Electrically tunable silicon nitride microring resonator with a polymer-stabilized blue phase liquid crystal cladding

Chun-Ta Wang, Yuan-Cheng Li, Chih-Wei Tseng, Jui-Hao Yu, Hung-Chang Jau, Yung-Jui Chen, and Tsung-Hsien Lin
Department of Photonics, National Sun Yat-Sen University, Kaohsiung 804, Taiwan

Tunable microring resonators (MRs) have attracted more attention due to their wavelength-selective abilities, which can be as optical filters for WDM technique application. So far, many tunable MRs have been demonstrated using electro-optic effect, thermo-optic effect, and nematic liquid crystal (NLC) [1]. Among these methods, the MRs using NLCs as a cladding possesses a wide resonant wavelength tuning range because of the large birefringence of NLCs. However, the NLCs based MR encounters some problems such as large scattering loss and slow response due to the anisotropic molecular structure of NLCs. This work demonstrated an electrically tunable SiN MR using polymer-stabilized blue phase liquid crystals (PSBPLCs) as a cladding. Unlike typical NLCs, the PSBPLCs exhibit optically isotropic and thus have lower scattering. Besides, their response time of induced birefringence, governed by the Kerr effect is submicrosecond [2]. The proposed device comprises two parts, waveguide chip and PSBPLC film, as presented in Fig. 1(a). The chip consists of a Si substrate, a 16 µm thick SiO2 layer and a 0.5 µm thick SiN layer. The designed resonator structure, as shown in Fig. 1(b), includes a straight waveguide and a ring with radius of 40 µm. The width and thickness of both SiN waveguides are 1.2 and 0.5 µm, respectively. The PSBPLC film, two positive nematic LCs, JC1041 and 5CB, were mixed with two UV-curable monomers, TMPTA and RM257, a chiral agent, R1011, and the photoinitiator DMPAP in a ratio of 43.6:33.5:5.4:7.1:10:0.4. The sample was cooled to 36°C (BPI) at a rate of 0.5°C/min, and then irradiated with ultraviolet light (0.8mW/cm²) for 20min to achieve phase separation, forming the PSBPLC film.

Figure 2 (a) plots the variation of the resonance wavelength (at 1548.98nm) of such filter for TM mode with the applied voltages from 0 to 150V. As the applied voltage was increased, the resonance wavelength shifted toward longer wavelengths because the effective refractive index of the PSBPLCs was increased. When the applied voltage was 150V, the resonance wavelength was shifted by 0.45 nm. The FWHM width of the resonance at 0, 90, and 150V are 0.059, 0.064 and 0.062 nm, and their corresponding Q-factor are 26254, 24205 and 24990, respectively, as illustrated in Fig. 2(b). The experimental results indicate that the device can maintain the high quality under the influence of an electric field. Figure 2 (c) presents the response times of the device under various applied voltages form 40 to 150V. All data of response time is in the millisecond.

Fig. 2.

References

* presenting author; E-mail: DADAER22@hotmail.com