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A New Design of Photonic Crystal Filter and Power Splitter Based on Ring Resonators

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ABSTRACT

Here, we propose an optical filter and an optical power splitter based on two-dimensional photonic crystal all circular ring resonators. These structures are made of a square lattice of silicon rods with the refractive index n1=3.464 surrounded by air (with refractive index n2=1). First, we have designed the filter and by using that, we designed a power splitter. The transmission efficiency and Quality factor for both, an optical filter and an optical power splitter, respectively, are more than 90% and 1000. Resonant modes of the all-circular ring resonator with their corresponding degenerated poles and the transmission spectra are calculated using the PWE, and 2D-FDTD methods respectively.

KEYWORDS: Filter, Photonic crystal, power splitter, Ring resonator

1. INTRODUCTION

Photonic crystals (PhCs) composed of periodic dielectric materials dielectric or metallo-dielectric nanostructures, have been intensively studied in the past decade, because they possess many unique properties to control the propagation of electromagnetic (EM) waves [1]. As a result of this periodicity, the transmission of light is absolutely zero in certain frequency ranges which is called as Photonic Band Gap (PBG) [2-4]. PCs are classified mainly into three categories according to its nature of structure periodicity, that is, One Dimensional (1D), Two Dimensional (2D), and Three Dimensional (3D) PCs. The geometrical shape of 1DPCs, 2DPCs and 3DPCs [1]. The ability to control and manipulate the spontaneous emission by introducing defects in PCs, and related formation of defect state within PBG has been used for designing the optical devices for different applications that are directed towards the Integration of photonic devices [5]. photonic crystal ring resonators (PCRR) can be considered as a new type of linear defects which their size is determined by the desired resonant wavelength. In recent years many optical devices are made based on PCRRs such as multiplexers [6], de-multiplexers [7], power splitters [8], and add-drop filters [9], channel-drop filters [9-11] and so on. In this paper, our goal is design power splitter. The calculations of band structure are done using PWE method and the power transmission spectrum, resonance frequency and corresponding quality factors and add-drop filter are calculated using the 2D-FDTD method.

2. NUMERICAL RESULT AND ANALYSIS

To design a power splitter, we have designed the filter and by using that, we designed a power splitter. The basic structure is used to design the proposed filter and power splitter, by square lattice constant of silicon bars is surrounded by air. The refractive index of silicon is 3.46 and the refractive index of air is 1. First, we will examine the structure of the filter, and then we analyze the power splitter. Lattice constant for both the structure is equal to 494.5 nm and dielectric rods radius for both structures, is 95 nm. Ring structure used in both of these devices filter and power splitter, as is shown in Figure 1.

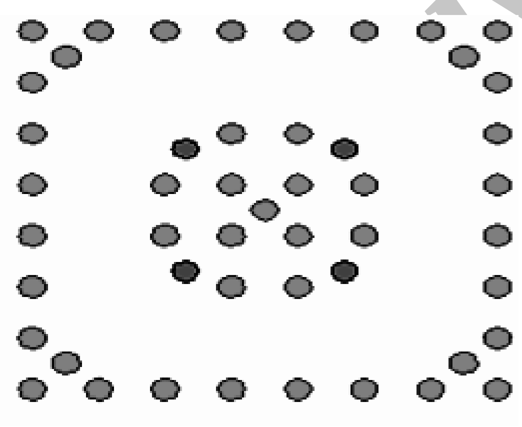

Figure.1. Ring structure used in both of these devices filter and power splitter.

In four ears ring, there are four scatters and for enhanced device performance that we have designed them with these rings, are used. Ring rods are darker, 15% in the x, z directions have been displaced from their places, and central rod ring correct in the middle of the ring is located. The number of rods for our proposed filter in the x and z directions are respectively, 22 and 20. Our filter structure, only has a one photonic band gap be in TM mode. The normalized frequency bandgap, is equal to $0.288 \le a/\lambda \le 0.426$. Which has a finite wavelength, $1.16 \le \lambda \le 1.717$.Figure 2 shows the band structure of our proposed filter.

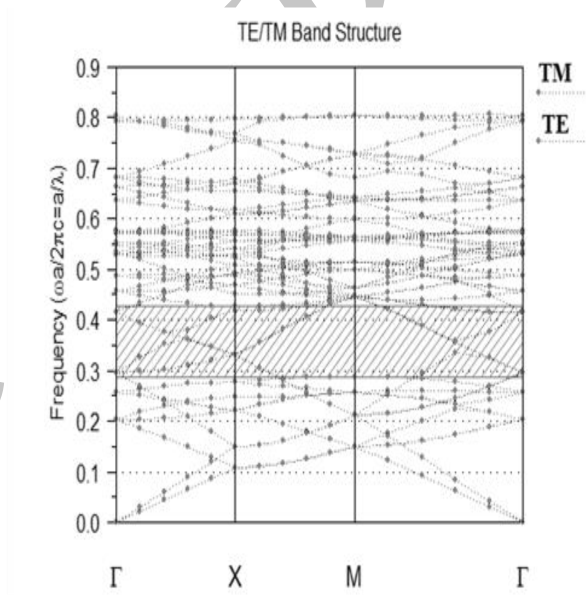

Figure.2. Shows band structure of our proposed filter

This structure has three main parts. An input waveguide is vertical, and a ring resonator and an output waveguide is to form horizontal. Light is entered from the vertical waveguide and intensifies in the ring resonator and is entered to horizontal waveguide, and output is calculated by method FDTD . Figure 3 shows our proposed filter.

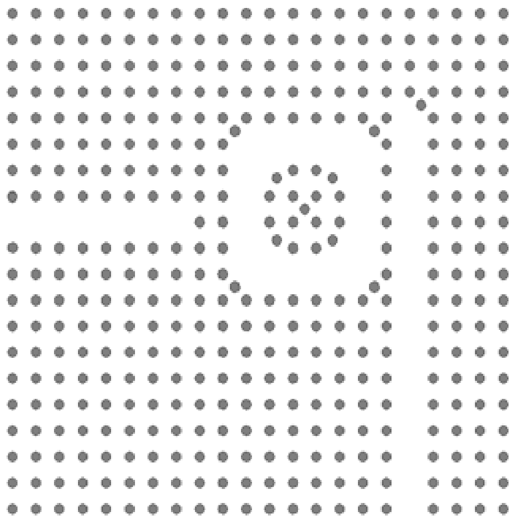

Figure.3. Shows our proposed filter.

In addition, in Figure 4, the normalized spectrum transmission filter is based on our ring resonators.

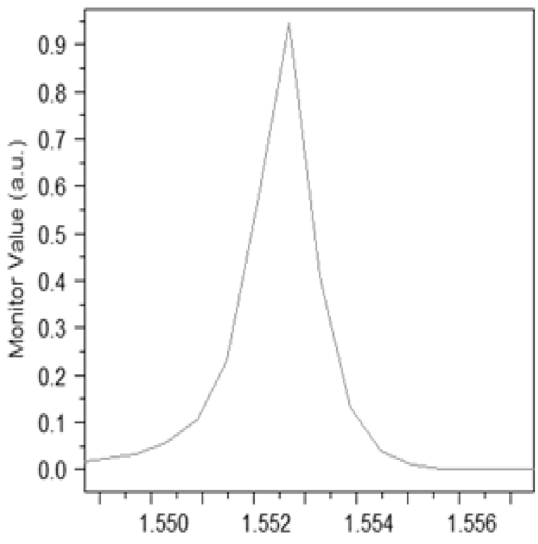

Figure.4. Is the normalized spectrum transmission filter

The transmission efficiency of this filter is equal to 95% and the quality factor of this filter is equal to 3905.2. Now using this filter structure, we have designed a power splitter. Figure 5 is the structure of the proposed power splitter.

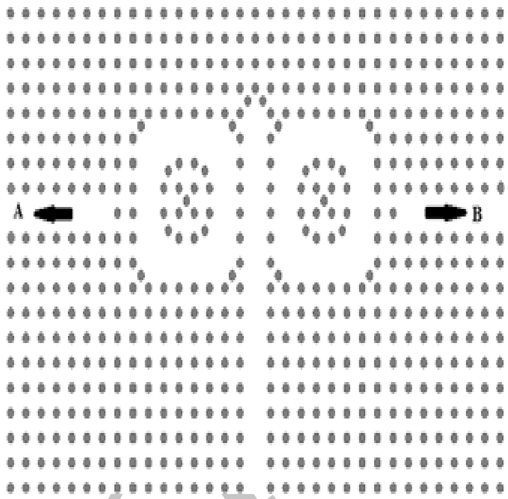

Figure.5. Structure of proposed power splitter

The number of rods for our proposed power splitter in the x and z directions are respectively, 33 and 20. This structure has three waveguides and two ring resonators .Vertical waveguide is between the 2 resonators, and two horizontal waveguide as being a previous filter. Light is entered from the central waveguide between the two rings, and exits by two other waveguide, which shows A and B. Figure 6, the normalized spectrum power splitter is our proposed.

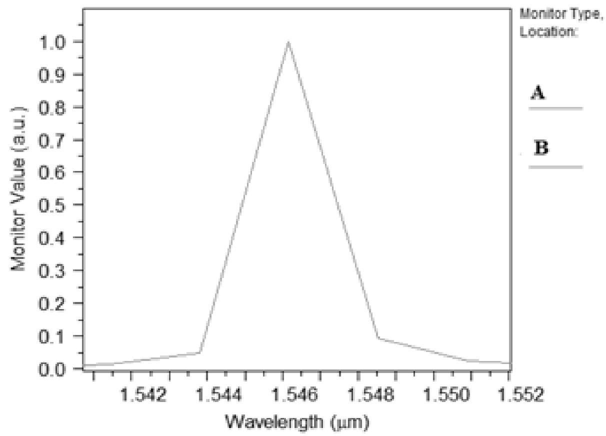

Figure.6. The normalized spectrum power splitter

According to Figure 6, the transmission efficiency of this power splitter for both outputs is equal to 100% and the quality factor for both outputs is equal to 1030.6. Figure 7.shows *the electric field distribution in photonic crystal ring resonator for* Wavelength of 1.55.

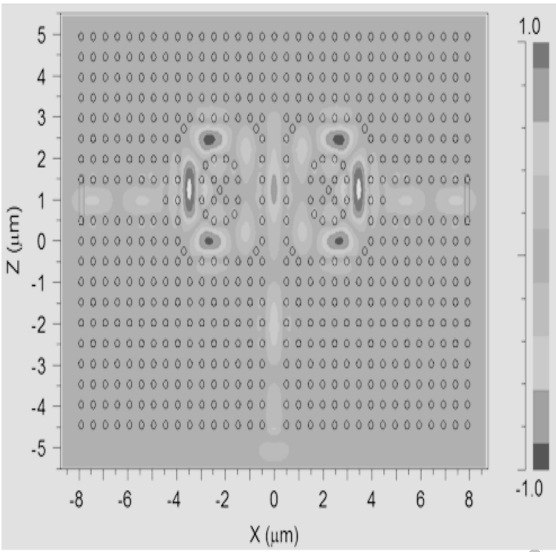

Figure.7.shows the electric field distribution

3. CONCLUSIONS

In this paper, first we design an optical filter based on photonic crystal ring resonator. The transmission efficiency of this filter is equal to 95% and the quality factor of this filter is equal to 3905.2. Then using this filter structure, we have designed a power splitter. The transmission efficiency of this power splitter for both outputs is equal to 100% and the quality factor for both outputs is equal to 1030.6. According both, an optical filter and an optical power splitter, we can use of these structures for optical integrated circuits.

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