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Performance Evaluation of a Square Lattice Micro- Structure Optical Fibre in Communication & Multiplexing Technique

By Avizit Basak & Mohibur Rahman

Rajshahi University of Engineering & Technology, Bangladesh

Abstract - Although optical fiber communication is the best for transmitting data at a high rate, we are trying to push the data rate even higher. While the fiber channel may be capable of transmitting terabit-per-second data rates, no existing single communication system can make complete use of this speed. Adding more and more fibers to the system as a method of increasing speed is uneconomical. Optical fibers in discussion that guide signals in the form of light are typically made of from two glasses. It is a cylindrical in shape waveguide consisting of a higher refractive index solid glass core which runs down middle of the fiber. The other solid glass with a lower refractive index surrounds the core and makes the homogeneous cladding. The two glasses are made of from the common material silica. Photonic crystal fibers can be divided into two modes of operation, according to their mechanism for confinement. Those with a solid core, or a core with a higher average index than the micro structured cladding, can operate on the same index-guiding principle as conventional optical fiber.

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Abstract - Although optical fiber communication is the best for transmitting data at a high rate, we are trying to push the data rate even higher. While the fiber channel may be capable of transmitting terabit-per-second data rates, no existing single communication system can make complete use of this speed. Adding more and more fibers to the system as a method of increasing speed is uneconomical. Optical fibers in discussion that guide signals in the form of light are typically made of from two glasses. It is a cylindrical in shape waveguide consisting of a higher refractive index solid glass core which runs down middle of the fiber. The other solid glass with a lower refractive index surrounds the core and makes the homogeneous cladding. The two glasses are made of from the common material silica. Photonic crystal fibers can be divided into two modes of operation, according to their mechanism for confinement. Those with a solid core, or a core with a higher average index than the micro structured cladding, can operate on the same index-guiding principle as conventional optical fiber. They can have a much higher effective- refractive index contrast between core and cladding, and therefore can have much stronger confinement for applications in nonlinear optical devices, polarization-maintaining fibers. Alternatively, one can create a photonic band gap fiber, in which the light is confined by a photonic band gap created by the micro structured cladding – such a band gap, properly designed, can confine light in a *lower-index* core and even a hollow core. Band gap fibers with hollow cores can potentially circumvent limits imposed by available materials, for example to create fibers that guide light in wavelengths for which transparent materials are not available. Another potential advantage of a hollow core is that one can dynamically introduce materials into the core, such as a gas that is to be analyzed for the presence of some substance. MOF can also be modified by coating the holes with sol-gels of similar or different index material to enhance its transmittance of light. Microstructure optical fibre technique has the advantage of higher bit rates and is well equipped for long haul applications. This types of fibres are mostly used for its advantages over other multiplexing schemes. In this paper, performance analysis of MOF in multiplexing technique was explored and different aspects of communication and multiplexing. Dense WDM and Coarse WDM technique has the advantage of higher bit rates and is well equipped for long

haul application and MOF performs here in better way in communication and Multiplexing technique.

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I. INTRODUCTION

In optical communications system the transmitter is a light source whose output acts as the carrier wave. Although frequency division multiplexing techniques are used in longer broadcast systems, most optical communication links use time division multiplexing techniques. The components that are used to transmit or receive the optical signal are usually semiconductor devices. For transmission the most common light source used are laser diode and light emitting diode. At the receiving end of the optical link a PIN photodiode or Avalanche photodiode, acts as a photo detector and converts the modulated light back into an electrical signal. The photodiode current is directly proportional to optical power. The receiver block which is the last part of the system which converts the optical signal back into the replica of the electrical signal using PIN-type photodiode then to the amplification stage before reaching the end. The early all-glass fibers experienced large amount of optical losses thus limiting the transmission distance. This was because the transparent transmitting rod was surrounded by air and as a consequence, excessive losses occurred at any discontinuities of the glass-air interface. This realization motivated scientists to develop glass fibers that included a separate glass coating. The fiber was made of two layers. The innermost region of the fiber referred to as the core, was used to transmit the light while the glass coating or the cladding prevented the light from leaking out of the core by reflecting it within its boundaries.

II. BASIC OF MICROSTRUCTURE OPTICAL FIBRE

Development of wavelength division multiplexing (WDM) networks in recent years and the requirement of transmitting data over optical fibers in high bitrates in the second and third wavelength window have caused serious concerns using conventional single mode fibers in optical communications. High dispersion

Author α : Avizit Basak; B.Sc in Electrical & Electronics Engineering from Rajshahi University of Engineering & Technology (RUET), Rajshahi, Bangladesh. E-mail : dhrubo_eee88@yahoo.com

Author σ : Md.Mohibur Rahman; B.Sc in Electrical & Electronics Engineering from Rajshahi University of Engineering & Technology (RUET), Rajshahi, Bangladesh. E-mail : mrahman051118@gmail.com

in conventional single mode fibers leads to partial loss of data in long distances of data transmission. The MOF is a single material optical fiber consisting of a silica-air microstructure. It contains microscopic air-holes in a silica background running down length of the fiber that form the silica-air microstructure as well as the lower refractive index cladding. The former core type MOF guides light based on the modified TIR in terms of coupling between air and dielectric modes in a single tube waveguide, a simple and useful model is proposed and numerically validated. It is able to predict mechanism likewise conventional fibers. The later guides light based on a new mechanism which is known as the photonic band gap. Most MOF have been fabricated in silica glass, but other glasses have also been used to obtain particular optical properties. MOFs with small core and large sized identical air-holes tend to shift zero dispersion wavelengths toward shorter wavelengths. The mode field distribution has its maximum amplitude at the center core region. The structural parameters of the fiber to enhance or to degrade the high nonlinearity of the fiber, effective mode index, and group velocity dispersion. Through optimizing design parameters, we can alter and improve the propagation characteristics in this fibre according to its application, which makes it a proper choice for communication applications, is that nearly zero flattened dispersion and low confinement loss in this fiber is attainable at the same time.

III. FUNDAMENTAL OF WDM SYSTEM

A WDM system uses a multiplexer at the transmitter to join the signals together and a demultiplexer at the receiver to split them apart. With the right type of fiber it is possible to have a device that does both simultaneously, and can function as an optical add-drop multiplexer. WDM combines multiple optical time division multiplexed (TDM) data streams onto one fiber through the use of multiple wavelengths of light. Each individual TDM data stream is sent over an individual laser transmitting a unique wavelength of light. Wavelength division multiplexing was used with only two wavelengths 1310 nm and 1550 nm. However, this was suitable only for limited applications for example; applications in which analog optical cable television signals co-existed with digital optical telecommunication signals. WDM takes advantage of the fact that different wavelengths of light can be transmitted over a single fiber simultaneously. The light sources of different wavelengths can be combined using suitable components like couplers, splitters etc.

IV. OPTICAL LOSSES

Once power is coupled into the fiber, the optical signal will interact with the fiber. One of these interactions is the attenuation of the light signal as it

moves through the medium. Attenuation is caused by two physical effects, which are absorption and scattering. Absorption has an effect of removing photons, when they interact with atoms and molecules of the medium while scattering redirects the light out of the core of the fiber. Absorption occurs when the energy of the photon is equal to a difference between two electronic energies. A major cause of absorption is the presence of OH⁻ radicals, which results from the presence of water (H₂O). The OH⁻ enters the fiber through either a chemical reaction (during fiber manufacturing) by-product, or as humidity in the operating environment. The main OH⁻ absorption peak occurs at 1400nm and the second peak at 950 nm, while the lowest absorption occurs in the wavelength window around 1300 nm and 1550 nm.

V. BIDIRECTIONAL TRANSMISSION SYSTEM

Bidirectional transmission is an appealing means of increasing the bandwidth utilization in a single optical fiber and, at the same time, reducing the operation and maintenance cost, and therefore a long haul optical links will likely require a considerable increase in total spectral efficiency. Recently the most interesting area is engaging (WDM) in Bidirectional transmissions over a single fiber in terms of increase the capacity of transmitted data. Recent progress on access network systems has increased the communication bit rate to several Gb/s. Now a low cost optical transceiver is required for optical access network systems. Specifically, a bidirectional single fiber optical transceiver is expected to be an effective way of reducing system cost. There are certain approaches to designing the optical transceiver configuration that will enable achieving such a low cost

VI. SYSTEM CROSSTALK & POWER PENALTY

Crosstalk occurs in multi channel optical transmission systems. Crosstalk can be caused by the following: the spectral skirts of one channel entering the de-multiplexing and filtering pass-band of another cause crosstalk, practical limits on selectivity and isolation cause crosstalk. Non-linear effects within the fiber at the high power densities possible in single mode systems can cause crosstalk or cross modulation, the mechanism is Raman scattering, which is a non-linear stimulated scattering effect that allows the optical power at one wavelength to affect scattering and thus the optical power in another wavelength. In optical communication the receiver sensitivity is defined with respect to the receiver noise for several basic detection scenarios. The power penalty is equal to the increase in signal power that is needed to keep the Q-factor and BER at the same level that would exist if no impairments were present. The impact of different impairments can

due to Extinction Ratio, Power Penalty due to Intensity Noise, etc.

VII. SYSTEM DISPERSION

Dispersion factor must be taken into account during designing any fiber optic transmission system. The effect of this factor causes crosstalk problem at the far end of the system, especially in transmitting more than one wavelength in both directions with close wavelengths between channels. There are two kinds of dispersion. Material dispersion and chromatic dispersion, the most common is called Dispersion chromatic dispersion. The effects of polarization mode dispersion are much more insidious and difficult to make compensation for in the real networks.

VIII. GEOMETRIC DESCRIPTION OF BEAM PROPAGATION IN MOF FIBER

The ray description of light propagation in fiber is based on the phenomenon of total internal reflection. The theory of TIR states that when a beam is incident at the boundary between two media where the incident medium is of a higher refractive index than the second medium and the angle of incidence exceeds a critical value θ_c , the light will be totally reflected. Beyond this angle light is no longer transmitted into the second medium, instead it is reflected into the original medium.

IX. MULTIPLEXING

Multiplexing is an essential technique for fibre optic communication. It is a method by which multiple analogue message signals or digital data streams are combined into one signal over a shared medium. The aim is to share an expensive resource. The multiplexed signal is transmitted over a communication channel, which may be a physical transmission medium. The multiplexing divides the capacity of the high-level communication channel into several low-level logical channels, one for each message signal or data stream to be transferred. Multiplexing technologies may be divided into several types. Such as space-division multiplexing (SDM), frequency-division multiplexing (FDM), time-division multiplexing (TDM), and code division multiplexing(CDM),Board WDM, Coarse WDM, Dense WDM, etc. CWDM, DWDM, OADM are mostly used in telecommunication & computer networks. Wavelength Division Multiplexing is the technology enabling cost efficient upgrade of capacity in optical networks. This explains the fundamental principles for optical networks.

X. SYSTEM DESIGN ANALYSIS

Two analyses are usually carried out to ensure that the system performs satisfactorily: the link power budget and the system rise-time budget analyses. The

power budget analysis is used to determine the power margin between the output power of the transmitter and the minimum receiver sensitivity needed to ensure a specified bit error rate (BER). The power loss between transmitter and receiver can be allocated to the connector, splices and fiber losses. Should the system not meet the desired performance, components used in the link must be varied. This process is iterated until the desired performance is met. Once the power budget has been established, a system rise-time analysis is performed to ensure that the desired overall performance is achieved.

XI. LINK POWER BUDGET & RISE TIME BUDGET

The link power budget is determined by establishing the minimum power required to fall on the photodiode in order to ensure a certain BER. In light wave system a BER = 10^{-9} is considered acceptable. The light coupling efficiency of the transmitter, the loss of the fiber and the sequential loss contributions of each element in the link determine the power received at the detector. The dispersion limitation of an optical fiber link must be determined because it sets the upper limit for the transmission bit-rate. The rise-time budget analysis is a convenient method for establishing the allowable bit rate in the optical system. The rise time budget analysis is essentially a measure of how fast the system responds to a step stimulus. There are four basic elements that limit the speed of response of an optical system: these are the transmitter rise-time t_{tx} the fiber rise time that comprises of the GVD rise-time t_{GVD} and the inter modal dispersion rise-time t_{mod} , and finally the receiver rise-time.

XII. PERFORMANCE EVALUATION OF SQUARE LATTICE MICROSTRUCTURE OPTICAL FIBER

The analyses performed according to the waveguide contribution to the dispersion, noise level, losses, frequency distribution etc.



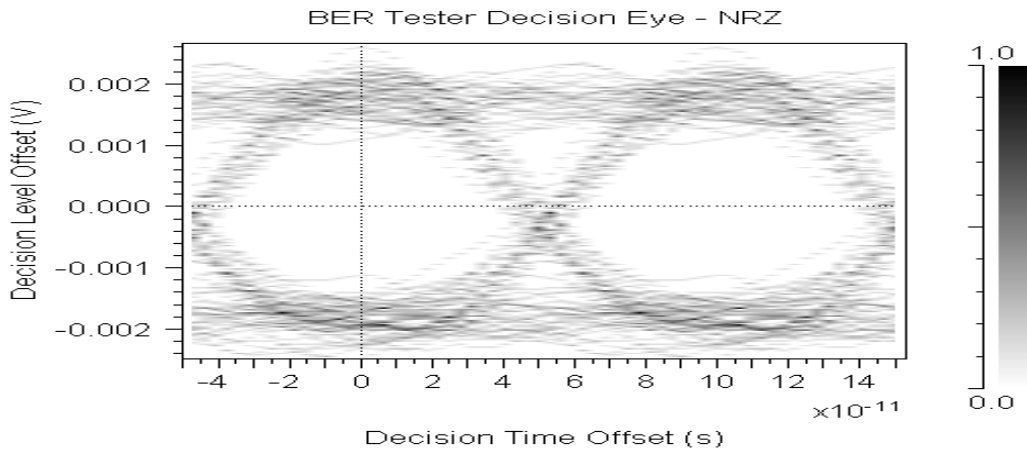


Figure 1 : NRZ operation for multiplexing technique in MOF

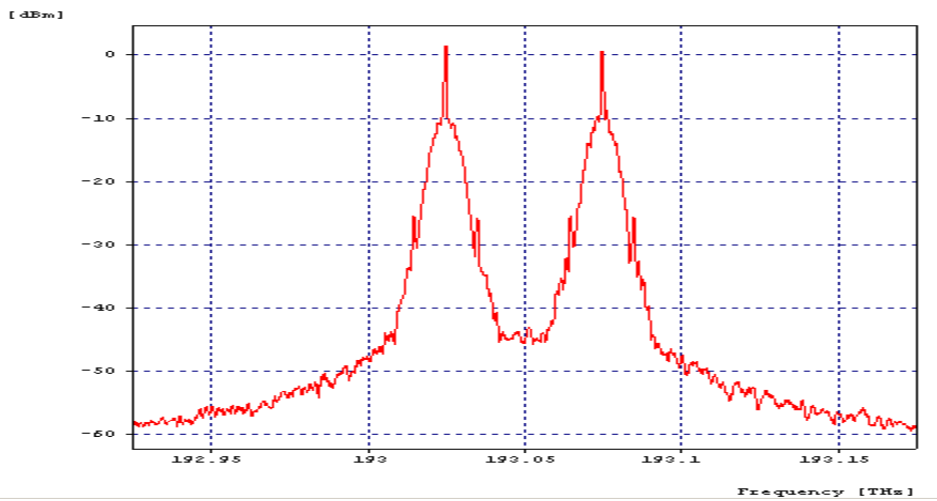


Figure 2 : Optical spectrum while multiplexing operation

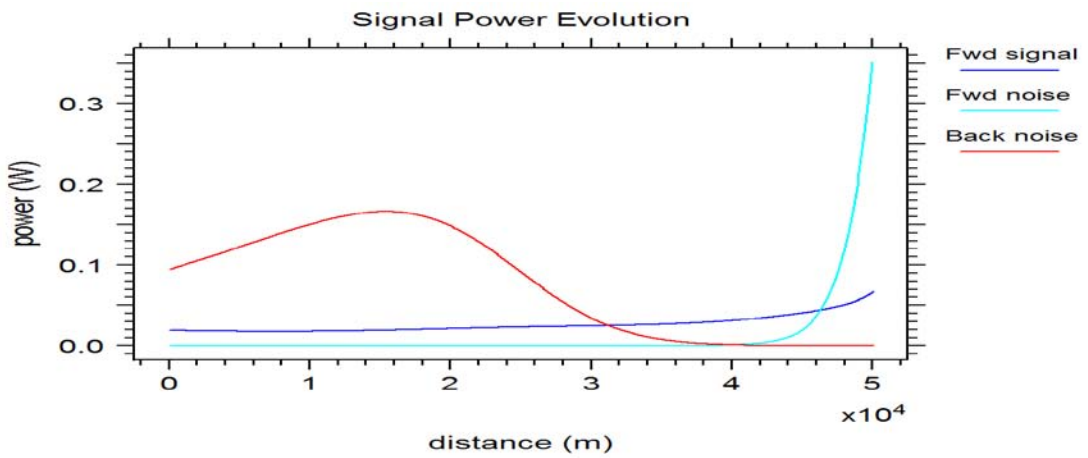


Figure 3 : Noise Level in MOF while multiplexing

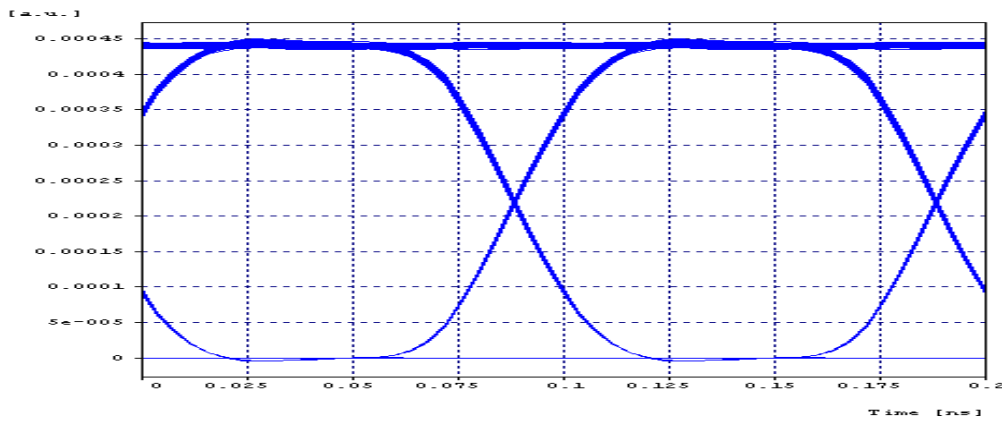


Figure 4 : Eye diagram while transmission

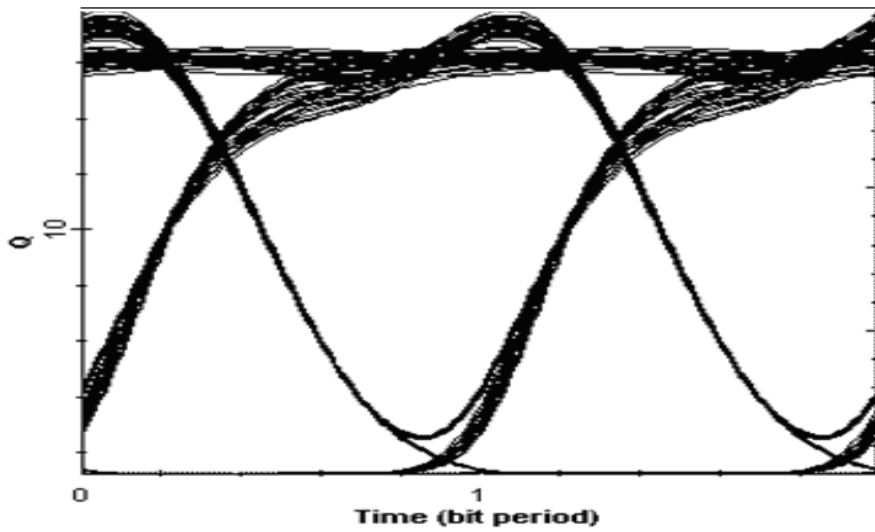


Figure 5 : Dispersion in MOF while multiplexing

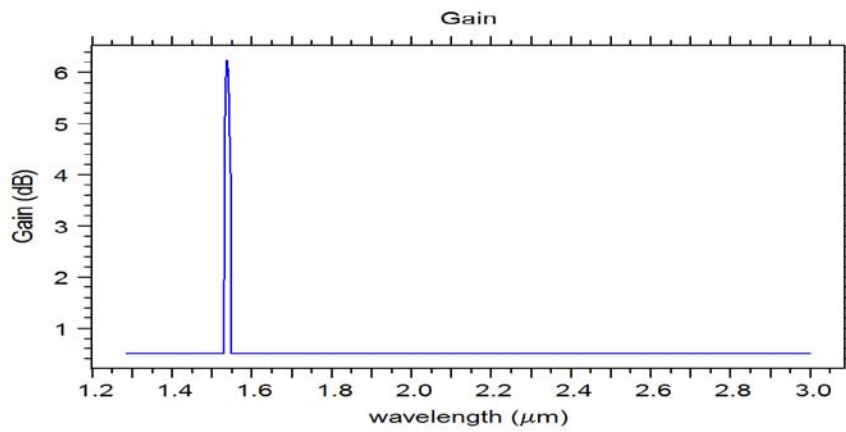


Figure 6 : Frequency response in MOF while multiplexing

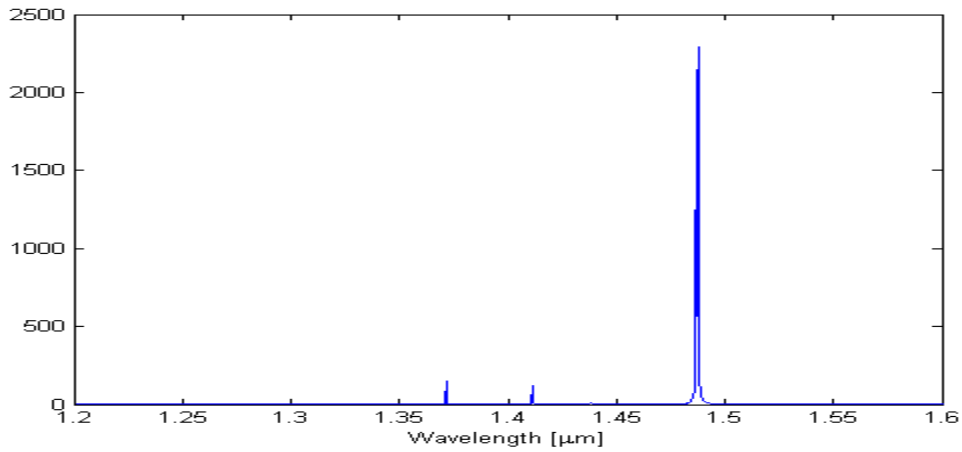


Figure 7 : Spectrum of a MOF while multiplexing

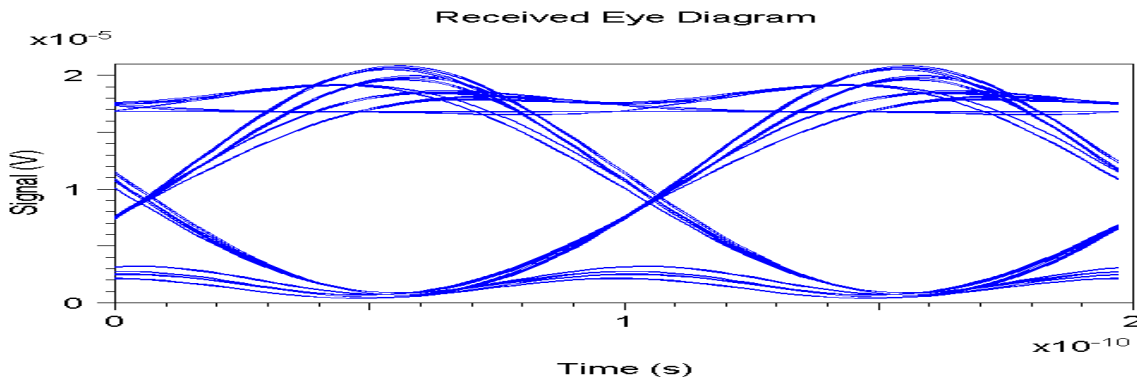


Figure 8 : Received eye diagram of Received signal

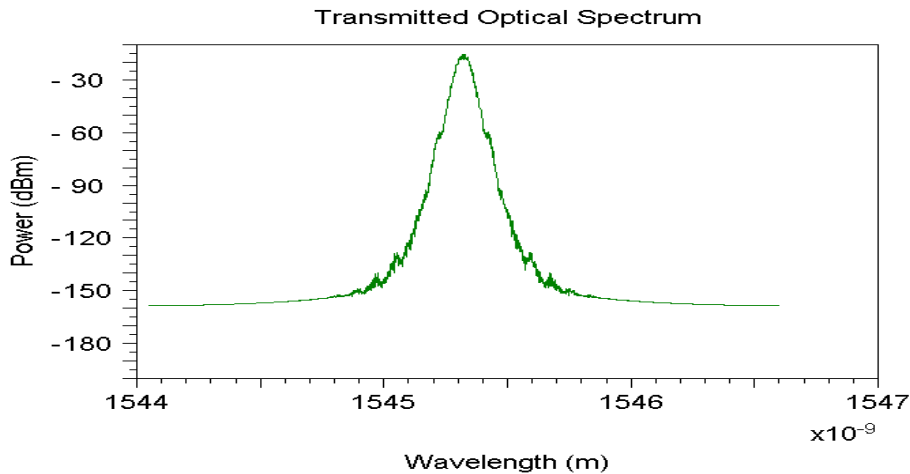


Figure 9 : Transmitted optical spectrum

XIII. ADVANTAGES OF MOF

Excellent performance, high Mechanical sensitivity, operational flexibility, transparent to digital signal format and data rate, reduces transmission losses, economical etc.

XIV. CONCLUSION

Here, investigation are made according to the specific air hole size and hole to hole spacing over a wide wavelength range. From the numerical simulation results, better dispersion slope, and low losses in the telecommunication operation. Moreover, Optical

communications by Dense Wavelength Division Multiplexing (DWDM) uses 100 wavelength channels enabling high-speed, high-capacity optical communication system for the Internet age. A new trend is to use Coarse Wavelength Division Multiplexing (CWDM) system in these networks to lower the cost dramatically at sufficient bandwidth capacity. In addition, to the stability required for DWDM sources passive modules such as mux/demux and add/drop modules used in DWDM systems also need to have very narrow filtering or wavelength separating characteristics that stay stable over a considerable temperature range. These filters are required to have very stringent tolerance. For a CWDM system, on the other hand the spacing between channels wavelengths is large so that the requirements and tolerances for components and modules are more relaxed. To maintain proper operation with less losses and to confirm operational flexibility, square lattice multi structure optical fiber is used in these type of multiplexing. Propagation in this fibre is acceptable than conventional fibre, noise level and losses is also low of this fiber. Moreover we can choose the parameters to achieve the desirable dispersion compensation over different communication band and multiplexing technique.

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