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Design of Ring resonator in waveguide and hexagonal lattice in Photonic Crystal using FDTD method

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***Abstract*— In this paper, we designed the ring resonator in two different structure which waveguide and hexagonal Crystal lattice structure. We have used the holy fiber to design the waveguide structure of ring resonator. We proposed the comparative analysis of both field analysis and mode propagation using FDTD analyzer. Due to the comparison we analyses the parameters like power, mode, distribution of light through the ring resonator and refractive index of the Photonic Crystal.**

***Index Terms*— FDTD method, Waveguide, Rod, Lattice cells, PCF.**

I. INTRODUCTION

In global communication systems, we follow the backbones of all-optical fiber networks and PCF. Because they have been based on the extremely wide optical transmission bandwidth provided by dielectric material. We know already, lot of research has been focused on PCF. Photonic Crystal Fiber designs are categorized in three fiber levels they are Holy fiber (HF), Field-Confined Holy Fiber (FCHF) and Hole Assisted Light-guide Fiber (HALF). PCF is used in applications in fiber optic communications, nonlinear devices, and high-power transmissions highly sensitive gas sensors. In our system we use FDTD for simulation purpose. FDTD is a powerful, highly integrated, user-friendly software and simulation of advanced passive photonic components. 2D FDTD approach is based on a direct numerical solution of the time-dependent Maxwell's curl equations. The first version of FDTD is in 2D [10]. The photonic device is laid out in the X-Z plane. The Propagation is along Z. The Y-direction is assumed to be infinite in both waveguide and PCF. The main advantages of the FDTD approach is the lack of approximations for the propagating field-light is modeled in its full richness and complexity. The other significant advantage is the great variety of materials that can be consistently modeled with the FDTD context. Optical Ring resonator is a set of waveguide in which at least one is a closed loop coupled to some sort of light input and output. It obeys the properties of constructive interference and total internal reflection. When the light of the resonant wavelength is passed through the loop from input waveguide, it builds up in intensity over multiple round trips due to constructive interference and its output and output bus waveguide which serve as a detector waveguide [5]. Because only a select few wavelengths will be at resonance within the loop, the optical ring resonator functions as a filter. We know
the applications of the photonic crystal ring resonator. Ring resonator acts as a tunable channel drop filter and its waveguide model of ring resonator also act as a channel drop filters[13]. They are varying by the power level and pointing vector-Z.

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II. DESIGN OF RING RESONATOR

Designing of ring resonator obtained by removing or creating defects in a ring shape of columns from a square lattice of dielectric rods in air background. Refractive index and radius of dielectric rods is 3.2 and 0.3 is located in air. Lattice constant is the dielectric constant it is mainly for the dielectric rod. These dielectric rod have a dielectric constant of 10.65 corresponding design of ring resonator using waveguide is described below. Linear waveguide is used as a input plane in ring resonator and ring waveguide PC is done by using the Photonic Band Gap crystal structure but the waveguide ring resonator is done by linear waveguide. Input field transverse in input field property select as model. Amplitude of the input or power is set as 1 V/m or 1 W/m. Gaussian modulated CW time offset is 5e-14 and its half width is 1.4e-14. Input property is in the mode of Gaussian modulated continuous wave. Placing of ring waveguide in the waveguide profile is the design procedure of ring resonator waveguide.

III. SIMULATION

Now we analyze the comparison between the hexagonal PC and waveguide ring resonator by using FDTD analyzer. The spectrum of the power transmission is obtained with finite difference time domain (FDTD) method. This software is the famous method for PC analysis. FDTD is the best method for solving Maxwell's equation. This simulation is mainly for finding the mode effective and refractive index of resonant structure. This is mainly for study of propagation characteristics [4] & [5]of holy PCF. Run this structure with specific time steps for analyze mode effective area.

The main advantage of Photonic Crystal Ring Resonators [8] & [9] is smaller in size. PBG effect of PCs provides highly confined modes to control the propagation of light. The PC rings could be produce with a smaller bend radius. The PC cavities possess strong optical confinement, high Q-factor, small mode volume and small footprint. In this we used in-plane (TE) polarization excitation for both waveguide and photonic resonator. When we change the waveguide of ring resonance wavelength, we observe a rapidly changing free-spectral range (FSR).

Linear waveguide gap resulted a loss decay rate is much smaller than the coupling decay rate. When the slow light propagation phenomena that occurs around the band edge of PC to increase the Q-factor of the resonator to reduce its FSR.

IV. RESULT ANALYSIS

The Comparison factors for Photonic crystal ring resonator and waveguide ring resonator are given below. Those factors are analyzed for power level and pointing vector of the ring resonator. The refractive index of the photonic crystal ring resonator shown in fig.1.

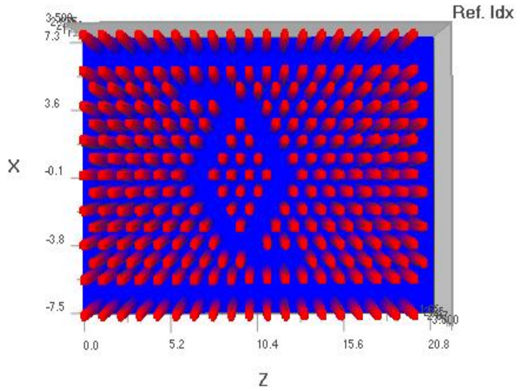

Fig. 1 Refractive Index profile for PCRR

Then the Waveguide Ring Resonator (WRR) was designed for one input and one output port. Refractive index profile for waveguide ring resonator is shown in fig.2. Comparatively PCRR and WRR are same. When the light propagation through the ring resonator is varied in both PCRR and WRR

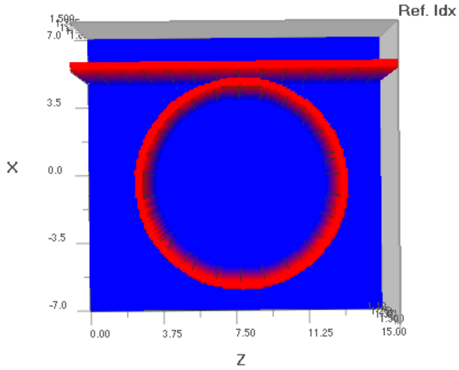

Fig. 2 Refractive index profile for WRR

PCRR and WRR have a pointing vector for analysis the power level and distribution of light. When the light passed through the resonator that propagated region is shown in pointing vector fig.3 and WRR pointing vector shown in fig.4 and 5they can allow the light throughout the ring.

Compared to point defect or line defect PC cavities, Photonic Crystal Ring Resonators[10][11] (PCRRs) offer scalability in size, flexibility in mode design due to their multimode nature, easy integration with other devices and adaptability in structure design. An optical cavity confines light at resonance frequencies and can therefore be regarded as an optical resonator. Optical resonators are characterized by two key parameters reflecting their ability to confine the optical energy temporally and spatially.

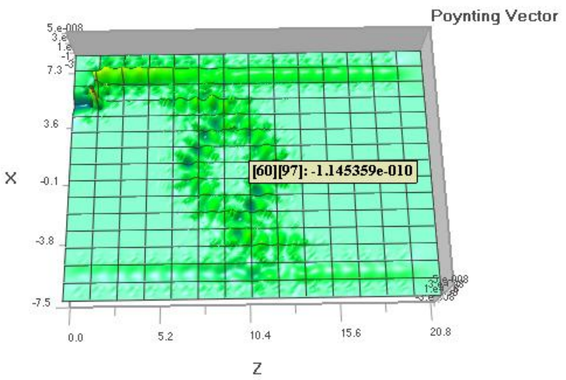

Fig. 3 Pointing vector for PCRR

The former is quantified by the quality factor Q and the latter by the mode volume V. The Q-factor is directly proportional to the decay time, a large value indicating long decay time. The mode volume measures the volume occupied by the optical mode, and a small value represents strong Spatial confinement.

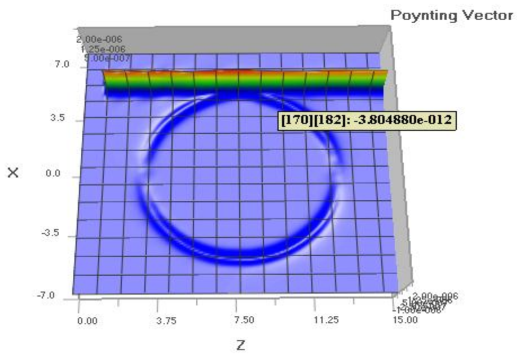

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Fig. 4 Pointing vector for WRR

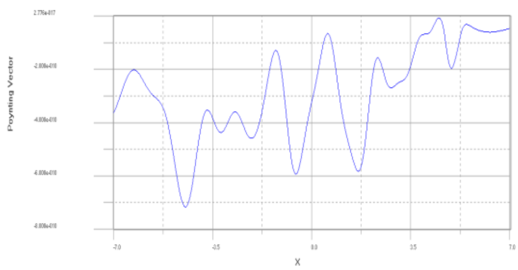

Fig. 5 Pointing vector analysis in Z-direction

One more feature about optical coupling is the critical coupling. The critical coupling shows that no light is passing through the waveguide after the light beam is coupled into the ring resonator. The light will be stored and lost inside the resonator thereafter. Lossless coupling is when no light is transmitted all the way through input waveguide to its own output and all of the light is coupled into the ring waveguide. Electric field and Magnetic field light distribution parameter for Photonic crystal ring resonator and waveguide ring resonator are shown in fig. 6 and fig. 7. This observation area analysis of WRR is observed by the Frequency DFT with minimum and maximum range of sample point is 150-230µm are shown in fig. 8. They normalized with the input plane mode of real with Ey field. Representation of analysis defines the two observation point of WRR from input and output port

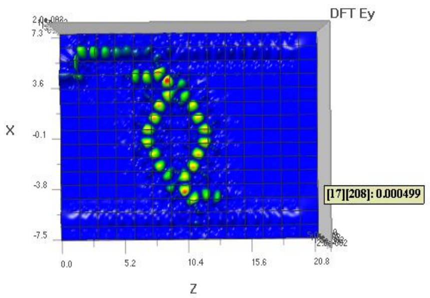

Fig. 6 Electric Field distribution for PCRR

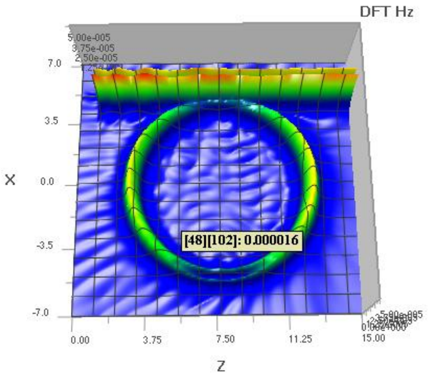

Fig. 7 Magnetic Field distribution for WRR

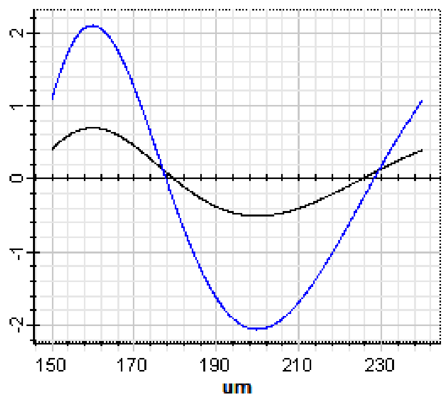

Fig. 8 Observation Area Analysis for WRR

V. CONCLUSION

We have analyzed two different structure of optical ring resonator in waveguide as well as lattice structure and its output behavior is also analyzed with respect to mode propagation. The comparison shows that the pointing vector and the refractive index of Electric and magnetic field distribution was observed by FDTD software. Further investigation will be carried out consideration different geometry of Holy PCFs to get the accurate modal index.

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