M.F. Shielel and K. Fahrenschon, “Deformation of Nematic Liquid Crystals with Vertical Orientation in Electrical Fields” *Appl. Phys. Lett*., pp. 391-393, Vol. 19 (1997).

[3] M. Oh-e and K. Kondo, “Electro-optical characteristics and switching behavior of the in-plane switching mode,” *Appl. Phys. Lett*., pp. 3895-3897, Vol. 67 (1995).

[4] J. S. Gwag, K. Sonh, Y. K. Kim and J. H. Kim, “Electro-optical characteristics of a chiral hybrid in-plane switching liquid crystal mode for high brightness,” *Opt. Express*, pp. 12220-12226, Vol. 16 (2008).