A Study on Fast Response Time for Twisted Nematic Liquid Crystal Display

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Fast response characteristics of twisted nematic liquid crystal display (TN-LCD) cell with different nematic liquid crystals (NLCs) and cell gap on a rubbed polyimide (PI) surface were studied. High transmittance and fast response time of the TN-LCD on the rubbed PI surface were achieved by using high birefringence (Δ n) and low cell gap. It is considered that the transmittance and response time of the TN-LCD on the rubbed PI surface decreased as Δ nd decrease.

Keywords : transmittance, response time, polyimide (PI), twisted nematic (TN), Δ nd.

1. Introduction

Active matrix (AM)-liquid-crystal displays (LCDs) are widely used in information display devices, such as notebook computers, monitors and televisions because they have excellent resolution quality. However, AM-LCD performance has not been satisfactory because of limitation of response time for displaying moving pictures.

Various techniques developed to improve slow response time of liquid crystal. Development of new mode in capable of fast optical switching, such as VA(vertical alignment) mode[1] with fast optical switching has been tried and progressed as well as OCB(optically compensated bend) mode[2] and ferroelectric liquid crystal. On the other side, combination method adjusting rotational viscosity and cell gap have been attempted to improve response time in a view of liquid crystal material and cell design.

These methods are pretty much reliable ways considering response time but fast switching is getting more interests because TN mode liquid crystal dominates major portion of the active matrix LCD. In this study, we investigated response time and electro-optic properties of normally white TN devices by using NLCs and cells with several cell gaps.

2. Experimental

In these experiments, we used a SE-7492 (from Nissan Chemical Industries Co.) for a homogeneous alignment layer. The polymer was coated on indium-tin-oxide (ITO)-coated glass substrates by spin-coating, and was imidized at 180℃ for 1 h. The thickness of PI layers was 500Å. The PI films were rubbed using a machine equipped with a nylon roller (Y_0-15-N, Yoshikawa Chemical Industries Co.). Rubbing strength (RS) used is 187 mm for the medium-rubbing region[3,4]. Physical properties of NLCs are shown in Table 1 and these values have been measured without adding chiral dopants. Table 2 shows NLCs and cell gaps in this experimental. The voltage transmittance (V-T) and response time were measured using the LCD evaluation system (LCD 7000, Otsuka).

Table 1. Physical properties of NLCs.

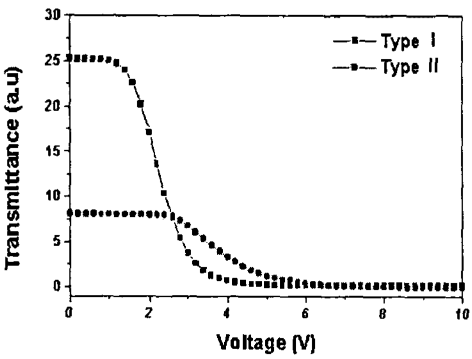
No	NLC	Δ n	Δ ε	Tni (℃)	η (mPas)
Type I	MLC-6295-000	0.2106	8.6	106.5	28
Type Ⅱ	C519LA	0.105	8.7	64.6	30
Type Ⅲ	MJ97359	0.0683	8.4	72	19

Table 2. NLCs and cell gap.

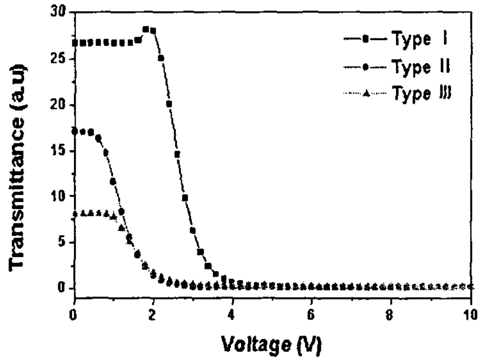
NLC	Δ n	d (μ m)	Δ nd
Type Ⅰ	0.2106	1.63	0.343
Type Ⅱ	0.105	1.83	0.192
Type Ⅰ	0.2106	3.53	0.743
Type Ⅱ	0.105	3.65	0.383
Type Ⅲ	0.0683	3.68	0.251
Type Ⅰ	0.2106	4.25	0.895
Type Ⅱ	0.105	4.30	0.452
Type Ⅲ	0.0683	4.43	0.303

3. Results and Discussion

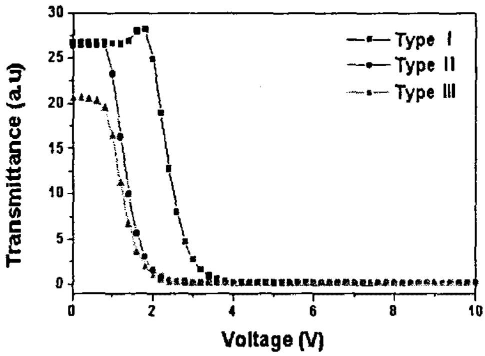
Figure 1 shows the voltage-transmittance (V-T) properties in the TN-LCDs with different NLCs and cell gap. Type Ⅰ which has the highest Δ n has the highest transmittance among three NLCs regardless of cell gap d. Also, Transmittance was decreased with decreasing Δ nd in similar cell gap d. In brief, TN-LCD with high Δ nd has higher transmittance. However, threshold voltage (V_{th}) has lower value with decreasing Δ n.



(a) cell gap ≒ 1.7 μ m



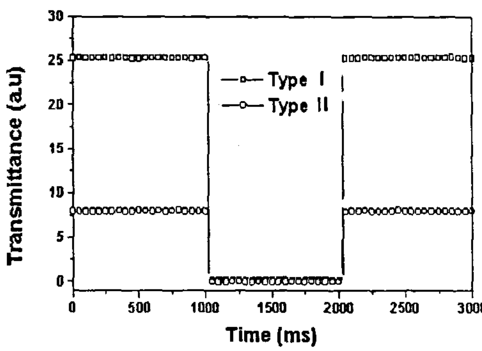
(b) cell gap ≒ 3.5 μ m



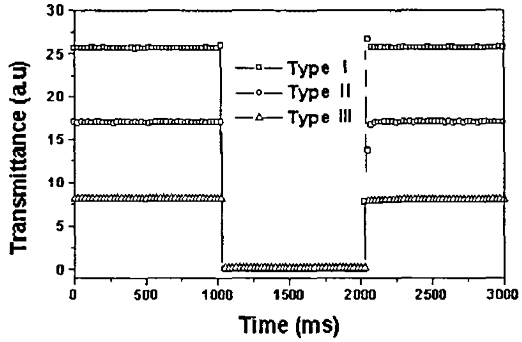
(c) cell gap ≒ 4.3 μ m

Fig. 1. V-T characteristics of the TN-LCD as NLCs and cell gap d on the rubbed PI surface.

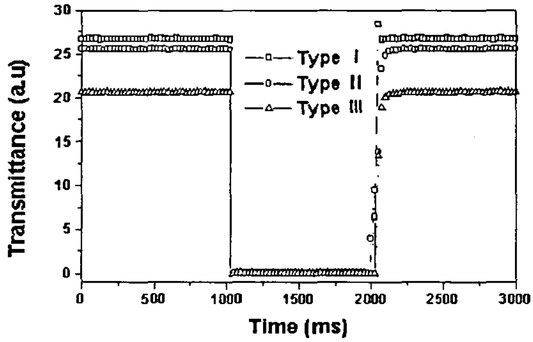
Figure 2 shows response properties in the TN-LCD with NLCs and cell gap.



(a) cell gap ≒ 1.7 μ m



(b) cell gap ≒ 3.5 μ m



(c) cell gap ≒ 4.3 μ m

Fig. 2. Response characteristics of the TN-LCD as NLCs and cell gap d on the rubbed PI surface.

Table 3 shows the response characteristics with different NLCs and cell gap. TN-LCD with higher Δ n has faster response time in same cell gap as shown in Table 3. Although TN-LCD with low Δ n has faster response time, the transmittance of the TN-LCD is low.

Consequently, TN-LCD should have high Δ n and low cell gap for high transmittance and fast response time in this experiment.

Table 3. Response times of the TN-LCD as NLCs and cell gap on the rubbed PI surface.

No	Δ n	d(μ m)	Response time		
			τ_r	τ_f	τ
1	0.2106	1.63	1.5	3.6	5.1
2	0.105	1.83	1.7	3.8	5.5
3	0.2106	3.53	0.8	9.5	10.4
4	0.105	3.65	1.6	15.6	17.2
5	0.0683	3.68	0.8	23.9	24.7
6	0.2106	4.25	0.8	16.1	16.9
7	0.105	4.30	0.8	44.3	45.1
8	0.0683	4.43	1.1	35.7	36.8

4. Conclusion

We investigated electro-optical (EO) properties of TN-LCD on a rubbed PI surface with different NLCs and cell gap. Some of EO characteristics are also observed in practical experiment. EO characteristics of TN-LCD on a rubbed PI surface can be improved with increasing Δ n. Especially, In case of using NLCs that has birefringence more than 2 and cell gap that is 1.7μ m, response time of TN-LCD is very fast by 5.1ms.

Acknowledgements

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