Journal of Modeling & Simulation in Electrical & Electronics Engineering Vol 4 (4). 33-39.

Semnan University

Journal of Modeling & Simulation in Electrical & Electronics Engineering (MSEEE)

Journal homepage: https://mseee.semnan.ac.ir/journal/about /

ISSN: 2821-0786

Design and Simulation of an Eight-Channel Demultiplexer Based on Photonic-Crystal Ring Resonators

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***Abstract*--In the present study, an eight-channel photonic crystal wavelength demultiplexer is designed for separating eight telecommunication wavelengths: λ_1=1.5552 nm, λ_2= 1.5563 nm, λ_3 =1.5579 nm, λ_4=1.5593 nm, λ_5 =1.5608 nm, λ_6 = 1.5623 nm, λ_7 =1.5638 nm, and λ_8 =1.5653 nm. To this end, a two-dimensional photonic crystal structure composed of circular silicon rods arranged in an air background and fabricated on a silica (SiO_2) substrate is employed.**

The design and analysis are performed using the Plane Wave Expansion (PWE) method to compute the photonic band structure and guided modes, while the Finite-Difference Time-Domain (FDTD) method is used to calculate transmission efficiency and analyze propagation characteristics during wavelength-selective separation. Ultimately, by optimizing the resonator placement and the radius of point defects, a channel spacing of 1.44 nm and a transmission efficiency (TE) of 93% were achieved.

***Keywords*-- Optical Demultiplexer, Channel Spacing, Crosstalk, Ring Resonator**

I. INTRODUCTION

Today, increasing bandwidth alongside higher data transmission speeds is fundamental to the realization of optical networks. Various optical networks have been developed to meet this need. Among them, wavelength splitter systems play a crucial role. These systems optimize media capacity by simultaneously multiplexing and transmitting multiple wavelengths. The efficient use of media capacity, combined with low cost, justifies their widespread application.

Photonic crystals represent a significant breakthrough in optical technologies. They are inhomogeneous materials with spatially varying dielectric constants, widely used in designing and fabricating optical integrated circuits. These structures, created by periodically repeating a unit cell, affect photon propagation and have numerous applications in photonics, physics, chemistry, and microelectronics [1].

In photonics, integrating devices such as lasers, detectors, couplers, and waveguides remains at a nascent stage compared to electronic semiconductors. A primary challenge is that device dimensions cannot be reduced below certain physical limits [2]. Photonic crystals offer a solution by enabling light conduction with minimal attenuation through their unique properties. Moreover, photonic crystals exhibit remarkable features absent in homogeneous media [3]. It is expected that they will play a role in optical telecommunications similar to that of semiconductor structures in electronic circuits [4].So far, various photonic crystal-based components, such as 90° bends [5], waveguides [6], filters [7], power splitters, multiplexers/demultiplexers [8], amplifiers [9], and sensors [10], have been designed and studied. Photonic crystals consist of two materials with differing refractive indices arranged alternately, forming one-, two-, or three-dimensional periodic structures. The primary effect of this periodicity is the formation of photonic band gaps—frequency ranges in which wave propagation is forbidden.

Between each two consecutive photonic band gaps lies a frequency conduction band that allows wave propagation [11]. Photonic crystals are highly dispersive, with permittivity and reflectance depending on the wavelength. Consequently, transmittance can be nearly zero for certain wavelengths (λ_1, λ_2) within the band gap. An intriguing feature is the angular dependence of photonic bands due to the differing optical path lengths within the crystal, causing variations in the photonic band gap transmission [12].

The superiority of photonic crystal components over conventional micro-photonic devices stems from their enhanced waveguide interconnection efficiency. Two- and three-dimensional photonic crystals enable strong light

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Cite this article as:

Motiedizaji, A., Masoumi, S., Beyza,B. and Mohammadian, L., 2024. Design and Simulation of an Eight-Channel Demultiplexer Based on Photonic-Crystal Ring Resonators. Journal of Modeling & Simulation in Electrical & Electronics Engineering (MSEEE), 4(4), pp. 33-39.

https://doi.org/10.22075/MSEEE.2025.37588.1209

confinement and guiding by exploiting band gaps. Introducing defects—especially linear ones—disrupts periodicity, allowing the creation of photonic crystal waveguides that direct light between points. Thus, light within the band gap frequency can be confined and guided effectively [13].

Today, access to high-speed telecommunication devices and high-capacity channels is among the most critical needs. One approach to maximizing channel capacity is Wavelength Division Multiplexing (WDM), which multiplexes multiple wavelengths over a single channel. Demultiplexers at the receiver then separate these wavelengths [14]. Therefore, multiplexers/demultiplexers are essential devices in integrated optical circuits.

This paper introduces a special type of demultiplexer and simulates its performance using the Finite-Difference Time-Domain (FDTD) method [15].

II. MATHEMATICAL THEORY OF METHODS FOR ANALYZING PHOTONIC CRYSTALS

The analysis of photonic crystals involves solving Maxwell's or Helmholtz equations using analytical, semi-analytical, and numerical methods [16]. Analytical methods are mostly limited to solving Helmholtz equations in heterogeneous environments under specific conditions, and direct solutions for arbitrary refractive index distributions are generally impossible. Although analytical solutions provide valuable physical insights, they do not cover all cases, necessitating semi-analytical and numerical approaches.

Semi-analytical methods represent solutions as expansions of analytical functions, with coefficients or eigenvalues determined by boundary conditions. These expansions are truncated at finite lengths, resulting in approximate solutions akin to numerical methods. Since their formulation is analytical before simulation, they differ somewhat from fully numerical approaches.

Each numerical method in electromagnetism has particular strengths, and choosing the right method depends on the problem at hand. Calculating photonic crystal band structures is fundamentally an eigenvalue problem best handled by frequency-domain methods like PWE. Modal analysis of cavities and waveguides also favors frequency-domain techniques. Conversely, time-domain methods are preferable for calculating reflection and transmission in waveguide bends or junctions. Considering the high computational cost of 3D photonic crystal analysis, the method's compatibility with parallel processing is also vital.

Currently, two of the most important methods for photonic crystal analysis are the Plane Wave Expansion (PWE) method for band gap extraction and the Finite-Difference Time-Domain (FDTD) method for output spectrum simulation.

PWE Method

This method is based on frequency-domain analysis, where the wave behavior in periodic environments is modeled as the product of a plane wave function and a periodic envelope function.

$$E(z,y,z) = E_p(x,y,z)e^{-j\beta.r} \quad (1)$$

$$H(z,y,z) = H_p(x,y,z)e^{-j\beta.r} \quad (2)$$

In which E_p and H_p are periodic functions, r is the position vector, and β is the propagation constant or wave vector. r and β can be expressed as:

$$r = a_X x + a_y y + a_z z \quad (3)$$

$$\beta = a_X \beta_X + a_y \beta_y + a_z \sigma \beta_z \quad (4)$$

Assuming a one-dimensional periodic structure, the Helmholtz equation governing the electromagnetic field can be written as follows:

$$\frac{1}{\varepsilon(x)} \frac{\partial^2 E_z}{\partial x^2} = -\omega^2 \mu_0 E_z \quad (5)$$

Finally, by applying a Fourier series expansion, the envelope functions can be expressed as follows:

$$E_z(x) = E_p(x)e^{-j\beta x} \quad (6)$$

$$E_p(x) = \lim_{N \to x} \sum_{n--N}^{N} e_n e^{-j\frac{2\pi n}{p}x} \quad (7)$$

Ultimately, this process leads to a matrix eigenvalue equation, the solutions of which yield the allowed frequencies corresponding to different propagation modes within the structure.

The implementation of the Plane Wave Expansion (PWE) method is relatively straightforward, and it offers high computational accuracy when a limited number of harmonics are used. However, as the number of harmonics increases, numerical instabilities may occur, leading to a decline in the precision of the computed eigenvalues and, consequently, the overall accuracy of the method. The primary application of the PWE method is in calculating the photonic band structure of periodic photonic crystals. While it is generally limited to this purpose, with appropriate method integration—such as the supercell approach—it can also be extended to analyze more complex structures, including cavities and waveguides [6].

FDTD Method

The Finite-Difference Time-Domain (FDTD) Method The Finite-Difference Time-Domain (FDTD) method is a fully vectorial numerical technique that provides both time-domain and frequency-domain information about electromagnetic fields, offering valuable insights into a wide range of problems in electromagnetics, optics, and photonics. As one of the most widely used methods for analyzing photonic crystal structures, FDTD also serves as a benchmark for validating other analytical and numerical techniques.

FDTD is known for its high precision, as it is based on the direct numerical solution of Maxwell's curl equations through space and time discretization. The method involves no matrix inversion in its standard form, which contributes to its computational efficiency. Sources of numerical error in FDTD simulations are well-understood and can be effectively minimized through appropriate meshing and time-step choices, thereby enhancing accuracy.

Due to its time-domain nature, FDTD is particularly well-suited for handling broadband and nonlinear problems. It is currently regarded as one of the most advanced and versatile techniques for computing electromagnetic field distributions in photonic crystal devices with complex, non-uniform refractive index profiles. Conceptually, FDTD operates by discretizing continuous spatial and temporal domains into a grid of discrete points.

An additional advantage of this method is that the divergence equations for electric and magnetic fields are inherently satisfied due to the specific arrangement of field components on the Yee grid. Therefore, only the curl equations need to be explicitly solved. In the case of two-dimensional (2D) simulations, the field components for transverse electric (TE) polarization are as follows:

(This can be followed by equations or a diagram of the field components.)

For transverse electric polarization, to obtain the new E_z at the next time step, the spatial derivatives of H_x and H_y are required. Similarly, for transverse magnetic polarization, if the time derivative of H_z is needed, the spatial derivatives of E_y and E_x will be necessary. Therefore, to achieve a stable numerical solution, both spatial and temporal derivatives must be centered.

III.DESIGN OF A DEMULTIPLEXER

The growing demand for higher bandwidth presents a significant challenge for optical telecommunications worldwide. The rapid increase in internet users, along with the surge in data, audio, and video transmissions, has created an urgent need to upgrade existing communication systems.

Wavelength Division Multiplexing (WDM) is a key technique that enables the simultaneous transmission of multiple wavelengths over a single optical fiber. By increasing the number of concurrent transmission channels, WDM effectively maximizes the utilization of the fiber's capacity. This paper focuses on the design of an eight-channel demultiplexer, a critical component in WDM systems.

The basic structure used for designing the proposed demultiplexer is a (N_1, N_2) 53, 100 network of dielectric rods on an air substrate. The refractive index of the dielectric rods is 3.46 (equal to the refractive index of silicon), and the radius of the dielectric rods is 128 nm, with a lattice constant of 641 nm. The photonic band gap of the structure shown in Fig. 1 was calculated using the Plane Wave Expansion (PWE) method with the Rsoft BandSolve software for TM polarization.

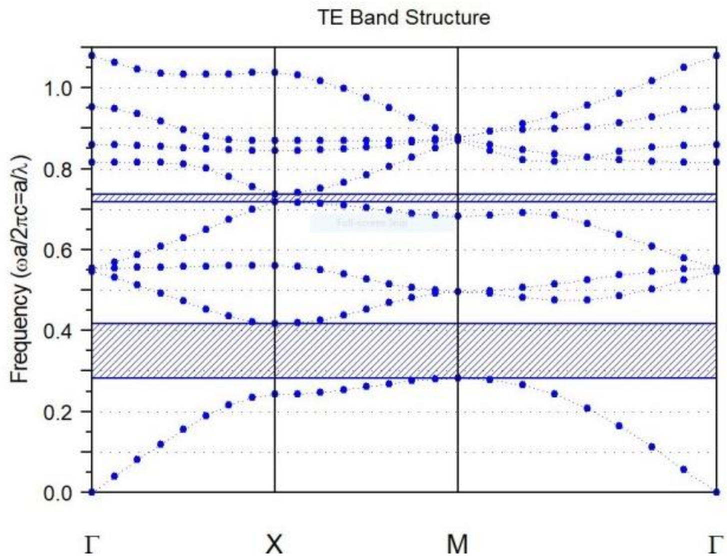

Fig. 1. Photonic crystal band structure for the TE mode

We found two PBGS in TE mode (blue color areas) and no PBG in TE mode. The first PBG is between 0.28-0.42. considering a = 641 nm the PBG will be 1526-2290 nm, that is in the range of optical communication applications.

Now, we are going to design and propose a 8 channel optical demultiplexer. Based on photonic crystal ring resonators. Our proposed demultiplexer consists of 3 main part on input waveguide, 8 output waveguides and 8 resonant rings (Fig. 2).

The schematic design of the 8-channel demultiplexer is shown in Fig. 2.

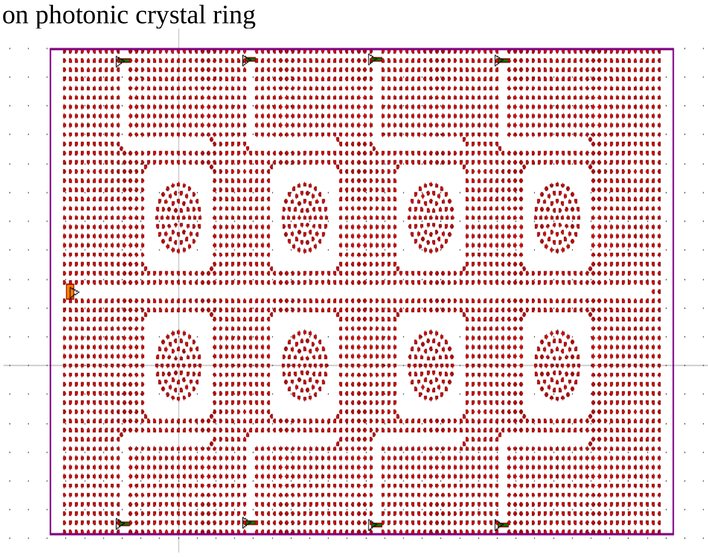

Fig. 2. Final design of the proposed demultiplexer

To create the input waveguide, 98 dielectric rods were removed along the Γ-M direction. Subsequently, eight output waveguides were formed by removing 25 dielectric rods along the M-X direction for each output channel.

To establish resonant rings between the input waveguide and each output waveguide, a 9×9 array of dielectric rods was first removed at the designated locations. These were then replaced with eight quasi-crystal structures—one for each ring resonator. Each 12-fold quasi-crystal structure consists of a central core rod surrounded by four concentric orbitals of rods. The radii of the first, second, third, and fourth orbitals are 0.9a, 1.8a, 2.7a, and 3.6a, respectively, where *a* is the lattice constant. The number of rods in the first, second, third, and fourth orbitals are 6, 12, 18, and 24, respectively.

By adjusting these parameters, different resonant wavelengths can be achieved. The resonant wavelength exhibits high sensitivity to changes in the refractive index; however, to maintain consistent channel spacing, the refractive index of the core rods in all photonic crystal ring resonators (PhcRRs) is kept identical to that of the fundamental photonic crystal structure.

Another parameter influencing the resonant wavelength is the radius of the dielectric rods within the 12-fold quasi-crystal structure. To minimize channel spacing, the radii of the central rods and the rods in the four orbitals of each 12-fold quasi-crystal structure are kept uniform, while only the radii of the outer orbital rods are varied for each resonator.

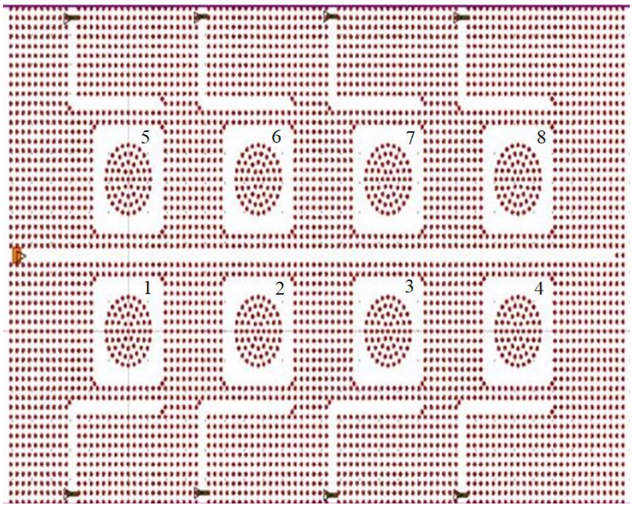

Fig. 3. According to the Fig. 5., ring No. 1, 2, 3, 4, 5, 6,7,8 corresponds to the wavelength

IV.SIMULATION

The finite-difference time-domain (FDTD) method [17] is the most commonly used approach for analyzing the properties of photonic crystal (PhC)-based devices. In our simulations, perfectly matched layer (PML) boundary conditions were applied to surround the structure, with a PML width of 500 nm. The grid size was set to *a*/32, corresponding to 20 nm. To ensure numerical stability, the time step (Δt) was chosen according to the Courant stability condition, resulting in Δt = 0.026 ns.For simulation calculations, we have used the simulation parameters in Fig. 4. .The simulation was carried out over 20,000 time steps, requiring approximately 4.9 hours of runtime and 30.4 MB of memory for the proposed demultiplexer. The output spectra of the demultiplexer for the wavelengths λ_1 = 1.5552 µm, λ_2 = 1.5563 µm, λ_3 = 1.5579 µm, λ_4 = 1.5593 µm, λ_5 = 1.5608 µm, λ_6 = 1.5623 µm, λ_7 = 1.5638 µm, and λ_8 = 1.5653 µm are shown in Fig. 3.

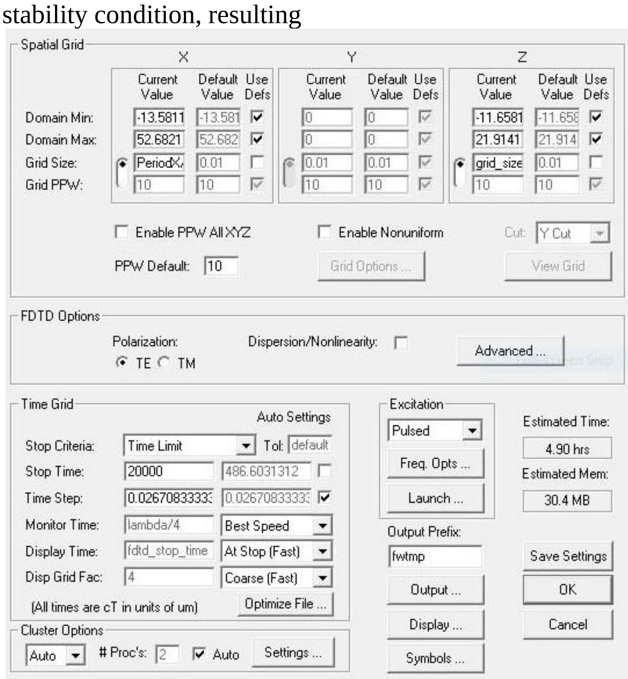

Fig. 4. Main view of the calculations

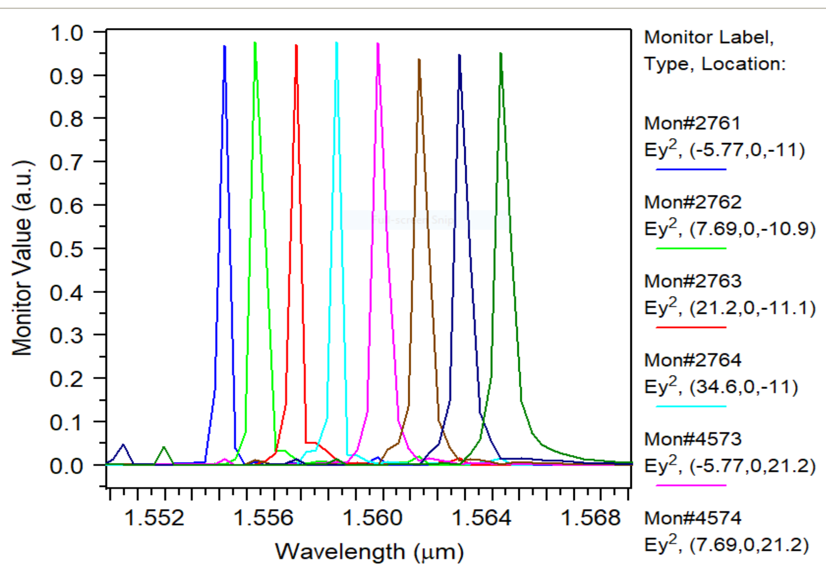

Fig. 5. Output spectrum of the 8-channel demultiplexer with even channel spacing on linear scales

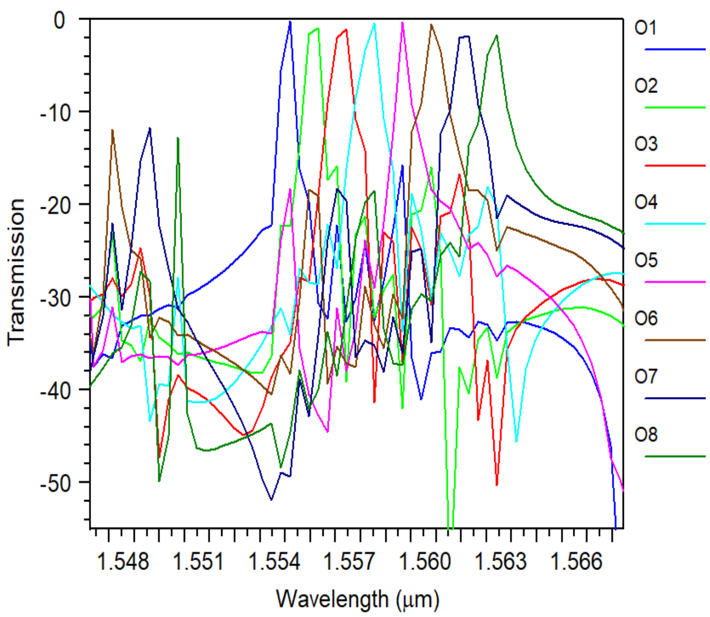

Fig. 6. Crosstalk between the channels of the 8-channel demultiplexer

After simulation, the output spectra of the demultiplexer were plotted in Figs. 5 and 6, and the results are summarized in Tables I and II.

The full specifications of the demultiplexer are listed in Tables I and II.

TABLE I

Full Detail for Output Spectrum of an 8-channel de Multiplexer

Channel	R (nm)	λ (nm)	Δλ (nm)	Q	TE (%)
1	105	1.5552	0.3	5814	96
2	110	1.5563	0.5	3112	97
3	115	1.5579	0.4	3894	96
4	120	1.5593	0.4	3198	97
5	125	1.5608	0.7	2229	97
6	130	1.5623	0.7	2231	93
7	135	1.5638	0.7	2234	94
8	190	1.5653	0.6	2608	95

The number of telecommunication channels in Wavelength Division Multiplexing (WDM) systems is a critical parameter in the design and fabrication of optical demultiplexers.

R: To create the desired ring resonator (intensifier), dielectric rods within the structure are removed to form a circular (ring-shaped) pattern. The radius of the core rods of the resonator is selected within the range of R_1 = 105 nm to

R = 140 nm to achieve effective separation of the intended wavelengths.

λ (nm): In the design of WDM systems, the channel spacing, i.e., the wavelength separation between telecommunication channels, is a crucial design factor.

Δλ (nm): Bandwidth and bandwidth latency refer to the data transmission rate over a network connection or interface. Bandwidth represents the range between the highest and lowest frequencies within the telecommunication channel spectrum and is typically measured in Hertz (Hz).

Q: In optical demultiplexers, the quality factor (Q) is defined as the ratio of the central separated wavelength of the device to its spectral bandwidth. A narrower bandwidth corresponds to a higher quality factor.

TE (%): The transmission efficiency (TE) indicates the percentage of the electromagnetic light wave that successfully passes through the optical surface or element. Transmission coefficients can be determined based on both the amplitude and intensity of the wave. These values are calculated as the ratio of the transmitted quantity to the incident quantity and are usually expressed as a percentage.

TABLE II
Full Details for Crosstalk Between the Channels of 8-channel de Multiplexer in dB.

channels	1	2	3	4	5	6	7	8
1		-22.2	- 34.7	-34.1	-18.2	-38	-49.4	-46.7
2	-31		-18.6	-28.4	-42.9	-18.6	-30.7	-39.7
3	-32.5	-38.2		-15.2	-37.8	-37.2	-20.4	-30.9
4	-32.3	-32.2	-40.8		-28.8	-32.8	-35.7	-18.8
5	-16.2	-41.5	-36.9	-33.1		-32.2	-33.6	-37
6	-36.3	-16.3	-30.7	-26.9	-18.2		-34.7	-30.3
7	-34.1	-39.1	-25	-23.1	-24.8	-18.5		-13.6
8	-34.6	-38.7	-49.7	-20.4	-27.9	-25.3	-21.3	

Crosstalk: in telecommunication issues, crosstalk is equal to the extent of telecommunication channels interference on adjacent telecommunication channels.

V.DISCUSSION AND CONCLUSION

This paper investigates a two-dimensional photonic crystal structure using Rsoft-Bandsolve software to determine its band structure diagram and photonic band gap region. The propagation and transmission characteristics of the desired wavelengths were analyzed using the Finite-Difference Time-Domain (FDTD) simulation method with Rsoft-Fullwave software. An eight-channel demultiplexer structure based on resonant cavities is proposed. The channel spacing and transmission efficiency (TE%) of the structure were calculated using the Plane Wave Expansion (PWE) and FDTD methods. A comparison of channel spacing and TE% with similar structures was performed.

As shown in Table III, the designed eight-channel demultiplexer achieves an optimal combination of channel spacing and transmission efficiency compared to previously reported devices, making it one of the best-performing demultiplexer designs to date.

TABLE III
Comparison of Previous Work on 8-Channel Ring Demultiplexers with the Current Work

Reference	Channels	Channel Spacing (nm)	TE (%)
Mehdizadeh et al [18]	8	2.1	94
Venkatachalam et al [19]	8	0.9	47
Rakhshani [20]	8	2.25	65
Dhandrapati et al [21]	8	1	55
Berry et al [22]	8	3.2	91
Kavitha et al [23]	8	2.25	90
This work	8	1.3	93

Suggestions

All designs and simulations performed in this paper are based on 2D simulations. Given that many photonic crystal devices are fabricated in 3D in the real world, it is suggested that the simulations be implemented in 3D, although such simulations require powerful computer systems.

REFERENCES

[1] R.D. Meade, A. Devenyi, JD. Joannopoulos, O.L. Alerhand, D.A. Smith, and K. Kash, "Novel applications of photonic band gap materials: Low-loss bends and high Q cavities", Journal of applied physics, Vol. 75, No.9, pp. 4753-4755, 1994. https://doi.org/10.1063/1.355934

[2] Y. Zhao and D.R. Grischkowsky, "2-D terahertz metallic photonic crystals in parallel-plate waveguides", IEEE transactions on Microwave Theory and Techniques, vol. 55, No. 4, pp. 656-663, 2007. https://doi.org/10.1109/TMTT.2007.892798

[3] E. Özbay, B. Temelkuran, M. Sigalas, G. Tuttle, C.M. Soukoulis and K.M. Ho, "Defect structures in metallic photonic crystals", Applied physics letters, Vol. 69, No. 25, pp. 3797-3799, 1996. https://doi.org/10.1063/1.117002

[4] H. Altug and J. Vučković, "Two-dimensional coupled photonic crystal resonator arrays", Applied Physics Letters, Vol. 84, No. 2, pp. 161-163, 2004. https://doi.org/10.1063/1.1639505

[5] A. Sharkawy, D. Pustai, S. Shi, and D.W. Prather, "High transmission through waveguide bends by use of polycrystalline photonic-crystal structures", Optics letters, Vol. 28, No. 14, pp. 1197-1199, 2003. https://doi.org/10.1364/OL.28.001197

[6] A.L. Bingham and D.R. Grischkowsky, "Terahertz 2-D photonic crystal waveguides", IEEE Microwave and Wireless Components Letters, Vol. 18, No. 7, pp. 428-430, 2008. https://doi.org/10.1109/LMWC.2008.924906

[7] M. Imada, S. Noda, A. Chutinan, M. Mochizuki and T. Tanaka, "Channel drop filter using a single defect in a 2-D photonic crystal slab waveguide", Journal of Lightwave Technology, Vol. 20, No. 5, pp. 873-878, 2002. https://doi.org/10.1109/JLT.2002.1007943

[8] D. Bernier, X.L. Roux, A. Lupu, D. Marris-Morini, L. Vivien and E. Cassan, "Compact, low cross-talk CWDM demultiplexer using photonic crystal superprism", Optics express, Vol. 16, No. 22, pp. 17209-17214, 2008. https://doi.org/10.1364/OE.16.017209

[9] X. Chen, Z. Qiang, D. Zhao, H. Li, Y. Qiu, W. Yang and W. Zhou, "Polarization-independent drop filters based on photonic crystal self-collimation ring resonators", Optics express, Vol. 17, No. 22, pp. 19808-19813, 2009. https://doi.org/10.1364/OE.17.019808

[10] W.J. Bock, J. Chen, T. Eftimov and W. Urbanczyk, "A photonic crystal fiber sensor for pressure measurements", IEEE Transactions on Instrumentation and Measurement, Vol. 55, No. 4, pp. 1119-1123, 2006. https://doi.org/10.1109/TIM.2006.876591

[11] O. Painter, J. Vučković and A. Scherer, "Defect modes of a two-dimensional photonic crystal in an optically thin dielectric slab", JOSA B, Vol. 16, No. 2, pp. 275-285, 1999. https://doi.org/10.1364/JOSAB.16.000275

[12] W.D. Zhou, J. Sabarinathan, P. Bhattacharya, B. Kochman, E.W. Berg, P.C. Yu and S.W. Pang, "Characteristics of a photonic bandgap single defect microcavity electroluminescent device", IEEE journal of quantum electronics, Vol. 37, No.9, pp. 1153-1160, 2001. https://doi.org/10.1109/3.945320

[13] C. Manolatou, M.J. Khan, S. Fan, P.R. Villeneuve, H. A. Haus and J.D. Joannopoulos, "Coupling of modes analysis of resonant channel add-drop filters", IEEE journal of quantum electronics, Vol. 35, No. 9, pp. 1322-1331, 1999. https://doi.org/10.1109/3.784592

[14] C. Jin, S. Han, X. Meng, B. Cheng and D. Zhang, "Demultiplexer using directly resonant tunneling between point defects and waveguides in a photonic crystal", Journal of applied physics, Vol. 91, No. 7, pp. 4771-4773, 2002. https://doi.org/10.1063/1.1456956

[15] T.M. Monro and H. Ebendorff-Heidepriem, "Progress in microstructured optical fibers", Annu. Rev. Mater. Res, Vol. 36, No. 1, pp. 467-495, 2006. https://doi.org/10.1146/annurev.matsci.36.111904.135316

[16] S.G. Johnson and J.D. Joannopoulos, "Block-iterative frequency-domain methods for Maxwell's equations in a planewave basis", Opt Express, Vol. 8, No. 3, pp. 1703-9, 2001. https://doi.org/10.1364/OE.8.000173

[17] E. Talebzadeh, M. Soroosh, Y. S. Kavian and F. Mehdizadeh, "All-optical 6-and 8-channel demultiplexers based on photonic crystal multilayer ring resonators in Si/C rods", Photonic Network Communications, Vol. 34, No. 2, pp. 248, 2017. https://doi.org/10.1007/s11107-017-0688-x

[18] F. Mehdizadeh, M. Soroosh and H. Alipour-Banaei, "An optical demultiplexer based on photonic crystal ring resonators", Opt-Int J Light Electron Opt, Vol. 127, No. 20, pp. 8706–9, 2016. https://doi.org/10.1016/j.ijleo.2016.06.086

[19] K. Venkatachalam, D.S. Kumar and S. Robinson, "Investigation on 2D photonic crystal-based eight-channel wavelength-division demultiplexer", Photonic Netw Commun, Vol. 34, No. 1, pp. 100–10, 2017. https://doi.org/10.1007/s11107-016-0675-7

[20] M.R. Rakhshani, "Compact eight-channel wavelength demultiplexer using modified photonic crystal ring resonators for CWDM applications", Photonic Netw Commun, Vol. 39, pp. 143–51, 2020. https://doi.org/10.1007/s11107-020-00879-8

[21] L. Dhandrapati and S. Tupakula, "A novel 8-channel DWDM demultiplexer on silicon photonic crystal slab: Design and analysis", Optik (Stuttg), Vol. 256, pp. 168734. 2022. https://doi.org/10.1016/j.ijleo.2022.168734

[22] A. Berry, N. Anand, S. Anandan and P. Krishnan, "High-Performance Eight-Channel Photonic Crystal Ring Resonator–Based Optical Demultiplexer for DWDM Applications", Plasmonics, Vol. 16, No. 6, pp. 2073–80, 2021. https://doi.org/10.1007/s11468-021-01463-0

[23] V. Kavitha, V.R. Balaji, S.S. Dhanabalan, T. Sridarshini, S. Robinson, M. Radhouene, G. Hegde and R.J. Sugesh, "Design and performance analysis of eight channel demultiplexer using 2D photonic crystal with trapezium cavity", J Opt, Vol. 25, No. 6, pp. 65102, 2023. Doi: 10.1088/2040-8986/acceb3