Enhancement of Response Time in Cholesteric Liquid Crystal Grating

Minju Kim[1], Jeoung-Yeon Hwang[2], Kwang-Soo Bae[2], Chuhyun Cho[1], Jae-Hoon Kim[1, 2], and Chang-Jae Yu[1, 2*]

[1]Department of Electronic Engineering, Hanyang University, Seoul 121-791, Korea
[2]Department of Information Display Engineering, Hanyang University, Seoul 133-791, Korea
*Tel.: +82-2-2220-0343, *E-mail: cjyu@hanyang.ac.kr*

Keywords: ***reactive mesogen, cholesteric liquid crystals, grating, polymer network***

Abstract

We report the enhanced response time characteristics in a cholesteric liquid crystal grating using surface treatment with reactive mesogen (RM). The RM-mixed alignment layer generates the stable grating properties through polymeric structure on the surface. The memorized grating structure by the polymer improves the switching time of the grating since the rearranging process is eliminated.

1. Introduction

Optical diffraction grating has been widely applied to latest technologies such as beam steering and optical interconnection [1]. The cholesteric liquid crystals (CLCs) on the vertical alignment layer have been studied for the switchable gratings since the fingerprint textures observed in the CLCs exhibited periodic modulation of the refractive index [2-4]. However, these methods required the complicated treatments such as patterned alignment layer or electrode [2]. Recently, the CLC grating produced by the photo-induced structural transition was reported [5]. Since any periodic surface treatments are not required in the CLC grating, the CLC gratings are easily fabricated. Here, the periodicity of the gratings is controlled by the helical pitch of the CLC. However, in the CLC gratings, the switching time is quite slow due to the rearrange process reaching the stable state. In general, the grating patterns are not replicated with repeated switching.

In this work, we report a CLC grating with an enhanced response time using surface treatment with the reactive mesogen (RM). The RM monomers mixed to the vertical alignment layer are polymerized by the ultra-violet (UV) light exposure and the polymerized RMs memorize the stable fingerprint texture of the CLC. To switch the grating properties, the CLC with negative dielectric anisotropy was used and the planar texture was obtained under an applied electric field. Memory characteristics produced by the polymerized surface eliminated the rearranging process of the CLC molecules and thus the response time was remarkably improved.

2. Experiment

The experiment was carried out using conventional sandwich cell. Figure 1 shows a schematic diagram of the CLC grating with the RM-mixed alignment layer. First, the glass substrates coated indium-tin-oxide (ITO) were spin-coated with the mixture of the vertical alignment layer (AL60702, JSR), RM (RM257, E. Merck), and photo-initiator (Irgacure651, Ciba Specialty Chemicals) at 1000 rpm for 10 sec for dispensing and at 3000 rpm for 20 sec for coating. The alignment layer mixture was pre-baked at 100 °C for 10 min in order to remove solvent and followed by hard-baking at 210 °C for 1 h. To obtain a stable one dimensional (1D) grating, we rubbed the substrates. After rubbing process, two rubbed substrates were assembled maintaining the cell gap of 15 μm by spacers.

The CLC was prepared with the nematic LCs with negative dielectric anisotropy (MLC-7026-100, $n_e = 1.5924$, $n_o = 1.4833$, E. Merck) and chiral dopant (R811, E. Merck) with a right-handed helical sense where the ratio of the cell gap to pitch (d/p) was 0.75. The CLC was injected by capillary action in the isotropic phase into the sandwich cell and the CLC cell was irradiated by UV for 1 h.

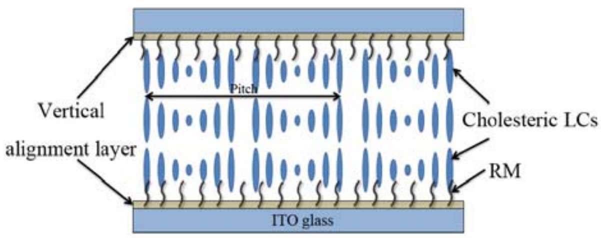

Fig. 1 The schematic diagram of polymer-stabilized cholesteric grating cell by the surface treatment proposed in this work.

3. Result and Discussion

Figure 2 shows the time-resolved microscope textures of the conventional CLC cell and the proposed cell with the RM-mixed alignment layer. We investigated the stability of LC reorientation when the applied voltage was removed. In both cells, the planar texture of the CLC was observed at 20 V where the CLC molecules were twisted with chirality

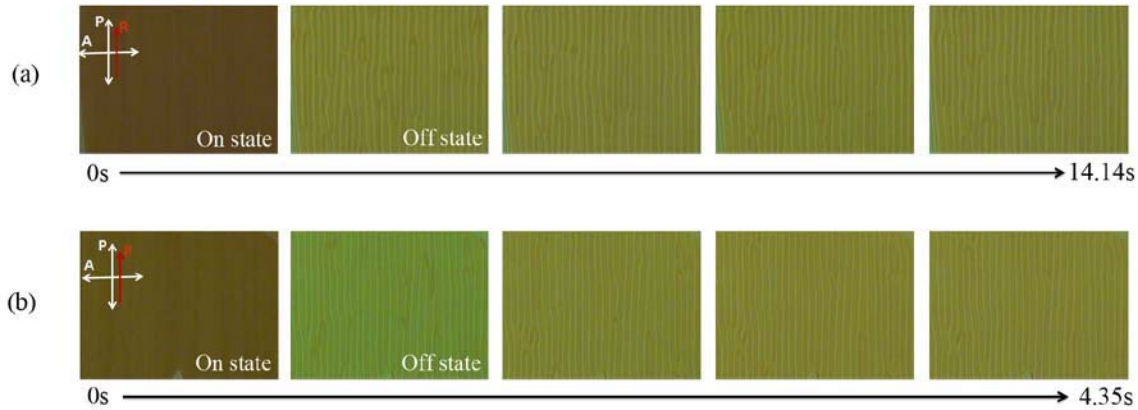

Fig. 2 The time-resolved microscopic textures for (a) the conventional cell and (b) proposed cell with surface treatment at the rising time. It measured in magnification of 100.

perpendicular to the substrates. When the applied voltage was removed, the helical axis was moved parallel to the glass substrate and the fingerprint texture was obtained. Here, the grating direction is parallel to the rubbing direction. In general, the CLC gratings exhibits the polarization-dependent diffraction features.

In the conventional CLC grating as shown in Fig. 2(a), the planar texture was slowly changed to the fingerprint textures forming the grating. After moving the helical axis to parallel to the substrates, the CLC molecules were rearranged to reach the stable state. In addition, the grating patterns were varied during the repeated switching. On the other hand, in the UV-treated CLC grating as shown in Fig. 2(b), the transition time was remarkably improved due to elimination of the rearranging process for the stabilization and the grating patterns were kept. The memorization of the fingerprint texture by the polymerized RMs gives rise to the stable grating features with an enhanced response time in the CLC gratings.

4. Summary

We reported the enhancement of response time in the CLC grating with the RM treatment on the alignment layer. Exposing UV light to the CLC cell prepared with the mixture of the RM and the alignment layer, the fingerprint texture was memorized and thus the CLC molecules directly reoriented to the stable state without the rearranging process. As a result, the direct transition from the planar to fingerprint textures gives rise to the enhancement of the response time.

Acknowledgment

This research was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MEST) (No. 20110016968) and a grant from LG display Co. Ltd.

References

1. R. L. Sutherland, V. P. Tondiglia, L. V. Natarajan, T. J. Bunning, and W. W. Adams, *Appl. Phys. Lett*. **64**, 1074 (1994)
2. D. Subacius, P. J. Bos, and O. D. Lavrentovich, *Appl. Phys. Lett.* **71**, 3323 (1997)
3. S. N. Lee, L. C. Chien, and S. Sprunt, *Appl. Phys. Lett.* **76**, 3516 (2000)
4. S. N. Lee, L. C. Chien, and S. Sprunt, *Appl. Phys. Lett.* **78**, 3782 (2001)
5. I. Gvozdovskyy, O. Yaroshchuk, M. Serbina, and R. Yamaguchi*, Opt. Express*. **20**, 3499 (2012)