Fabry-Perot cavity filter based on lithium niobate

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***Abstract*—An optical filter based on lithium-niobate-on-insulator using a Fabry-Parot cavity with multimode waveguide gratings. The fabricated device with a length of ~60μm and a large Free Spectral Range (FSR)，most considerable FSR of ~ 22nm.**

Keywords—Fabry–Perot cavity, optical filter, mode multiplexer, lithium niobate, wavelength division

+multiplexing

I. Introduction

In recent years, Lithium-niobate-on-insulator (LNOI) has attracted more and more attention due to its excellent electro-optical effect (~ 34 pm/V), ultra-wide transparent window (350-5000nm), and excellent nonlinear effect [1]. Various high-performance devices have been developed based on the LNOI platform, such as E-O modulators, optical frequency comb, wavelength converters, etc. [2-3]. Wavelength filters, one of the most important passive devices in wavelength division multiplexing (WDM) systems, have been extensively investigated[4]. In general, on-chip optical filters can be implemented by using a variety of promising waveguide structures, such as micro-ring resonators (MRRs)[5,6], array waveguide gratings (AWGs)[7], cascaded Mach-Zehnder interferometers (MZIs)[8], waveguide Bragg gratings [9,10], etc. However, the situation becomes very different for the LNOI platform. The LNOI has a much smaller index contrast than silicon on insulator (SOI), and the mode hybrids also forbid the design of the sharp bend. Thus one couldn't achieve an MRR with a larger FSR. On the other hand, the LN material anisotropy makes creating phase-sensitive devices complex, especially AWG for WDM. Recently, a high-performance optical filter based on multimode waveguide grating (MWG) has been fabricated on lithium niobate. Still, it is challenging to realize broadband filtering due to the design of the structure [11]. This paper proposes and demonstrates an LNOI Fabry-Perot optical filter by integrating a mode multiplexer with an F-P cavity based on multimode waveguide gratings. The measurement results show that the filter has a 3dB bandwidth of 0.3 nm, a large FSR of 16~20 nm（The largest FSR of 21nm）, a low excess loss of 1 dB, and an extinction ratio of ~ 15-25 dB. Our scheme provides a new solution to the limited FSR of microring on the LNOI platform.

II. Design, Fabrication, and Characterization

Figure 1(a) shows the proposed Fabry-Perot optical filter, it consists of a multiplexer and an F-P cavity, and the F-P cavity is formed with two rectangular corrugated MWG. The working principle is shown in Figure 1. Two Bragg gratings reflect the mode, and resonance is realized in the cavity. Moreover, an amplitude apodization is introduced to suppress the sidelobes of the filter and reduce link loss. And including a mode (de-) multiplexer and two cascading Fabry-Perot optical filters composed of three Bragg gratings, as shown in Fig. 1(b), the extinction ratio of the filter can be further improved.

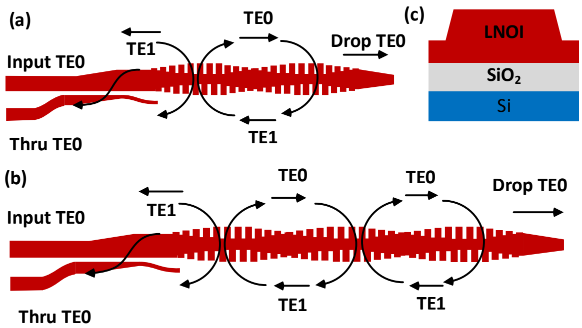

Fig. 1 The current structure diagram of the on-chip Fabry-Perot optical filter, (a) Single cavity and (b) double cavity structures. (c) The cross-section of the LNOI waveguide.

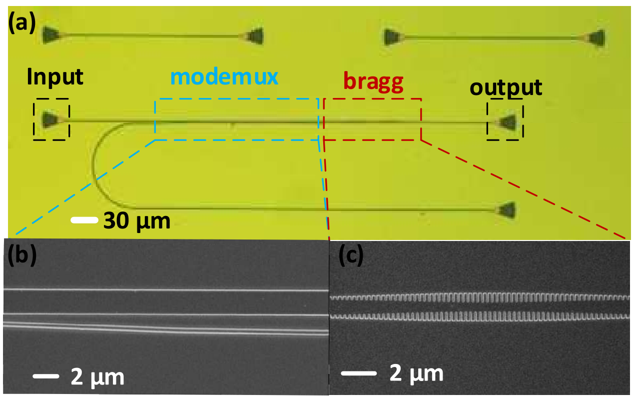

Fig. 2 (a) Microscope image of the fabricated polarization-insensitive optical filter on silicon. SEM images of the Modemux (b) and the MWG (c).

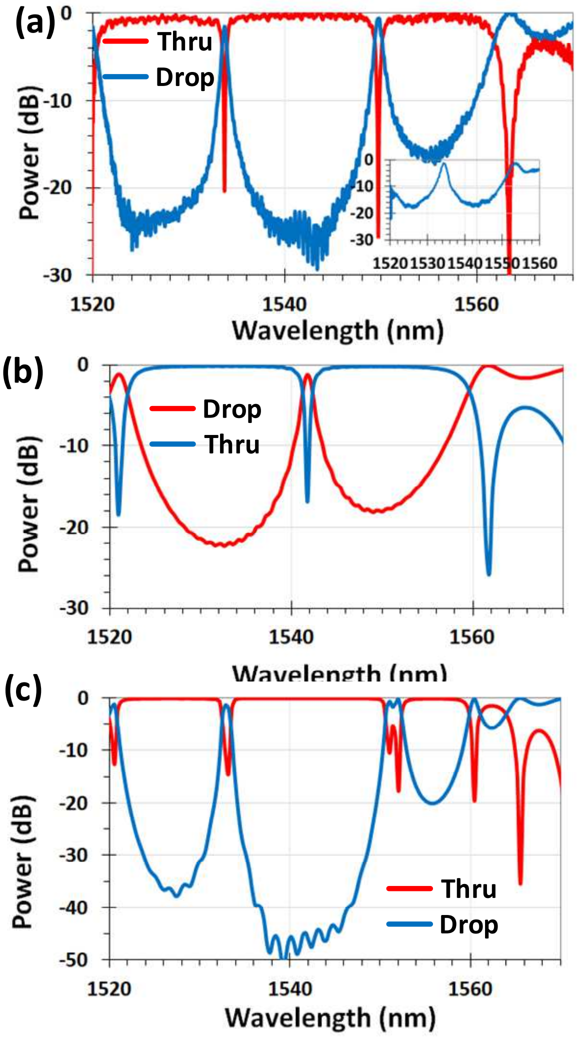

Fig. 3 (a)Measurement results of single Fabry-Perot optical filter, Inset: FSR-22nm Fabry-Perot optical filter. (b) simulation results of Fabry-Perot optical filter (b) simulation results of cascaded Fabry-Perot optical filter

The Fabry-Perot filter is designed based on an LNOI platform with a 400nm top-LN layer and a 3μm thick buffer layer, the etching depth is 200nm, and the inclination angle is 60 degrees shown in Figure 1 (c). Figures 2(a)-2(c) show the microscopic and scanning electron microscope (SEM) images of the fabricated Fabry-Perot optical filter. Fig. 3(a) shows the measured， and Fig. 3(b) and (c) is the simulation result of the Single cavity. Structure and double cavity structures spectral responses of the fabricated Fabry-Perot filters at the through the port and the drop port, respectively. Here, the measured transmission is normalized with a straight waveguide fabricated on the same sample. It can be seen that the faked F-P filter has a maximum FSR of ~ 22nm, and the corresponding extinction ratio is 15db. Another example (Fig. (b)) has an FSR of 18nm and an extinction ratio of 25db. Furthermore, we designed and simulated a double cascade Fabry-Perot filter, as shown in Fig. 2(b); it has an FSR ~ 19nm, an excess loss of 1 dB, as well as a maximum extinction ratio more significant than 48 dB, as shown in Fig. 3(c).

III. CONCLUSIONS

We propose a low-loss LNOI Fabry-Perot optical filter with a large FSR. The demonstrated filter has a 16-20nm FSR, low loss of 0.6-1.5 dB, and extinction ratio of 15-48 dB. Modifying the resonator's length can adjust this filter's 3db bandwidth and FSR. It overcomes the problem of limited FSR of ordinary microring structure, which is helpful in many applications, especially for the LNOI-dense WDM technology.

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