Analysis and Simulations of Photonic Crystals in Order to Reduce Losses in Photonic Crystal Fibers

Sheler Maktoobi

***Abstract*— Applications of photonic crystals has been expanding rapidly over the past decade. Probably the most interesting and the most important application of photonic crystals in telecommunications is optical fibers. The unique feature of photonic crystals, photonic band gap are reflected gently and frequency losses in the fiber sheath are reduced dramatically. It is not also necessary that the light spreads in Dielectric either. It is actually light in vacuum or low air pressure which is guided in such a manner so non-linear effects and losses of fiber will be decreased. In this paper, a design is offered and simulated based on the photonic crystals to reduce losses in optical fibers.The FDTD method and COMSOL software have been applied for simulation of the structure.**

***Index Terms*— Photonic crystals - optical fiber -reducing losses.**

I. INTRODUCTION

With the growing advances in science and technology, the needs for transferring data is greater. Today, one of the most important and key media in transmission of data is Optical fibers. Thus, they have been researched and investigated by many researchers around the world. Since the creation of optical fiber we have already seen much progress in this field and still this topic in the process of developing. One of the great leaps in the field of optical fiber development is photonic crystal fiber.Through designing Photonic crystal fiber Dissipation effects, changes in polarization and nonlinear effects can be reduced.

The function of optical fiber is possible between any two points of the globe without the need for amplifiers or repeaters. This type of fiber, the air -fiber also called porous fiber or holey fiber .like typical fibers this kind also has core and jacket butthe main difference is the structure. Manufacturers of photonic crystals have used Nano-sized periodic structures designed to move photons and to control the flow of light; thus reducing losses.

II. PHOTONIC CRYSTALS

Photonic Crystals are periodic Nano-scale structures made of dielectric or metal –dielectric that can affect the direction of the electromagnetic wave just like what semiconductor crystals do with electrons. Photonic crystals are available in different shapes and properties. In the same way that a periodic potential moves in semiconductor electrons, photoniccrystals are affected by creating forbidden and allowed energy bands. Photonic crystals based on internal changes in the refractive index of the crystal are less and more. Photon propagation inside the structure depends on the wavelength.

One of the most important applications of photonic crystal structure is their ability to make compact optical devices, which would play an important role in integrated optical circuits [1]–[3]. These devices perform various functions in optical circuits, for instance power splitting and combining [4]–[7], wavelength-selective coupling, optical filters [8], resonators [9] ,switching [10],[11], laser[12], Photonic crystal waveguide directional couplers[13] , planar antenna[14] .

Photonic crystals are structured based on two general ways. The first method, layer or dielectric rods with different constants are placed next to each other in the air. The second, photonic crystal structure is designed by creating holes within the dielectric material.

For reducing losses in optical fiber, it is used from aPhotoniccrystal (10 * 10) as shown in Fig. 1 by using COMSOL sotware.

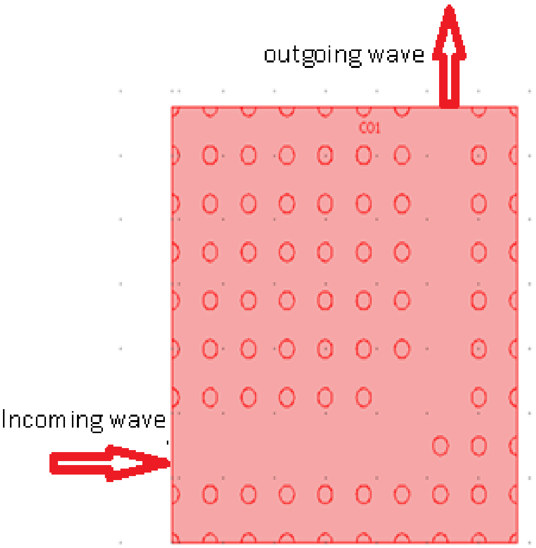

Fig. 1. Periodic structures of Photonic crystal

III. PHOTONIC CRYSTAL FIBERS

Due to the high losses in optical fibers in comparison to the axial cables that were used in microwave, signal transmission, the usage of optical fiber was not feasible.So scientists have long tried to reduce losses in structure in order to Use effectively optical fiber and thus make data

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transmission with a possibility at higher speed. Today, photonic crystal fibers produce a wide bandwidth with alower rate of loss.Fig. 2illustrates two main types of optical fibers in photonic crystal substance [15].

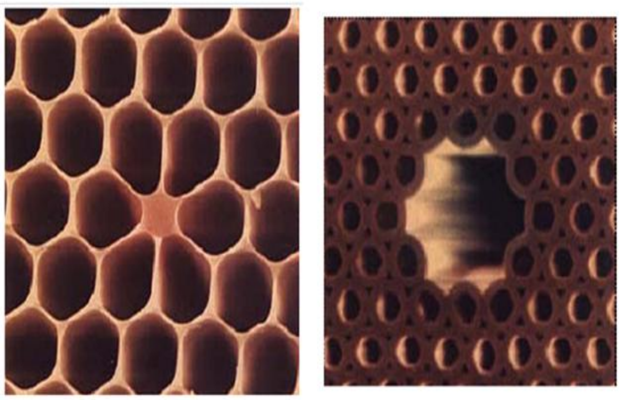

Fig. 2. Two types of optical fibers in photonic crystal substance.

The general terms holey fiber and micro-structure optical fiber(MOF) refer to any kind of fiber with a set of inclusions running along the Fiber axis.

Fig. 3 demonstrats Schematic representation of the cross-section of a typical solid core MOF (left) and hollow core MOF (right) with holes on a triangular lattice with a single central core. The micro-structured part is often referred to as the cladding.. The jacket represents the physical boundaries of the MOF, and can be a solid jacket e.g. for mechanical protection or simply just air [15].

Optical fibers based on the reflection of light transmit the optical signal but in intense and sharp angles, the angle of the micro-structured part is often referred to as the cladding. Radiation is greater than the total reflection thus light exits the optical fiber, this will cause the loss of signal. In photonic crystals, severe bends solve this problem.

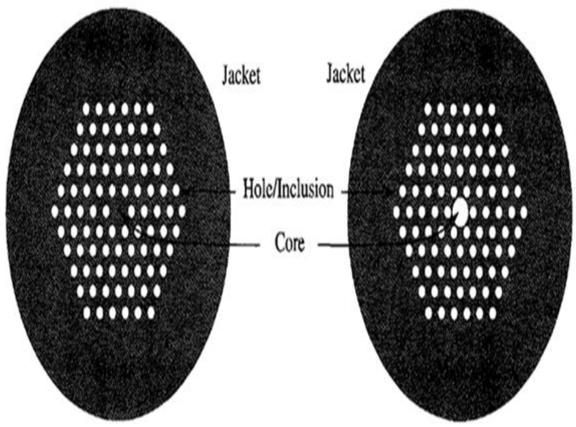

Fig. 3. Non-periodic arrangements of holes, either with a solid or a hollow core

IV. SIMULATION OF PHOTONICCRYSTAL

in this paper,In order to reduce losses ofOptical fibers a structure based on photonic crystal has been designed and simulated by COMSOL software .Thefinite difference time domain method(FDTD)has been applied to simulat the structure.

The geometry is a square of air with an array of circular pillars of GaAs. Some pillars are removed to make a waveguide with a 90° bend (The eighth row on the top and the right). The chosen photonic crystal (PC) is made of GaAs rods that have refractive index of 3.47 and radius of rods is 0.2a, where a is the structure lattice constant.the results of which are depicted in Fig. 4.

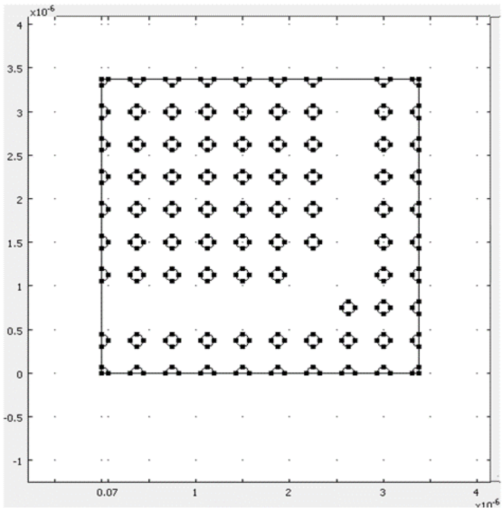

Fig. 4. A photonic crystal without propagation.

This model describes the wave propagation in a photonic crystal consisting of GaAs pillars placed equidistant from each other. The distance between the pillars prevents light of certain wavelengths to propagate into the crystal structure. Depending on the distance between the pillars, waves within a specific frequency range are reflected instead of propagating through the crystal. This frequency range is called the photonic bandgap [16].

By removing some of the GaAs pillars from the crystal structure, a guide for the frequencies within the bandgap will be created. Light, as depicted in Fig. 5, can then propagate along the outlined geometry guide

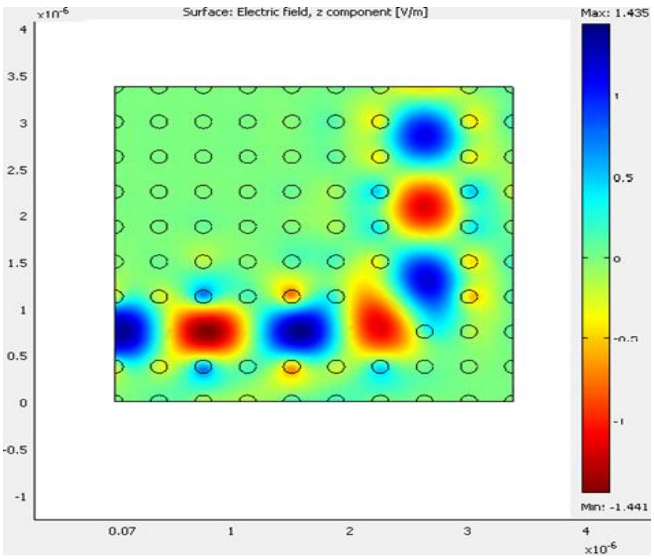

Fig. 5. The z component of the electric field showing how the wave propagates along the path defined by the pillars.

Fig.6 shows the three-dimensional plot of wavepropagating of the z component of the electric field that is simulated by using COMSOLsoftware. It clearly shows the propagation of the wave through the guide.

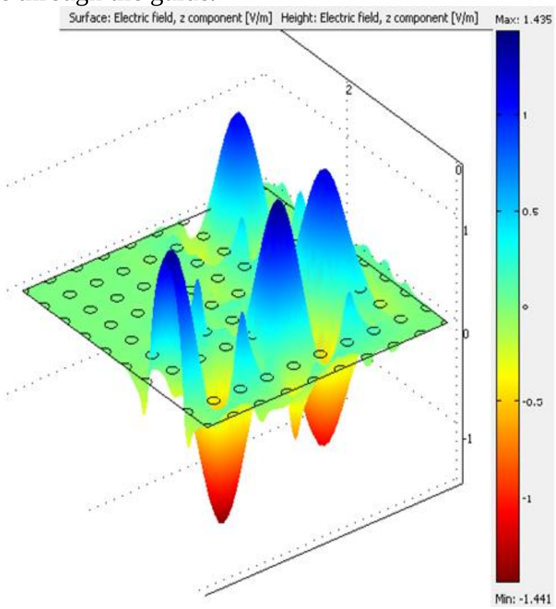

Fig. 6.3D plot of wave propagating

The objective of the model is to study TE waves propagating through the crystal.Equation (1) is the TE model. To model these, use a scalar equation for the transverse electric field component E_z,

$$-\nabla.\nabla E_z - n^2 k_0^2 E_z = 0 \quad (1)$$

Where n is the refractive index and k_0 is the free-space wave number. Because there are no physical boundaries, the scattering boundary condition at all boundaries is used.

In this paper, we have used the COMSOL software for simulation and analysis of photonic crystal to reduce losses of photonic crystal fiber.The resulting plot, as depicted in Fig. 7,8indicate that the z component of the electric field and normalized electric field decline exponentially along the plot line.

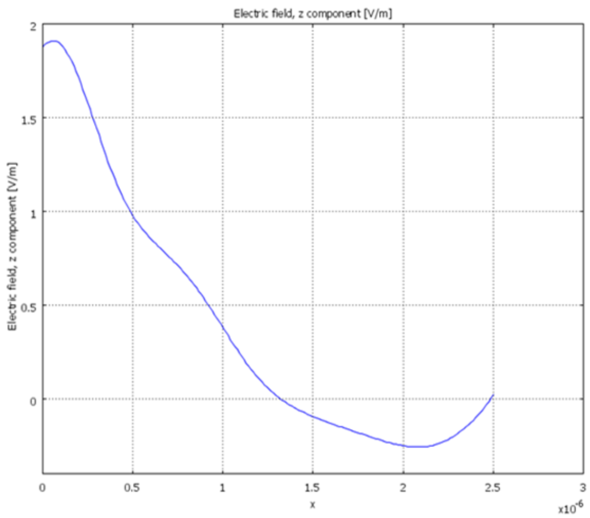

Fig. 7.Z component of the electric field for our proposed structures.

To derivePropatation, which the input signal guides to a special output,electricfield of the lightwave signals is determinedby Fig. 7 and 8.

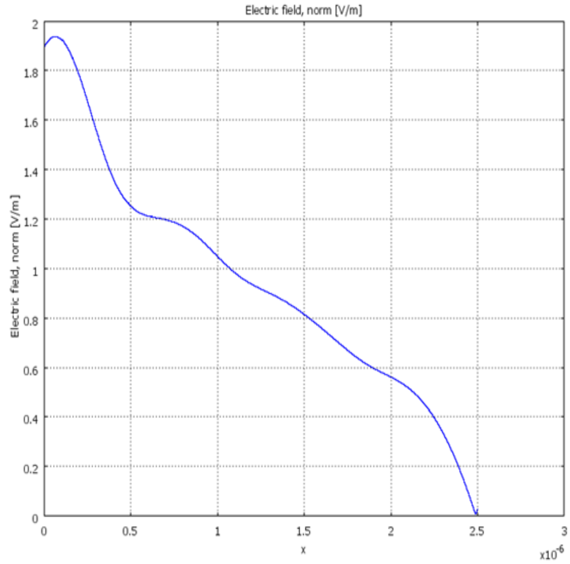

Fig. 8. Normalized electric field for our proposed structures

Some methodsimproveperformanceofdevices,power output can evaluate Photonic crystal efficiency.Fig. 9 contains a plot of normalized power flow where the highest and lowest power for the proposed structure are illustrated.One of the most important factors in designing and analyzing is output power and numerous applications are foundby super flexiblein power output.

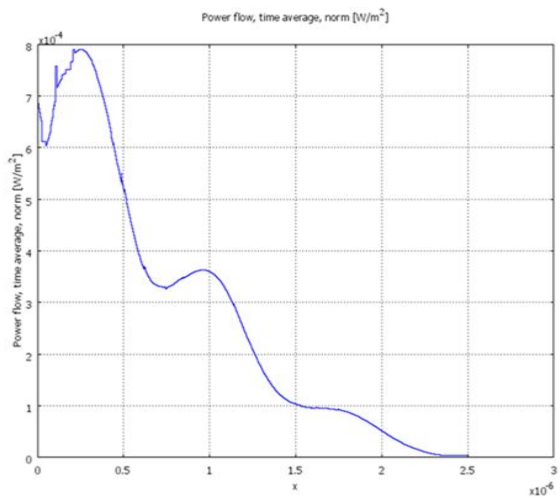

Fig. 9normalized output power

V. CONCLUSION

Photonic crystal devices are periodic structures of alternating layers of materials with different refractive indices. Waveguides confined inside of a photonic crystal can have very sharp low-loss bends, which may enable an increase in integration density of several orders of magnitude. In this paper, a photonic crystal has beenanalyzedandsimulated by COMSOL software.for this simulation the finite difference time domain method (FDTD) is used. We have triedto increase the efficiency of output power and reduce losses that have been used in Photonic crystal fibers. We also obtain the z component of the electric field that shows how the wave propagates along the path defined by the pillars

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