Optically addressed electrically tunable prism grating based on a liquid crystal film with a poly(N-vinyl carbazole) alignment layer

Ying-Chuan Wang

Department of Optometry, Shu-Zen College of Medicine and Management, No. 452, Huanqiu Rd., Luzhu Dist., Kaohsiung 821, Taiwan, yingchuan@szmc.edu.tw

Abstract: An electrically tunable prism grating based on homogeneously aligned liquid crystals (LCs) with a poly(N-vinyl carbazole) alignment layer was experimentally analyzed in this study. The gradient refractive index of the LC film was obtained using a conductivity-gradient electrode-like grating pattern of a poly(N-vinyl carbazole) alignment layer. The application of the DC electric field yields an asymmetric diffraction pattern. The dependence of the grating period on the prism effect was also discussed.

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Keywords: prism grating, poly(N-vinyl carbazole), asymmetric diffraction.

1. Introduction

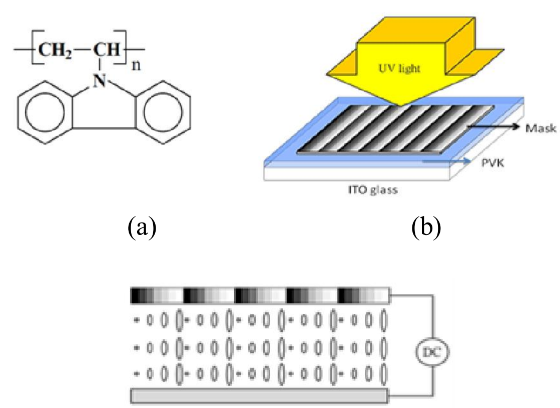
Liquid crystal (LC) beam steering devices have received considerable interest because of their applications in optical interconnects, optical communications, projection displays, optical data storage, and optical switches [1–10]. Patterned electrodes and photomasks are often used to fabricate the beam steering devices. One common drawback of these devices is the complexity of fabrication. Prism gating has shown better potential among the beam steering devices because of its high diffraction efficiency, highly asymmetric diffraction pattern, and simplicity of fabrication. A well-designed prism grating ideally attains 100% diffraction efficiency for the first-order beam. Hence, LC prism gratings are potential materials for beam steering.

This study presents an LC prism grating using a homogeneously aligned LC cell with a poly(N-vinyl carbazole) alignment layer. The gradient refractive index of the LC film is obtained by a conductivity-gradient electrode-like grating pattern of the polymer layer with a uniform UV light through a periodic photomask. The dependence of the grating period on the prism effect are also discussed [11–18].

2. Experimental

Sample preparation

Electrically tunable prism gratings were fabricated based on homogeneously aligned LCs with a poly(N-vinyl carbazole) alignment layer (Fig. 1). Fig. 1(a) shows the chemical structure of poly(N-vinyl carbazole), a transparent thermoplastic material with good thermal stability. Pure poly(N-vinyl carbazole) is a good insulator in the dark and under visible light illumination, which is photoconductive upon exposure to ultraviolet (UV) light. Periodically grayscale photomasks have strip widths of 150, 200, 250, and 300 μm [Fig. 1(b)]. A UV light with an intensity of ~8 mW/cm^2 illuminates a poly(N-vinyl carbazole) alignment layer for ~8 h. Indium tin oxide glass substrates were separated by 25 μm plastic spacers and were combined to produce a sample cell. E7 LCs were injected into each cell to form LC prism gratings [Fig. 1(c)].



(a) (b)

(c)

Fig. 1 Fig. 1. (a) Chemical structure of poly(N-vinyl carbazole); (b) electrically tunable prism gratings based on homogeneously aligned LCs with a poly(N-vinyl carbazole) layer; (c) electrically tunable prism grating.

Experimental setup

Figure 2 shows the experimental setup for measuring the asymmetric diffraction intensities of the 0th, +1st, and –1st orders. The diffracted signals were probed using a He–Ne laser (λ = 633 nm).

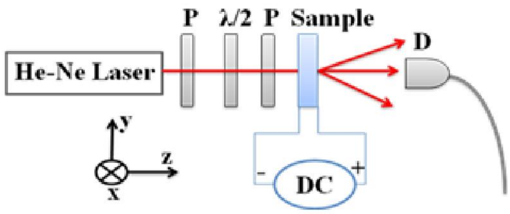


Fig. 2 Experimental setup for the measurement of asymmetric diffraction intensities. Abbreviations: P, polarizer; λ/2, half-wave plate; D, photodetector.

3.Results and discussion

Figure 3 shows the variations in the first-order diffraction efficiency (η) of the LC prism grating with an increased DC voltage; the parameters were initially set to V = 0 and η = 0%, respectively. Increasing the applied voltage to 2.5 V allows the measurement of η; the latter significantly increases from 5 V to 15 V, and reaches a maximum value of ~62% at 15 V. η gradually decays and the prism grating effect decreases when the applied voltage exceeds 15 V because the LC gradient reorientation gradually disappears.

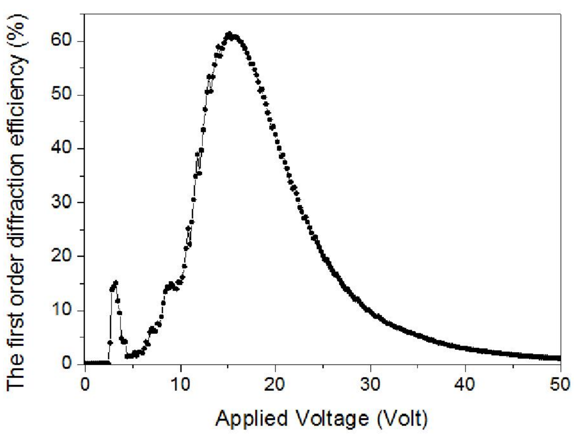


Figure 3 Variations in the first-order diffraction efficiency (η) of the LC prism grating with increasing DC voltage.

Figure 4 depicts the dependence of grating period on η. As the narrow stripe (150 μm) on the LC prism grating, η is about 58.7 %. η increases for grating periods less than 250 μm, and then decreases when the grating period is 300 μm, which is too wide. Maximum η occurs at 250 μm.

4. Conclusion

This study proposed an electrically tunable prism grating based on homogeneously aligned LCs with a poly(N-vinyl carbazole) alignment layer. Variations in η for the LC prism grating with increased DC voltage were shown. η increases from 5 V to 15 V, and reaches a maximum value of 62% at 15 V. Furthermore, a grating period of 250 μm yields the maximum value of η.

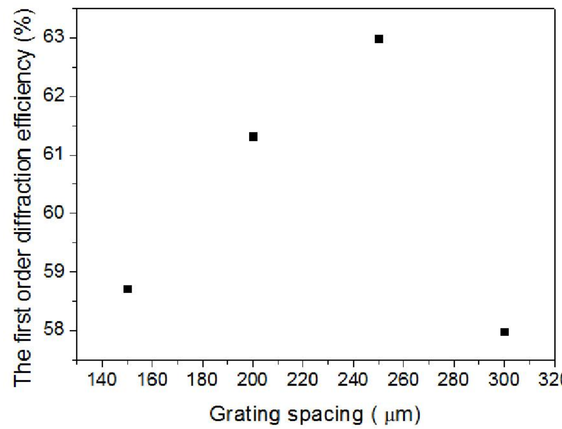


Figure 4 Dependence of grating period on η.

Corresponding Author:
Ying-Chuan Wang, Ph.D.
Department of Optometry,
Shu-Zen College of Medicine and Management,
No. 452, Huanqiu Rd., Luzhu Dist., Kaohsiung 821, Taiwan
E-mail: yingchuan@szmc.edu.tw

References

1. W. M. Gibbons and S. T. Sun, Appl. Phys. Lett. 65, 2542 (1994)
2. R. L. Sutherland, Appl. Phys. Lett. 64, 1074 (1994)
3. H. Okada, P. J. Bos, and H. Onnagawa, Jpn. J. Appl. Phys., 37, 2576 (1998)
4. S. W. Kang, S. Sprunt, and L. C. Chien, Appl. Phys. Lett. 76, 3516-3518 (2000)
5. H. SAKATA and M. NISHIMURA, Jpn. J. Appl. Phys., 39, 1516 (2000)
6. C. M. Titus, J. R. Kelly, E. C. Gartland, S. V. Shiyanovskii, J. A. Anderson, and P. J. Bos, Opt. Lett. 26, 1188 (2001)
7. X. Wang, D. Wilson, R. Muller, P. Maker and D. Psaltis, Appl. Opt, 35, 6545 (2000)
8. B. Apter, U. Efron and E. B.Treidel, Appl. Opt, 43,11 (2004)

9. H. Ren, Y.H Fan, and S.T Wu, Appl. Phys. Lett. 82, 3168 (2003)
10. S.Y. Huang, H.Y. Zheng, K. Y. Yu, B.Y. Huang, H.R. Lin, C.R. Lee, and C.T. Kuo, OPTICAL MATERIALS EXPRESS, 2,1791 (2012)
11. R. A. M. Hikmet, Liq. Cryst. 9, 405 (1991)
12. H. Ren, Y. H. Lin, and S. T. Wu, Opt. Commun. 261, 296 (2006)
13. J. Sun, H. Xianyu, Y. Chen, and S. T. Wu, Appl. Phys. Lett. 99, 021106 (2011)
14. J. Sun, Y. Chen, and S. T. Wu, Opt. Express 20, 20124 (2012)
15. H. Ren, S. Xu, and S. T. Wu, Opt. Express 20, 26464 (2012)
16. J. Sun, R. A. Ramsey, Y. Chen, and S. T. Wu, J. Disp. Technol. 8, 87 (2012)
17. S. W. Kang, S. Sprunt, and L. C. Chien, Macromolecules 35, 9372 (2002)
18. V. V. Sergan, T. A. Sergan, and P. J. Bos, Chem. Phys. Lett. 486, 123 (2010).

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