Transflective IPS LCD with Multi-Domain Structures

Kyoung-Ho Park, Young Jo Ko, Jung Hyoung Kim,
Jae Chang Kim, and Tae-Hoon Yoon

Dept. of Electronics Eng., Pusan National University, Busan 609-735, Korea

Abstract

We propose configurations for a transflective in-plane switching (IPS) cell using muti-domain structures. Usually, the cell configurations for a transflective liquid crystal(LC) cell have a complicated structure, because retardation change of transmissive part and reflective part are not same. The transflective LC cell should have two configurations for each part, such as a multi-cell gap structure. With the ion-beam alignment and the horizontal switching LC cell, a simple structure for a transflective LC cell is proposed. The configuration only adopts one cell gap structure, which may help the enhancement of a yield. Their original optical properties in conventional transmissive and reflective type IPS liquid crystal dispaly(LCD) are kept, it shows the wide-viewing angle and the good wavelength dispersion characteristics.

1. Introduction

A transflective LCD has possibility of low power consumption and high display performance.[1-4] Its superior performance in and out-door environments is becoming the most applicable display solution for the mobile application, such as a tablet personal computer, an e-book, a personal data assistant(PDA), and a mobile phone, etc.. In order to achieve high image quality, wide viewing angle and high contrast ratio are important factors even in transflective LCDs. Most conventional transflective LCDs adopt the twisted nematic(TN) LC mode or the non-twisted LC mode using vertical switching, the narrow viewing angle characteristics or the multi-cell gap structure are inevitable.[5-6] One of the solutions for the problems mentioned before, the in-plane IPS LCD mode[7] is the most representative. Its wide-viewing angle characteristics without any compensation film for viewing angle enhancement and an applicable configuration of a single cell gap are the unique characteristics for the transflective LCDs.

In this paper, we propose configurations for a transflective IPS cell using multi-domain structures. The multi-domains are form by the ion-beam exposure. Using the multi-domain structures, the transflective IPS LCD keeps its optical properties in conventional transmissive and reflective IPS LCD mode.

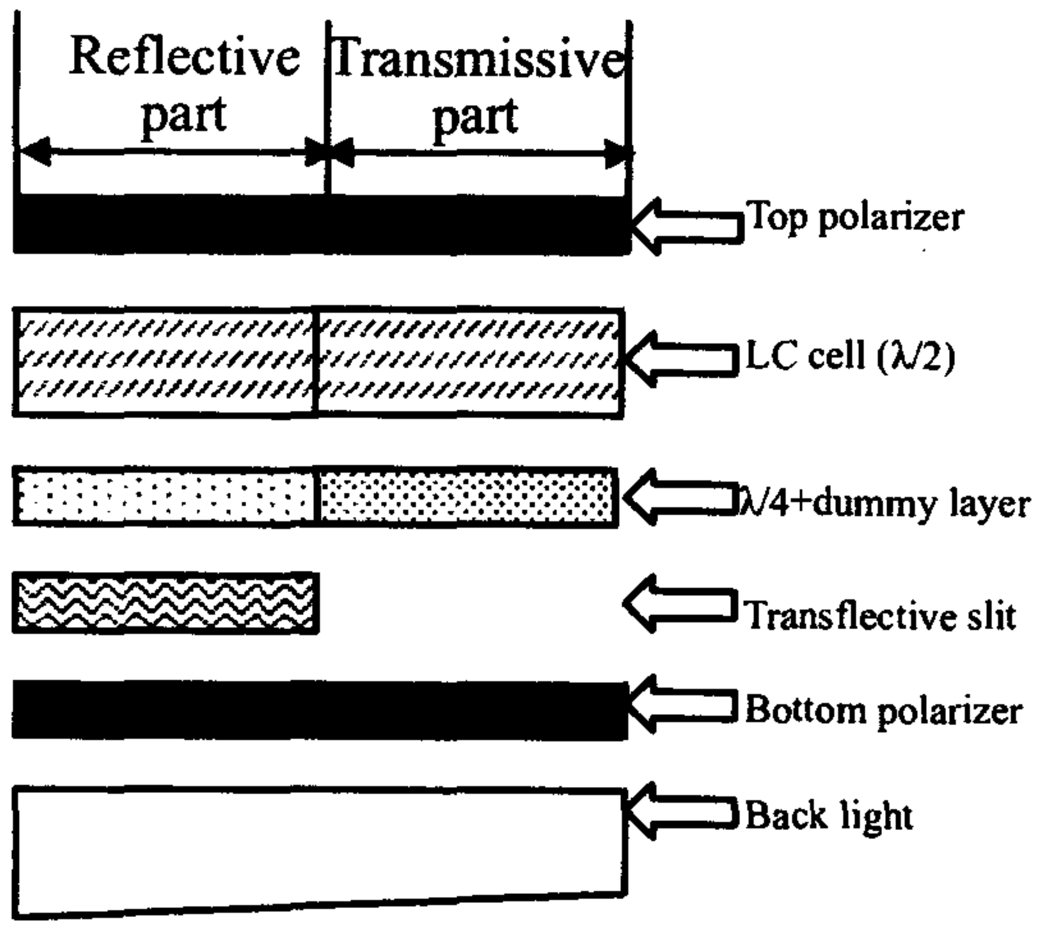


Fig. 1. Schematic diagram of the transflective IPS LC cell with the optically dummy layer

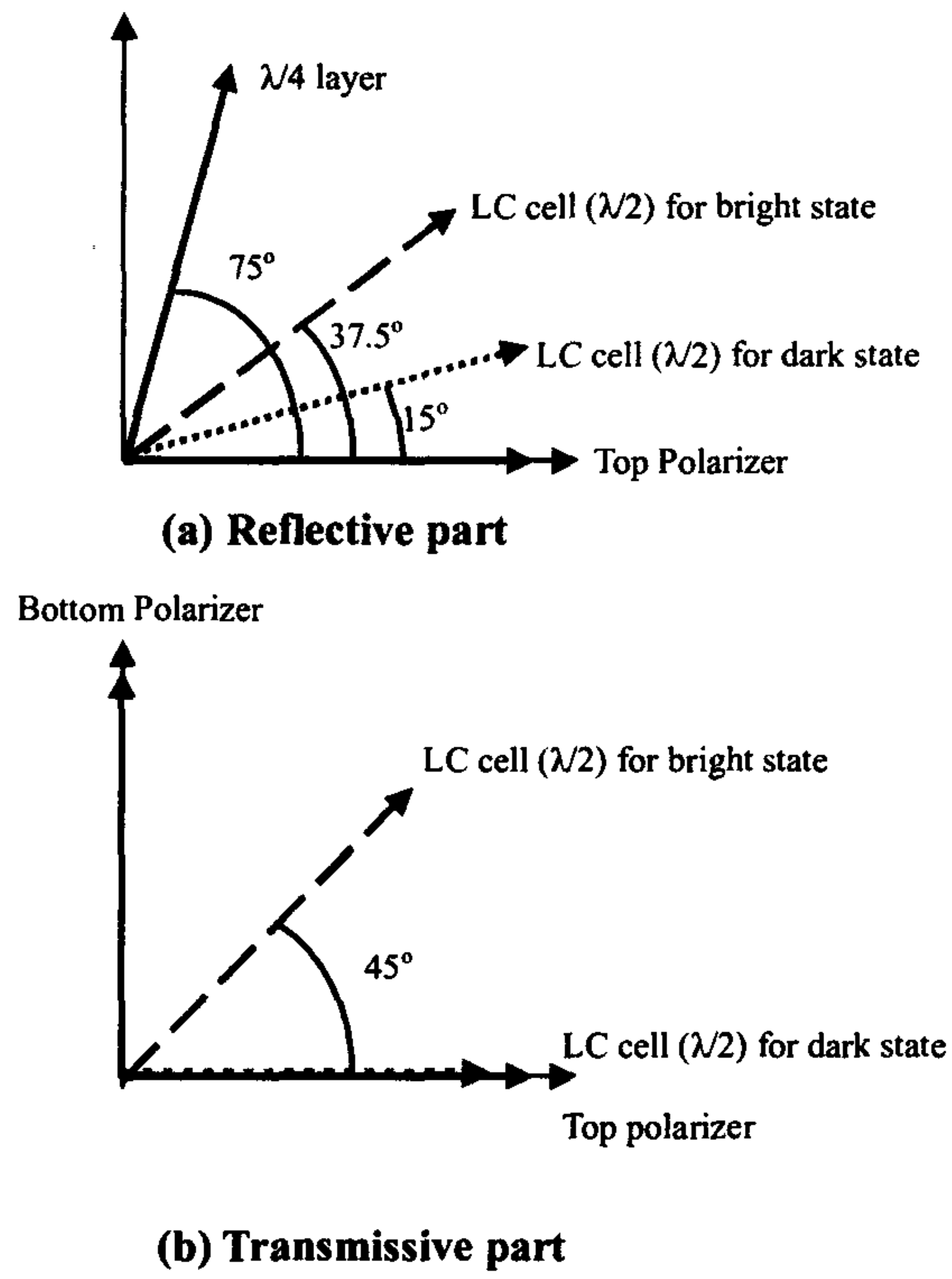


Fig. 2. Optical configuration of the transflective IPS LC cell

2. Configuration of the transflective IPS LCD

A proposed transflective LC cell is separated into two parts; the transmissive and the reflective part. Each part is designed separately, they are combined in a pixel by using the optical dummy layer.

Figure 1 shows the configuration of the transflective IPS LC cell. It is consist of two polarizer, a half wave IPS LC cell, a quarter wave layer which has an optically mummy layer for transmissive part, and transflective slit. The LC cell has a multi-domain alignment to separate the transmissive and the reflective parts. To eliminate the retardation of the quarter wave layer which affect on the retardation of the transflective part, the optically dummy layer is replaced by using the multi-pretilt method.[8] Figure 2 shows the optical configuration of the proposed transflective LC cell. In reflective part, the top polarizer is at the 0°, the half wave LC cell which is switchable to 37.5° is at 15°, the quarter wave layer is at 75°, and the reflector is under the quarter wave layer.[9] In transmissive part, the top polarizer is at 0°, the LC cell is at 45°, and the bottom polarizer is at 90°. The dummy layer does not affect optically on the transmittance. In reflective part, the dark and the bright state can be achieved by using the wide-band quarter wave theory and the horizontal switching.[9] To achieve dark state, the wide-band quarter wave theory is used. To achieve a bright state, the half wave LC director is rotated to 37.5°. In transmissive part, the optical condition is same as that of a conventional transmissive type IPS LCD. Under the crossed polarizers, the direction of the LC director is parallel to the top polarizer to achieve dark state. As the LC director is rotated to 45°, the bright state can be achieved.

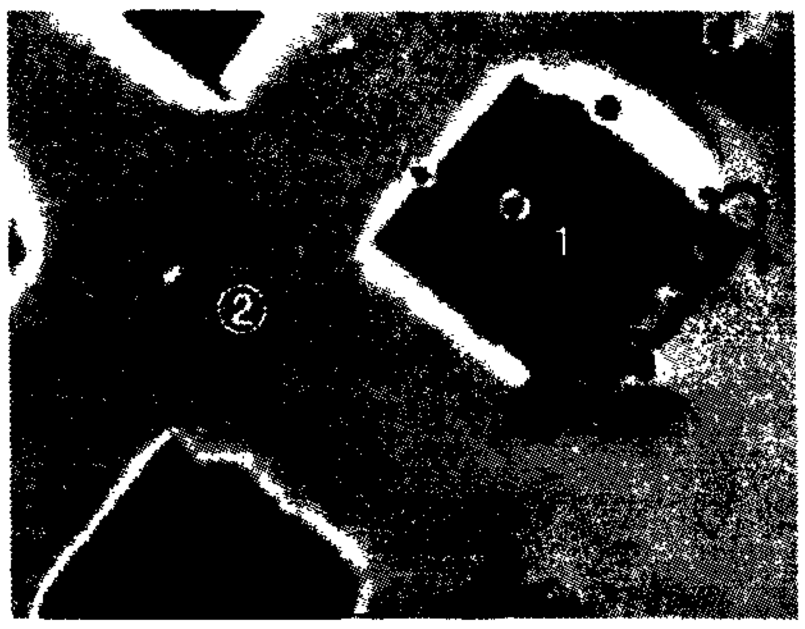


Fig. 3. formation of a optically dummy with muti-pretilt formation method.

3. Calculated and experimental results

We fabricated the transflective IPS LC cell with the optically dummy layer, whose transmission and the reflection spectra in the bright state and in the dark state are measured. Experimental results are compared with numerical calculation obtained by using the 2x2 Jones matrix method. Additionally, the viewing angle characteristics are calculated with respect to the incident light.

To form the optically dummy and the quarter wave layer in same cell, the RMS03001(Merck) was used as an inner retardation layer. Indium-Tin-Oxide (ITO) patterned on glass substrate was used as an IPS electrode for the cell. The substrate was spin coated with JALS-2021-1(JSR Ltd.) used as polyamide for vertical alignment. The mask covered the polyamide for the region of the transmissive part, the polyamide was bombarded by a low energy argon ion beam. Then, the RMS03001 was coated, cured in UV light. Figure 3 shows the quarter wave layers and the optically dummy layer. The region ① of Fig. 3 is an optically dummy layer for the transmissive part, the region ② is a quarter wave layer for the reflective part.

A multi-domain IPS LC cell was fabricated to achieve the initially different LC directions for the both transmissive and reflective parts. The upper substrate and the lower substrate which the optically dummy layer was formed were spin coated with SE-3140(Merck) used as polyamide for horizontal alignment. The ion-beam exposure was performed twice; the mask covered the region of the transmissive part on exposing to reflective part and vice versa. The ZLI-4119(Δn = 0.0603: Merck) was used. The cell gap was 4.5 um to get the half wave LC cell. The optical characteristics was calculated and compared with the measured results. The reflectance and the transmittance were calculated with the LCD MASTER(Shintech Ltd.).

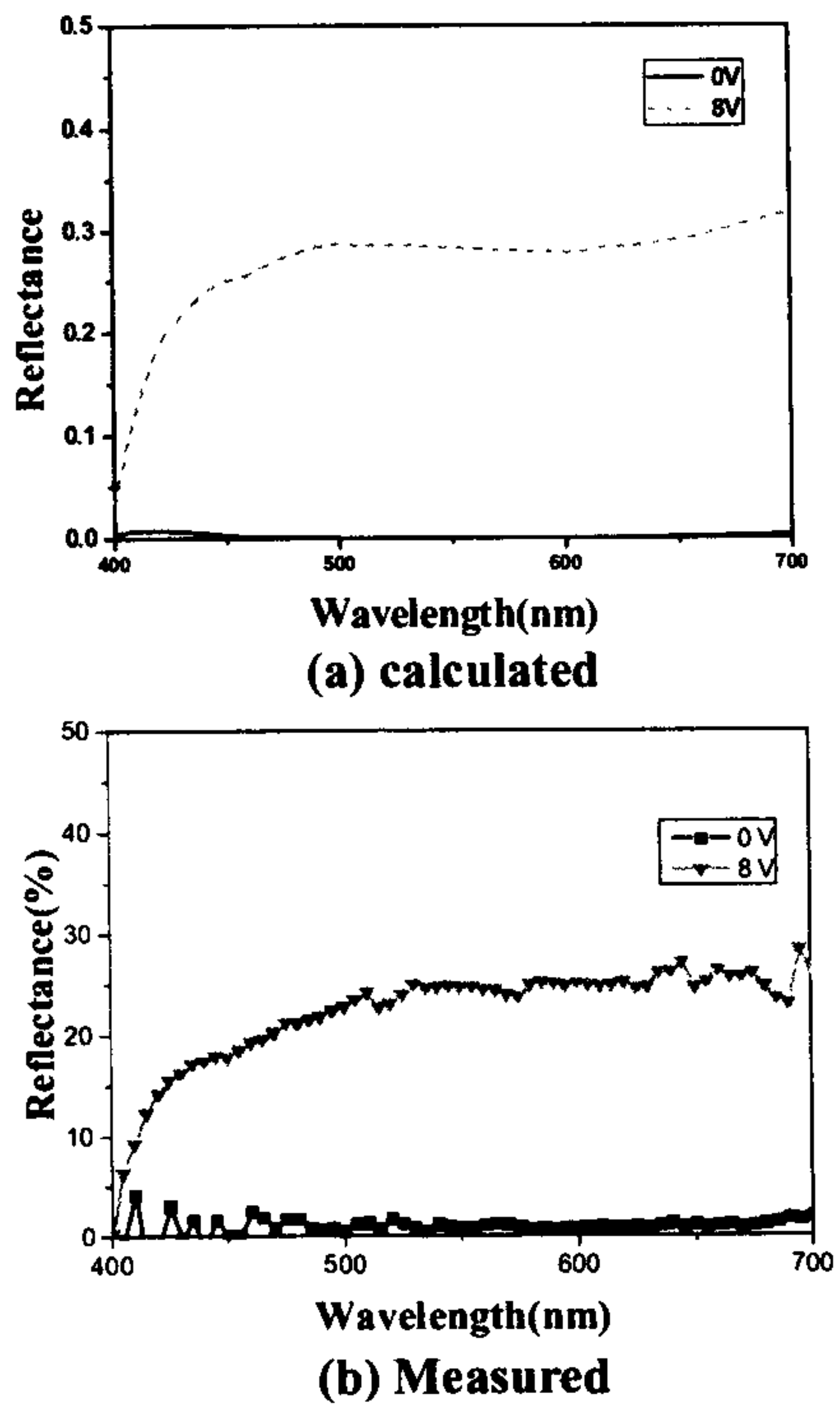
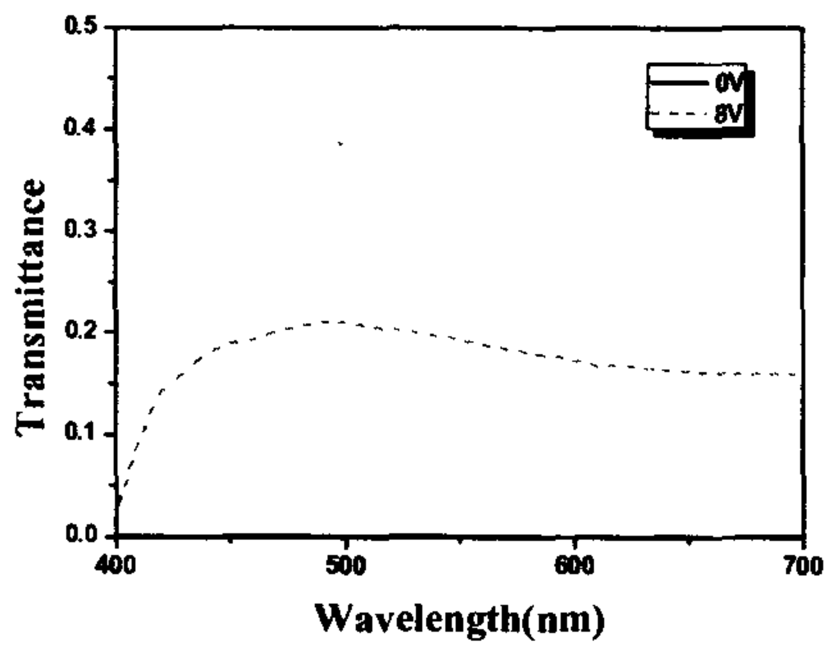
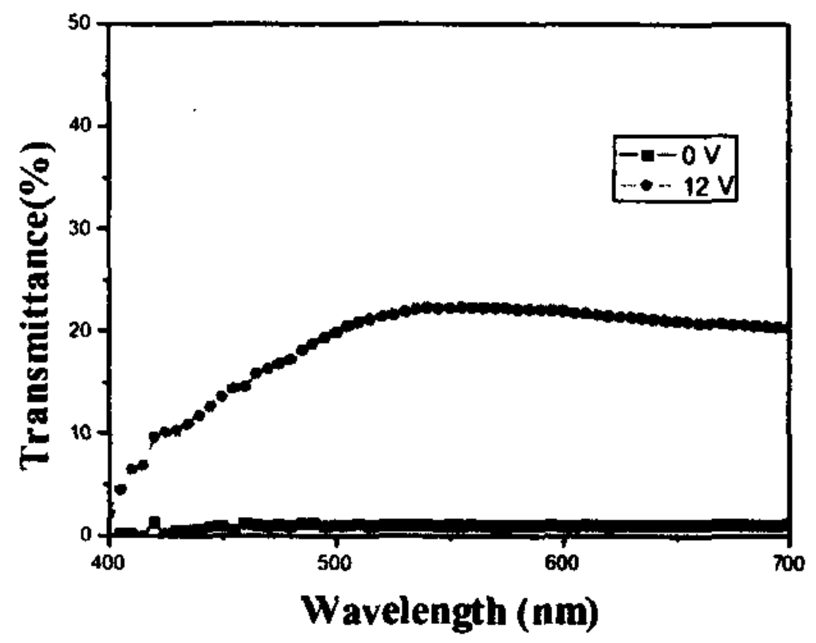


Fig. 4. Reflection characteristics of the reflective part.



(a) calculated



(b) Measured

Fig. 5. Transmission characteristics of the transmissive part

The calculation parameters were same as those of the experiment.

Figure 4 shows the reflection characteristics of the reflective part for the proposed configuration. Because the wide-band design is employed, the dispersion characteristics of the dark state and the bright state are excellent. The calculated and the measured results are almost same. In the dark state, the little light leakage is found. That is because the dispersion characteristics between LC and quarter wave layer formed by inner retardation layer is not same. The transmission characteristics are shown in Fig. 5. That is the characteristics of a conventional transmissive IPS LCD. As we mentioned before, the optically dummy layer does not affect on the transmittance except that of the oblique angle.

5. Conclusion

We proposed an optical configuration for a transflective LCD with a half-wave cell. We found that measured transmission and reflection spectra in the bright state as well as in the dark state of the proposed configurations show excellent optical performance as expected by numerical calculation. The proposed transflective configurations can be applied to most of IPS LCD modes.

References

[1] T. Uchida, T. Nakayama, T. Miyashita, M. Suzuki, and T. Ishinabe, Proc. IDRC '95, p. 599.

[2] T. Ogawa, S. Fujita, Y. Iwai, and H. Koseki, SID '98 Dig., p. 217.

[3] S. H. Lee, K. H. Park, J. S. Gwag, T. H. Yoon, and J. C. Kim, Jpn. J. Appl. Phys. vol. 42, no. 8, p.5127, 2003.

[4] W. S. Park, S. C. Kim, S. H. Lee, Y. S. Hwang, G. D. Lee, T. H. Yoon, and J. C. Kim, Jpn. J. Appl. Phys., vol. 40, no. 11, p. 6654, 2001.

[5] H. I. Baek, Y. B. Kim, K. S. Ha, D. G. Kim, and S. B. Kwon, Proc. IDW '00, p. 41.

[6] M. Kubo, S. Fujioka, T. Ochi, and Y. Narutaki, Proc. IDW '99, p. 183.

[7] M. Oh-e, and K. Kondo, Appl. Phys. Lett., vol. 67, p. 3895, 1995.

[8] K. H. Park, D. C. Jeong, J. S. Gwag, S. H. Lee, T. H. Yoon, and J. C. Kim, Proc. IDW '02, p. 129.

[9] T. H. Yoon, G. D. Lee, and J. C. Kim, Opt. Lett., vol. 25, no. 20, p.1547, 2000.