Wavelength-Controllable Cholesteric Liquid Crystal Devices based on In-Cell Temperature Control

Joon Sang Yoo[1], Jae-Hoon Kim[1,2], and Chang-Jae Yu[1,2*]
[1]*Department of Information Display Engineering, Hanyang University, Seoul 133-791 Korea*
[2]*Department of Electronic Engineering, Hanyang University, Seoul 133-791, Korea*
cjyu@hanyang.ac.kr

***Abstract*— We designed a cholesteric liquid crystal (ChLC) device with high reflectivity by stacking the ChLC layers with different directions of helix. Reflective color was continuously varied by in-cell temperature control by a Joule heating method.**

I. Introduction

Cholesteric liquid crystals (ChLCs) have been widely studied since their several distinctive advantages such as wavelength-selective reflection. A pitch of the ChLC was directly matched to a wavelength of the reflected light from the ChLC. In general, the pitch of the ChLC is varied by temperature. Also, a polarization state of the reflected light is governed by a helical sense of the ChLC [1]. In general, the maximum reflectance of the ChLC devices is below 50 % due to such circular polarization selectivity originated from the helical sense of the ChLC.

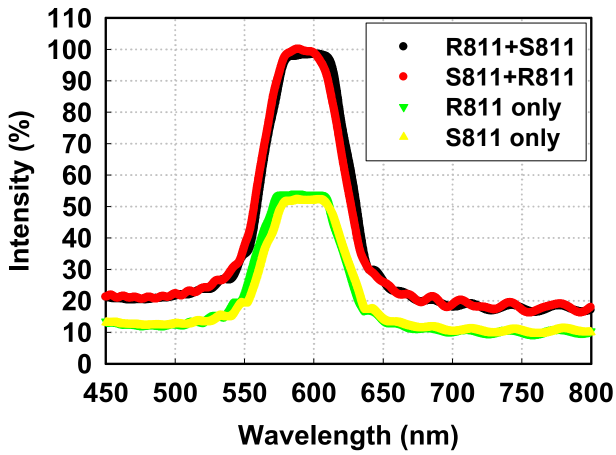
In this work, we demonstrated the ChLC device with high reflectance by stacking two ChLC layers with the different helical directions of the ChLC. Also, to control the wavelength of the reflected circular light, an in-cell temperature controlling system was used. The in-cell temperature controller was prepared with Joule heating method using a transparent electrode.

II. Experiments

The ChLC sample was fabricated with a patterned indium-tin-oxide (ITO) electrode for the Joule heating. The patterned electrode was prepared by a conventional photolithography process and sputtered by an insulator of Al_2O_3 with a thickness of 200 nm. The alignment layer (RN 1199A, Nissan) was spin-coated on the patterned ITO substrate to promote planar alignment of the ChLC. After the spin-coating process, the substrate was pre-baked to vaporize solvent for 10 min at 100 °C and post-baked and to imidize the polyimide for 1 h at 210 °C. Two substrates are anti-parallelly rubbed and assembled. The ChLCs were prepared with mixing two chiral dopants of R811 (E. Merck) and S811 (E. Merck), exhibiting different helical senses, to a nematic LC of E7 (E. Merck). The ChLCs were injected by a capillary phenomenon.

III. Result and Discussion

Figure 1(a) shows the reflection spectra of the ChLC sample. Without applied voltage, wavelength-selective reflection of the ChLC was observed. However, the reflectance of a single ChLC layered sample was about 50 %. With stacking two ChLC layers (R811-mixed ChLC and S811-mixed ChLC), the reflectance was enhanced twice as shown in Fig. 1. The passed circular polarization through the first ChLC layer is totally reflected from the seconds ChLC layer since two ChLC layers have opposite helical senses.

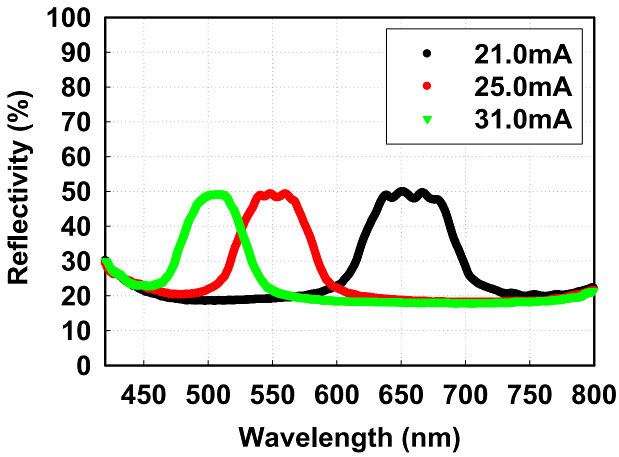


[Fig.1] Spectra of the ChLC samples.

To control the wavelength and the resultant color of the reflected light, we varied temperature by the Joule heating system as an in-cell temperature controller. With increasing current, the temperature of the ChLC sample was increased and thus the helical pitch of the ChLC was decreased. As a result, the reflected color was continuously varied with changing current.

Figure 2 shows the reflective microscopic images of the ChLC sample and the corresponding spectra for different current levels. When we applied current of 21 mA, the central wavelength of the reflection was about 650 nm [Fig. 2(a)]. With increasing the current, the central wavelength of the reflection was gradually decreased to 550 nm (at 25 mA) and 500 nm (at 31 mA). In addition, when we applied electric field across the sandwiched cell, the reflectance was switched as shown in the conventional ChLC switching devices.

(a) (b) (c)



(d)

[Fig.2] Reflective microscopic images at current of (a) 21 mA, (b) 25 mA, and (c) 31 mA, and the corresponding reflection spectra.

References

[1] P. G. de Gennes and J. Prost, *The Principle of Liquid Crystals* (Oxford University Press, New York 1993).

[2] D. W. Berreman et al., Phys. Rev. Lett.25, 577 (1970)

[3] N. Tamaoki, Adv. Mater., 13, 1135-1147 (2001)

[4] R. A. van Delden et al., Adv. Funct. Mater., 13, 319 (2003)

[5] Xiao-yang Huang, *Liquid Crystal Meterials, Devices and Applications Ⅶ,* 120 (1999)

[6] Na Young Ha. *et al*., Nat. Mater., 7, 43-47 (2008)