Electro-optical Characteristics of a Multi-domain Vertical-alignment Liquid Crystal Display on Homeotropic Photopolymer Layer

Jeoung-Yeon Hwang, Kyung-Jun Lee, and Dae-Shik Seo
Dept. of Electrical & Electrical Eng. (A-226), College of Eng., Yonsei Univ., Seoul, Korea

Abstract

Electro-optical characteristics of new multi-domain vertical-alignment (MVA) liquid crystal displays (LCDs) with negative dielectric anisotropy on a homeotropic photopolymer were studied. Good voltage-transmittance (V-T) curves by the new MVA-LCD on the homeotropic photo-polymer were obtained. Also, the stable response time of MVA-LCD on the homeotropic photopolymer can be achieved. The viewing angle of the new MVA-LCD could be improved by the grating groove with UV exposure and development on the photo-polymer.

1. Introduction

Active-matrix (AM) liquid crystal displays (LCDs) are adopted a twisted nematic (TN) cell. But, LCD performance using the TN cell has not been satisfactory due to the narrow viewing angles. To improve the viewing angle characteristics, various techniques have been proposed, such as the addition of birefringence films [1], the in-plane-switching (IPS) mode [2], and the multi-domain vertical-alignment (MVA) mode [3]. MVA-LCD requires the dividing each pixel into multi-domains and creating a fringe field to improve the viewing angle characteristics. In this study, we report on electro-optical (EO) characteristics for NLC with negative dielectric anisotropy using the new MVA cell with UV exposure and development on the homeotropic photopolymer surface.

2. Experimental

Figure 1 shows the chemical structure of the PMI5CA, poly {*N*-(phenyl)maleimide -co-3-[4-(pentyloxy)cinnamate]propyl-2-hydroxy-1-methacrylate}, for homeotropic LC alignment used in this study [4]. The polymers were coated on indium-tin-oxide (ITO)-coated glass substrates by spin coating and exposed by UV for 1 min. The UV source was a 500 W Murray lamp. The UV was exposed on the substrates. The energy density of UV used was 33.2 mW/cm^2. The thickness the polymer layer was 1200Å.

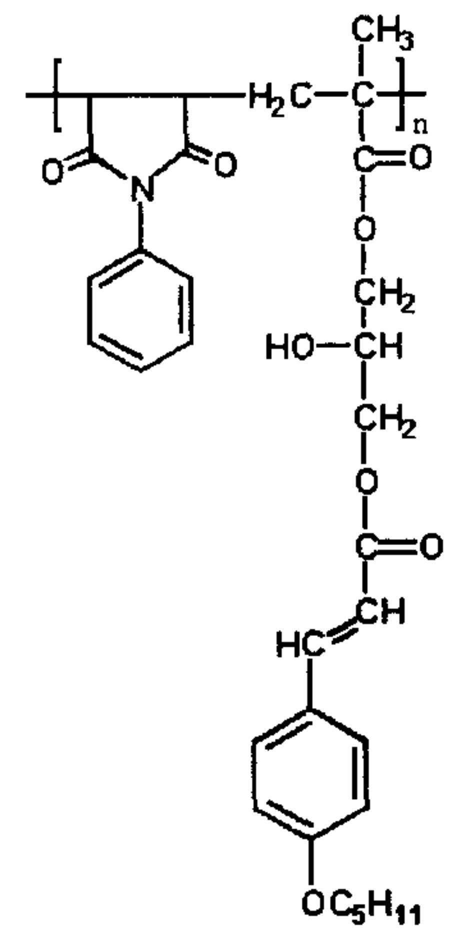


Figure 1. Chemical structure of PMI5CA used in this study.

Figure 2 shows the schematic diagram of photolithograph pattern used. We used a slit electrode for photolithograph pattern. For slit electrode, the electrode distance was 20 μm, and the electrode width was 5 μm. The electrode used was Cr. The photopolymer film was developed with the developing solution. The photo-dimerization material was used a negative type photoresist film. Therefore, we can use a photoalignment, together with a photolithograph. The grating groove was obtained by development of the photopolymer film after patterned exposure as shown Fig. 3. The cell was assembled by cross of 90° with photolithograph direction in upper and bottom substrate. The MVA cells was set at 4.0 μm. NLC is used in negative dielectric anisotropy ($\Delta\varepsilon$ = -4, from Merck Co.). The MVA cell fabricated was normally black (NB) mode. The voltage transmittance (V-T) and viewing angle measurement for the new MVA and conventional VA cells were performed at room temperature (22℃). The EO characteristics were measured using the LCD evaluation system. (LCD7000, Otsuka Co.)

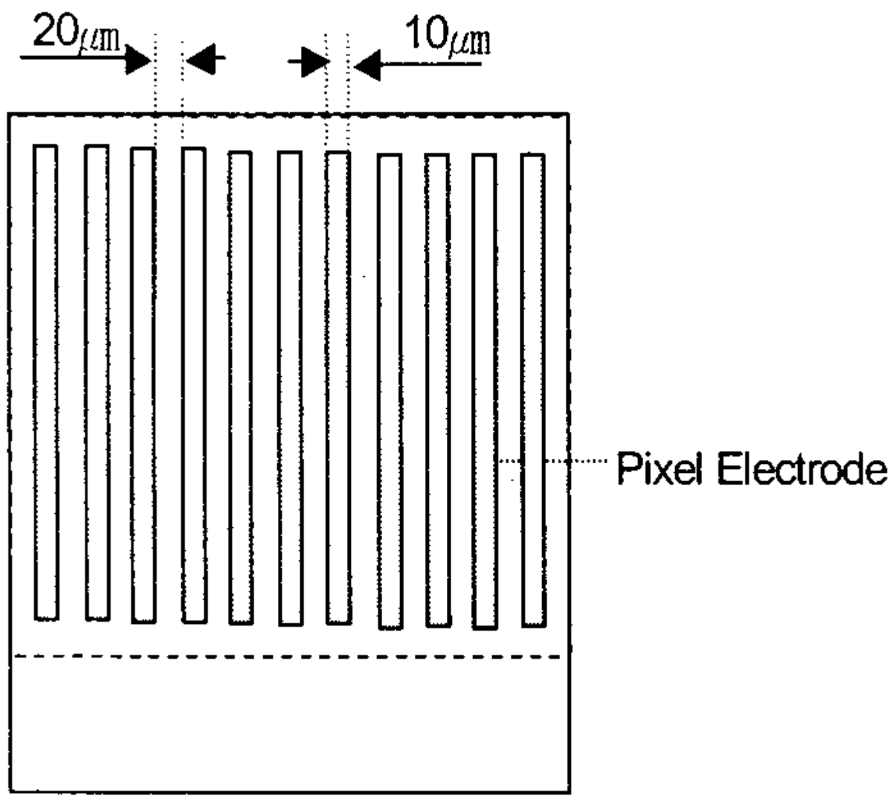


Figure 2. Schematic diagram of photolithograph pattern used.

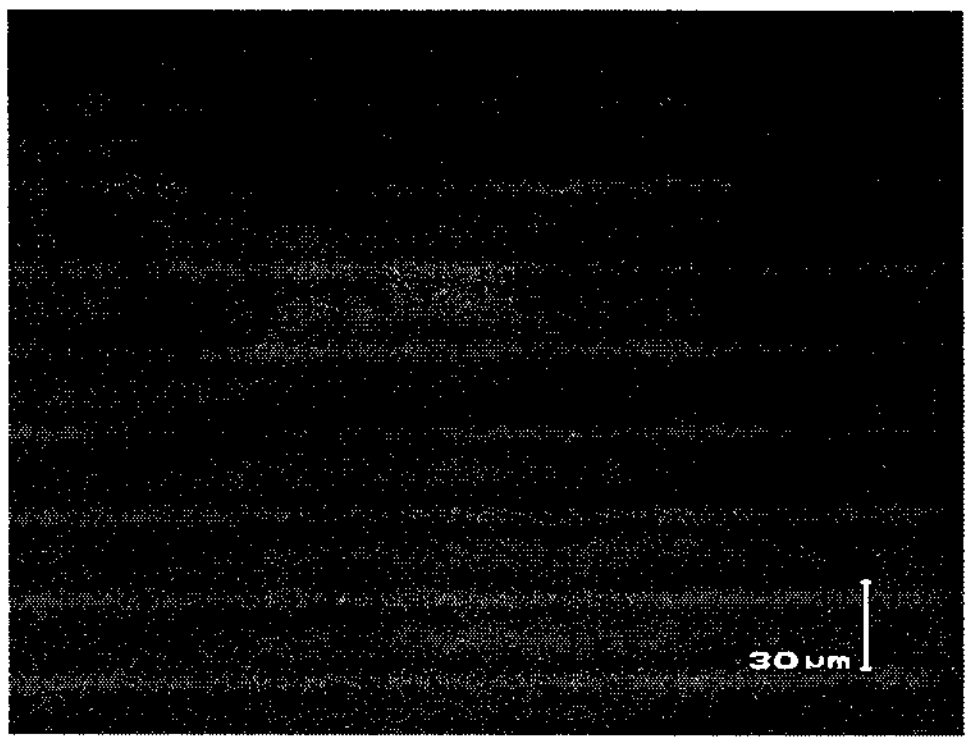


Figure 3. Microphotographs of photopolymer surface after photolithograph.

3. Results and Discussion

Figure 4 shows the top view of schematic diagram of the new MVA cell using a homeotropic photopolymer without an optically compensated film. The grating groove was formed by UV exposure on the photopolymer. In the off-state, the LC directors are aligned vertically to the glass substrates. Under the crossed polarizers, the normal viewing direction indicates no phase retardation. Therefore, the off-state of the new MVA cell is very dark in the normal direction. In the on-state, 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. We consider that the 4-domains were formed by the grating groove with UV exposure on the photopolymer. The 4-domains for the MVA cell contributes to wide viewing angle.

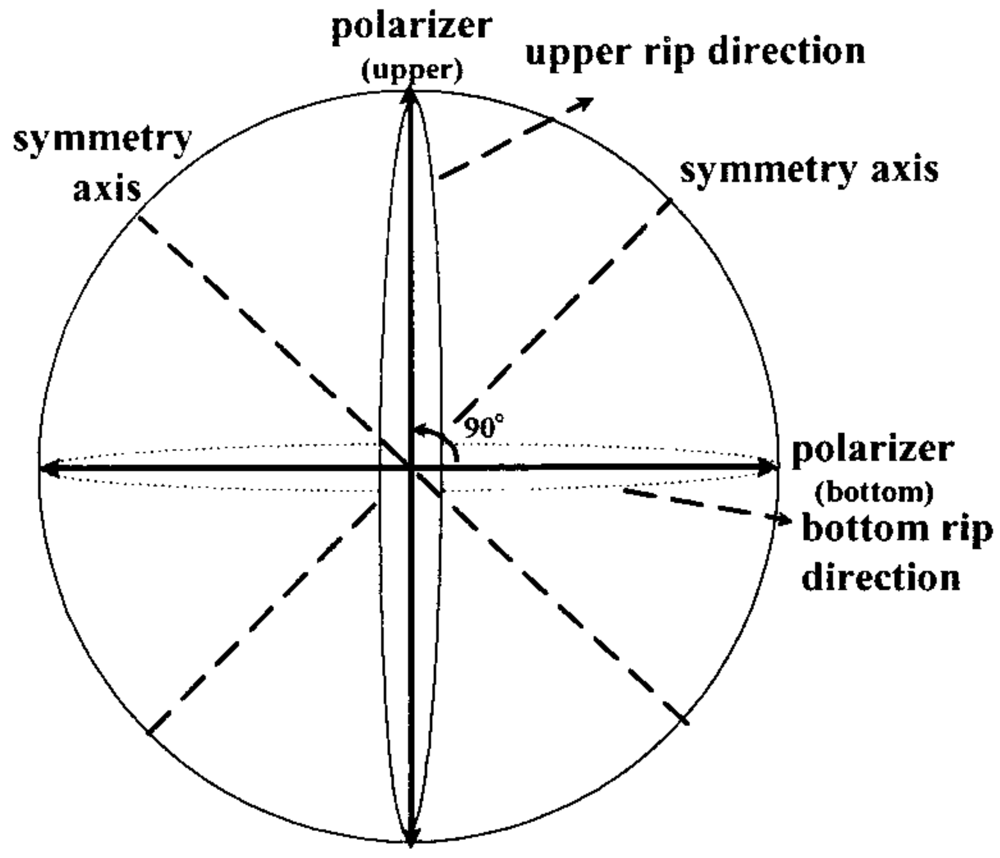
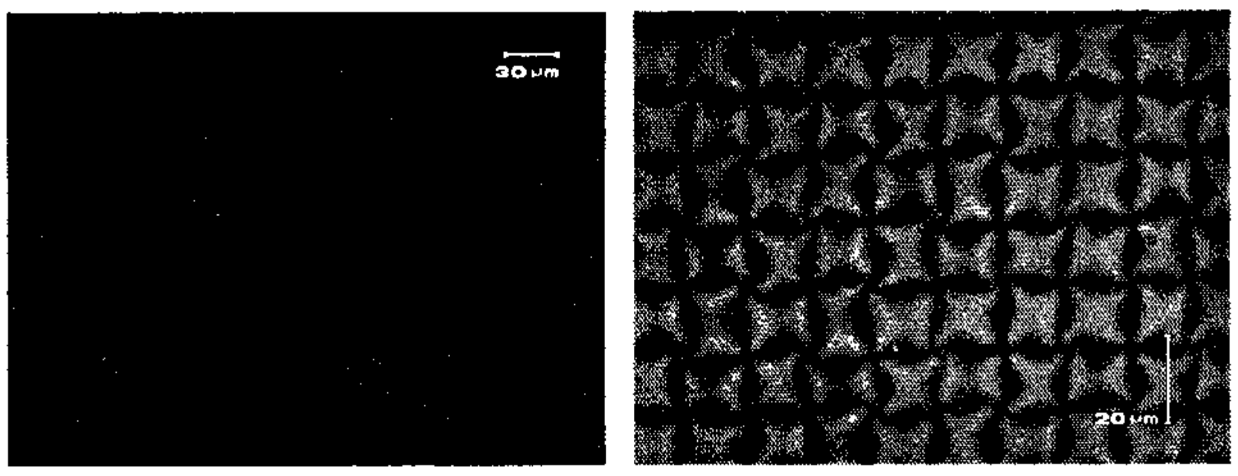


Figure 4. Top view of schematic diagram of the new MVA cell.

Figure 5 shows the photomicrographs of the MVA cell using homeotropic photopolymer surfaces. The multi-domain alignment of the NLC on the polymer surface can be observed.



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

Figure 5. Microphotographs of MVA cell on the homeotropic photopolymer surfaces (in crossed Nicols).

Figure 6 shows the V-T characteristics of the new MVA cell using the homeotropic photopolymer. A good V-T curve for the new MVA cell was measured. A small light leakage in the off-state was observed. Usually, utilization of a negative compensation film compensates for the light leakage.

Figure 7 shows the response time characteristics of the new MVA cell using the homeotropic photopolymer. A stable response time of the new MVA cell on homeotropic photoplymer surface was measured.

Figure 8 shows the viewing angle characteristics of the new MVA cell using the homeotropic photopolymer surface. Wide viewing angles were successfully achieved.

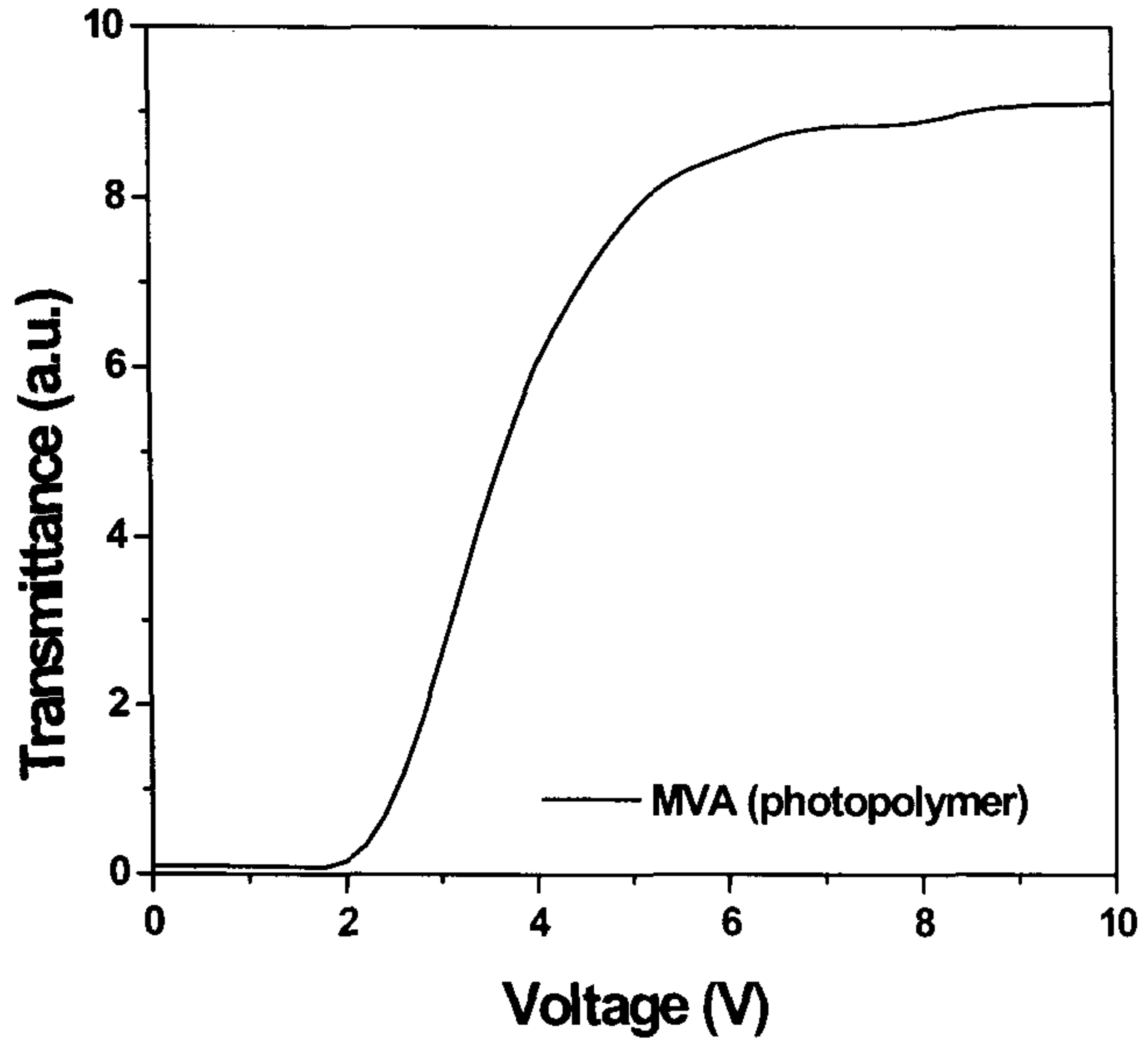


Figure 6. V-T characteristics in the MVA cell on the homeotropic photopolymer surfaces.

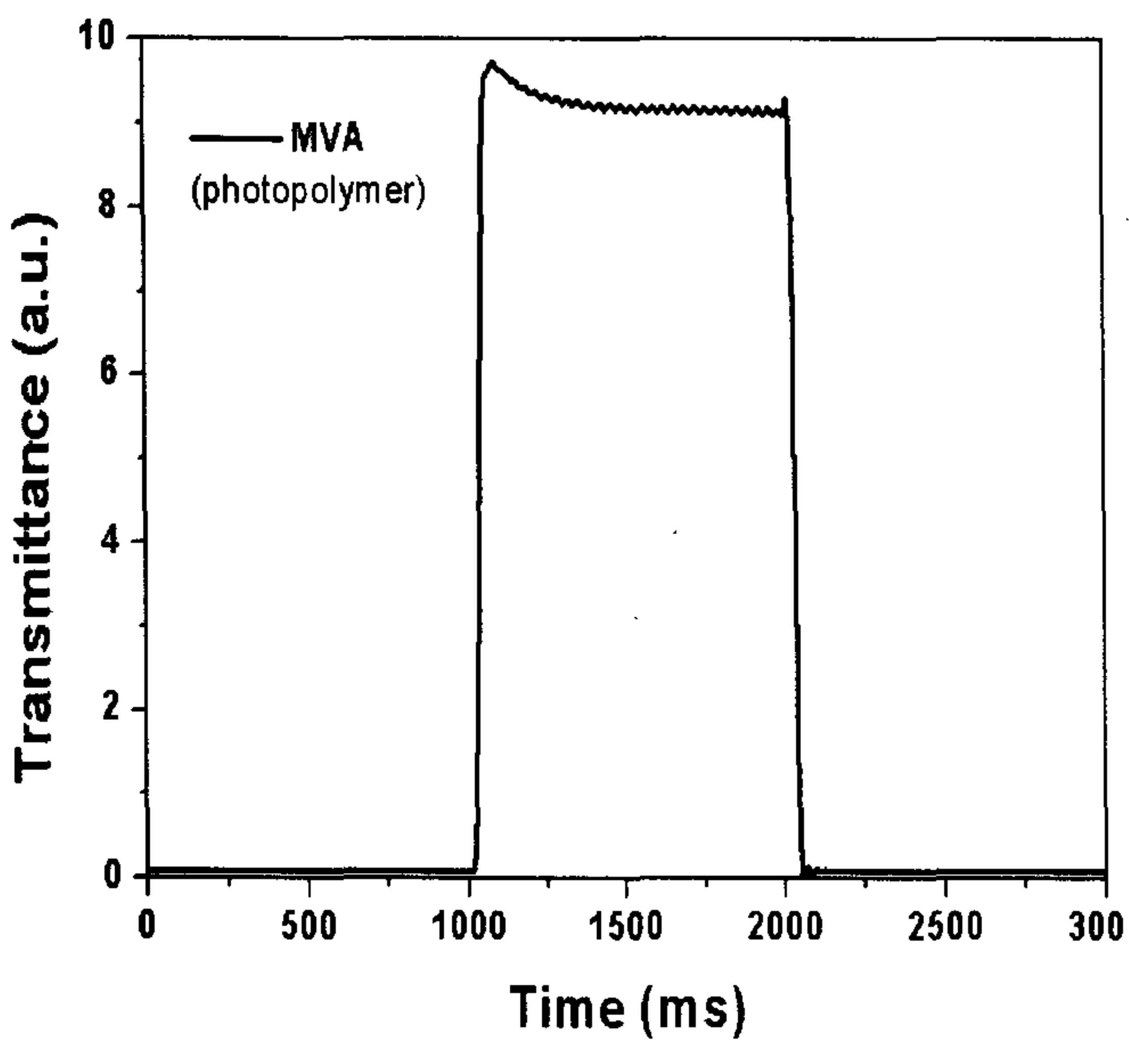


Figure 7. Response time characteristics in the MVA cell on the homeotropic photo polymer surfaces.

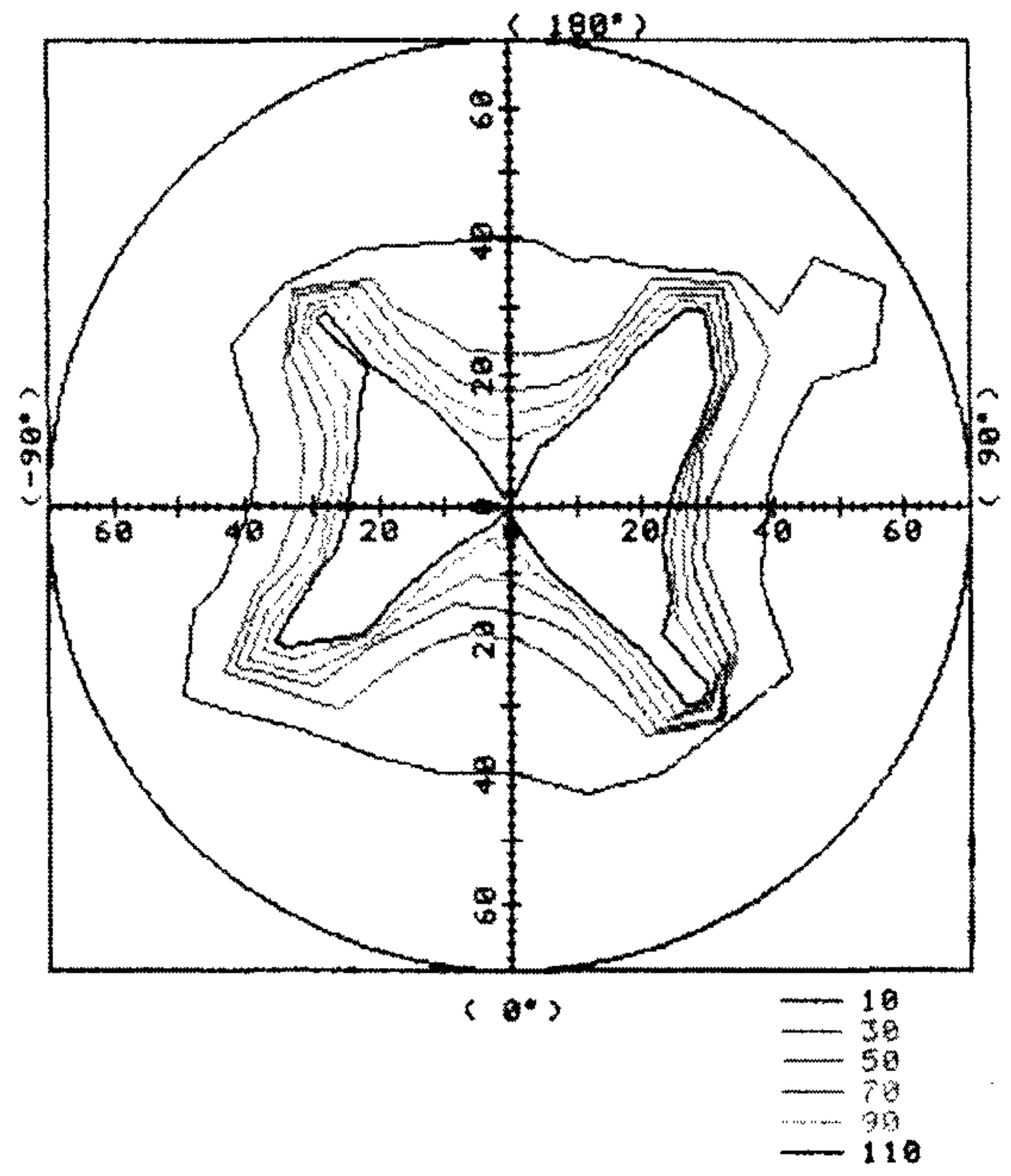


Figure 8. Viewing angle characteristics of the new MVA cell using the homeotropic photopolymer surface.

In conclusion, we have investigated the EO performances for NLC with negative dielectric anisotropy using the new MVA cell on the homeotropic photopolymer surface can be achieved. Good V-T and response time curves using the new MVA cell on the homeotropic photopolymer were obtained. The viewing angle of the new MVA cell using the homeotropic photopolymer can be achieved.

4. Acknowledgements

This work was performed Advanced Backbone IT technology developement project supported by Ministry of Information & Communication in republic of Korea

5. References

[1] T. Toyooka, E. Yoda, Y. Kobori, T. Yamanashi and H. Itoh, SID 98 digest, 698 (1998).

[2] M. Oh-e and K. Kondo, Appl. Phys. lett., 69, 623 (1996).

[3] Y. Koike, S. Kataoka, T. Sasaki, H. Chida, A. Takeda, K. Ohmuro, T. Sasabayashi and K. Okamoto, IDW'97, 159 (1997).

[4] J.-Y. Hwang, D.-S. Seo, J.-Y. Kim, and T.-H. Kim, Jpn. J. Appl. Phys. 41, L58 (2002).