The Future of Technology Contingent on Optical Fiber due to Its Uncomplicated Design Framework

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ABSTRACT

Optical fiber plays a crucial role in the improvement of high quality and high-speed telecommunication systems. Optical fibers are not only used in telecommunication links but also used in the Internet and local area networks (LAN) to achieve high signaling rates. This paper illustrates with the development and working principle with basic parameter of optical communication systems. This paper reviews the latest development in broadband access technologies and ability of those technologies to meet the future requirement of broadband users. Finally the fiber optical sensors are briefly mentioned along with the current state of the art of plastic optical fiber technology, namely its main characteristics and sensing advantages.

Keyword: - *Optical fiber, Different Optical fiber, broadband technologies & their comparison, Optical Sensors.*

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1. INTRODUCTION

Optical fiber is dielectric waveguide that operate at the optical frequency and used to carry the light beam from one place to another. It is highly efficient and provides sufficient power output[1]. It has the ability to give the desire modulation and compatibility with fiber end.

As we move back in the history then it is observed that metallic and non-metallic wave guides were fabricated to guide light in a waveguide. But they have huge losses. So they were not suitable for telecommunication. According to the Tyndall, , light can transmitted via optical fibers by the phenomenon of total internal reflection.[1] During 1950s, the optical fibers with large diameters of about 1 or 2 millimetre were used in endoscopes to observe the internal parts of the human body. Optical fibers can provide a much more trustworthy and flexible optical channel than the environment. But the fibers produced an enormous loss of 1000 dB/km[1,4]. But in the atmosphere, there is a loss of few dB/km. and these high losses were a result of impurities in the fiber material. Using a pure silica fiber these losses were reduced to 20 dB/km.r. At this attenuation loss, repeater spacing for optical fiber links become comparable to those of copper cable systems. Thus the optical fiber communication system became an engineering reality.

As the broadband revolution continues, the internet and intranet have increasing requirement for the bandwidth. The next generation TV and video service such as video on demand ,etc [1,2,3]requires bandwidth in broadband network. HDTV requires in order of 15 to 20 Mbps bandwidth which insures the capability of broadband Technologies. Optical fiber offers limitless bandwidth capabilities. Optical fiber is superior as compared to other broadband technologies.

Optical fiber sensors have several advantageous features: they are compact, lightweight and enable the implementation of multiplexing schemes. As the principle of operation is based on an optical signal, they also exhibit immunity to electromagnetic interference.Fibers have many uses in remote sensing. In some applications, the sensor is itself an optical fiber. In other cases, fiber is used to connect a non-fiber optic sensor to a measurement system. Depending on the application, fiber may be used because of its small size, or the fact that no electrical power is needed at the remote location, or because many sensors can be multiplexed along the length of a fiber by using different wavelengths of light for each sensor, or by sensing the time delay as light passes along the fiber through each sensor. Time delay can be determined using a device such as an optical time-domain reflectometer. Extrinsic fiber optic sensors use an optical fiber cable, normally a multi-mode one, to transmit modulated light from either a non-fiber optical sensor—or an electronic sensor connected to an optical transmitter. This paper illustrate review of Plastic Optical Fiber (POF) sensor.

2. ARCHITECTURE OF OPTICAL FIBER

An optical fiber is a flexible, transparent fiber made of glass (silica) or plastic, slightly thicker than a human hair. It functions as a waveguide, or "light pipe",[3] to transmit light between the two ends of the fiber.

Fig.1 bundles of optical fiber

The bundle of optical fiber is as shown in fig.1.The field of applied science and engineering concerned with the design and application of optical fibers is known as fiber optics. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication. Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference. Fibers are also used for illumination, and are wrapped in bundles so that they may be used to carry images, thus allowing viewing in confined spaces[1,4]. Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide.

3. VARIOUS OPTICAL FIBERS

An optical fiber is a cylindrical dielectric waveguide that transmits light along its axis, by the process of total internal reflection[1,5]. The fiber consists of a core surrounded by a cladding layer, both of which are made of dielectric materials. To confine the optical signal in the core, the refractive index of the core must be greater than that of the cladding. Based on the refractive index profile we have two types of fibers (a) Step index fiber (b)Graded index fiber.

(a) Step index fiber:

In the step index fiber, the refractive index of the core is uniform throughout and undergoes an abrupt or step change at the core cladding boundary. The light rays propagating through the fiber are in the form of meridional rays which will cross the fiber axis during every reflection at the core cladding boundary and are propagating in a zigzag manner as shown in figure 2a.

(b) Graded index fiber:

In the graded index fiber, the refractive index of the core is made to vary in the parabolic manner such that the maximum value of refractive index is at the centre of the core. The light rays propagating through it are in the form of skew rays or helical rays which will not cross the fiber axis at any time and are propagating around the fiber axis in a helical (or) spiral manner as shown in figure 2b.

Based on the number of modes propagating through the fiber, there are multimode fibers and single mode fibers. Mode is the mathematical concept of describing the nature of propagation of electromagnetic waves in a waveguide. Mode means the nature of the electromagnetic field pattern along the light path inside the fiber.

(c) Single mode fibers:

In a single mode fiber, only one mode can propagate through the fiber (figure 2c). Normally the number of modes propagating through the fiber is proportional to its V-number where

$$\text{V-no.} = 2\pi n1a(2\Delta)1/2 \ / \ \lambda$$

In this case a is the = radius of the core of the fiber; η1 is 1refractive index of the core, λ is wavelength of light propagating through the fiber; Δ is relative refractive index difference .

The single mode fiber has a smaller core diameter (10 mm)[3,4] and the difference between the refractive indices of the core and the cladding is very small. Fabrication of single mode fibers is very difficult and so the fiber is expensive. Further the launching of light into single mode fibers is also difficult. Generally in the single mode fibers, the transmission loss and dispersion or degradation of the signal are very small. So the single mode fibers are very useful in long distance communication.

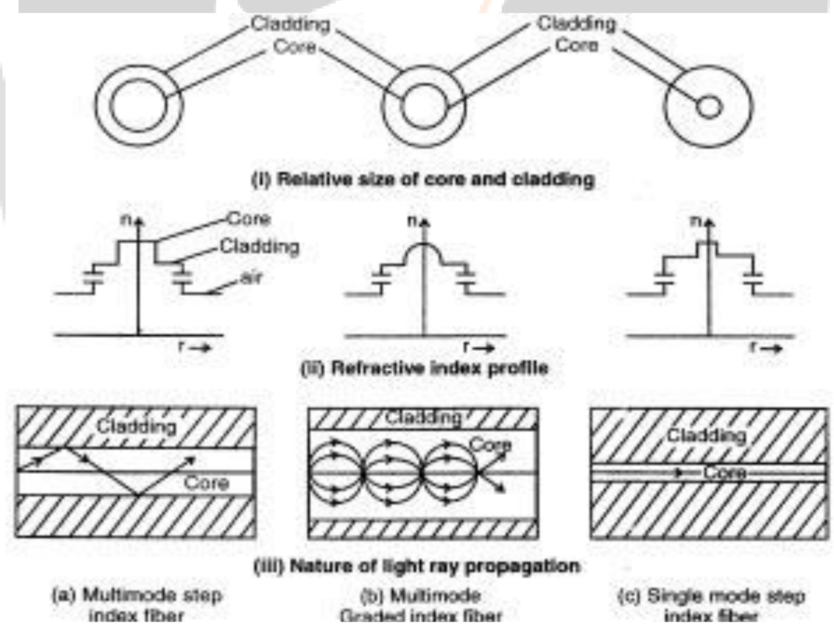

Fig 2. Different types of fibers.

4. BROADBAND TECHNOLOGY

There are a myriad of competing technology which can provide the bandwidth required to delivered broadband services but each technology has its limit in terms of bandwidth, reliability, coverage or cost. Optical fiber is the best solution to overcome such limits. There are two types of broadband technology viz, fixed line technology and wireless technology. fixed line technology communicate through physical network i.e. wired connection between customer and the operators network[3] , its best example is old telephone system where as in wireless technology radio or microwave frequency are used to established connection in between customer and the operators network. Let's talk about them in detail,

4.1 FIXED LINE TECHNOLOGY

Fixed line broadband technologies rely on direct physical connection to customer's home or office. Many broadband technologies such as cable modem, DSL and BPL (Digital Subscriber Line & Broadband Power Line) are use for the communication but they strive to avoid any upgrade to existing network due to inherent implication for capital expenditure. On the other hand fiber to the home (FTTH) requires new link from local exchange directly to customer. FTTH is ultimate fiber access solution where each customer is connected to an Optical fiber. So fiber as communication medium offer infinite bandwidth over greater distance than other.

4.2 WIRELESS TECHNOLOGY

Wireless technology refers to the technology that point to point microwave in various frequencies in 2.5 to 43 GHz to transmit signal between hub site and end user receiver. Wireless technology can be divided on the basis of line-of - sight (LOS). Point to point microwave, free space optics and broadband satellite requires LOS where as GSM, CDMA, 3G don't require LOS hence provide wide coverage range. Free space optics (FSO) provide bandwidth in Tera hertz .

4.3 COMPARISON OF TECHNOLOGY

Table 1 gives comparative details of FTTH of Fixed Line technology and FSO of Wireless technology.

Table 1 Comparision

Technology	Fixed Line(FTTH)	Wireless(FSO)
Spectrum usage	THz	THz
Capacity	Upto 1 Gbps per channel per fiber	Upto 2.5 Gbps per link
Maximum range	20KM	4KM
Merit	Unlimited BW	Low setup cost
Demerit	Require new fiber access overlay	LOS performance is weather sensitive

5.OPTICAL SENSOR

The expectations for the production of optical fiber sensors at low or competitive cost compared to the well-established conventional technologies are still demanding [8]. Plastic or polymer optical fiber (POF) can helpful to achieve t these expectations. The term optical fiber is often synonymous with glass optical fiber (GOF), although chronologically, the first POF was produced by DuPont at the end of the 60s, so POF appeared at the same time as glass fibers.GOF dominated the market since they presented lower attenuation and POF was set aside. POFs have the intrinsic advantages of any optical fiber and in addition are easy to handle, reliable and flexible. Due to their large core diameters, POFs allow the use of low precision connectors which reduces the total cost associated with a complete system. There are various optical fibers available; they can be divided on the basis of different stuff such as the refractive index distribution, number of cores, number of propagating modes, and material composition[7]. The most often used material in the production of POF is the thermoplastic polymer PMMA, commonly known as Plexiglas. Sensor can be classified into two broad categories i.e. extrinsic and intrinsic sensors, to explain these examples are shown in figure 3. In the intrinsic scheme, the optical signal doesn't leave the optical fiber.

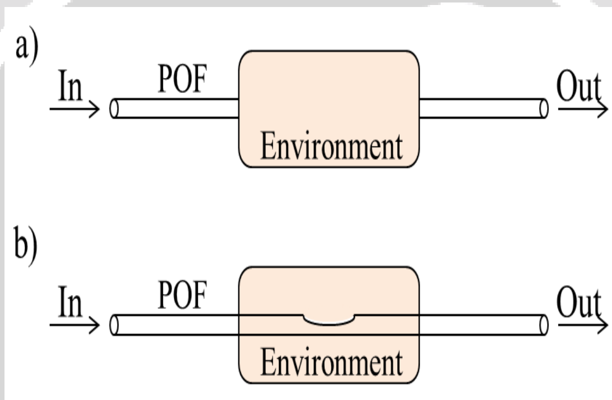

Fig 3. (a) extrinsic and (b) intrinsic intensity-based sensor.

If the transmitter and receiver are in same or opposite ends it is considered a reflection or transmission configuration, respectively [10]. Regarding to the reflection method, reflective surfaces are commonly used to reintroduce the optical signal into the fiber [11]. Other sensors are based on Fresnel reflection mechanisms [10,11]. In this case, special geometries at the end of the fiber have been used.

In the various reflection and transmission systems, Spectroscopic detection has been employed in optical fiber sensors based on absorption, fluorescence and refractive index changes. The Figure 4(a) shows optical power variation in case of direct spectroscopic measures, the sensors may be composed only by an optical fiber and cell samples. The attenuation due to the optical path cross can be related with the absorption properties or the medium scattering. Otherwise, chemical reagents can be immobilized on selective inorganic or organic matrices which are deposited onto the fiber [Figure 4(b), (e) and (f)] or on its end [Figure 4(c,d)]. An alternative of the method includes the use of fluorescent materials [10,11].

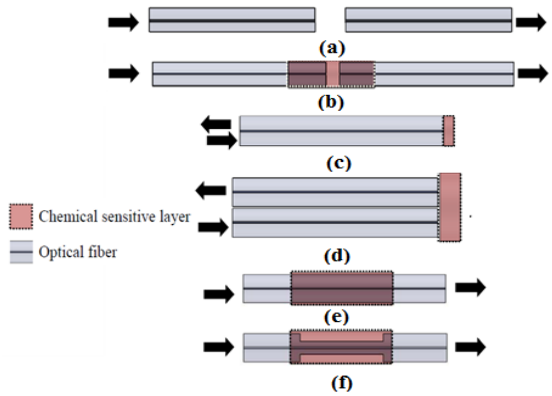

Fig 4.Spectroscopic methods: (a)–(d) extrinsic and (e), (f) intrinsic configurations.

The optical signal propagates predominantly into the optical fiber core, however there is a small amount that penetrates into the fiber cladding and whose energy decays exponentially with the distance from the core. In standard optical fibers, the interaction between the core and the surrounding environment is negligible.

4. CONCLUSIONS

This paper has presented a review study of optical fiber and how technology get advanced by introducing optical fiber in communication media due to its availability of the unlimited bandwidth .This paper also deals with recent research and developments of POF sensor technology, with special focus on intensity variation schemes and low cost solutions. From this review it can be conclude that POF-based sensors will continue to be a very active research topic in the near future.

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