Paper No P09: Electrically Tunable Grating Using Holographic Polymer Templated Blue Phase Liquid Crystal

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Abstract

In this paper, we demonstrate an alternative approach to fabricating an electrically tunable holographic polymer-templated blue phase liquid crystal grating. This grating is obtained by preforming a polymer grating template, and then refilling it with the blue phase liquid crystal. Compared with conventional holographic polymer dispersed liquid crystal gratings, its driving voltage can be reduced to 43 V, while maintaining sub-millisecond response time.

1. Introduction

Tunable gratings based on holographic polymer dispersed liquid crystal (HPDLC) have been extensively studied for achieving low driving voltage, high diffraction efficiency, and fast response time. Sarkar et al. reported that the driving voltage can be decreased from 9.0 to 2.5 V/μm by using partially fluorinated monomers, but its decay time is slowed from 1.6 to 18 ms [1]. Jang et al. reported a HPDLC that is fabricated with the chemically incorporated graphene oxide, by which the driving voltage is reduced from 70 to 25 V. However, its decay time is slightly slowed from 3.2 to 4.8 ms [2]. In this paper, we propose a holographic polymer templated blue phase liquid crystal (HPTBPLC) grating, which is fabricated by refilling the blue phase liquid crystal (BPLC) into a grating template that is pre-formed by the holographic exposure [3].

2. Experiments

In experiments, the mixture for the polymer template comprises 21.9 wt %: 7.5 wt %: 1 wt %: 0.6 wt %: 69 wt % of TMPTA monomer (Aldrich): *N*-vinylpyrrollidone (Aldrich): *N*-phenylglycine (Aldrich): Rose Bengal (Aldrich): nematic liquid crystal (BP-06, $\Delta n = 0.158$, $n_{iso} = 1.56$, $\Delta\varepsilon = 34.2$, Jiangsu Hecheng). The BPLC for refilling is composed of LC host (BP-06) at 96.5% and chiral dopant (R5011, Jiangsu Hecheng) at 3.5%.

3. Results and Discussion

3.1. Driving Voltage

Diffraction efficiency (DE) versus applied voltages of HPDLC and HPTBPLC gratings is plotted in Figure 1. The DE is defined as a ratio of the power of the first-order diffraction to the total output power. For HPDLC grating, DE = 15% and driving voltage is 200 V at room temperature. For HPTBPLC grating, DE = 14.7% and driving voltage is 43 V at 70.5°C. The relatively low DE for HPTBPLC comes from the small refractive index contrast. The refractive index of the polymer matrix is 1.527, and $n_{iso} = 1.56$ for the BPLC. If n_{iso} could be increased to 1.59, the maximum phase modulation will reach π, at which DE is 33%. Moreover, for getting higher DE, smaller grating period and larger cellgap are both desired.

3.2. Response Time

The measured response time is shown in Figure 2, where the red dashed curve and blue solid curve represent the first-order transmittance of HPDLC and HPTBPLC gratings, respectively. The rise and decay time measured at room temperature are 341 and 424 μs for the HPDLC grating, respectively. While for the HPTBPLC grating, the rise and decay time measured at 70.5°C are 610 and 890 μs, respectively.

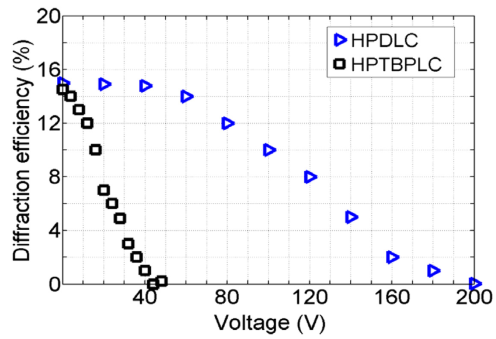

Figure 1. Measured DE versus driving voltage.

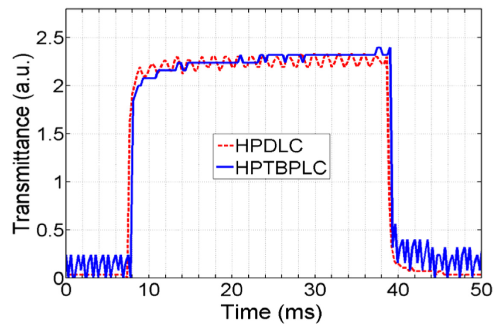

Figure 2. Measured response time of grating switching.

4. Conclusion

We have demonstrated a tunable HPTBPLC grating. This method is eligible in lowering the driving voltage to tens of volts, while maintaining sub-millisecond response time.

5. Acknowledgements

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6. References

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