# Design of an All- Optic Communication Filter Based on Photonic Crystal Structure

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**ABSTRACT:**
One of the structures made of photonic crystal is all-optic filter which these filters are widely used in optic telecommunications systems and networks. In this paper, a method has been presented to design an optic filter based on two-dimensional photonic crystals. The crystal which we suggested, was obtained by FDTD and PWE numeric methods, that influenced different parameters of output wavelength of filter. The result showed that increase of refraction index of Dielectric, leads information in output wavelength of filter.

**KEYWORDS**: All- optic filter, Photonic crystal, FDTD, PWE.

## 1. INTRODUCTION

Expanding communication and the simplicity of data transfer through transfer systems and optic fiber is one of the important cases of today communications. The speed, suitable quality and transfer simplicity in transferring signals containing digital information is one of the most important features of communication through optic fiber. The optic communication may be investigated in three general parts including optic sender (Transponder), optic fiber, and optic receiver. The sender (transponder) part sends the information in the form of light. This information is transferred to destination by optic fibers, and is decoded in receiver part. Demand for new services leads increase in speed and volume of sending information incredibly in recent years. For this reason, all- optic systems and optic integrated circuits are of practical and interesting subjects which are the background of different researches.

In an all-optic communication, processing the optic information is done by optic devices, and the optic signal does not change to electric signals. The photonic crystals are the best options to design all- optic pieces. The photonic crystal is a structure with frequency coefficient. If the frequency is in one dimension, the photonic crystal will be one-dimensional and if it is the repeat of structure in two or three dimensions, the photonic crystal will be two-dimensional and three-dimensional.

The different crystal structures represent a wide range of physical features because of having different electrical structures. While entering light into photonic crystal structure, the diffusion takes place in special frequencies because of its structural features and electrical characteristics.

This is called the allowed range. When the diffusion does not take place in a range of special frequencies sit forms unallowable range which is called forbidden band. One of the structures made of photonic crystal is optic waveguide which has the ability of transferring optic photonic pulses from one point to the other point.
The photonic crystal waveguides may be created by creating network defects. In this paper, a new structure is formed for all- optic filter of photonic crystal as two sense ring- one of the advantages of this structure is the capability of configuring exacerbated wavelength. The simulation and analysis of structure have been done by plane wave expansion (PWE) and finite difference time domain (FDTD) methods. This paper continues as follows that the first discussion is about the importance of subject and a short background is stated then the process of designing filter is investigated, in next part we deal with simulation and finally we discuss about the results.

## 2. THE IMPORTANCE OF SUBJECT AND THE NECESSITY OF RESEARCH

The utilization of optic technology in telecommunication systems caused that high frequency of light as a carrier, provide the capability of sending more information in one channel. Also the utilization of optic technology enjoys other advantages such as security against interference of electro- magnetic waves and a better quality of information transfer.

The difference in speed of electrons and photons is so that rate of sending information of electrons in a range is multi- ten mega bit on second, while this rate increases to range of Tera bit by utilization of photons in optic networks. The power of electronic switching devices is about one micro-watt, while the power in optic devices is in the range of Nano-watt. The optic devices have smaller volume and they are lighter comparing to electronic devices. The optic telecommunication systems are as one of the most efficient ways of information transfer.

## 3. A REVIEW OF FORMER RESEARCHES

In 2002, Imada et. Al designed a filter based on two-dimensional optic beams and hexagonal network structure that resulted central wavelength of 1563 nm and passage hand of 4/1 nm.

A crooked beam was used in this structure and the quality factor was about 400. The signal return flow is less than 50% in this device which is its most important weakness. In 2006, Ren et.al presented a structure with two outputs based on Cavity (Cavak) project which separated 1531 nm and 1529 nm wavelengths from other wavelengths. The quality factor of suggested device was about 1050. The best feature of this structure comparing to its similar devices was presenting two outputs that simplified the application of de-multiplexing too.

The return flow less than 20% made applying this device impossible, and the only interesting idea was the suggested structure.

In 2011, Badaoui et. Al suggested a structure which was set in the route of waveguide, beams with smaller radius. This filter, however, presented a return flow about 70%, but its passage band was more than 70nm. This subject, in addition to decrease of quality factor, regarding little distance of sending channels was inconsistent in wavelength division multiplexing (WDM) systems.

In 2013, Al-Islam et. Al presented a structure enjoying exacerbating surrounding Cavaks which had three outlet port. These ports were used for three output channels in the range of 1350nm, 1500nm and 1660nm wavelengths. This subject caused enjoying suggested device in windows of 1310nm and 1550nm. 70% return flow was presented as a well-structured feature.

The existence of unwanted harmonics in the proximity of central wavelength of outlet ports, the biggest deficiency of this device is that it loads the selected wavelength be with.

## 4. DESIGNING FILTER

Designing the base structure filter applied for designing an optic filter are a square two- dimensional photon crystal consisting of de-electric beams in air bed. The beam refractive index is 3.2, diameter (radius) of de-electric beams is 130nm and network invariable is 650nm. The structure of base photon crystal band is simulated using expanding flat waves and band solve software. Figure 2 shows that structure has two forbidden bands which are highlighted. The larger forbidden band is shown by blue color and in TE mode and it is in the range of $a>0.31$ , $\lambda<0.43$ which is equal to 1488nm $<\lambda<$ 2089nm wavelength. The forbidden band is desirable for telecommunication applications.

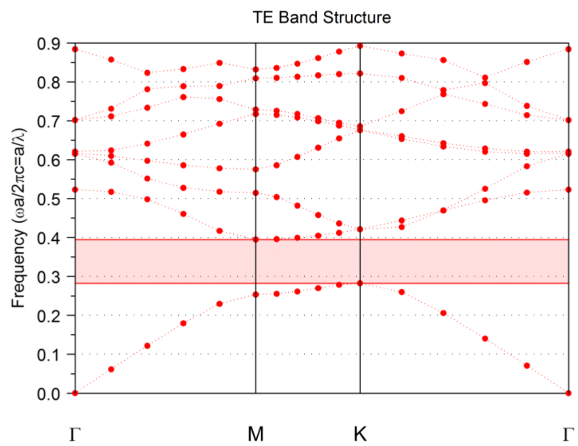


**Fig 1:** The structure of crystal band used for designing an optic filter

Our suggested filter includes three main parts: 2 defect lines are as input waveguide and output waveguide and a defect point between waveguides. To create defect point, we reduce the diameter of one cell between waveguides, this change leads creating resonance manners between two waveguides. Therefore, the optic waves in a special wavelength may be transmitted from waveguide input to waveguide output through resonance defect. The signal diagram of suggested filter is shown in figure 2. The paint defect is shown by dark blue.

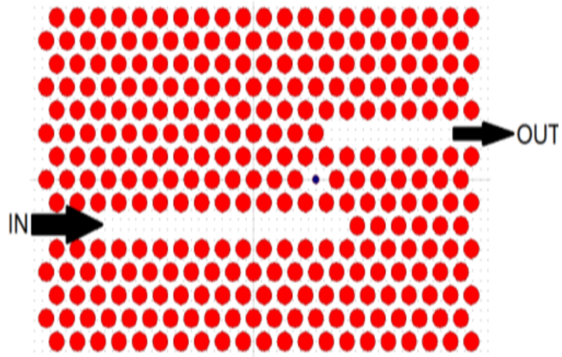


**Fig 2:** Signal diagram of suggested filter

## 5. THE RESULT OF SIMULATION OF SUGGESTED STRUCTURE

The output spectrum of filter for R equals to 420 nm is shown in figure 3. As it is clear in figure 3, the transfer domain of filter is 100% and bandwidth of its output spectrum is 7/1 nm. As a result, the quality factor of filter is about 2316.

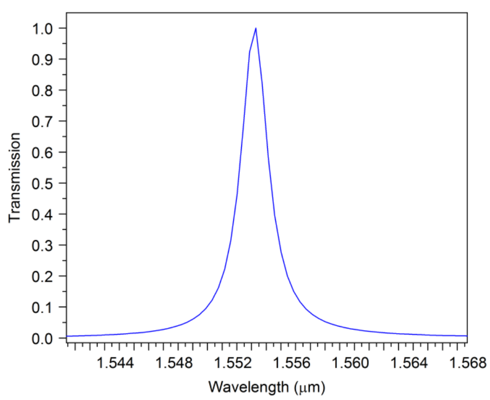


**Fig 3:** Output spectrum of suggested filter

Then, the change of R and a (network invariable) on output spectrum of filter will be investigate. Finite difference method in time zone is a suitable potion for simulation of light in the moon which is used. The output spectrum for different amounts of R is shown in figure 4. As you can see in figure 4, by increasing the diameter of this beam (di-electric bean), the output wavelength changes toward longer wavelengths, while the output efficiency does not change so much. Based on figure 5, by increasing the network invariable, the output wavelength will change toward longer wavelengths.

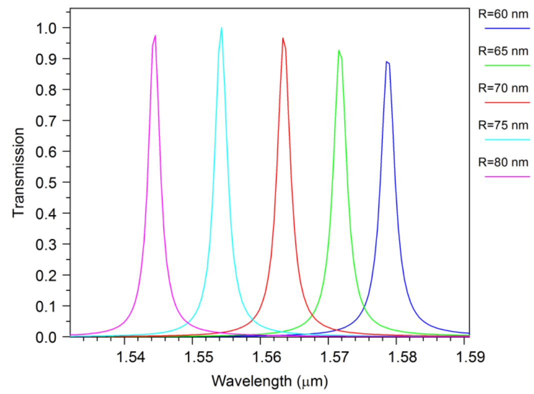


**Fig 4**: Output spectrum of filter for different amounts of R.

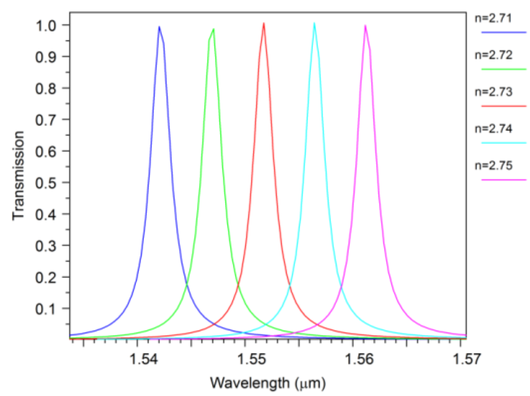


**Fig 5:** Output spectrum of filter for different amounts

## 6. CONCLUSION

In this paper, 20 intra-photon points defect was used. The crystal which we suggested, was obtained by numeric methods of FDTD and PWE which influenced different parameters on output wavelength of filter. The results Showed that with the increase of diameter, a change takes photo in output wavelength of filter. Although increasing the refractive index of de-electric causes a red change in output wavelength of filter. Total shadow of filter is less than 76μm2 and this shows that filter is suitable for using in all integrated circuits. One of the other advantages of our suggested structure is its simple design.

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