KLCC 2011, Vol. 13,
Reprints available directly from the publisher
Photocopying permitted by license only

Fabrication Method of Patterned Retarder Based on Electrohydrodynamic Instability

Dae-Ho Jung[1], Young Wook Kim[2], Chang-Jae Yu[1, 2], and Jae-Hoon Kim[1, 2*]

[1]*Dept. of Electronic Engineering, Hanynag University, Seoul, 133-791, Korea*
[2]*Dept. of Information Display Engineering, Hanyang University, Seoul, 133-791, Korea*
jhoon@hanyang.ac.kr

We proposed a fabrication method of the patterned retarder based on the electrohydrodynamic (EHD) instability. The anisotropic flow of the liquid crystalline polymer (LCP) film enables a net force induced by utilizing the distorted electric field. The patterned retarder based on the EHD instability has simple process with an easy control of the phase retardation and no residual LCP. Therefore, it is applicable to the three dimensional displays, transflective liquid crystal displays and other optical devices.

1. Introduction

The liquid crystalline polymers (LCPs), having large optical anisotropy, great durability and good alignment property, are promising materials for many optical devices such as a patterned retarder film, liquid crystal (LC) lens, gratings, polarization rotators [1-6]. Among them, the patterned retarders using LCPs appeal to many researchers in the three dimensional (3D) display and transflective LC displays. The patterning methods of LCPs, in general, have proposed such as a thermal annealing and solvent washing method [1]. Through a designed photomask, the partially exposed regions by UV light maintain the aligned nematic phase, but the others are changed by thermal energy and/or solvent washing. In these methods, there are some drawbacks which are difficult to obtain the clear pattern-shapes and to control the precise phase retardation value. In this work, we propose a novel patterning method of LCPs for a patterned retarder, based on electrohydrodynamic (EHD) instability [7-11]. The distorted electric field by patterned electrodes supplies a net force to form an anisotropic flow toward the high electric field regions. And this method controls the phase retardation by changing the cell gap. Thus, this patterning method using EHD instability is much simple than two conventional methods.

2. Experiments

Figure 1 shows the fabrication procedure of the patterned retarder by using EHD instability. Firstly, we prepared two substrates which have patterned and non-patterned electrodes, respectively. And then, two substrates are spin-coated with a planar alignment layer, RN1199 (Nissan Chemical Industries). Next, the LCP is spin-coated onto the patterned substrate which was introduced by O_2 plasma treatment to minimize interaction between the polymerized LCP and alignment layer. In order to align LCP molecules, two substrates are rubbed unidirectionally. The LCP is spin-coated onto the patterned substrate with a thickness of 1.3 μm and cured at 60°C for 1 min to evaporate solvent in the LCP solution. After that, two substrates are assembled, maintaining with 2 μm glass spacers, which corresponds to a half-wave plate (HWP). The extraordinary and ordinary refractive indices of the used LCP are 1.684 and 1.529, respectively. When a high electric field (~80V) is applied, relative field

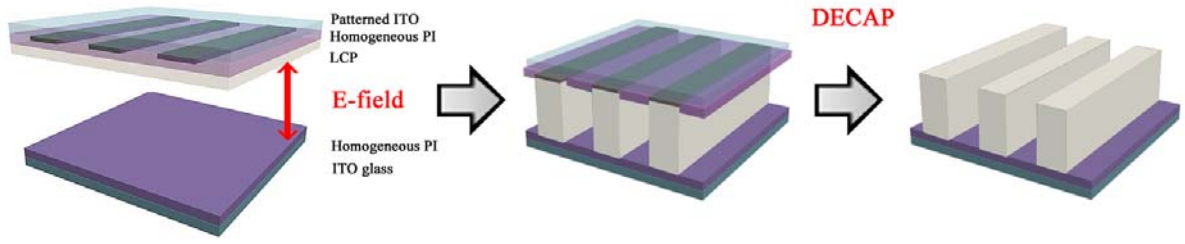

Figure 1. Schematic diagram of the fabrication procedure for the proposed fabrication method.

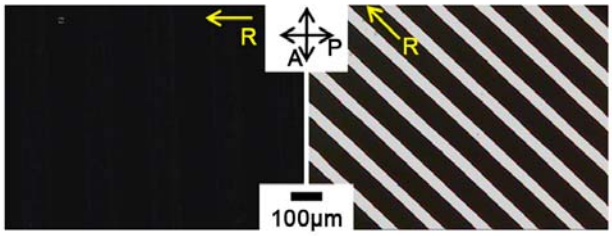

Figure 2. Microscopic images of the patterned retarder observed under crossed polarizers.

strength is a maximum at edge of patterned electrode due to the fringe field effect. So, LCP film is flowed toward the high field regions due to the difference of electrostatic pressure induced by a mismatch in the dielectric constants between air and LCP [8]. The LCP film on the electrode region is contacted with non-patterned substrate. Because the ratio of the initial LCP thickness to the cell gap of assembled cell is larger than 0.5 [11], the contacted LCP pillars are aggregated until forming rectangular stripe structures. Finally, we obtained patterned retarder by detaching the assembled cell after the UV light is exposed to the cell for some minutes to polymerize LCP. Here, the used patterned substrate is reusable for fabricated a new cell by cleaning process.

3. Results

Figure 2 shows the polarizing microscopic texture of the patterned retarder observed under crossed polarizers. No residual LCP was observed in the whole region. In the Fig. 2 (a), bright region, namely HWP region is evidently showed at the optic axis of the patterned LCP which is 45° with respect to the transmission axes of crossed polarizers. Also, in the Fig. 2 (b), the whole region is perfectly dark state even at HWP region due to no retardation. It means that the LCP was easily transferred from patterned substrate to non-patterned substrate and well-aligned by surface roughness anisotropy induced by rubbing effect. Figure 3 shows the surface profile of the patterned retarder. The measured width, interval, and thickness of the patterned LCP are 35 μm, 65 μm and 2.1 μm, respectively. Note that width and thickness of the patterned retarder, retardation value, is easily controllable by changing the photomask and cell gap.

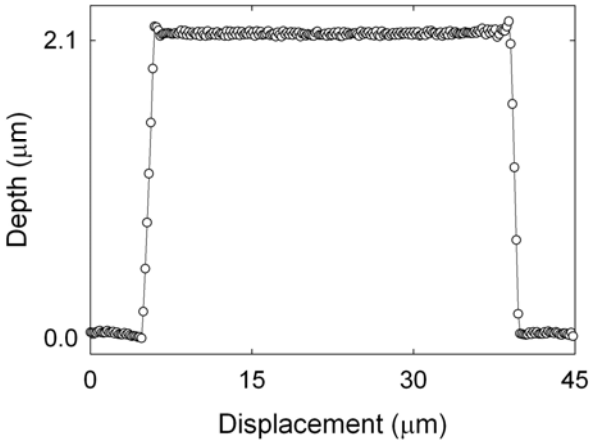

Figure 3. The cross-sectional profile of the patterned retarder film.

4. Conclusion

We proposed a fabrication method of the patterned retarder based on the EHD instability. By utilizing a distorted electric field in the LCP film, the patterned retarder can be simply fabricated. The phase retardation can be easily controlled by changing the cell gap between two substrates, and also no residual LCP can be observed. Therefore, the proposed patterned retarder is applicable to 3D display and the transflective LC displays.

5. Acknowledgements

This work was supported by a grant (F0004121-2010-33) from Information Display R&D Center, one of the Knowledge Economy Frontier R&D Program funded by the Ministry of Knowledge Economy of Korean government.

References

[1] R. Harding, I. Gardiner, H. –J. Yoon, T. Perrett, O. Parri, and K. Skjonnemand, *Proc. of SPIE.* **7140**, 71402J, (2008).

[2] Y. Choi, H. –R. Kim, K. –H. Lee, Y. –M. Lee, and J. –H. Kim, *Appl. Phys. Lett.* **91**, 221113, (2007).

[3] V. S. Soloviev, Y. B. Boiko, P. Perlo, and C. P. Grover, *Proc. of SPIE.* **4658**, 137, (2002).

[4] H. Ono, A. Hatayama, A. Emoto, N. Kawatsuki, and E. Uchida, *Jpn. J. Appl. Phys.* **44**, L306, (2005).

[5] S. Y. Chou, and L. Zhuang, *J. Vac. Sci. Technol. B.* **17**, 3197, (1999).

[6] Z. Zhou, G. Rothrock, D. Mar, X. Meng, J. Orr, R. Henn, *Proc. of SID Digest,* 534, (2008).

[7] S. Y. Chou, L. Zhuang, and L. Guo, *Appl. Phys. Lett*. **75**, 1004, (1999).
[8] E. Schaffer, T. Thurn-Albrecht, T. P. Russell, and U. Steiner, *Nature* **403**, 874, (2000).
[9] M. D. Dickey, E. Collister, A. Raines, P. Tsiartas, T. Holcombe, S. V. Sreenivasan, R. T. Bonnecaze, and C. G. Willson, *Chem, Mater*. **18**, 2043, (2006).
[10] Deshpande, X. Sun, and Y. Chou, *Appl. Phys. Lett.* **79**, 1688, (2001).
[11] N. Wu, W B. Russel, *Nano Today*. **4,** 180, (2009).