Bistable switching of a polymer-walled liquid crystal phase grating cell

Su-Min Do, Tae-Hoon Choi, Byoung-Gyu Jeon, Tae-Hoon Yoon
Department of Electronics Engineering, Pusan National University, Korea

Abstract

We report bistable switching of a liquid crystal (LC) phase grating cell. Polymer walls are formed in an LC cell by phase separation of an LC mixture, induced by the spatial difference of the elastic energy and electric field intensity. Bistable switching of a polymer-walled liquid crystal phase grating cell could be realized by applying vertical and in-plane electric fields.

1. Introduction

Recently, liquid crystal (LC) light shutters have been studied extensively for smart window and see-through display applications. By controlling the haze value [1,2], LC light shutter can be switched between the transparent and translucent states. However, they suffer from a serious issue with the power consumption. These devices require continuous supply of power to maintain either the transparent or translucent states. To reduce the power consumption, bistable operation of a light shutter, which consumes power only when it is being switched between the states, is essential.

In this paper, we report bistable switching of a phase grating cell. Polymer walls are formed in an LC cell by phase separation of an LC mixture, induced by the spatial difference of the elastic energy and electric field intensity. We believe that this device could be a potential candidate for power-saving smart window or window display applications.

2. Operating Principle

To switch the state by applying an in-plane or vertical electric field, we formed interdigitated electrodes separated from the common electrode by an insulating layer on the top and bottom substrates. The two interdigitated electrodes are positioned at right angles to each other. When an in-plane electric field is applied to a vertically-aligned LC/reactive mesogen mixture, a large spatial elastic energy is induced along the direction perpendicular to the interdigitated electrodes on each substrate [3]. We formed polymer walls in the LC cell through ultraviolet irradiation while applying an in-plane electric field. When a vertical electric field applied to a polymer-walled liquid crystal (PWLC) phase grating cell is removed, LC molecules remain vertically-aligned due to vertical anchoring. On the other hand, when an in-plane electric field is removed, LC molecules remain homogeneously-aligned due to in-plane anchoring between the LC and polymer structure.

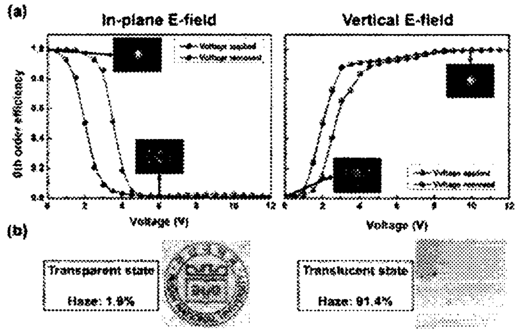

Figure 1: Zeroth-order diffraction efficiency(a) and images of the fabricated PWLC phase grating cell (b)

3. Experimental Results

The diffracted light intensity can be controlled by applying in-plane and vertical electric fields. Owing to the vertical alignment layer and polymer walls, the cell can maintain its state after the applied field is removed, as shown in Fig. 1(a). We have shown that 98.4% of the incident light can be transferred from the zeroth to higher orders. Owing to the high diffraction efficiency, the fabricated LC cell can provide a high-haze (~91.4 %) translucent state under a low in-plane voltage of 6 V and a low-haze (~1.9%) transparent state under a vertical voltage of 10 V, as shown in Fig. 1(b).

4. Acknowledgments

This work was supported by National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIP). (No. 2017R1A2A1A05001067).

5. References

[1] T.-H. Choi, J.-H Woo, J.-M. Baek, Y. Choi, and T.-H. Yoon, "Fast control of haze value using electrically switchable diffraction in a fringe-field switching liquid crystal device," IEEE Trans. Electron Dev. **64**, p. 3213, 2017.

[2] J.-W. Huh, J.-H. Kim, S.-W. Oh, S.-M. Ji, and T.-H. Yoon, "Ion-doped liquid-crystal cell with low opaque-state specular transmittance based on electro-hydrodynamic effect," Dyes Pigments **150**, p. 16, 2018.

[3] D. Voloschenko, O. P. Pishnyak, S. V. Shiyanovskii, and O. D. Lavrentovich, "Effect of director distortions on morphologies of phase separation in liquid crystals," Phys. Rev. E **65**, p. 060701, 2002.