Advanced Full Color Cholesteric Liquid Crystal Display in a Single-Layered Configuration by Pixel Isolation

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ABSTRACT

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 many merits applicable to color flexible displays since no requirement of optical components such as polarizer, color filter, and backlight unit in the reflective ChLC displays. Previously, we demonstrated a multi-color ChLC display in a single-layered configuration by introducing reactive mesogen (RM) to the ChLC [1,2]. The pitch of the ChLC was controlled by the temperature and maintained by the photo-polymerization of the RMs. 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]. This is applicable to a flexible substrate and thus is expected to become a viable technology to fabricate the electronic paper displays. However, the RM monomers moved to neighboring pixels due to the diffusion of RMs during the UV exposure, which gives rise to non-uniformity of the polymer density in each pixel. 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 introduce pre-defined polymer wall to isolate each pixel in the full color ChLC display in a single-layered configuration. Blocking the monomer diffusion by the pre-defined polymer wall during the multi-pitch stabilization, 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 μm, respectively. The cell thickness was maintained about 6 μm 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 Iragacure 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.

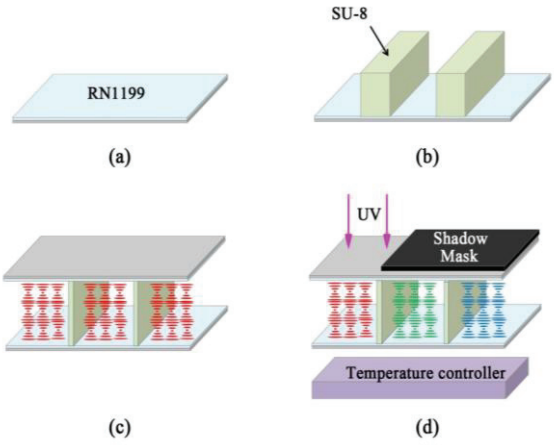

Fig. 1 Schematic diagrams of the fabrication processes.

3. RESULTS

Figure 2 shows the measured depth information of the fabricated SU-8 polymer wall. The depth was formed about 6 μm which is same as cell gap. The SU-8 layer was used not only wall structure but also adhesive layer as we previously reported [6]. It should be noted that glass spacer and adhesive material were not used in fabrication processes to maintain the cell gap.

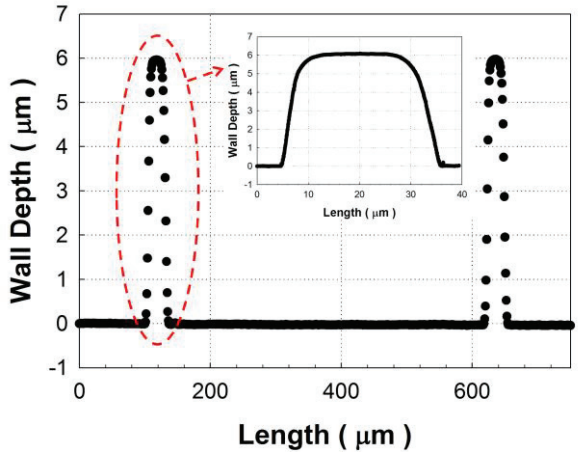

Fig. 2 Measured depth of the wall structure by the photolithography method using the SU-8 photoresist.

Figure 3 shows the microscopic textures for the ChLC cells with and without polymer wall. In our processes, the red pixel was exposed to the UV for the first time. Therefore, monomers at the blocked region (green, blue pixel) are moved to the red pixel and more polymer network structures are clearly observed at the red pixel as shown in Fig. 2(a).

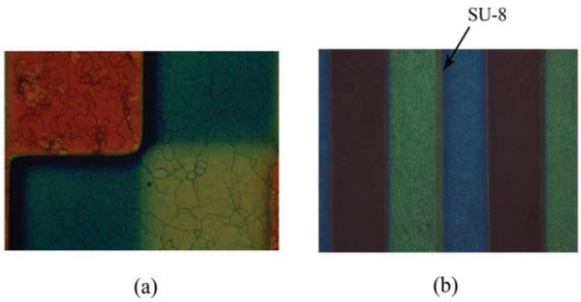

Fig. 3 Microscopic textures of the ChLCs (a) without polymer wall and (b) with polymer wall.

Due to 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 due to 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 due to the confinement of the RMs. Also, the polymer density is almost similar by observing the microscopic textures of the fabricated cell. As a result, color reproducibility was enhanced about 23.7 % due to the improvement of color reflectance as shown in Fig. 4.

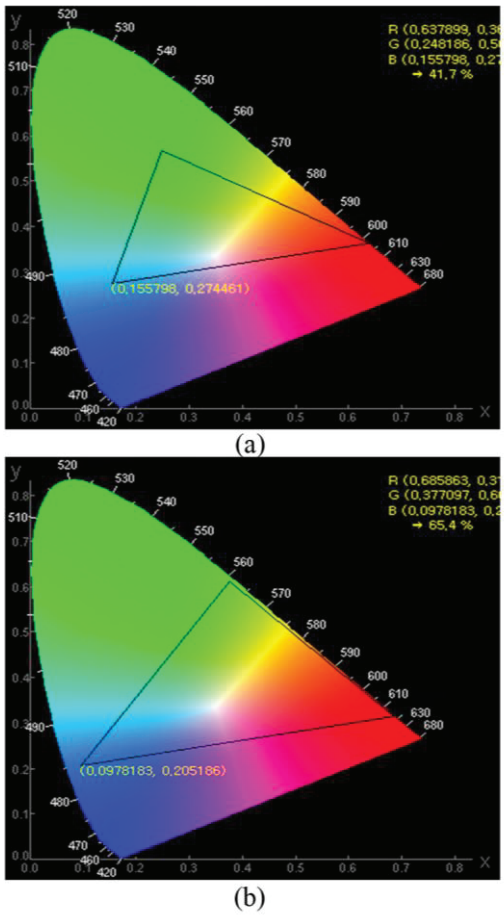

Fig. 4 Color gamut of ChLCs (a) without polymer wall and (b) with polymer wall.

4. CONCLUSION

We introduced the polymer wall defining each pixel to improve the color gamut in the full color ChLC display in a single-layered configuration. Blocking the inter-pixel diffusion of the RMs by the pre-defined 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 pre-defined polymer wall acted as the rigid spacer and the adhesive for the flexible displays.

5. ACKNOWLEDGMENT

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 2 W).

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