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Effect of Defect Pillars in T-Junction Photonic Crystal 1310/1550 nm Demultiplexer

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Abstract: *The splitting characteristics between 1310 nm and 1550 nm wavelengths in T-junction photonic crystal is studied numerically. The higher number of defect pillar gives a high transmission and low reflectance of the split optical signals.*

I. INTRODUCTION

Photonic crystals (PhC) have inspired a lot of research recently due to the ability to control the propagation of light in more drastic way compared to conventional planar waveguide. The periodic variation of the permittivity in photonic crystals can resort in photonic band gap, ie. a range of frequencies with no allowed electromagnetic mode. By creating a defect in these structures, the periodicity and consequently the completeness of the band gap are broken and the propagation of light can be localized in the defect region. Its frequency is corresponding to the defect frequency inside the gap.

II. 1310/1550nm PhC DEMULTIPLEXING

Figure 1 shows the band gap region for a range of r/a (rod radius divided by pitch) value. The horizontal solid lines indicates the channels of normalized frequencies w_{r1} and w_{r2}, while vertical solid lines indicate rod radius for the first filter r_1, main waveguide channel r, and the second filter r_2. Figure 1 also shows that the PhC with rod radius r has the band gap that permits the reflectance for both frequency channel and splitter. At the same time, PhCs with rod radius r_1 and r_2 have the band gap only for one of two frequency channels.

In this paper we investigate the demultiplexing property of wavelengths 1.55 μm and 1.31 μm in a T-junction PhC wavelength selective splitting device.

The relative frequency and the pitch value for PhC of the first filter can be obtained through equation (1)

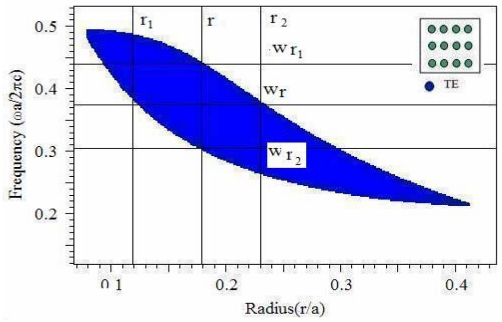

Figure 1. Scheme for selection of geometric parameters using band gap map.

$$w_r = \omega a/2\pi c = a/\lambda \qquad (1)$$

We have a PhC structure with the following parameters for square lattice: the background refractive index $n_1 = 1$, rod refractive index, $n_r = 3.4$, distance between rod centers a = 0.52 μm, $r_1=d_1/2=0.109a$, $r=0.179a$ and $r_2=d_2/2=0.253a$. The T-junction device is shown in Figure 2.

Thereupon we present a spectral analysis (the spectral dependence of the power on each output port of the device) using finite difference time domain (FDTD) numerical method.

III. NUMERICAL RESULTS

The wavelength demultiplexing is carried out by the two filter channels, left and right, for wavelength 1310 nm and 1550 nm respectively. As shown in Figure 2, the device consists of input channel produced by the W1 waveguide that is formed by removing one row of rods from the background PhC. This waveguide connects to the splitter waveguides with two output ports SO1 and SO2.

Fig. 3 shows the transmission characteristics at monitor of filter 1, filter 3 and reflectivity detected behind W1 for wavelength 1310 nm. It is clearly shown from Fig. 3a, filter 1 only allows wavelength of 1310 nm to penetrate into filter 1.

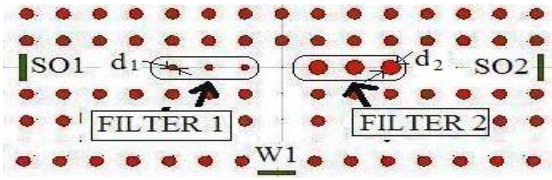

Figure 2. Diagram of the optical demultiplexer based on a PC splitter with the square.

The increase in the number of pillars, will give higher transmission power inside the filter 1. Fig. 3b shows transmission inside filter 2. Power from this wavelength (1310 nm) should be reflected when entering filter 2 because it can create crosstalk. Single pillar will give high crosstalk and full pillars in line defect will almost eliminate the crosstalk. Fig. 3c shows reflectivity in the device. The monitor for reflectivity is placed behind input channel, W1. The higher number of pillars will help to reduce the reflectivity.

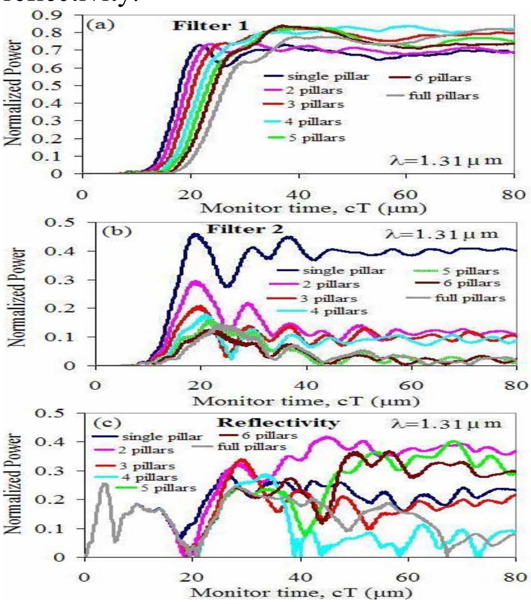

Figure 3. Transmission characteristics at monitor filter 1, filter 2 and reflectivity for λ = 1.31 µm.

Fig. 4 shows transmission characteristics at monitor of filter 1, filter 2 and reflectivity for wavelength 1550 nm. Fig. 4a shows the crosstalk transmission which has similar characteristics with Fig. 3b. In Fig. 4b, transmission characteristics for 1550 nm in filter 2 using 3 pillars give the higher transmission power and small reflectivity (Fig. 4c) in the device.

From the investigation of the characteristics above, we propose the 1310/1550 nm multiplexing PhC using full defect pillars with diameter d_1 in filter 1 and 3 pillars defect with diameter d_2 in filter 2.

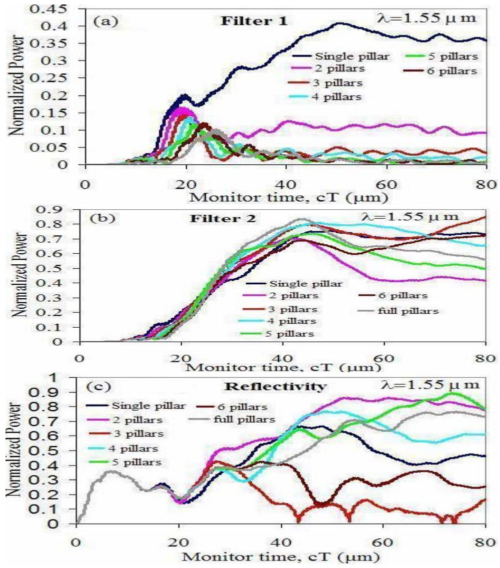

Figure 4. Transmission characteristics at monitor filter 1, filter 2 and reflectivity for λ = 1.55 µm.

With this design it is found that it will help to reduce reflectivity and boost up the power transmission in the device. Computed electromagnetic field distribution in the square lattice PhC demultiplexing is shown in Fig. 5 for two transmitted signals with wavelength 1310 nm (Fig. 5a) and 1550 nm (Fig. 5b).

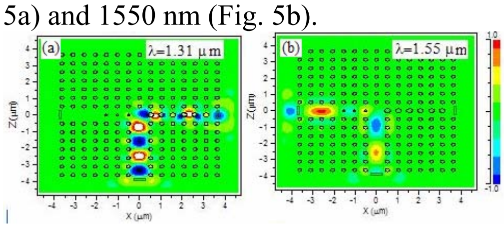

Figure 5 Results of FDTD simulation of wavelength channel for splitting for (a) source wavelength 1.31 µm and (b) 1.55 µm.

IV. CONCLUSION

In this work we have investigated the properties of the rectangular PC based on finite difference time domain method. Numbers of defect pillars in the defect line will affected the transmission characteristics at the monitor of filter 1, filter 2 and reflectivity. The new design of the wavelength division multiplexer based on the integrated was also proposed.

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