Image Sticking Property in the In-Plane Switching Liquid Crystal Display by Residual DC Voltage Measurements

Yong-Je Jeon, Dae-Shik Seo, Jae-Hyung Kim and Hyang-Yul Kim

Abstract - The residual DC phenomena in the in-plane switching(IPS)-liquid crystal display(LCD) by the voltage-transmittance (V-T) and capacitance-voltage (C-V) hysteresis method on rubbed polyimide (PI) surfaces were studied. We found that the residual DC voltage in the IPS-LCD was decreasing with the increasing concentration of cyano LCs. The residual DC voltage of the IPS-LCD can be improved by the high polarity of cyano LCs.
Keywords - nematic liquid crystal, in-palne switching liquid crystal display, cyano LC, residual DC voltage

1. Introduction

Nowadays, the thin-film-transistor(TFT)-liquidcrystal displays (LCDs) are widely utilized in notebook computers, mobile phones, and monitors because they have excellent resolution quality. However, LCD performance has not been satisfactory because of a narrow viewing angle. Previously some techniques have been proposed to improve the viewing angle characteristics such as the film-compensated twisted nematic (TN) cells, optically compensated birefringence (OCB) cells, in-plane-switching (IPS) cells, and multidomain vertical-alignment (MVA) cells. Also, the fringe field effects using a slit-patterned electrode and protrusion have been reported to improve the viewing angle.

IPS-LCD used for desktop monitors is required to have high resolution, a wide viewing angle, vivid color performance, and no image sticking[1]. It is well known that the PI layer influences the electrical properties of LC cells such as VHR and residual DC. It is commonly understood that the residual DC has some relations with image sticking. The image remains even after the display signal changes when the voltage is displayed for a long time. Recently, the residual DC voltages of the NLCs on the rubbed PI layers have been proposed by many researchers[2-4]. But, the residual DC in the IPS-LCD on the rubbed PI layers has not yet been reported.

In this work, we report the residual DC property in the IPS-LCD by the V-T and C-V hysteresis method on the rubbed PI surface.

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2. Experimental

Fig. 1 shows the structure of the IPS-LCD used in this study. The electrode width used was 10 μm, and electrode distance was 20 μm. The electrode was formed by MoW. The PI (AL-1051; for low pretilt, JSR Co., Ltd.) films were formed on the ITO (indium-tin-oxide) coated glass substrate by curing at 180° C for 1 hr. The rubbing[5] was treated by 78° to the electric field on the PI surfaces as shown in Fig. 1.

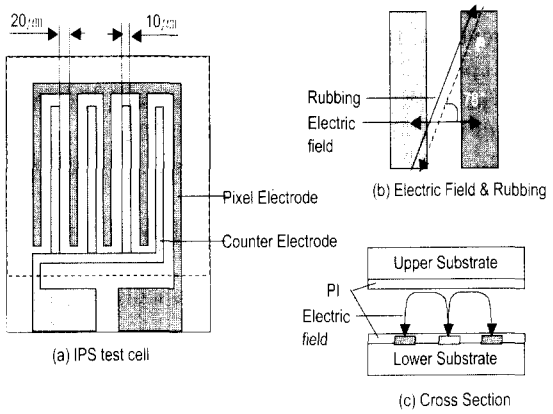

Fig. 1 Structure of the IPS-LCD

The IPS-LCD was assembled by an anti-parallel structure. The cell thickness was 4.7 μm. NLCs used were positive dielectric anisotropy. The IPS-LCD fabricated was an NB (normally black) mode. Table 1 shows the physical properties of the LCs. The residual DC voltage by the V-T hysteresis method was measured using the LCD evaluation system (LCD7000, Otsuka Co., Ltd.) as shown in Fig. 2.

Table 1 Physical properties of LCs

NLC	△n (25° C, 589nm)	△ε	Tni (° C)	η (mPas) (at 25° C)	ρ (25° C)	(mPas) (25° C)	CN (wt%)
C5023	0.075	7.2	72.0	18.9	$>1\times10^{13}$	90.1	0
C5048	0.075	7.3	71.6	17.9	5.4×10^{12}	88.8	5
C5049	0.075	7.3	71.5	18.3	2.9×10^{12}	84.3	10
C5050	0.075	7.2	71.1	18.1	3.8×10^{12}	82.4	15
C5051	0.075	7.3	70.9	18.2	9.2×10^{12}	80.2	20

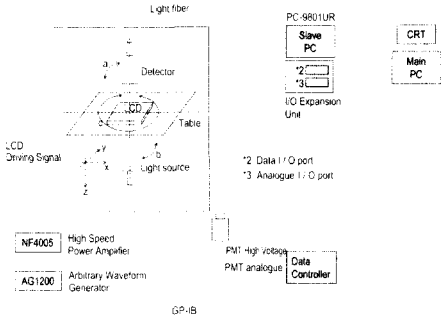

Fig. 2 Measurement system of V-T hysteresis

Also, the residual DC voltage by the C-V hysteresis method was measured using the LCR meter (4284A, Hewlett Packard Co., Ltd.) as shown in Fig. 3.

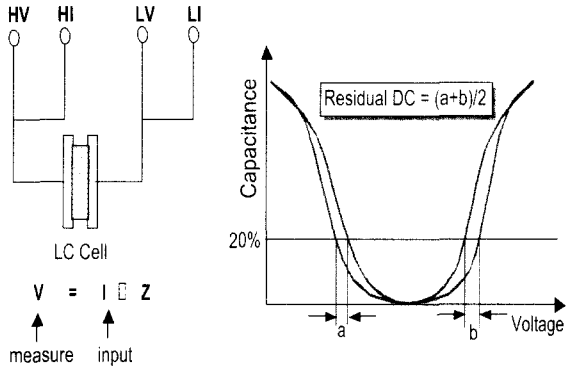

Fig. 3 Measurement system of C-V hysteresis

3. Results and Discussion

Fig. 4 shows the V-T hysteresis properties in the IPS-LCDs with different cyano NLC concentration on the rubbed PI surfaces. It is clearly observed that the transmittance hysteresis of the IPS-LCD decreases with increasing cyano LC concentration. Table 2 shows the residual DC voltage in the IPS-LCDs with different cyano LC concentration by the V-T hysteresis method on the rubbed PI surfaces. The residual DC voltage in the IPS-LCD decreases with increasing cyano LC concentration.

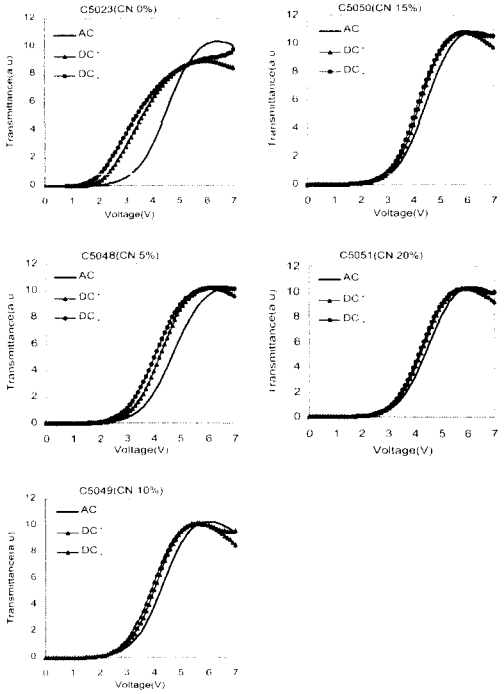

Fig. 4 V-T hysteresis characteristics in the IPS-LCDs with different cyano LCs concentrations on the rubbed PI surfaces.

Table 2 Residual DC voltage in the IPS-LCDs by V-T hysteresis method on the rubbed PI surfaces.

LC Materials	AC	DC↑	DC↓	AC-DC↑	DC↑-DC↓
C5023(CN 0%)	4.50	3.69	3.46	0.81	0.23
C5048(CN 5%)	4.68	4.23	4.03	0.45	0.20
C5049(CN10%)	4.25	4.00	3.90	0.25	0.10
C5050(CN15%)	4.42	4.22	4.13	0.20	0.09
C5051(CN20%)	4.38	4.21	4.14	0.17	0.07

Fig. 5 and 6 show the residual DC voltage characteristics of the IPS-LCDs with different cyano LC concentration on the rubbed PI surfaces. It is shown that the hysteresis of the capacitance of the NLC decreases with increasing cyano LC concentration as shown in Fig. 5.

Therefore, the residual DC voltage decreases with increasing cyano LC concentration. In a previous paper, a unified model of the residual DC phenomena has been proposed[3]. The residual DC characteristics are complex of two phenomena; one is the interfacial and dipole polarization of dielectric multi-layers and the other is the electric potential of adsorbed ions on the surface between the NLC and the PI layer. Consequently, the residual DC voltage of the IPS-LCD was decreasing with increasing concentration of cyano LCs, indicating that the high polarity of cyano LCs help reduce the residual DC voltage. Also, the residual DC can be improved by the high polarity of cyano LCs.

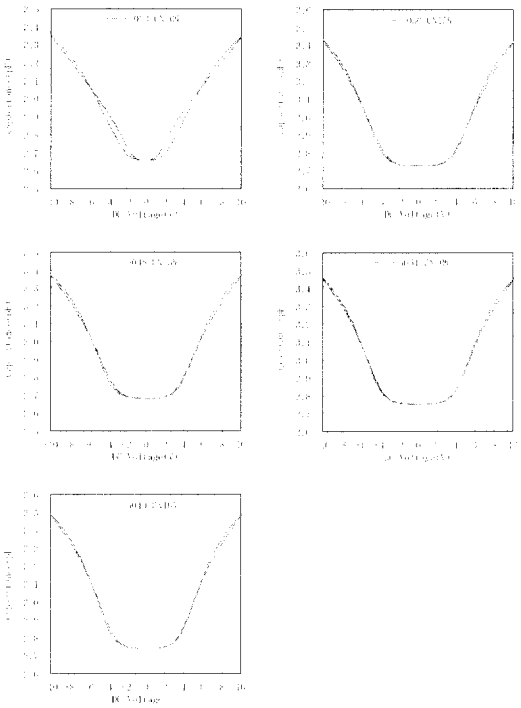

Fig. 5 C-V hysteresis of the IPS-LCDs with different cyano LCs concentrations on the rubbed PI surfaces.

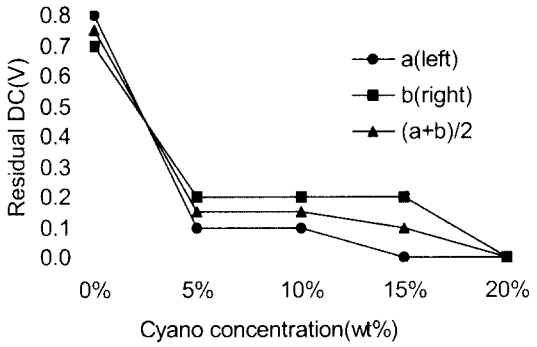

Fig. 6 Residual DC voltage of the IPS-LCDs on the rubbed PI surfaces as a function of cyano LC concentrations

4. Conclusion

In conclusion, the residual DC characteristics in the IPS-LCD by the V-T and C-V hysteresis method on the rubbed PI surfaces were investigated. The residual DC voltage in the IPS-LCD was decreasing with the increasing concentration of cyano NLCs. Also, the residual DC can be improved by the high polarity of LCs. Consequently, the residual DC voltage in the IPS-LCD can be improved by the low molecular weight and high polarity of cyano LCs.

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References

[1] M. Oh-e and K. Kondo, "Advantageous voltage-holding ratio characteristics induced by in-plane electric fields and the optimization concept of liquid crystals for an in-plane switching electro-optical effect", Liquid Crystals, Vol.25, pp.702, 1998.

[2] Y. Tanaka, Y. Goto, and Y. Iimura, "Mechanism of DC offset voltage generation in hybrid-aligned nematic liquid crystal displays", Jpn. J. Appl. Phys., Vol.38, pp.L1115, 1999.

[3] Y. Nakazono, T. Takagi, A. Sawada, and S. Naemura, "A novel model of residual DC in LC cells", IDW '98, pp.61, 1998.

[4] N. Fukuoka, M. Okamoto, Y. Yamamoto, M. Hasegawa, Y. Tanaka, H. Hatoh, and K. Mukai, "DC offset voltage in liquid crystal cells", AM-LCD '94, pp.216, 1994.

[5] D.-S. Seo, K. Muroi, and S. Kobayashi, "Generation of pretilt angles in nematic liquid crystal, 5CB, media aligned on polyimide films prepared by spin-coating and LB techniques: effect of rubbing", Mol. Cryst. Liq. Cryst., Vol.213, pp.223, 1992.

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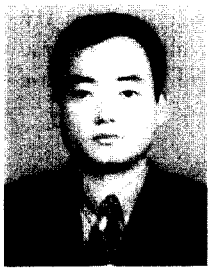

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