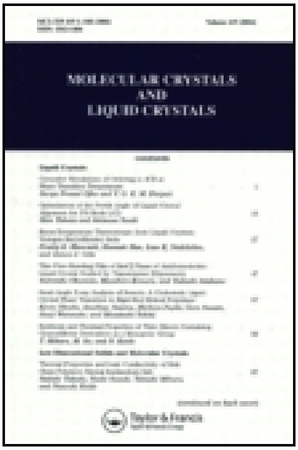

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A Study on Wide Viewing Angle and Fast Response Time Characteristics for the Novel VA Mode

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A Study on Wide Viewing Angle and Fast Response Time Characteristics for the Novel VA Mode

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We investigated the wide viewing angle and the fast response time characteristics for negative dielectric anisotropy nematic liquid crystal (NLC) using a vertical-alignment (VA) mode on a rubbed polyimide (PI) surface. Good voltage-transmittance (V-T) curves using a VA – 1/4 π cell and a VA-π cell without a negative compensation film were measured. The iso-viewing angle characteristics using a VA - 1/4 π cell and a VA-π cell without a negative compensation film can be achieved. The fast response time of 24.2 ms for NLC was successfully observed. Consequently, the iso-viewing angle, fast response time, and low driving voltage characteristics using a VA – 1/4 π cell and a VA-π cell on a rubbed PI surface can be achieved.

Keywords: vertical alignment; rubbing; wide viewing angle; nematic liquid crystal; VA – 1/4π cell; VA-π cell

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 the narrow viewing angle.

Various techniques developed to improve the viewing angle characteristics have been presented, such as the addition of birefringence films,[1] domain-divided (DD) twisted nematics (TNs),[2] in-plane-switching (IPS) mode,[3] and multi-domain VA mode.[4,5] MVA-LCD is expected to achieve a wide viewing angle and fast response time. However, a method of dividing each pixel into multi-domains and a fringe field are required in MVA-LCD. The optically compensated bend (OCB) mode has been introduced to improve the narrow viewing angle and response time.[6] However, this mode may have some difficulties with regard to controlling the LC conformation and pretilt angle. In addition, a fast response time of the AM-LCD is required in order to achieve high-quality images in a large area. Recently, we reported the electro-optical (EO) performance for a novel VA - 1/4 π cell on a rubbed PI surface.[7]

In this study, we report the EO performance using a novel VA - 1/4 π cell and a VA - π cell on a rubbed rubbed PI surface.

EXPERIMENTAL

In these experiments, we used a JALS-696-R2 (from Japan Synthetic Rubber Co., Ltd.) for a homeotropic alignment layer. The polymer was coated on indium-tin-oxide (ITO)-coated glass substrates by spin-coating, and were 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_o-15-N, Yoshikawa Chemical Industries Co., Ltd.). The definition of the rubbing strength (RS) has been given in previous papers.[8-11] The RS used is 187 mm for the medium-rubbing region. The VA - 1/4 π cell was assembled by a twist of 45 degrees with the rubbing direction. The LC layer thickness for a VA - 1/4 π and VA - π cell was set at 4.25μm. NLC is used in negative- type dielectric permittance. The voltage transmittance (V-T), viewing angle, and response time measurements for a VA - 1/4 π cell and a VA -π cell were performed at room temperature (22℃).

RESULTS and DISCUSSION

Figure 1(a) shows a schematic diagram of a VA - 1/4 π cell without optically compensated film in the off- and on-state. In the off-state, the NLC directors are aligned vertically to the glass substrates. Under the crossed polarizers and in the normal viewing direction there is only an ordinary wave and no phase retardation to modulate the polarization of light. Therefore, the off-state of a VA - 1/4 π cell is very dark in the normal direction. In the on-state, it requires pretilt to reorient in order to be perpendicular to the electric anisotropy. By the implications of pretilt, the stable LC director field is symmetrically aligned and the light is transmitted with this transition.

Figure 1(b) shows the schematic diagram of a VA -π cell without negative compensation film, in the off- and on-state. In the off-state, the NLC directors are aligned vertically to the glass substrates.

Figure 2 shows the V-T curves of a various VA cells without a negative compensation film on a rubbed PI surface. A good V-T curve of a VA - 1/4 π cell was measured as shown in Figure 2(a). Also, a good V-T curve of a VA-π cell was observed as shown in Figure 2(b). The light leakage in the off-state was measured. Utilizing a negative compensation film can usually compensate the light leakage. The V-T characteristics of a conventional VA cell on a rubbed PI surface are shown in Figure 2(c). A good V-T curve of a conventional VA cell is obtained. Table 1 shows the threshold voltage for the three kinds of cells on a rubbed PI surface. The threshold voltage of a VA - 1/4 π cell and a VA-π cell is shown to be almost the same when compared to a conventional VA cell.

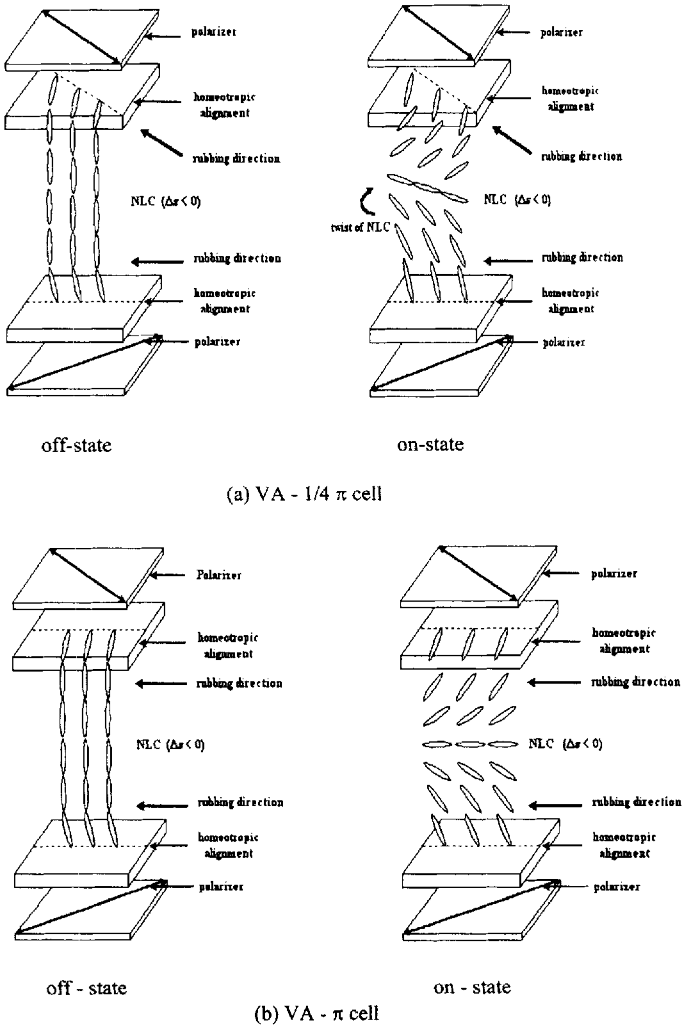
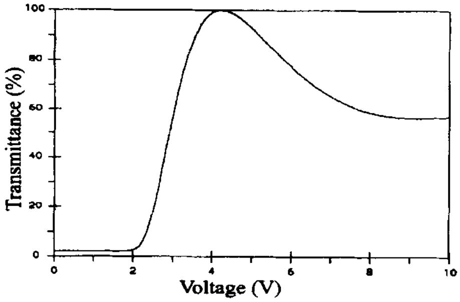
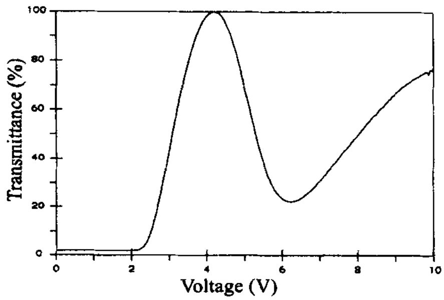


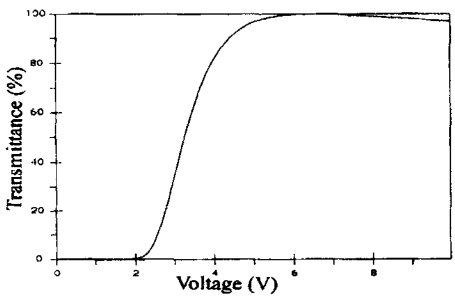
FIGURE. 1 Schematic diagram of VA cells without negative compensated film in the off- and on-state. (a) VA - 1/4 π cell, (b) VA - π cell.



(a) VA - 1/4 π cell



(b) VA - π cell

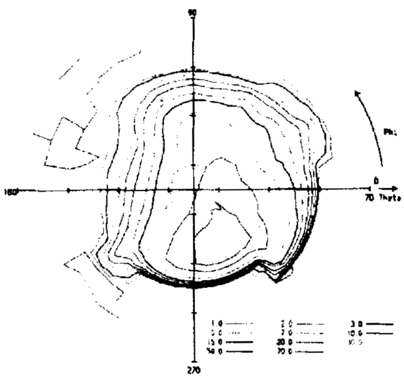


(c) Conventional VA cell

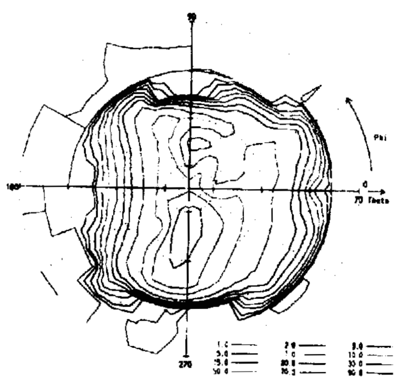
FIGURE. 2 V-T curves of various VA cells without a negative compensation film on a rubbed PI surface. (a) VA - 1/4 π cell, (b) VA - π cell, (c) conventional VA cell.

TABLE 1. Threshold voltages for various VA cells on a rubbed PI surface.

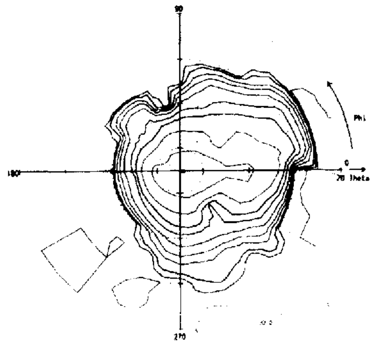
Cells	V_{10}	V_{90}
VA - 1/4 π cell	2.38	3.57
VA -π cell	2.54	3.72
Conventional VA cell	2.56	4.39



(a) VA −1/4 π cell



(b) VA-π cell

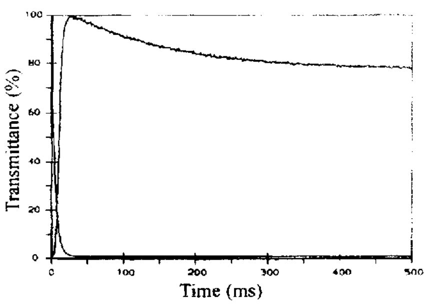


(c) Conventional VA cell

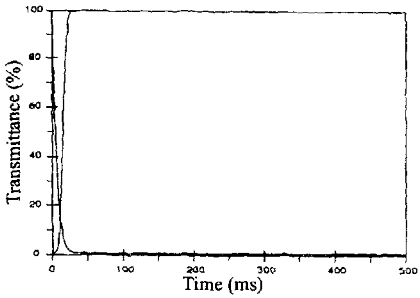
FIGURE 3 Viewing angle characteristics for various the VA cells without a negative compensation film on a rubbed PI surface. (a) VA-1/4 π cell, (b) VA-π, (c) conventional VA cell.

Figure 3 shows the viewing angle characteristics for the three kinds of VA cells without a negative compensation film on a rubbed PI surface. The iso-viewing angle characteristics have been successfully measured with their characteristics being dependent on the level of darkness. Therefore, a wide viewing angle can be achieved by utilizing a negative compensation film. The asymmetric viewing angle characteristics were observed in a conventional VA cell as shown in Figure 3(c).

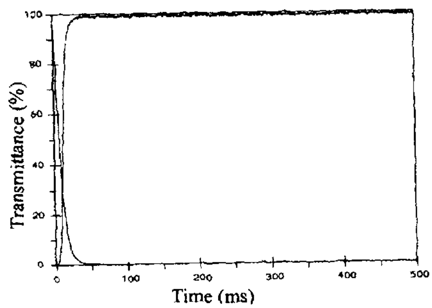
Figure 4 shows the response time characteristics for the three kinds of a VA cells without a negative compensation film on a rubbed PI surface. Fast response time characteristics for a VA - 1/4 π cell and a VA - π cell were obtained. The excellent response time characteristics of a conventional VA cell were measured. Table II shows the response time for various VA cells on rubbed PI surfaces. The response time of a VA - 1/4 π cell was measured at approximately 24.4 ms. Therefore, a fast response time of a VA - 1/4 π cell mode without a negative compensation film can be achieved. The response time of a VA - 1/4 π cell was faster than that of a conventional VA cell. The response time of a VA- π cell was measured; this was faster than that of a conventional VA cell.



(a) VA-1/4 π cell



(b) VA-π cell



(C) Conventional VA cell

FIGURE 4 Response time characteristics of the VA cells without a negative compensation film on a rubbed PI surface. (a) VA-1/4 π cell, (b) VA-π cell, (c) conventional VA cell.

TABLE 2. Response times for various VA cells on a rubbed PI surface.

Cells	τ_r(ms)	τ_d(ms)	τ (ms)
VA – 1/4 π cell	12.4	12.0	24.4
VA -π cell	19.1	13.6	32.7
Conventional VA cell	18.1	18.5	36.6

CONCLUSION

In conclusion, the EO performances for a VA – 1/4 π cell and a VA -π cell without a negative compensation film on a rubbed PI surface were studied. The iso-viewing angle and fast response time using a VA - 1/4 π cell and a VA-π cell on a rubbed PI surface was achieved. We suggest that the developed a VA - 1/4 π cell and a VA-π cell on a rubbed PI surface is a promising technique to improve a wide viewing angle and a fast response time.

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