Wide viewing angle and fast response time using novel vertical-alignment - 1/4 π cell mode

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Abstract

The wide viewing angle and fast response time characteristics of negative dielectric anisotropy nematic liquid crystal (NLC) using a novel vertical-alignment (VA) - 1/4 π cell mode on a homeotropic alignment layer were investigated. Good voltage-transmittance curves and low driving voltage using the novel VA - 1/4 π cell mode without a negative compensation film were obtained. The iso-viewing angle characteristics of NLC using the novel VA - 1/4 π cell mode without a negative compensation film can be achieved. The fast response time of 24.4 ms in NLC was successfully measured. The iso-viewing angle, fast response time, and low driving voltage characteristics using the novel VA - 1/4 π cell mode can be achieved.

Introduction

TFT-LCD performance has not been satisfactory because of the narrow viewing angle and slow response time. Various techniques developed to improve the viewing angle characteristics have been presented such as the addition of birefringence films, domain divided (DD) twisted nematic (TN), in-plane-switching (IPS) mode, and multi domain vertical alignment (VA) mode [1, 2]. MVA-LCD is expected to achieve as such a wide viewing angle, fast response time, and high contrast ratio. However, the method of dividing each pixel into multi-domains and a fringe field are required in MVA-LCD. Also, the optically compensated bend (OCB) mode has been introduced to improve the response time [3].

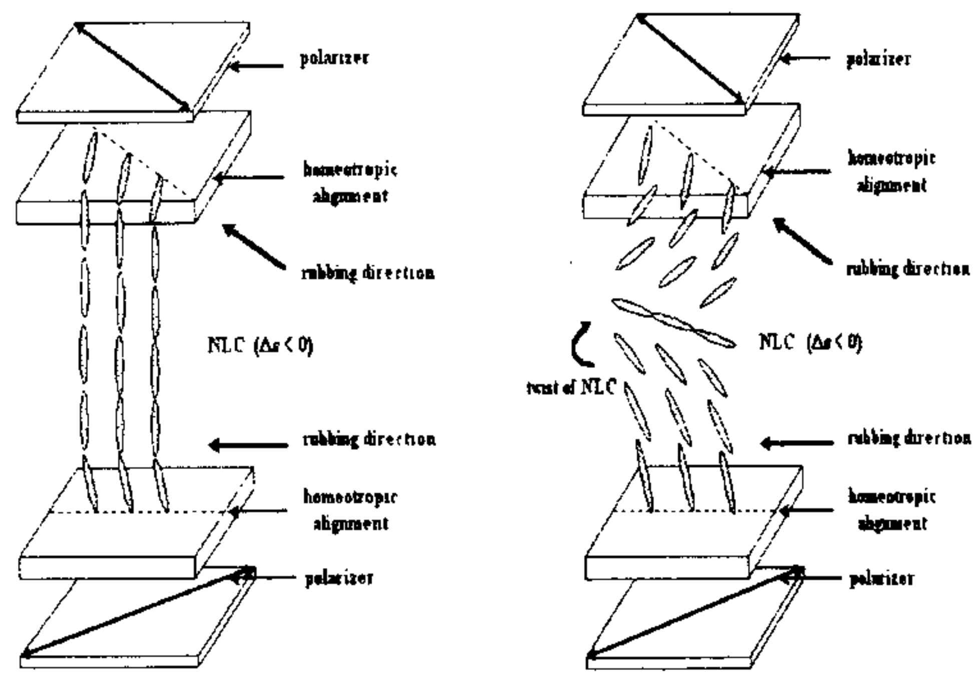
In this work, we report the viewing angle and fast response time characteristics of negative type NLC using a novel VA - 1/4 π cell mode on a rubbed homeotropic layer.

Experimental

In these experiments, we used a JALS-696-R2 for a homeotropic alignment layer. The polyimide (PI) films were coated on indium-tin-oxide (ITO) coated glass substrates by spin-coating, and were imidized at 180℃ for 1 hour. The thickness of PI layers was 500Å. The PI films were rubbed using a machine equipped with a nylon roller. The rubbing strength (RS) has been used for medium rubbing region. The LC cell was assembled by a twist of 45 degrees with rubbing direction. The LC layer thickness of a VA - 1/4 π cell was set at 4.25 μm. NLC is used in a negative type of dielectric permittance. The voltage-transmittance, viewing angle, and response time measurements of a VA - 1/4 π cell mode were performed at room temperature (22℃).

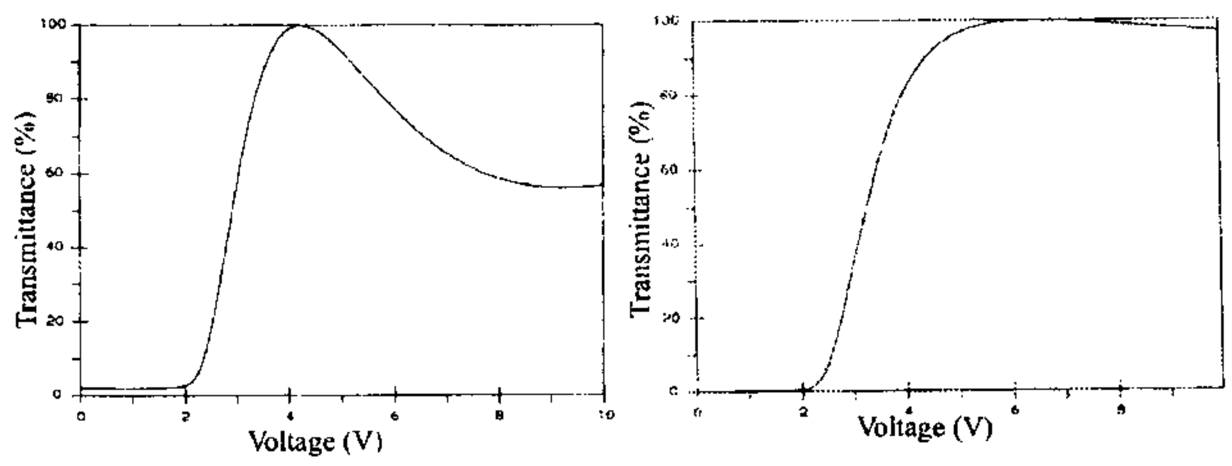
Result and Discussion

Figure 1 shows the schematic diagram of a VA - 1/4 π cell mode without optically compensated film in the off and on state. In the off state, the LC directors are aligned vertically to the glass substrates. Under the crossed polarizers and in normal viewing direction there is only an ordinary wave and no phase retardation to modulate the polarization of light. Therefore, the off state of novel the VA - 1/4 π cell mode is very dark in the normal direction. In the on state, in order to be perpendicular to the electric anisotropy, we need the implication of pretilt to reorient. By the implications of pretilt, the stable LC director field is symmetrically aligned. With this transition, the light is transmitted. The symmetric LC director fields can reduce the gray scale inversion in a large viewing angle.



(a) off-state (b) on-state

Fig. 1. Schematic diagram of a novel VA-1/4 π cell mode without a negative compensated film in the off- and on-state.



(a) VA-1/4 π cell (b) conventional VA cell

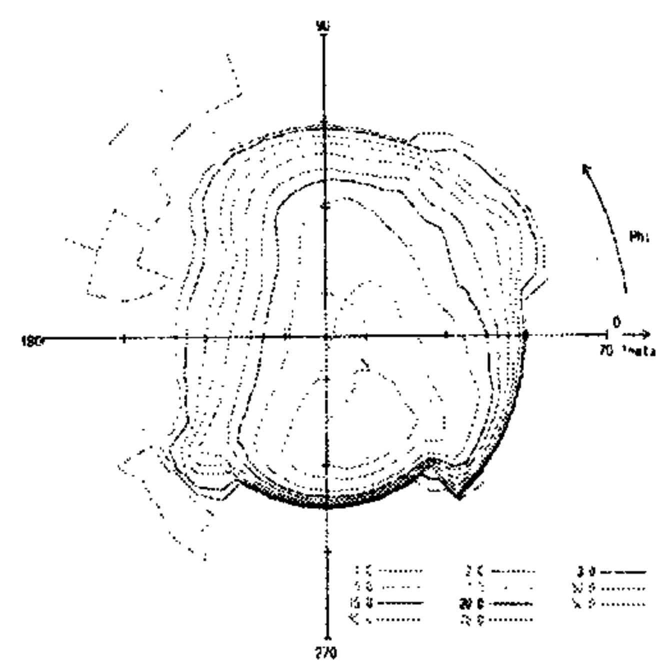
Fig. 2. V-T characteristics of the novel VA-1/4 π and the conventional VA cell without a negative compensation film on a homeotropic PI surface.

Figure 2 (a) shows the V-T characteristics of the VA - 1/4 π cell without a negative compensation film on a homeotropic PI surface. It is shown that a good V-T curve of a VA - 1/4 π cell was measured. The V-T characteristics of a conventional VA cell on a homeotropic PI surface is shown in Fig. 2 (b). The good V-T curve of a conventional VA cell is obtained. Table 1 shows the threshold voltage for a novel VA - 1/4 π cell and a conventional VA cell on a homeotropic PI surface. It is shown that the threshold voltage of a novel VA - 1/4 π cell is almost the same when compared to that of a conventional VA cell.

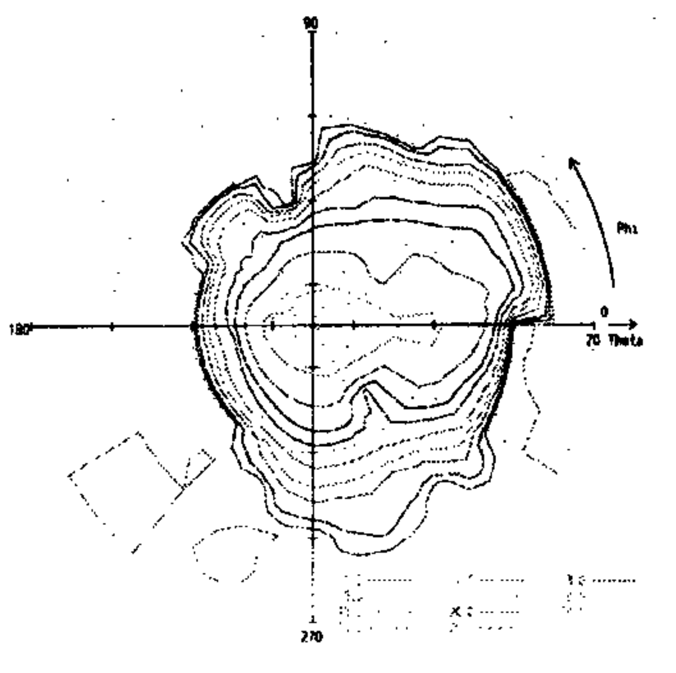
Table 1. Threshold voltage for VA modes on a homeotropic PI surfaces.

Mode	V_{10}	V_{90}
novel VA - 1/4 π cell	2.38	3.57
conventional VA cell	2.56	4.39

Figure 3 (a) shows the viewing angle characteristics of a novel VA - 1/4 π cell without negative compensation film on a homeotropic PI surface. It is shown that the iso-viewing angle characteristics are successfully measured. Also, viewing angle characteristics are dependent on the state of darkness. Therefore, the wide viewing angle can be achieved by utilizing a negative compensation film. The asymmetric viewing angle characteristics were measured in a conventional VA cell as shown in Fig. 3 (b).



(a) VA-1/4 π cell



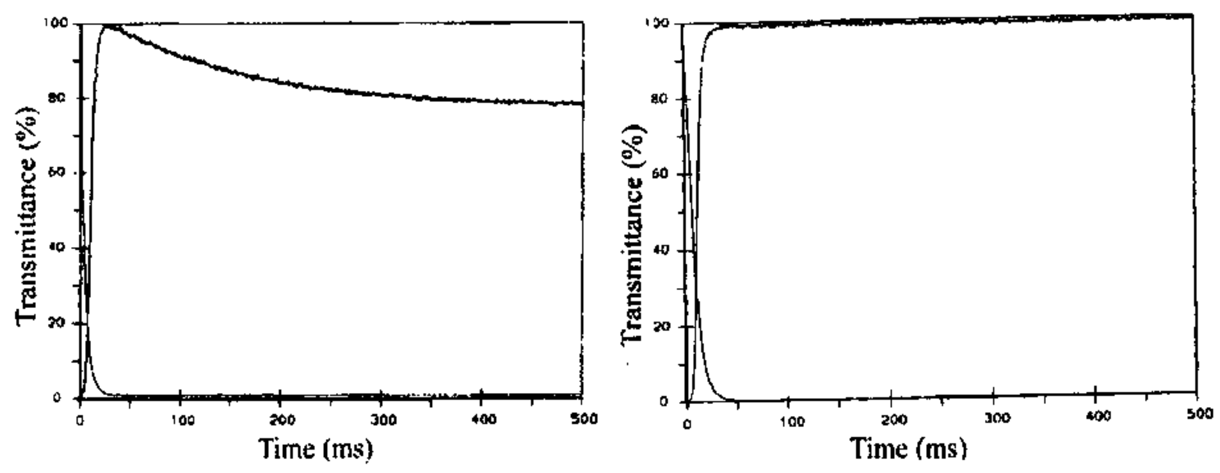
(b) conventional VA cell

Fig. 3. Viewing angle characteristics of the novel VA-1/4 π and the conventional VA cell without a negative compensation film on a homeotropic PI surface.

Figure 4 (a) shows the response time characteristics of a novel VA - 1/4 π cell without a negative compensation film on a homeotropic PI surface. The fast response time characteristics were obtained. The response time characteristics of a conventional VA cell on a homeotropic PI surface are shown in Fig. 5 (b). Also, the excellent response time characteristics of a conventional VA cell were measured. Table 2 shows the response time for a VA - 1/4 π cell and a conventional VA cell on homeotropic PI surfaces. The response time of a novel VA - 1/4 π cell mode was measured at about 24.4 ms. Therefore the fast response time of a novel VA - 1/4 π cell mode without a negative compensation film can be achieved. The response time of a novel VA - 1/4 π cell is faster than of a conventional VA cell.

Table 2. Response time for VA modes on a homeotropic PI surfaces.

Mode	τ_r(ms)	τ_d(ms)	τ (ms)
novel VA – 1/4 π cell	12.4	12.0	24.4
conventional VA cell	18.1	18.5	36.6



(a) VA-1/4 π cell (b) conventional VA cell

Fig. 4. Response time characteristics of the novel VA-1/4 π cell and the conventional VA cell without a negative compensation film on a homeotropic PI surface.

Conclusion

We investigated the novel VA – 1/4 π cell mode without a negative compensation film. Consequently, the iso-viewing angle and fast response time using a novel VA - 1/4 π cell mode was achieved. We suggest that the developed novel VA - 1/4 π cell mode on a homeotropic layer is a promising technique for the achievement of a wide viewing angle, fast response time, and a high contrast ratio.

References

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