

# Full Color Cholesteric Liquid Crystal Display with Wall Structure using SU-8 Photo-Resist Process

Kyoo Sung Shim<sup>1</sup>, Soo In Jo<sup>1</sup>, Jae-Hoon Kim<sup>1,2</sup>, and Chang-Jae Yu<sup>1,2</sup>

<sup>1</sup>Department of Electronics and Computer Engineering, Hanyang University, Seoul 133-791, Korea

<sup>2</sup>Department of Information Display Engineering, Hanyang University, Seoul 133-791, Korea

\*e-mail: [cjyu@hanyang.ac.kr](mailto:cjyu@hanyang.ac.kr)

We demonstrate a full color cholesteric liquid crystal display (ChLCD) with uniform color performance in a single-layered configuration through the pixel isolation. Each pixel was formed by the photo-polymerization at different temperatures. From avoiding the inter-pixel diffusion of monomers, we achieved the full color ChLCD with the well-defined pixels.

## 1. Introduction

Cholesteric liquid crystals (ChLCs) have attracted attention to color flexible displays since no requirement of optical equipments such as polarizer, color filter, and backlight unit in the reflective ChLC displays. Previously, we confirmed a multi-color ChLC display in a single-layered pixel arrangement using reactive mesogen (RM) to the ChLC [1,2]. By adjusting Temperature, The pitch of the ChLC is controlled and sustained by the photo-polymerization. The multi-pitch ChLC cell is prepared with the spatially selective ultraviolet (UV) exposure through a photo-mask at several temperatures within the cholesteric phase [3-5]. However, the RM monomers moved to adjacent pixels because RM is diffused gradually while the UV exposed. As a result, we observed non-uniformity of the electro-optical (EO) characteristics such as color reproducibility, driving voltage, and response time in each pixel.

In this study, we propose a established polymer wall to separate each pixel in the full color ChLC display in a single-layered pixel arrangement. Preventing the monomer diffusion by the established polymer wall during the multi-pitch fixation, we can obtain the same polymer density in each pixel and the uniform EO characteristics of the ChLC displays.

## 2. Experiments

Figure 1 shows the schematic diagrams of the fabrication processes. At first, the alignment layer was spin-coated on to the indium-tin-oxide (ITO) glass and thermal annealing process was performed. Next, the polymer wall structure was prepared by the photolithography method using photoresist (SU-

8). The stripe type mask was used to define the SU-8 wall structure. The width and pitch of the wall were 20 and 500  $\mu\text{m}$ , respectively. The cell thickness was maintained about 6  $\mu\text{m}$  which is similar depth with SU-8 wall. ChLC mixture was injected using capillary force at the isotropic temperature. The ChLC mixture used in this work consists of a host nematic LC (Merck E7, 59.5 wt.%), a chiral dopant (R811, 31.5 wt.%), reactive mesogen (RM257, 8 wt.%), and photo-initiator (Ciba Speciality Chemicals Irgacure 651, 1 wt.%). Here, R811 generates a helical structure of the LCs in right-handedness and RM257 stabilizes the helical pitch through polymerizing itself initiated by Irgacure 651. Finally, UV light was exposed to the cell for 3 seconds to produce polymer network by increasing temperature for defining each pixel from red to blue. At this time, SU-8 wall structure prevents the movement of the monomers.

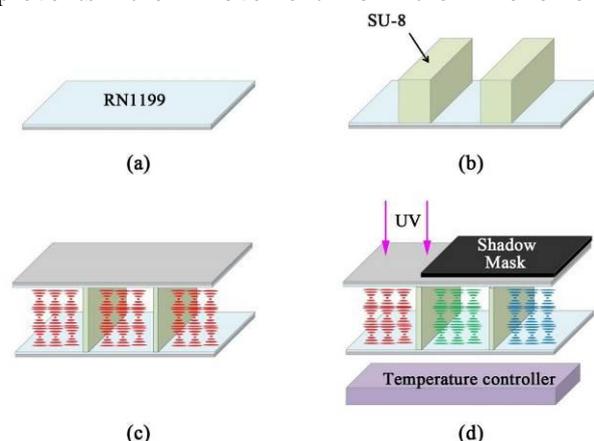


Figure 1. Schematic diagrams of the fabrication processes.

### 3. Results and Discussion

Figure 2 shows the measured depth information of the fabricated SU-8 polymer wall. The depth of polymer wall is maintained about 6  $\mu\text{m}$  as the cell gap. As previously reported, SU-8 layer is used an adhesive as well as wall structure [6]. It should be noticed that glass spacer and adhesive material were not used in fabrication processes to maintain the cell gap.

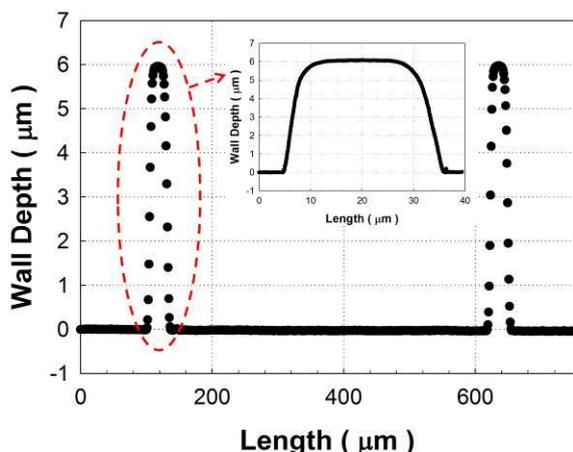


Figure 2. Measured depth of the wall structure by the photolithography method using the SU-8 photoresist.

Figure 3 shows the microscopic textures for the ChLC cells with and without polymer wall. In our processes, Because UV exposure for the first time in the red pixel, monomers are moved to the red pixel and more polymer network structures as shown in Fig. 2(a).

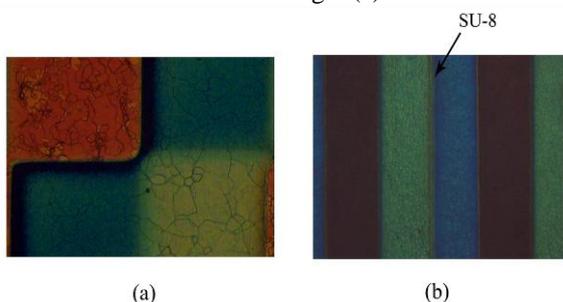


Figure 3. The measured response time of conventional SC-PVA cell and the proposed SC-PVA cell with double step UV processes (a) the rising time, (b) the falling time.

Because of the movement of RMs during the UV exposure, the size of the red pixel is larger than other pixels. Also, the color reflectance characteristics of the each color are different because of the density of the polymer network. If the polymer network density is higher, incident light

are scattered inside the cell. Therefore, in the red region, the bandwidth of the color reflectance is wider during the UV exposure process.

However, in our case, the boundaries of the pixel were clear because of the RMs placement. Also, the polymer density is almost similar by observing the microscopic textures of the fabricated cell. Therefore, color reproducibility was improved about 23.7 % due to the improvement of color reflectance as shown in Fig. 4.

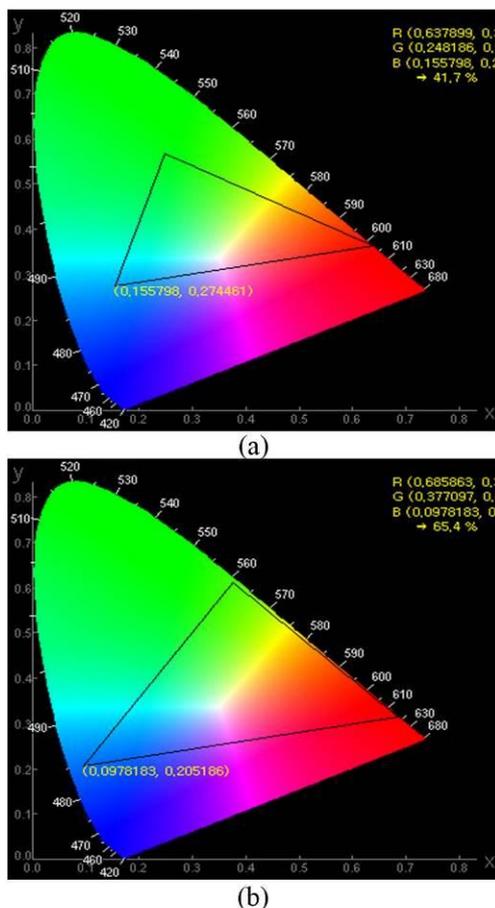


Figure 4. Color gamut of ChLCs (a) without polymer wall and (b) with polymer wall.

### 4. Conclusion

We proposed the polymer wall establishing each pixel to improve the color gamut in the full color ChLC display in a single-layered arrangement. Preventing the inter-pixel diffusion of the RMs by the established polymer wall during the multi-pitch stabilization, we can obtain the same polymer density in each pixel and thus the uniform EO characteristics of the ChLC displays and good color gamut. Also, the established polymer wall acted as the rigid spacer and the adhesive for the flexible displays.

## 5. Acknowledgements

This research was supported by the IT R&D program of MKE/KEIT (Grant No. 10041416, The core technology development of light and space adaptable new mode display for energy saving on 7 inch and 2W.)

## References

- [1] K.-S. Bae, Y.-J. Jang, Y.-K. Moon, S.-G. Kang, U. Cha, C.-J. Yu, J. E. Jang, J. E. Jung, and J.-H. Kim, *Jpn. J. Appl. Phys.* **49**(8), 084103 (2010).
- [2] K.-S. Bae, Y.-J. Jang, C.-J. Yu, J. E. Jang, J. E. Jung, J. S. Choi, S. J. Park and J.-H. Kim, *SID' 10 Digest* 1757 (2010)
- [3] S.-Y. Lu, and L.-C. Chien, *Appl. Phys. Lett.* **91**, 131119, (2007).
- [4] Y. Huang, Y. Zhou, C. Doyle, and S.-T. Wu, *Opt. Express* **14**, 1236-1242, (2006).
- [5] X. J. Yu and H. S. Kwok, *Appl. Phys. Lett.* **85**, 3711-3713 (2004).
- [6] K.-S. Bae, B.-S. Ban, and J.-H. Kim, *Proc. of SPIE*, 7232, 72320 (2009).