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The New Design and Simulation of an Optical Add Drop Filter Based On Hexagonal Photonic Crystal Single Ring Race Track Resonator

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ABSTRACT

In this paper, using annular resonator we have designed an adding and dropping filter light based on two-dimensional photonic crystals. The shape of ring resonator filter adding and dropping that we have proposed is Race Track. This filter has a hexagonal lattice structure of silicon bars with refractive index 3/46 that is located in the context of air with refractive index 1. Transmission efficiency and quality coefficient of our proposed filter are respectively 94% and 310. Finite difference method in two-dimensional time domain (2-D FDTD) used for normalized transmission spectra of photonic crystal ring resonator and to calculate the photonic band, plane wave expansion method (PWE) has been used.

KEYWORDS: Add drop filter Photonic Crystal, Race Track 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]. Because 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]. . By using the defects effects in photonic crystal structures, periodicity and photonic band gap has been broken, and the light is entered to region of photonic band gap and this could lead to the design of optical devices be based photonic crystals such as optical demultiplexers [6] and optical filters [7],and etc.

Ring resonators photonic crystal due to the coefficient of the high quality and the nature of their single mode ring and flexibility have a choice of high spectral resolution that provides optical design types of electronic devices [8]. In this paper, we designed an add-drop filter by using racetrack ring resonators two-dimensional photonic crystal with the new structure. Also for simulation of electromagnetic wave propagation in time domain is used finite difference method in 2D time-domain (2D-FDTD) and to calculate the photonic band gap is used of the plane wave expansion method (PWE).

2. STRUCTURE DESIGN

The desired system is a set of rods with a two-dimensional hexagonal grid. Since the optical properties and Construction Technology of integrated optical components based on silicon, which is well known, refractive index of silicon bars is $n_{Si} = 3/46$ and the refractive index of air is $n_{air} = 1$. The number of bars in the space x-z is 21 × 27. As well as, optimal wavelength for Window Display is located inside the C-band of optical telecommunications band. Network constant of whole structure (a) equals 618 nm and the radius of each rod equals 7/129 nm. This structure is contains only two photonic band gaps in the TM mode. Normalized frequency of the first photonic band gap from the top is equal to $0/541 \leq \frac{a}{\lambda} \leq 0/592$ which corresponds to wavelength range 849 nm to 1043 nm.

The second photonic band gap has normalized frequency of $0/269 \leq \frac{a}{\lambda} \leq 0/430$ and the wavelength range from 2/1432 nm to 2291 nm. Figure 1 shows the band structure of the photonic crystal of TM polarization mode.

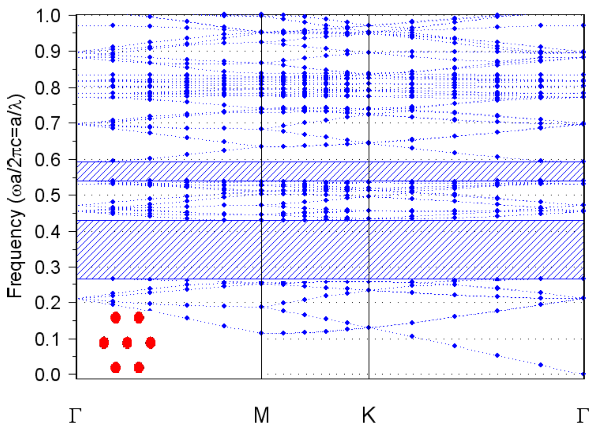

Fig.1. Band structure of a photonic crystal complete network calculated in TM polarization mode by PWE.

Figure 1 shows the structure of the photonic crystal complete band. In addition, it is known as PBG and for *r/a*= 0.2 is calculated by using PWE method with state of TM polarization (Electric field parallel to the axis of the rod). Compared with point or linear unrighteousness, annular resonator, suggest the scalability in the size and consistency of the structure design; because the broad design parameters and flexibility in design of state is due to the nature of their multimode. Aggravator Race track can be even makes improvements. Some of these parameters are scatter radius rods and dielectric constant of the structure. In the general case, Aggravator Race track consists of two paths and a ring which ring is placed between the two paths. PCRR shown in Figure 2 Has two waveguide. Upper waveguide called bus waveguide and lower waveguide called dropping. Waveguide caused by linear unrighteousness and ring by spot unrighteousness.

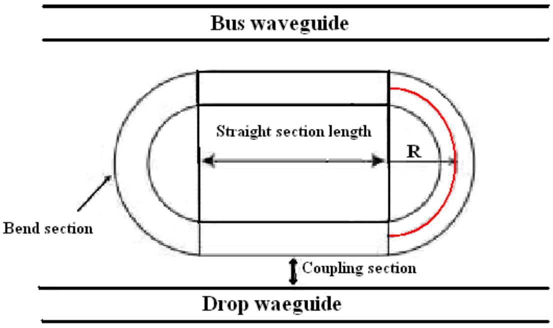

Figure.2. Schematic design of a single ring resonator Racetrack though. Racetrack includes a straight portion and a bent portion.

In this design, in Figure 3 have used four scatter marked with blue. The advantages of this design compared to the previous design of filter Race track is that the square structure were used in the previous structures, but to increase bandwidth of 30 nm to 5nm with center frequency of 1550 nm, we have used the hexagonal structure.

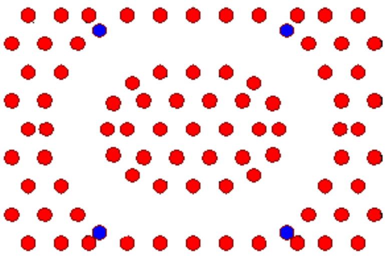

Fig.3. Display of Race track resonator of photonic crystal

Using this method, complete power transmission and selected wavelength operation from waveguide Bus to waveguide Drop obtained in our filter.

3. SIMULATION RESULTS

Figure 4 shows the final design of the proposed Canal of filter drop. This filter has an input called Input and three output channels called Output 1 and Output 2 and Output 3. Our waveguide Bus placed between the input and Output 1. Other waveguide is a dropping.

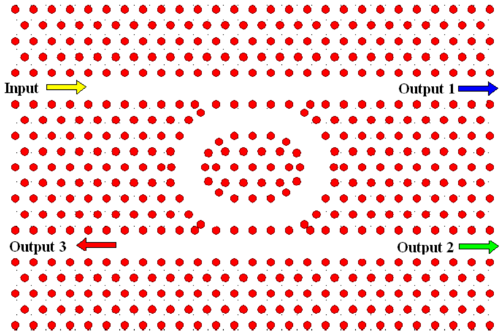

Fig.4. Schematic structure of the filter Race track based on photonic crystal.

Under resonance conditions, Output 3 is the main output of filter that does dropping. Function of desired wavelength is a typical filter C-band of optical telecom. Spectrum of transmission component by doing FFT (Fast Fourier Transform) on port fields of Output 1 and Output 2 and Output 3 calculated by two-dimensional FDTD method. Figure 5 is normalized spectrum of Race track filter transmission based on ring resonator structure of photonic crystal with a wavelength of 1550 nm which its center frequency is 1550nm and its quality coefficient is 310 and Its transfer efficiency is 94%. Full bandwidth from 1547 to 1552 is about 5nm. Figure 6 shows the electromagnetic field intensity for a wavelength of 1550 nm.

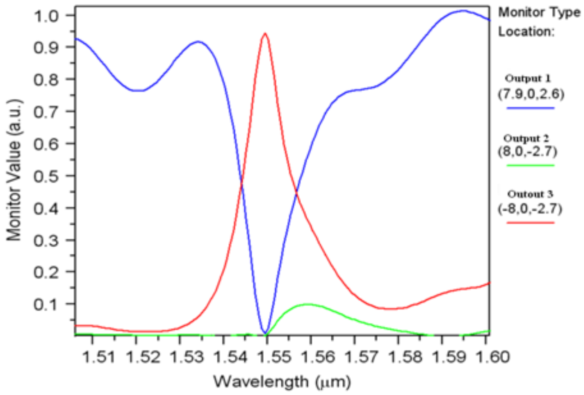

Fig.5. normalized transmission spectrum of the proposed filter Race track is calculated using FDTD method. The central wavelength of this filter, is λ = 1.55μm.

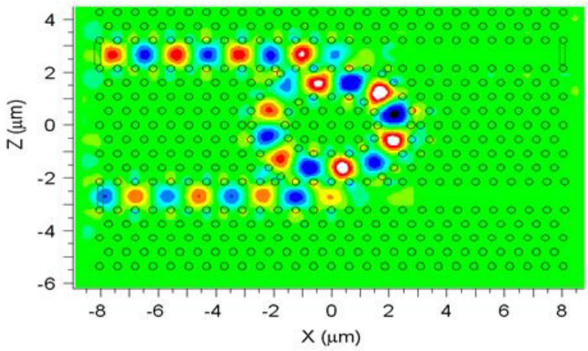

Fig.6. intensity of electromagnetic field for a wavelength of 1550 nm

Figure7.Also shows intensity of electromagnetic field for frequency of 1330 nm.

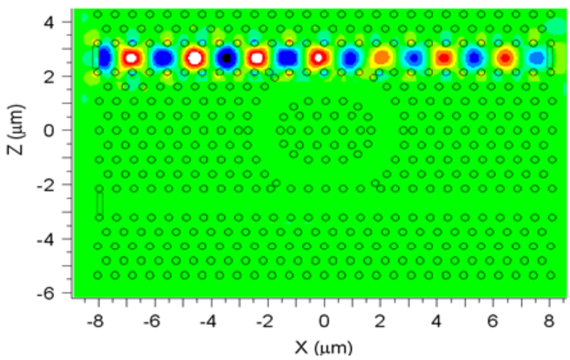

Fig.7. Intensity of electromagnetic field for frequency of 1330 nm.7

4. CONCLUSIONS

In this paper, we designed an optical adding and dropping filter using an annular resonator Race Track based on two-dimensional photonic crystals. This filter has a hexagonal lattice structure. This structure has two waveguide using linear unrighteousness are made and an annular resonator was design. This filter has a silicon rods with refractive index of 46/3 that surrounded by air with refractive index of 1. Transmission efficiency and quality factor of the filter is respectively 94% and 310 that occurs at a wavelength of 1550 nm, as well as, our proposed filter has small bandwidth of 5 nm. Considering these characteristics, this type of filter can be used in optical integrated circuits.

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