Fabrication of High Q-Factor Ring Resonator using LSCVD Si_3N_4 Film

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The micro-ring resonator is the promising optical device for a variety of applications due to its compact size design, wavelength selectivity, and flexible structure. The micro-ring resonators with high Q-factors are sensitive to intra-cavity refractive index modulation and useful for the reducing energy [1]. In terms of CMOS-compatible material, Si_3N_4 have been studied because of its wide transparent wavelengths ranging from visible to near infrared wavelengths. Additionally, Si_3N_4 has a high Kerr nonlinearity but a low two-photon induced free carrier absorption at 1550 nm, which is preferred for the parametric oscillation application [2]. In this work, we investigate the fabrication of a high Q-factor Si_3N_4 ring resonator by improving the propagation loss and controlling the precise control of the coupling intensity.

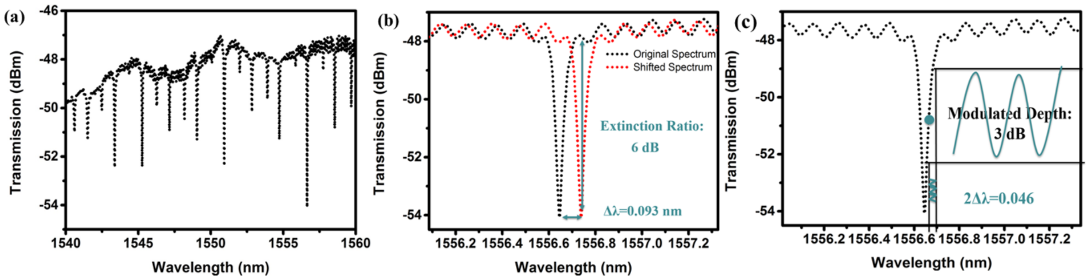

Fig.1 (a) Transmission spectrum of the ring resonator with Q-factor of 70,800 (b) theoretical 0.093 nm-shift of the resonance under 10^{-4} effective refractive index change and (c) 3 dB-modulation depth within the 0.046 nm wavelength shift.

Generally, the Si_3N_4 film was deposited on the SiO_2/Si substrate by using PECVD or LPCVD technique. However, as-deposited Si_3N_4 has dangling H and O bonds with Si and N in the films. These bonds have an intense absorption centered at 1520 nm, which overlaps with c-band and causes the excess propagation losses. In order to overcome this problem, we prepared Si_3N_4 films using the liquid source CVD (LSCVD). It turns out to be both refractive index and propagation loss can be effective optimized. In the fabrication of the Si_3N_4 ring resonator, different parameters of the ring structure are discussed in order to obtain a high- Q resonance. The measured Q factor was 70,800 as shown in Fig. 1 and it can be further improved with increased optical confinement and film deposition optimization. When the effective refractive index assumed to change 10^{-4}, a resonance spectral shift of 0.093 nm can be theoretically obtained with the corresponding extinction ratio of 6 dB (Fig. 1(b)). Thus, a modulated depth of 3 dB within the wavelength shift of 0.046 nm is also achieved as in Fig. 1(c). The proposed device shows potential for high-speed, low-energy, and small-footprint optical switch and modulator application.

Reference [1] W. Bogaerts, Laser Photonics REV 6, 47-73 (2012). [2] F. Qiu, ACS Photonics 3, 780-783 (2016).