Simulation Analysis of Microring Resonator in Mobius Topology

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***Abstract*—In this paper, a microring resonator in Mobius topology is modelled and simulation analysis is carried out. The free spectral range of this silicon-on-insulator based photonic device is found to be 23.4 nm. This structure of microring resonator finds place in various applications such as sensors, polarization analysis, wavelength-selective reflectors.**

***Index Terms*—Microring resonators, coupled resonators, triple ring resonators, Silicon photonics, Mobius topology**

I. Introduction

Microring resonators (MRR) are one of the widely used photonic devices in integrated photonic applications. Their ultra small footprint, large free spectral range, wavelength selectivity and simple fabrication techniques make it a commonly used building block in photonics [1]. In order to exploit the properties of microring resonators for various applications, different topologies of microring resonators have been proposed and studied exhaustively. Some of the commonly modelled topologies of microring resonators include series coupled resonators such as coupled resonator optical waveguide (CROW), parallel coupled resonators such as side coupled integrated spaced sequence of resonators (SCISSOR) and cascaded resonators [2]. Microring resonators have been configured to be used as reflectors [3] and this reflection property has been exploited to design a photonic analog of a Mobius strip [4]. A Mobius strip is formed by twisting one end of a waveguide by 180o and then joining the ends together. The structure of triple ring resonators coupled to form a structure similar to a Mobius strip is shown in Fig. 1.

In the Mobius topology, the resonant modes are distinguished by a phase of $2m\pi$ which is induced after one round trip inside the resonator. The coupling in this topology indicates that the mode (+m) in one MRR excites only the opposite mode (-m) in the other MRR. As a result of this unidirectional coupling, an odd number of MRRs coupled to each other such that a MRR couples to two adjacent MRRs resulting in a photonic analog of a Mobius strip as double round trip is required to excite the '+m' mode again in the MRR [5].

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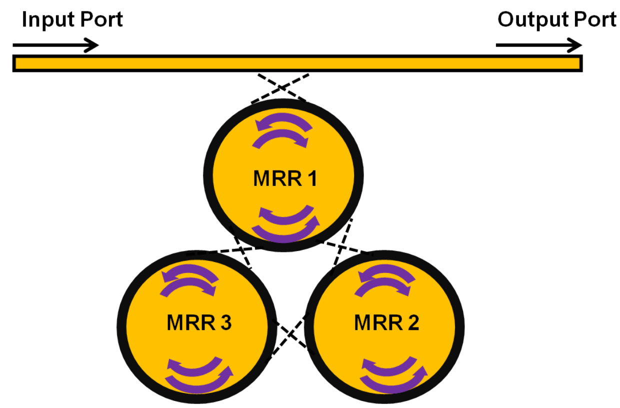

Fig. 1. Structure of triple ring resonators cascaded in Mobius topology.

II. Modelling of the MRR structure

The triple ring resonator structure in Mobius topology is modelled in RSoft's computer aided design tool which is based on finite difference time domain (FDTD) algorithm. The layout of the triple ring resonator is shown in Fig. 2(a).

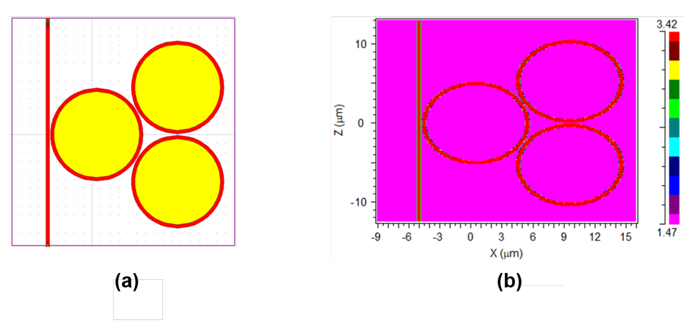

Fig. 2. (a) Structure of triple ring resonators modelled in CAD tool (b) Refractive Index Profile of the modelled structure.

The material used for modelling the ring resonator structure is silicon-on-insulator (SOI) where the refractive index of the core is 3.42 and that of cladding is 1.47. The radius of the three MRRs is 5µm, width of the ring resonators and the bus waveguide is 400 nm. The gap separation between the bus waveguide and MRR 1 and between MRRs 1, 2, 3 is 100 nm. The refractive index profile of the ring resonator structure and the mode propagation through the waveguide is illustrated in Fig. 2(b).

III. Simulation Results

The electric field propagation through the triple ring resonator structure in Mobius topology at different wavelengths is depicted in Fig.3. It is observed that propagation of electric field at different wavelengths is different through the modelled structure.

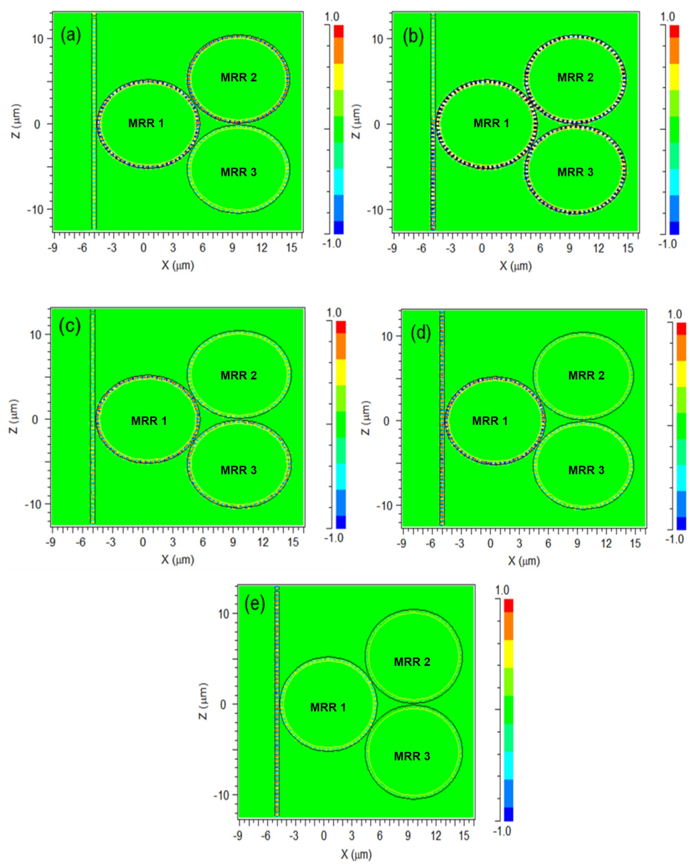

Fig. 3. Electric field propagation through the triple ring resonator in Mobius topology at wavelength of (a) 1539.79 nm (b) 1539.95 nm (c) 1541.59 nm (d) 1543 nm (e) 1545 nm

It is observed that when the incoming wavelength is 1539.79 nm, the electric field propagates through MRR 1, 2 only whereas MRR 3 is transparent to this wavelength as seen in Fig. 3(a). When the wavelength of incoming light is 1539.95 nm, the electric field propagates through all the three MRRs as observed in Fig. 3(b). Similarly for the wavelength of 1541.59 nm, the propagation of electric field is through MRR 1, 3 as observed in Fig. 3(c). When the wavelength of incoming signal is 1543 nm, the propagation of electric field is only through MRR 1 and MRR 2, 3 are transparent to the wavelength of 1543 nm as observed in Fig. 3(d). When the wavelength of incoming signal is 1545 nm, the electric field does not couple into the ring cavity and passes only through the bus waveguide as observed in Fig. 3(e). In this case, the triple ring resonator structure is said to be in OFF resonance. The transmission characteristics of the modelled ring resonator structure in Mobius topology is shown in Fig. 4.

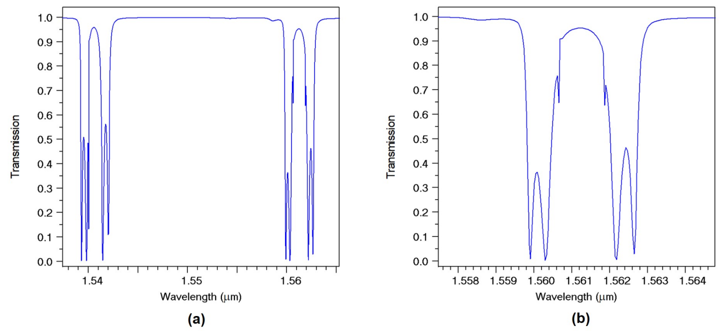

Fig. 4. (a) Transmission characteristics of coupled resonator in Mobius topology (b) Magnified version of (a)

IV. Conclusion

A triple microring resontaor in mobius topology is modelled and analyzed. The analysis is carried out in terms of E-field propagation through the modelled structure of microring resonator. From the transmission characteristics of the structure, the free spectral range is found to be 23.4 nm.

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