EO Characteristics of the New MVA-LCD using a Crossed Stripe Grating-Groove Vertical Alignment (CGVA) Layer

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Abstract

Electrooptical (EO) characteristics of a new multidomain vertical-alignment (MVA) liquid crystal display (LCD) with negative dielectric anisotropy on a homeotropic photopolymer were studied. Good voltage-transmittance (V-T) curves of the new MVA-LCD on the homeotropic photopolymer were obtained. Also, the stable response time of the new MVA-LCD on the homeotropic photopolymer was achieved. The viewing angle of the new MVA-LCD could be improved by a crossed stripe grating-groove surface as the alignment layer using a photolithograph method on the photopolymer.

Key Words : multidomain vertical-alignment cell, photolithograph, nematic liquid crystal, photopolymer, electrooptical characteristics

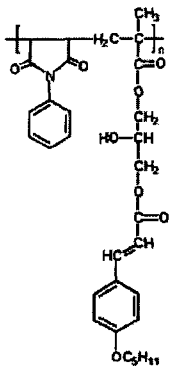
1. INDUCTION

A thin-film-transistor (TFT) - liquid crystal display (LCD) is widely used for desktop PCs, notebook-type PCs, and TVs. Active-matrix (AM) LCDs equipped with a twisted nematic (TN) cell. However, the LCD performance using the TN cell has not been satisfactory due to narrow viewing angles. To improve the viewing angle characteristics, various techniques have been proposed, such as the use of birefringence films [1], the in-plane-switching (IPS) mode[2], and the multidomain vertical-alignment (MVA) mode[3,4]. The MVA mode provides excellent performance characteristics such as high brightness, high contrast, and wide viewing angle. However, an MVA-LCD that each pixel be divided into multidomains and a fringe field be created to improve the viewing angle characteristics. One method for forming multidomains is that the surface with protrusion controls LC alignment[3]. The other method is that such patterns on the indium-tin-oxide (ITO) electrodes make a multidomain structure, spontaneously formed by an electric field[4-6]. However, each mode has its own disadvantages such as slow response time, low aperture ratio, and complicated production process.

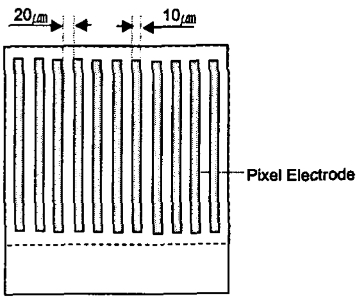
In this study, we report on EO characteristics for NLC with negative dielectric anisotropy using a crossed stripe grating-groove vertical alignment (CGVA) layer as the new MVA-LCD on a grating surface with a homeotropic photopolymer.

2. EXPERIMENTAL

Figure 1(a) shows the chemical structure of PMI5CA, poly {*N*-(phenyl)maleimide -co-3-[4-(pentyloxy)cinnamate]propyl-2-hydroxy-1 -methacryl-ate}, for homeotropic LC alignment used in this study.14) The polymers were coated on ITO-coated glass substrates by spin-coating and exposed to UV for 1 min. We used a slit electrode for a photolithograph pattern as shown in Fig. 1(b). For a slit electrode, the electrode distance was 20 ㎛, and the electrode width was 10 ㎛. The electrode used was Cr.



(a) Material



(b) UV pattern

Fig. 1. Chemical structure of PMI5CA and UV pattern used in this study.

A grating groove was obtained by development of a photopolymer film after patterned exposure as shown in Fig. 2. The grating groove was used as the alignment layer for the MVA-LCD. The cell was assembled by crossing at 90 degree in the photolithograph direction on the upper and bottom substrates. The MVA-LCD was set at 4.0 m. The NLC is used in negative dielectric anisotropy ($\Delta\varepsilon = -4$, from Merck Co.). The MVA-LCD fabricated was normally black (NB) mode. The voltage transmittance (V-T) and viewing angle measurements for the new MVA and conventional VA-LCD were performed at room temperature (22℃). The EO characteristics of the MVA-LCD were measured using an LCD evaluation system (LCD7000, Otsuka Co.).

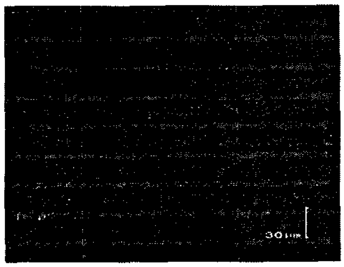
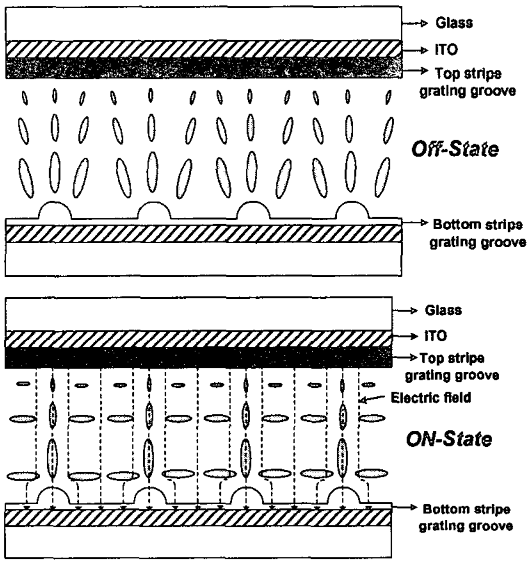


Fig. 2. Microphotographs of the photopolymer surface after photolithography.

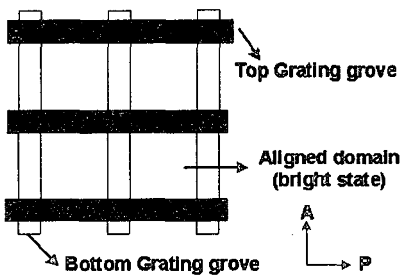
3. RESULTS AND DISCUSSION

Figure 3 shows schematics of the top and side views of the CGVA as the new MVA-LCD using a homeotropic photopolymer without an optically compensated film. Figure 3(a) shows a schematic drawing of the LC cell structure with the grating groove surface as the alignment layer on the top and bottom substrates. In the off-state, LC directors are aligned vertically to the glass substrates, and under crossed polarizers the cell appears black. A symmetric and small tilt around the grating groove is generated by the grating grove without a utilizing rubbing process. Therefore, the LC molecule in the center part of groove at initial state is located to homeotropic alignment, and the other LC molecules in the outside part of grooves is tilted toward the incline plane of the grating groove shown in Fig. 3(a).

A stripe grating-groove is a dielectric material. It contributes to the fringe field effect. Therefore, LC molecules are aligned perpendicular to an equipotential surface produced by the topographical and fringe field effects. When a bias voltage was applied to the electrodes, the NLC molecules were vertically transformed to the electric field. In the electric field, the stable LC director field was symmetrically aligned. The light was transmitted by the transition of the NLC molecules. The top view of the CGVA using the grating-groove surface as the alignment layer is shown in Figure 3(b). The CGVA cell was assembled by crossing it on the top and bottom substrates as illustrated in Fig. 3 (b).



(a) Side View



(b) Top View

Fig. 3. Schematics of the top and side views of the CGVA-LCD.

This crossed cell forms periodical microdomains in the pixel cell because deformation of LC molecules occurs in the region of topographical LC alignment and spatial variations of the electric field across the dielectric alignment surface. Therefore, due to the structure of the topographical effect and electric field, LC molecules form a periodical bright region to add the multidomains of the CGVA cell.

We consider that the multidomains were formed by the crossed grating-groove using the photolithograph method on the photopolymer with utilizing the rubbing-free process. The wide viewing angle for the CGVA-LCD is attributable to multidomains.

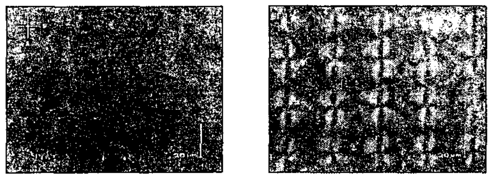


Fig. 4. Microphotographs of the CGVA cell on the homeotropic photopolymer sufaces.

Figure 4 shows the microphotographs of the CGVA using the homeotropic photopolymer surfaces. Without an no applied voltage, LC is homeotropically aligned so that a dark state similar to a normal VA state is obtained. Upon the application of voltage, the axially symmetric structure can be observed along the microgroove arrays. The multidomain alignment of the NLC on the polymer surface can be observed.

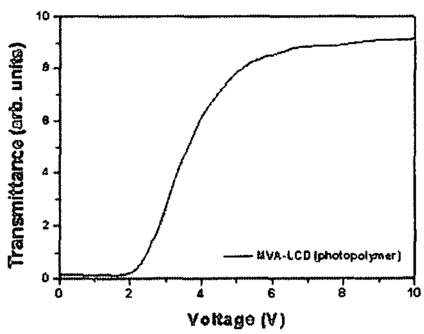


Fig. 5. V-T curve of the CGVA-LCD using the homeotropic photopolymer surface.

Figure 5 shows the V-T characteristics of the CGVA-LCD using the homeotropic photopolymer. A good V-T curve for the CGVA-LCD was obtained. A small light leakage in the off-state was observed. Usually, utilization of a negative compensation film compensates for the light leakage.

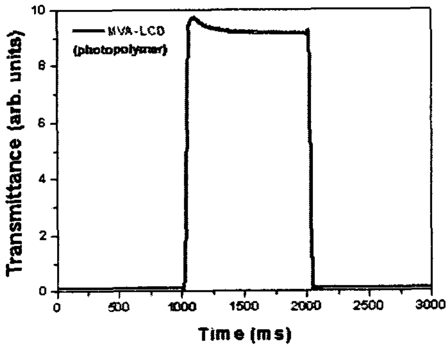


Fig. 6. Response time characteristics of the CGVA-LCD on the homeotropic photopolymer surface.

Figure 6 shows the response time characteristics of the CGVA-LCD using the homeotropic photopolymer. A stable response time of the CGVA-LCD on the homeotropic photoplymer surface was obtained.

4. CONCLUSION

In conclusion, we have investigated the EO performances for NLC with negative dielectric anisotropy using the CGVA-LCD on the homeotropic photopolymer surface without utilizing the rubbing process. Stable V-T and response time curves using the CGVA-LCD on the homeotropic photopolymer were obtained. The viewing angle of the CGVA-LCD using the homeotropic photopolymer could be improved. Consequently, we suggest that the wide viewing angle of the CGVA-LCD is attributed to multidomains produced by the grating-groove surface as the alignment layer with the photolithograph method on the photopolymer.

4. ACKNOWLEDGEMENTS

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