Journal of Artificial Intelligence in Electrical Engineering, Vol. 2, No. 8, March 2014

A New Design for Photonic Crystal Ring Resonator Based Add-Drop Filter Using Nested Rectangular Rings

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ABSTRACT
In this paper using nested Rectangular resonator we have designed an add-drop filter based on photonic crystal structures suitable for optical communication applications. The drop efficiency and the quality factor of our proposed filter is 100% and 2508. In this filter the quality factor is significantly improved with respect to other published reports. The simulation results are obtained using 2D Finite Difference Time Domain (FDTD) method. The Photonic Band gap (PBG) is calculated by Plane Wave Expansion (PWE) method.

KEYWORDS: Photonic Crystal, Add-drop Filter, FDTD, Nested Rectangular Resonator

1. INTRODUCTION

Photonic crystals (PhCs), also known as photonic band gap (PBG) materials, can manage the spontaneous emission and the propagation of electromagnetic (EM) waves [1–3]. Due to existence of PBG, PhCs have applications in various areas of optical engineering such as optical filters [4, 5], switches [6,7], beam splitters [8],and demultiplexers [9,10] which may ultimately make preparations for photonic integrated circuits (PICs). By engineering the photonic band gap, the confinement of light in given wave length scan be tuned. It means that, we can manage the transmittance and reflectance wavelengths interval by adjusting the band gap of each PhC structure. Filtering device enables us to extract from one waveguide one wavelength and to send it to another waveguide. Optical channel drop filter is one of the important components to select a single or multiple wavelength channels. So far, several topologies have been proposed for channel drop filters, such as using ring resonators [11]. In this paper we proposed a novel structure for designing a tunable PhCRR-based add-drop filter. For this purpose, we used a rectangular structure.

2. DESIGN OF PHOTONIC CRYSTAL ADD-DROP FILTER

This designed structure is based on two-dimensional photonic crystals which is located silicon rods with refractive index of 3.46 in the air with refractive index of 1. The number of bars in the X and Z are respectively 26 and 17. Network constant of the entire structure (a) equal to 606 nm and the radius of each of rods is 8/123 nm. This structure contains only two photonic band gap in the TM mode. Normalized frequency of the first photonic band gap from the top is $0.713 \le \frac{a}{\lambda} \le 0.736$ corresponding to the wavelength range 3/823 nm to 4/849 nm. The second photonic band gap has the normalized frequency$0.279 \le \frac{a}{\lambda} \le 0.413$ and its wavelength range is from 1460 nm to 2172 nm. Figure 1 shows the band structure of photonic crystal TM polarization mode.

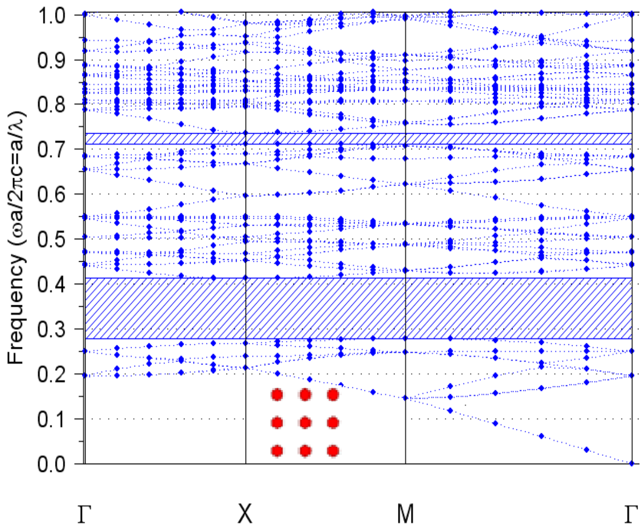

Fig.1. Band structure of the photonic crystal

3. SIMULATION RESULTS

In this paper, a new type of removed and added filter designed. This structure as shown in figure2 have a core that is made of the silicone inner rod as two nested rectangular in context of air. Removed and added filter based on photonic nested rectangular resonator structure includes one waveguide. Signal input port is marked with the word and Input Output 1 and Output 2 and Output 3 are port our output ports (According to Fig.3 our waveguide was created using linear unrighteousness). The photonic crystal removed and added filter with square lattice constant is formed using point defect. According to figure 2 bars that have been yellow are called the coupling rods. There are 8 black bars in the corner of loop due to waste the waves inverse scattering in the corner of the loop and the exacerbation within loop can be easily done. These bars called scatter bars.

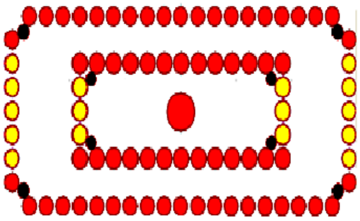

Fig.2. Display of structure of nested rectangular photonic crystal resonator

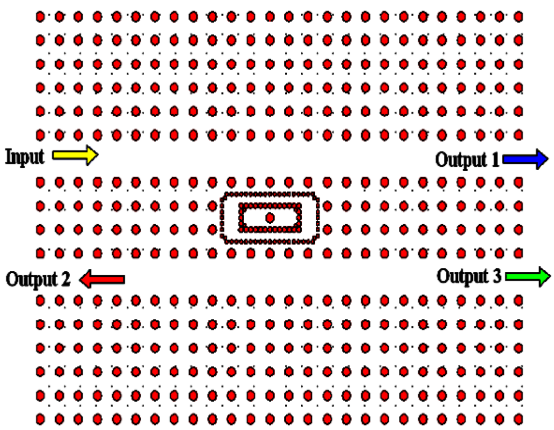

Fig.3. Schematic of structure of removed and added filter based on photonic crystal nested rectangular resonator

Gaussian excitation signal applied to the port Input 1. The output signal recorded by the time monitor, which placed in output port (Output 1, Output 2, Output 3). Spectrum of the transmitted component calculated by FFT (Fast Fourier Transform) on port fields Output 1, Output 2 and Output 3 by the two-dimensional FDTD method. Figure 4 is normalized transmission spectrum of the removed and added filter based on nested rectangular resonator structure of photonic crystals with a wavelength of 1550 nm that the center frequency is 8/1504 nm and quality coefficient equal to 2508 and transfer efficiency is 100%.

Figure 5 shows the intensity of the electromagnetic field for a wavelength of 1550 nm.

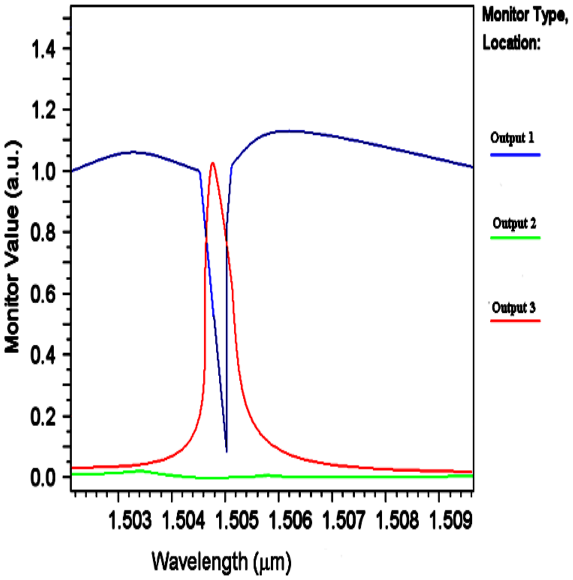

Fig.4. Normalized transmission spectrum of removed and added filter based on a photonic crystal rectangular resonator with a wavelength of 1550 nm

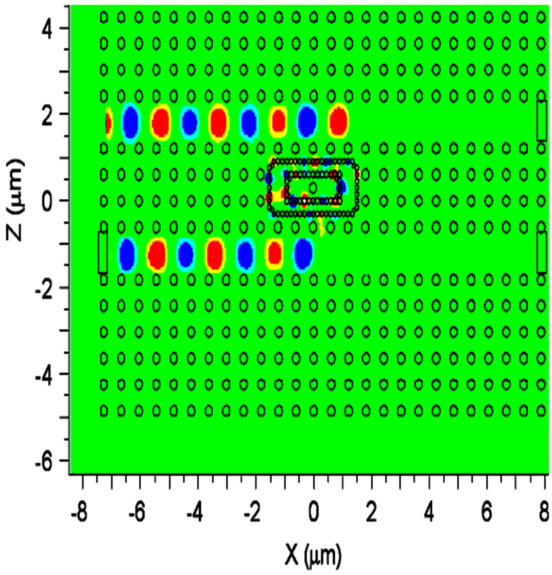

Fig.5. Electromagnetic field intensity for a wavelength of 1550 nm

As well as, Figure 6 shows the electromagnetic field intensity for the frequency of 1330 nm.

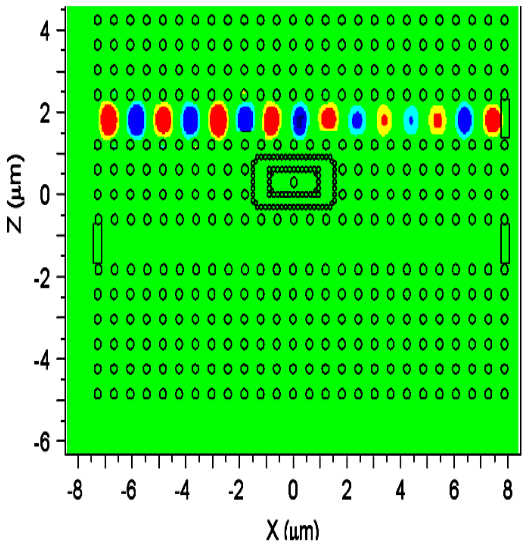

Fig.6. Electromagnetic field intensity for frequency of 1330 nm

4. CONCLUSIONS

In this paper we proposed a novel structure for designing all optical PCRR-based add-drop filters. We employed a rectangular shaped resonate ring for realizing our proposed add-drop filter. The quality factor of the structure is2508 and the drop efficiency is 100%. We have shown that there is flexibility in design of the add-drop with photonic crystal ring resonators. Such structure may offer promising applications for photonic integrated circuits based on PhCs and other Nano-photonic structures References.

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