Design and Simulation of Photonic Crystal Fiber with Low Dispersion Coefficient in Band Terahertz

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Abstract— *In this paper, a hexagonal solid state photonic crystal fiber at frequency 10 THz is presented. First, by finding the main conductive model and its dispersion rate to evaluate dispersion changes based on the fixed changes of fiber network in the main mode with the goal of achieving the lowest dispersion rate. In the next section, dispersion variations are measured and evaluated based on changes in the size of the radius of the cavities of the photonic crystal fiber area. Then the fiber-forming cavities of the fiber region have become elliptical geometry, and the size of the disintegration has been discussed for this change. Finally, by changing the refractive index of the fiber substrate region, the size of the disintegration has been investigated. For the geometries of all the steps that have the least disintegration, an optimized structure is obtained. In this way, the proposed structure has a dispersion rate of -75×10^{-3} ps/(nm km), which is a good fit for similar designs.*

Keywords— *photonic crystal fiber, dispersion, refractive index, substrate.*

I. INTRODUCTION

Today, the terahertz band is highly regarded by its electrical researchers because of its widespread use, such as medical, astronomy, imaging security detection, and so on. The frequency range of the terahertz band is between 0.1 to 10 THz .To date, many advances have been made in the field of methods for producing and detecting terrestrial waves, but most of the terahertz systems today have large dimensions and due to the lack of effective waveguide transmission in the field of terahertz, relies on the release of free space are . It's very difficult to control and direct these waves from this. In addition, terahertz radiation is strongly absorbed by the airborne vapor . To overcome these problems, the use of photonic crystal fibers to transmit these waves from terahertz waveguides is. One of the basic ways to send THz waves The use of photonic crystal fibers. Photonic crystal fibers have the same characteristics as common optical fibers, such as acting on a single-mode broadband, dispersing surface control [1,2], and so on. And usually, the PCF has a cross-section consisting of numerous cavities compared with optical fibers,

such as acting on a single-mode, broadband, having a cross-section consisting of numerous cavities (which are usually intermittent) (inside the silicon cavity) Which is both surrounded by solid silica. Nucleated fiber core and solid core . The guidance mechanism is provided using a change in the principle of the overall internal reflection or the effect of the photonic band gap. These fibers are used for various applications with attention to . The simplest type of PCF is solid core fiber consisting of a regular hexagonal network with small air cavities with center defects that is guided by the correction of the general internal reflection principle. So far, many scholars have worked on the hexagonal structure [3,4,5,6,7], and have been trying to improve fiber optics. In fact, the structure of crystal photonic crystal is such that ,the combination of air cavities (vents) in the shell section results in a reduction of the effective mean effective failure coefficient, which allows more variation in the coefficient of bridges and strange dispersal properties . The solid core fibers in which the shell has a higher fill rate of more than of the air leads to an effective delta parameter that is called high-fiber or spider fiber, which is dependent on cross-sectional dimensions. The enclosed field in the solid core, based on the effect of the photonic band gap, requires periodic arrangement of air cavities in the wavelength scale with an air filling coefficient sufficiently high in the shell to obtain a level surface in the gap of the bond For , the emission level is within the specific wavelength range.

The conduction of light in a solid core (photonic band gap fibers) is shown using a hexagonal pattern of air cavities in silicon as a shell; this arrangement makes it possible to direct light in gases. The conductive conductor in the solid core is not fully centralized and part of the power can still be transmitted through the air.

In this paper, we first tried to evaluate a hexagonal crystalline fiber and its disintegration. Continue with changing the radius of the cavities, turning the cavity to the elliptical cavity, and finally, with the fluid, the refractive index of the substrate, the amount of dispersion to the minimum amount possible. The fiber deflection design is small compared to other designs

with a high dispersion. A detailed description of the design is presented in the next section.

II. HEXAGONAL PHOTONIC CRYSTAL FIBER DESIGN

In the design of photonic crystal fiber, the microstructure of solid core is used. The photonic crystal fiber is composed of a silica substrate with a deflection coefficient of 1.4 and a coating area of 5 hexagonal circles with spherical cavities with a radius of 10 μm, with the removal of two rows of holes in the middle of the structure. In this structure, the ratio of radius changes to the fixed crystal photonic fiber network r / a = 0.40. The shape is used to create a hexagonal network in the fiber core of the photonic crystal core of the coding. Use of structured code to examine all parameters of the holes and geometric components of the structure as a unit parameter is essential. In the simulation of the structure of the numerical method (the method of the limited time difference variable in the time domain), this method is used to simulate waveguide devices, so in this method, all waveguide tools based on their constituents in two or three Next, a two-dimensional cross-sectional form of effective spraying material forms on the. By applying the varFDTD and PML boundary simulation in this structure, MODE Solutions software at 10 frequency terahertz, which is considered the optimal wavelength in the optical communication domain, has many conductive modes and unstable modes in the structure. Therefore, for the analysis of photonic crystal fiber and disintegration control, there should be a principal direction or a mode of investigation. The main conduction mode in this crystal is photonic crystal in the core at the frequency of 10 THz. The graphical representation of the main mode of conduction in a solid-state photonic crystal fiber is shown in Fig. 2
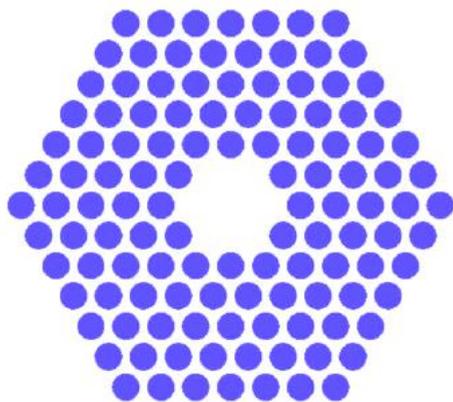

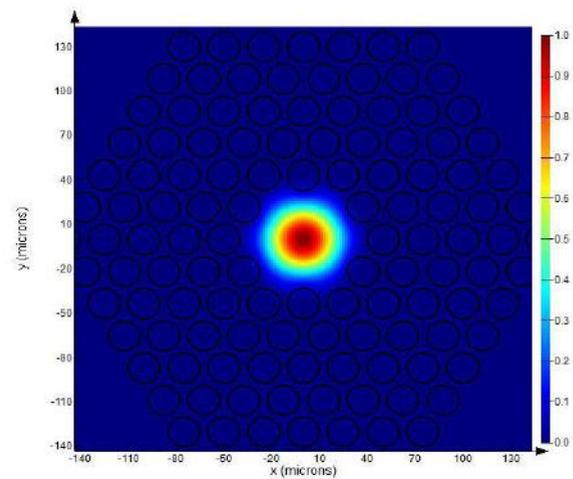*Fig.1: The design of a solid-state photonic crystal fiber structure*

Fig.2: The main mode of conduction in the design of fiber at a frequency of 10 THz with a core core and fixed network is 10 and 25 μm respectively

In the next sections, the simulation will be done by changing the radius of the core, the fixed network size, the coverage area, the change in the geometry of the fiber core, and the change of the refractive index of the core to improve and control the disintegration of the principal mode of design. In all simulations, all simulation parameters of the same structure are assumed. It's worth noting that this dispersion rate with this numerical method in this design, in turn, is unique to solid-state photonic crystal fibers like.However, we try to achieve the lowest degree of disintegration in the conduction modes by performing various evaluations of the photonic crystal geometry of the solid core and the refractive index of the substrate material. In all simulations, the main mode is guided and the results are plotted.The structure of the fiber provided by varFDTD numerical simulation and analysis.

III. CALCULATE THE DISPERSION IN A PHOTONIC FIBER CRYSTAL

3.1 Hexagonal constant variation

At this stage of the simulation, we will evaluate the splitting of the solid-state photonic crystal fiber by changing the fixed size of the solid fiber photonic crystal . To carry out this assessment to significantly reduce disintegration, we change the fixed size of the crystal crystal network of the solid state photon from 24 to 46 μm at 21 simulation points.In this simulation, the radius of the mesh cavities is considered to be the structure of the 10 μm structure. With this swap, it is observed that the least disintegration is in the range of -0.05 $ps/(nm\ km)$, 32 μm constant at the frequency of 10 THZ . Fig(3)
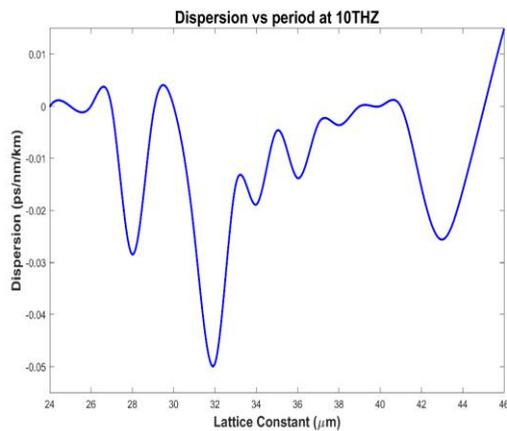
Fig.3: fiber dispersion assessed by measuring the change in frequency of 10 THz solid core photonic crystal fiber lattice constant

To find out about the accuracy of the evaluation, we simulate the simulation by resizing the photonic crystal network to 32 µM and the radius of the cavities in the coverage region of 10 µM. It is seen that the main conduction mode has a dispersion of -0.05 $ps/(nm\ km)$. It turns out that the accuracy of our disintegration assessment is verified by a fixed size coupling of a hexagonal photonic crystal network. Figure 4 illustrates the main modes of guidance obtained by this evaluation.
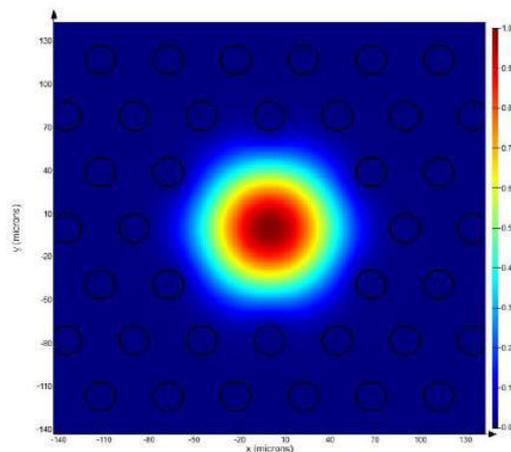

Fig.4: The main mode of conduction obtained from the evaluation of fiber dispersion by resizing the crystal lattice network Hexagonal photon from 24 to 46 µm

3.2 Change the cavity gap coverage

In the last step of our simulation to obtain the best conductive mode with the least degree of dispersion, with the same change approach, the radius of all the cavities of the fiber core of the crystalline solid core is discussed. To perform this evaluation to reduce disintegration, we first consider the fixed size of the photonic crystal fiber obtained from step a We consider 32 micrometers. We first consider the fixed size of

the photonic crystal fiber network, which then calculates the radius of the radius of all the cavities of the photonic crystal fiber area from 5 to 15 µM, so that we can evaluate the disintegration changes in the structure by numerical simulation. With this swap, it is observed that the minimum sputter is suspended at -0.06 $ps/(nm\ km)$, to the cavities of the region with a radius of 15 µM (Fig. 5).
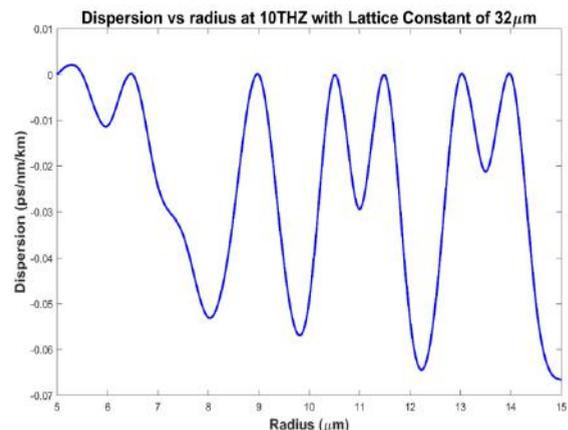

Fig.5: Estimation of fiber splitting by the radius of the cavity area of the coating. This assessment was performed by fixing the core radius , which is derived from the evaluation of step a.

Compared with the degree of disintegration in the state a, the disintegration is measured by changing the fixed size of the fiber network, and this state is observed, which is reduced to 16×10^{-3} $ps/(nm\ km)$. To find out the accuracy of the evaluation, the simulation is observed by varying the radius of all the cavities of the photonic crystal fiber area to 15 µM and by keeping the values obtained from step a, which is the principal mode of conduction having a dispersion 7×10^{-3} $ps/(nm\ km)$. It is obtained on that verifies the accuracy of our disintegration evaluation by the size of the cavity of the hexagonal mesh hole in the solid state photonic crystal. Figure 6 shows the main mode of guidance obtained by this assessment.
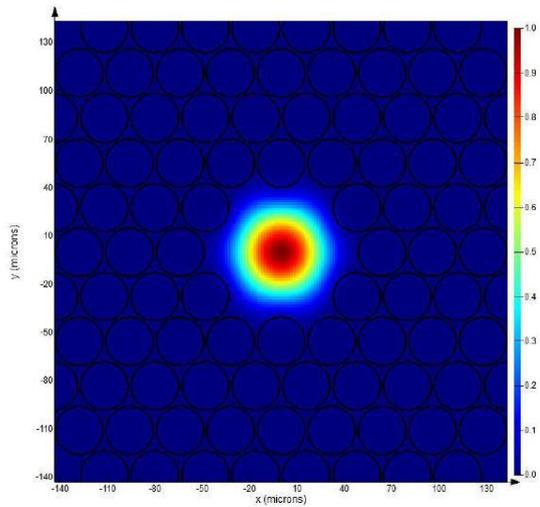
Fig.6: The main mode of conduction obtained from the evaluation of fiber splitting by resizing the cavities of the hexagonal mesh area of the crystal The solid core photon from 5 to 15 μM at 10 THZ frequencies is an optimum size of 11 μM

3.3 Slippage of the cavities of the area

As we already know, the change in structure geometry causes a change in the photonic band gap and is very effective in limiting strong light. According to the latest research, the transformation of defect cavities in photonic crystal waveguides, especially fiber, has resulted in a large increase in the frequency of the photonic band gap, which results in intensification of light-sealing operations.

In this phase of our simulation, we obtain a fuller and larger photon band gap and a main conduction mode with the least degree of disintegration with the approach of changing the geometry of the core cavity in solid-state photonic crystal fiber. To carry out this assessment for a significant reduction of disintegration, we first plotted the fixed size of the photonic crystal fiber from step a. (32 μM) and the radii obtained in step b for fiber area cavities (12 μM), then we change the size of the second radius of the coating area from 15 to 25 μM.

Obviously, the resulting shapes will have elliptical geometry. Sipes evaluate numerical simulation of disintegration in a photonic crystal fiber core with elliptic geometry.

With this swap, it is observed that the minimum disintegration of $-7 \times 10^{-2} ps/(nm\ km)$ is 15 μm radius, ie, a circular state. Figure 7 shows the effects of changes in the second circle radius to achieve a minimum spatial resolution in the structure for the elliptic geometry of the core region.

To find out the accuracy of the evaluation, the simulation is observed by varying the horizontal and vertical radii of the cavity of the photonic crystal fiber coating region to 15 and 15 μM, respectively, and by keeping the values obtained from

step a The primary mode is a dispersion conductor of - $0.07 ps/(nm\ km)$ which confirms the accuracy of our disintegration evaluation by the Swing transforming the spherical geometry of the nucleus through a hexagonal network of photon crystals of the nucleus.As already mentioned, the casualties are also reduced at this stage. The figure shows 8 main modes of guidance given by this evaluation.
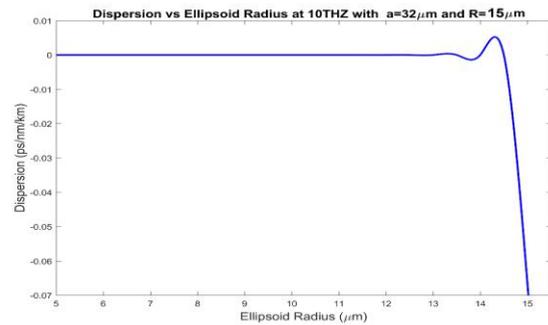

Fig.7: Evaluation of fiber splitting by the second radius of the area of the cavity at the frequency of 10 terahertz
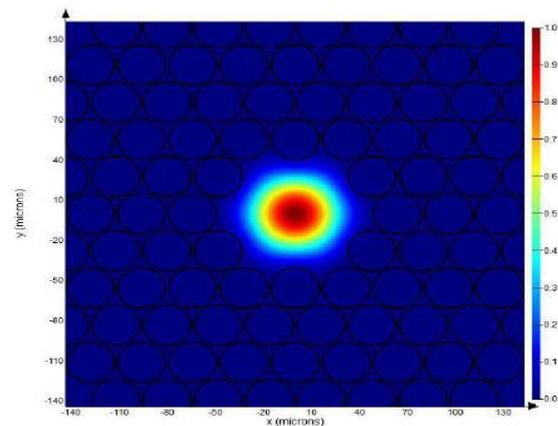

Fig.8: The main modes of conduction obtained from the evaluation of fiber splashing by the spin geometry swap area of the region. Coating to the hexagonal network of photonic crystals of solid core from 5 to 15 μm at a frequency of 10 THZ

3.4 Change in refractive index of substrate material

In addition to the change in the structure geometry that changes the photonic band gap, the changes in the refractive index of the material of the substrate material of the photons inside the cavity also cause changes in the photonic band gap and the intensity of light capture. In this section of the simulation, the degree of disintegration of the substance of the fiber substrate is evaluated. In the last step of our simulation to obtain the best conductive method with the least degree of disintegration, we consider the refractive index of the material of the substrate material of a solid-state photonic crystal. In order to obtain the lowest degree of disintegration,

we first obtain the fixed size of a photonic crystal fiber (32 μM), the radii obtained for the fiber area cavities (15 μM).Then, change the refractive index of the material of the solid-state photonic crystal cell base from the refractive index of the glass 1.4 to 3.4 times the GaAs refractive index.

Then, by performing numerical simulations, we will evaluate the diffusion changes in the photonic crystal fiber core with a change in the fractional deflection . With this switch, it is observed that the minimum disintegration is $-75 \times 10^{-3} ps/(nm\ km)$ to the coefficient Failure 1.6 belongs. Figure 9 shows the variation of the refractive index in order to achieve disintegration in the drain, in exchange for the refractive index of the solid-state photonic crystal fiber substrate.

To find out the accuracy of the evaluation, the simulation is observed by varying the refractive index of the material of the photonic crystal fiber substrate to 7.2, and by keeping the values obtained from steps c, b, and a, the main mode of conduction has a disintegration rate $-75 \times 10^{-3}\ ps/(nm\ km)$, which confirms the accuracy of our disintegration assessment by the spin-angular geometry swap to the elliptical cross-sectional network of the six-core cross-section of the photonic crystal. As already mentioned, the casualty rate has dropped to this level. Figure 10 main modes of guidance obtained by this assessment shows.
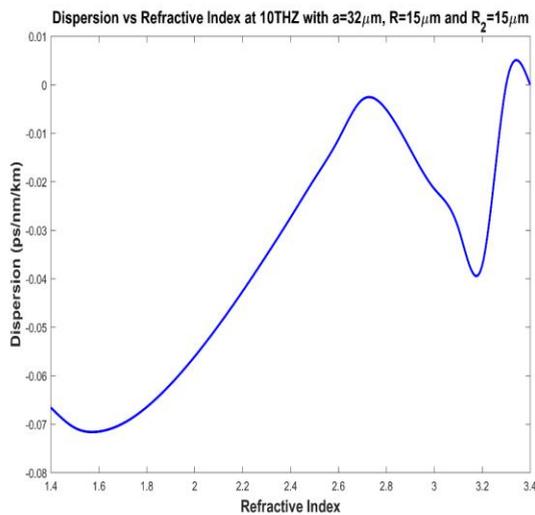
Fig.9: Fiber disintegration evaluation by refractive index variations of the material of photonic crystal fiber at a frequency of 10 THZ
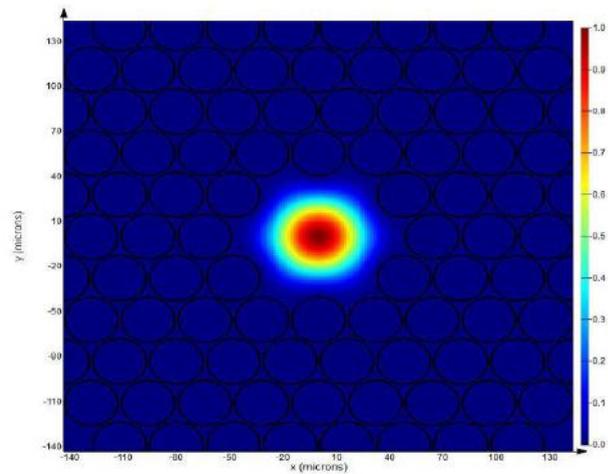
Fig.10: The main mode of conduction obtained from the evaluation of fiber splashing by the refractive index of the substrate material of the hexagonal network of photonic crystal solid core from 1.4 to 3.4

According to the steps a through b, it was found that the disintegration rate could be reduced by the geometric changes in the fiber structure and the change in the coefficient of defect in the substrate material. In this structure, the degree of spraying has been reduced step by step, and its structure and guiding mode are depicted in Figures 11 and 12. The structure has a disintegration of $-75 \times 10^{-3}\ ps/(nm\ km)$, simulated and analyzed by varFDTD method. The geometric properties of the structure have been obtained during the above steps, and for confirmation and repeatability of the simulation, several steps have been carried out to verify its accuracy.
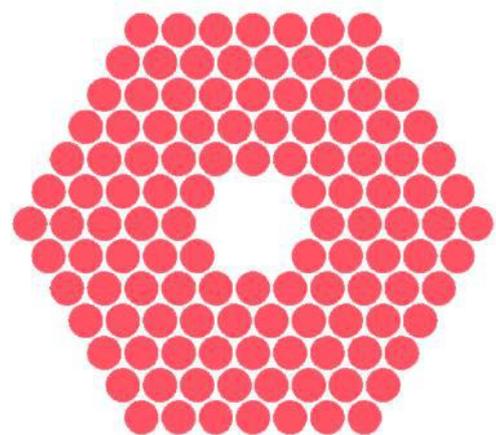
Fig.11: Optimized structure of photonic crystal solid hexagonal core during steps a to e
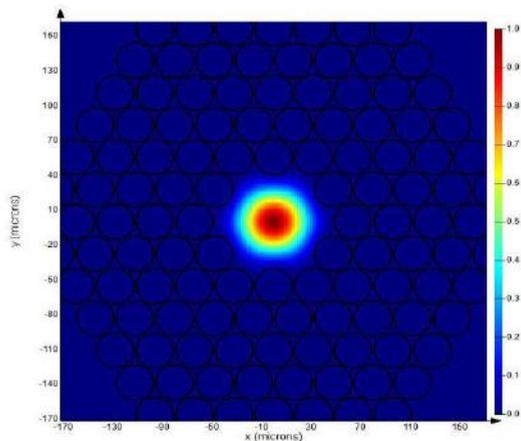
Fig.12: The main mode of conduction obtained for the optimized structure of the hexagonal helix fiber photonic crystal core during the steps a to d at 10THZ frequencies

IV.   CONCLUSION

In this paper, a hexagonal solid-state hexagonal crystal fiber in the terahertz band was presented. Geometric changes in the fiber structure and the variation in the refractive index of the substrate material led to a reduction in dispersion.

So that by making changes to optimize the fiber dispersion coefficient, we could reach the dispersion rate to $-75 \times 10^{-3} \, ps/(nm \; km)$, which is an optimal amount for photonic crystal fibers.As the photonic crystal fiber can be converted into an important candidate in the field of photonic photoconductivity, it can be applied in the industrial field

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