**I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. I would like to extend my sincere thanks to all of them.**

**I am highly indebted to Mrs. PRAMILA SHUKLA for their guidance and constant supervision as well as for providing necessary information regarding the project & also for their support in completing the project.**

**I would like to express my gratitude towards my parents & member of ASET for their kind co-operation and encouragement which help me in completion of this project.**

**I would like to express my special gratitude and thanks to industry persons for giving me such attention and time.**

**My thanks and appreciations also go to my friends in developing the project and people who have willingly helped me out with their abilities.**

**CERTIFICATE**

**This is to certify that Ms YUKTI GULATI, student of B.TECH. in CSE has carried out the work presented in the project of the Term paper entitle "Optical Fiber" as a part of First year program of Bachelor of Technology in CSE from Amity School of Engineering and Technology, Amity University, NOIDA, Uttar Pradesh under my supervision.**

**Name & signature of the faculty Guide**

**Department of Applied Sciences**

**ASET, NOIDA**

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**ABSTRACT**

**THIS report is about Optical Fiber and its Application in telecommunication and computer networking.** **Fibre optic communication has revolutionised the telecommunications industry. It has also made its presence widely felt within the data networking community as well. Using fibre optic cable, optical communications have enabled telecommunications links to be made over much greater distances and with much lower levels of loss in the transmission medium and possibly most important of all, fibre optical communications has enabled much higher data rates to be accommodated.**

**It works on the principle of total internal reflection which states that when light travel in an optically dense medium hits a boundary at an angle larger than the "critical angle" for the media, the light will be completely reflected.**

**There are different types of material from which optical fibre can be made. Glass optical fibers are almost always made from silica, but some other materials, such as  fluorides, and chalcogenides glasses as well as crystalline materials like sapphire, are used for longer-wavelength infrared or other specialized applications. Silica and fluoride glasses usually have refractive indices of about 1.5, but some materials such as the chalcogenides can have indices as high as 3. Typically the index difference between core and cladding is less than one percent.**

**Optical fiber has many advantages**

* **Much higher bandwidth- Thousands of channels can be multiplexed together over one strand of fiber**
* **Immunity to noise - Immune to Electromagnetic interference (EMI).**
* **Saftey-Doesn’t transmit electrical signals, making it safe in environments like a gas pipeline.**
* **Security - Impossible to “tap into.”**
* **Attenuation –It is a term that refers to the reduction in the strength of a signal. (fibers can be made to have only 0.2 dB/km of attenuation)**
* **Reliability - More resilient than copper in extreme environmental conditions.**
* **Size- Lighter and more compact than copper. Unlike impure, brittle glass, fiber is physically very flexible.**

**International and national status**

### *National Optical Fiber Agency*

**Department of Telecommunications has received the recommendations made by Telecom Regulatory Authority of India (TRAI) dated December 8, 2010 on ‘National Broadband Plan’ which inter-alia included setting up of National Optical Fiber Agency (NOFA). Government is actively working on formulation of a ‘National Broadband Plan’. However, no final decision has been taken in the matter so far.**

**As on January 31, 2011 number of Broadband subscribers in the country are 11.21 million. As per National**[**Broadband Policy**](http://currentaffairsappsc.blogspot.in/2011/03/national-optical-fibre-agency.html)**2004 target fixed for broadband subscribers are:**

|  |  |
| --- | --- |
| **Year Ending** | **Broadband Subscribers** |
| **2005** | **3 million** |
| **2007** | **9 million** |
| **2010** | **20 million** |

**Under the ‘Rural Wire line Broadband’ scheme of USOF, a total of 2,61,413 broadband connections and 2506 kiosks have been provided till 31.1.2011 in the rural and remote areas of the country against a target of 8,88,832 connections and 28,762 kiosks to be provided by 2014.**

**TRAI has recommended in its “National Broadband Plan” that a National Broadband network will be established, which will be an open access optical fiber network connecting all habitations with population of 500 and above. Government is working on a formulation of a National Broadband Plan. However, no final decision has been taken in this matter so far.**

**International**

### Sandia new fiber optic network is world’s largest

**Fiber optic network saves energy, money**

**ALBUQUERQUE, N.M. — Sandia National Laboratories has become a pioneer in large-scale passive optical networks, building the largest fiber optical local area network in the world**

### [World’s largest fiber optic network](http://www.flickr.com/photos/sandialabs/8559436329/)

### ****STEVE GOSSAGE, a senior engineer at Sandia National Laboratories, looks at fiber optics in a cable box that replaced heavier and bulkier copper cable for high-speed communications throughout much of the labs. Fiber offers more capacity and is more reliable than copper.****

**Adopting fiber optics**

**Sandia began looking at fiber optics early in the technology’s development because of its promise of higher bandwidth — greater communication speed — at longer distances. The labs started converting from copper in the 1980s, first installing then-emerging fiber optics in a single building and bumping that facility to megabit speeds. “Today we’re way past that. We’re at 10 gigabit-type rates and looking hard at 100,” GOSSAGE said.**

**After years of planning, Sandia completed a formal network plan in late 2008 and sought competitive bids the following year. Sandia selected Tellabs of Naperville, Ill., as the equipment vendor for the network, and Gossage and his colleagues simultaneously began to jumpstart the deployment of the fiber infrastructure and set up a test lab to validate the performance of configurations for the equipment and various network functions. The technology began moving to desktops in 2011, and by the end of 2012, Sandia had converted more than 90 percent of bulky copper cable to a fiber optics LAN.**

**Sandia, which will spend about $15 million on the project, needs superb computing capability for the problems it tackles as part of its support for the mission for the National Nuclear Security Administration.**

**“Whether it’s a materials science problem or modeling an event, we need a lot of data and a lot of processing capability,” Gossage said. “We need to be able to see it, we need to be able to view it, we need to be able to put teams together. This is a large laboratory, deeply stocked with scientists and engineers and test labs. For the analyses we get, the problems are not small and they’re not easy.”**

**Since its first experience with fiber optics, Sandia envisioned being able to use multiple wavelengths in a very high bandwidth single strand reaching the farthest tech areas. But decades ago, when Sandia began putting in single-mode fiber to desks and adding underground fiber capabilities, the technology wasn’t quite mature enough to take advantage of fiber optics’ inherent multiple wavelengths and speeds.**

**So Sandia continued to install the fiber optics cable foundation and waited as the technology developed, and moved quickly when commercial optical networks began deploying voice, data and video to large collections of homes and offices.**

**“There weren’t that many unknowns for us because we had been thinking about ways to do this on a large scale for quite a while,” Gossage said. “We had already thought through what this might mean to us, what it might mean to our lifecycle costs and where the investments would be, and we were already pretty comfortable with fiber and the technologies that go with it.”**

### 

**HISTORY**

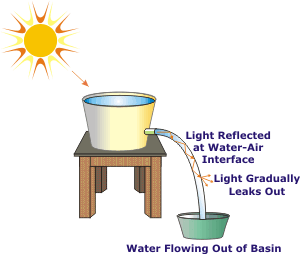
**The Nineteenth Century**

**The earliest attempts to communicate via light undoubtedly go back thousands of years. Early long distance communication techniques, such as "smoke signals", developed by native North Americans and the Chinese were, in fact, optical communication links. A larger scale version of this optical communication technique was the "optical telegraph" deployed in France and elsewhere in the late 18th century. The "optical telegraph" was a series of tall towers that passed along messages at a rate of a few words per minute by means of large semaphore flags that could be manipulated to spell out words. However, the development of fiber optic communication awaited the discovery of TIR (Total Internal Reflection) and a host of additional electronic and optical innovation.**

**Jean-Daniel Colladon, a 38-year-old Swiss professor at University of Geneva, demonstrated light guiding or TIR for the first time in1841.**

**COLLADON later on wrote:*"I managed to illuminate the interior of a stream in a dark space. I have discovered that this strange arrangement offers in results one of the most beautiful, and most curious experiments that one can perform in a course on Optics."***

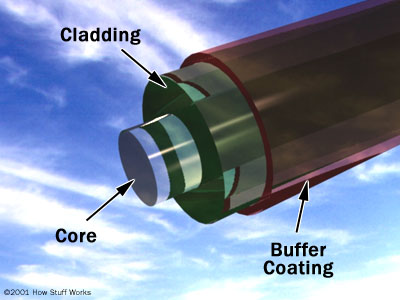
**In 1870, John Tyndall, using a jet of water that flowed from one container to another and a beam of light, demonstrated that light used internal reflection to follow a specific path.**

**John Tyndall William Wheeling, in 1880, patented a method of light transfer called “piping light.” Wheeling believed that by using mirrored pipes branching off from a single source of illumination.**

**That same year, Alexander Graham Bell developed an optical voice transmission system he called the Photo phone. The photo phone used free-space light to carry the human voice 200 meters**.

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| **The Twentieth Century**    **Fiber optic technology experienced a phenomenal rate of progress in the second half of the twentieth century. Early success came during the 1950’s with the development of the fiberscope. This image-transmitting device, which used the first practical all-glass fiber, was concurrently devised by Brian O’Brien at the American Optical Company and Narinder Kapany (who first coined the term “fiber optics” in 1956) and colleagues at the Imperial College of Science and Technology in London. Early all-glass fibers experienced excessive optical loss, the loss of the light signal as it traveled through the fiber, limiting transmission distances.** |  | |

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**This motivated scientists to develop glass fibers that included a separate glass coating. The innermost region of the fiber, or core, was used to transmit the light, while the glass coating, or cladding, prevented the light from leaking out of the core by reflecting the light within the boundaries of the core. This concept is explained by Snell’s Law which states that the angle at which light is reflected is dependent on the refractive indices of the two materials - in this case, the core and the cladding. The lower refractive index of the cladding (with respect to the core) causes the light to be angled back into the core.**

**The fiberscope quickly found application inspecting welds inside reactor vessels and combustion chambers of jet aircraft engines as well as in the medical field. Fiberscope technology has evolved over the years to make laparoscopic surgery one of the great medical advances of the twentieth century.**

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| **The early work on fiber optic light source and detector was slow and often had to borrow technology developed for other reasons. For example, the first fiber optic light sources were derived from visible indicator LED's. As demand grew, light sources were developed for fiber optics that offered higher switching speed, more appropriate wavelengths, and higher output power. For more information on light emitters see Laser Diodes and LED's.** | |
| **Fiber optics developed over the years in a series of generations that can be closely tied to wavelength. Figure  shows three curves. The top, dashed, curve corresponds to early 1980’s fiber, the middle, dotted, curve corresponds to late 1980’s fiber, and the bottom, solid, curve corresponds to modern optical fiber. The earliest fiber optic systems were developed at an operating wavelength of about 850 nm. This wavelength corresponds to the so-called “first window” in a silica-based optical fiber. This window refers to a wavelength region that offers low optical loss. It sits between several large absorption peaks caused primarily by moisture in the fiber and**[**Rayleigh scattering**](javascript:n_window('glossary-r.htm#Rayleigh_Scattering'))**.**  Records | **[Four Wavelength Regions of Optical Fiber](http://www.olson-technology.com/mr_fiber/images/fiber-history-04-big.gif)** |

**The first all optic fiber cable,TPC-5, that uses optical amplifers was laid acess the Pacific Ocean in 1996.The following year the fiber optic around the Globe (FLAG) become the longest single cable network in the world and provided the infrastructure for the next generation of Internet applications.**

**Today, a variety of industries including the medical, military, telecommunication, industrial, data storage, networking, and broadcast industries are able to apply and use fiber optic technology in a variety of applications.**

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**Introduction**

**An optical fiber is a flexible, transparent fiber made of glass or plastic, slightly thicker than a human hair. It can function as a waveguide, or “light pipe”, to transmit light between the two ends of the fiber. The field of**[**applied science**](http://en.wikipedia.org/wiki/Applied_science)**and** [**engineering**](http://en.wikipedia.org/wiki/Engineering)**concerned with the design and application of optical fibers is known as fiber optics.**

**Fibre optic communication has revolutionised the telecommunications industry. It has also made its presence widely felt within the data networking community as well. Using fibre optic cable, optical communications have enabled telecommunications links to be made over much greater distances and with much lower levels of loss in the transmission medium and possibly most important of all, fibre optical communications has enabled much higher data**

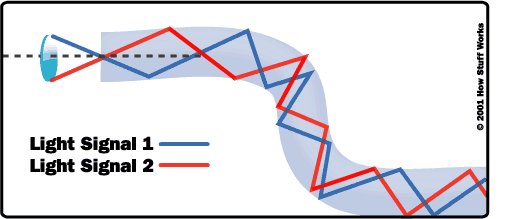
**Ethernet rates to be accommodated.**

**As a result of these advantages, fibre optic communications systems are widely employed for applications ranging from major telecommunications backbone infrastructure to systems, broadband distribution, and general data networking.**

**Principle and propagation**

**Principle: Total internal reflection**

**When light travelling in an optically dense medium hits a boundary at an angle larger than the "critical angle" for the media, the light will be completely reflected. This is called total internal reflection. Fibre optic cables use total internal reflection inside the optical fibre. The light enters the optical fibre, and every time it strikes the edge of the fibre it experiences total internal reflection. This way the light travels down the length of the optical fibre.**

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**MODE OF PROPAGATION**

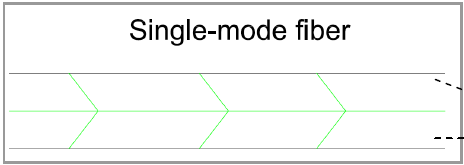
**There are two main categories of optical fiber used in fiber optic communications are**

* **Single mode optical fiber**
* **Multi mode optical fiber**

**Single mode optical fiber**

**This mode of optical fiber are used to transmit one signal per fiber (used in telephone and cable TV). They have small cores(9 microns in diameter) and transmit infra-red light from laser.**

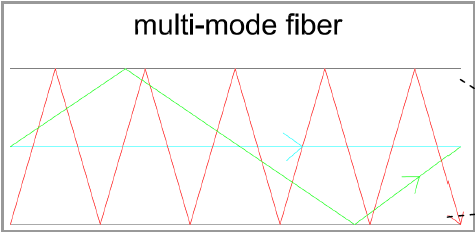
**Single-mode fiber’s smaller core (<10 micrometers) necessitates more expensive components and interconnection methods, but allows much longer, higher-performance links.**

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**MULTI MODE OPTICAL FIBRE**

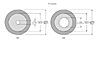
**This type of optical fiber are used to transmit many signals per fiber (used in computer networks). They have larger cores (62.5 microns in diameter) and transmit infra-red light from LED.**

**However, multi-mode fiber introduces multi-mode distortion which often limits the bandwidths and length of the link. Furthermore, because of its higher content, multimode fiber is some what more expensive.**

****

**Construction**

**The core is the highly refractive central region of an optical fiber through which light is transmitted. The standard telecommunications core diameter in use with SMF is between 8 *http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m and 10 *http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m, whereas the standard core diameter in use with MMF is between 50 *http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m and 62.5 *http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m. Figure 3-4 shows the core diameter for SMF and MMF cable. The diameter of the cladding surrounding each of these cores is 125 *http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m. Core sizes of 85 *http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m and 100 *http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m were used in early applications, but are not typically used today. The core and cladding are manufactured together as a single solid component of glass with slightly different compositions and refractive indices. The third section of an optical fiber is the outer protective coating known as the *coating*. The coating is typically an ultraviolet (UV) light-cured acrylate applied during the manufacturing process to provide physical and environmental protection for the fiber. The buffer coating could also be constructed out of one or more layers of polymer, nonporous hard elastomers or high-performance PVC materials. The coating does not have any optical properties that might affect the propagation of light within the fiber-optic cable. During the installation process, this coating is stripped away from the cladding to allow proper termination to an optical transmission system. The coating size can vary, but the standard sizes are 250 *http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m and 900 *http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m. The 250-*http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m coating takes less space in larger outdoor cables. The 900-*http://www.ciscopress.com/content/images/ch03_1587051052/elementLinks/mu.gif*m coating is larger and more suitable for smaller indoor cables.**

**Fiber-optic cable sizes are usually expressed by first giving the core size followed by the cladding size. Consequently, 50/125 indicates a core diameter of 50 microns and a cladding diameter of 125 microns, and 8/125 indicates a core diameter of 8 microns and a cladding diameter of 125 microns. The larger the core, the more light can be coupled into it from the external acceptance angle cone. However, larger-diameter cores can actually allow in too much light, which can cause receiver saturation problems. The 8/125 cable is often used when a fiber-optic data link operates with single-mode propagation, whereas the 62.5/125 cable is often used in a fiber-optic data link that operates with multimode propagation.**

**Materials**

**Three types of material make up fiber-optic cables:**

* **Glass**
* **Plastic**
* **Plastic-clad silica (PCS)**

**These three cable types differ with respect to attenuation. Attenuation is principally caused by two physical effects: absorption and scattering. Absorption removes signal energy in the interaction between the propagating light (photons) and molecules in the core. Scattering redirects light out of the core to the cladding. When attenuation for a fiber-optic cable is dealt with quantitatively, it is referenced for operation at a particular optical wavelength, a window,** **where it is minimized. The most common peak wavelengths are 780 nm, 850 nm, 1310 nm, 1550 nm, and 1625 nm. The 850-nm region is referred to as the *first window* (as it was used initially because it supported the original LED and detector technology). The 1310-nm region is referred to as the *second window*, and the 1550-nm region is referred to as the *third window*.**

**Glass Fiber-Optic Cable**

**Glass fiber-optic cable has the lowest attenuation. A pure-glass, fiber-optic cable has a glass core and a glass cladding. This cable type has, by far, the most widespread use. It has been the most popular with link installers, and it is the type of cable with which installers have the most experience. The glass used in a fiber-optic cable is ultra-pure, ultra-transparent, silicon dioxide, or fused quartz. During the glass fiber-optic cable fabrication process, impurities are purposely added to the pure glass to obtain the desired indices of refraction needed to guide light. Germanium, titanium, or phosphorous is added to increase the index of refraction. Boron or fluorine is added to decrease the index of refraction. Other impurities might somehow remain in the glass cable after fabrication. These residual impurities can increase the attenuation by either scattering or absorbing light.**

**Plastic Fiber-Optic Cable**

**Plastic fiber-optic cable has the highest attenuation among the three types of cable. Plastic fiber-optic cable has a plastic core and cladding. This fiber-optic cable is quite thick. Typical dimensions are 480/500, 735/750, and 980/1000. The core generally consists of polymethylmethacrylate (PMMA) coated with a fluropolymer. Plastic fiber-optic cable was pioneered principally for use in the automotive industry. The higher attenuation relative to glass might not be a serious obstacle with the short cable runs often required in premise data networks. The cost advantage of plastic fiber-optic cable is of interest to network architects when they are faced with budget decisions. Plastic fiber-optic cable does have a problem with flammability. Because of this, it might not be appropriate for certain environments and care has to be taken when it is run through a plenum. Otherwise, plastic fiber is considered extremely rugged with a tight bend radius and the capability to withstand abuse.**

**Plastic-Clad Silica (PCS) Fiber-Optic Cable**

**The attenuation of PCS fiber-optic cable falls between that of glass and plastic. PCS fiber-optic cable has a glass core, which is often vitreous silica, and the cladding is plastic, usually a silicone elastomers with a lower refractive index. PCS fabricated with a silicone elastomers cladding suffers from three major defects. First, it has considerable plasticity, which makes connector application difficult. Second, adhesive bonding is not possible. And third, it is practically insoluble in organic solvents. These three factors keep this type of fiber-optic cable from being particularly popular with link installers. However, some improvements have been made in recent years.**

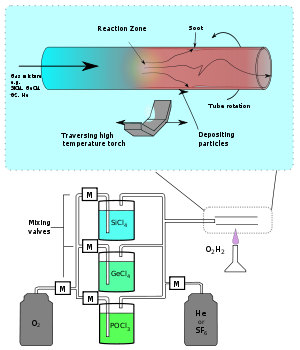
**Process and Coating**

**Process:**

**Standard optical fibers are made by first constructing a large-diameter "perform, with a carefully controlled refractive index profile, and then "pulling" the perform to form the long, thin optical fiber. The perform is commonly made by three chemical vapour deposition methods: *inside vapor deposition*, *outside vapor deposition*, and *vapor axial deposition*.**

**With *inside vapor deposition*, the perform starts as a hollow glass tube approximately 40 centimeters (16 in) long, which is placed horizontally and rotated slowly on a lathe Gases such as silicon tetrachloride (Standard optical fibers are made by first constructing a large-diameter "perform", with a carefully controlled refractive index profile, and then "pulling" the perform to form the long, thin optical fiber. The perform is commonly made by three chemical vapor deposition methods: *inside vapor deposition*, *outside vapor deposition*, and *vapor axial deposition*.**

**With *inside vapor deposition*, the perform starts as a hollow glass tube approximately 40 centimeters (16 in) long, which is placed horizontally and rotated slowly on a lathe Gases such as silicon tetrachloride (SiCl4) The perform, however constructed, is then placed in a device known as a drawing tower, where the perform tip is heated and the optical fiber is pulled out as a string. By measuring the resultant fiber width, the tension on the fiber can be controlled to maintain the fiber thickness**.

[](http://en.wikipedia.org/wiki/File:OF-MCVD.svg)

**Coating:**

**The light is "guided" down the core of the fiber by an optical "cladding" with a lower refractive index that traps light in the core through "total internal reflection."**

**The cladding is coated by a "buffer" that protects it from moisture and physical damage. The buffer is what gets stripped off the fiber for termination or splicing. These coatings are UV-cured urethane acrylate composite materials applied to the outside of the fiber during the drawing process. The coatings protect the very delicate strands of glass fiber—about the size of a human hair—and allow it to survive the rigors of manufacturing, proof testing, cabling and installation.**

**Today’s glass optical fiber draw processes employ a dual-layer coating approach. An inner primary coating is designed to act as a shock absorber to minimize attenuation caused by micro bending. An outer** **secondary coating protects the primary coating against mechanical damage and acts as a barrier to lateral forces. Sometimes a metallic armor layer is added to provide extra protection.**

**These fiber optic coating layers are applied during the fiber draw, at speeds approaching 100 kilometers per hour (60 mph). Fiber optic coatings are applied using one of two methods: *wet-on-dry* and *wet-on-wet*. In wet-on-dry, the fiber passes through a primary coating application, which is then UV cured—then through the secondary coating application, which is subsequently cured. In wet-on-wet, the** fiber **passes through both the primary and secondary coating applications, then goes to UV curing.**

**Fiber optic coatings are applied in concentric layers to prevent damage to the fiber during the drawing application and to maximize fiber strength and micro bends resistance. Unevenly coated fiber will experience non-uniform forces when the coating expands or contracts, and is susceptible to greater signal attenuation. Under proper drawing and coating processes, the**

**coatings are concentric around the fiber, continuous over the length of the application and have constant thickness.**

**Fiber optic coatings protect the glass fibers from scratches that could lead to strength degradation. The combination of moisture and scratches accelerates the aging and deterioration of fiber strength. When fiber is subjected to low stresses over a long period, fiber fatigue can occur. Over time or in extreme conditions, these factors combine to cause microscopic flaws in the glass fiber to propagate, which can** **ultimately result in fiber failure**.

**Three key characteristics of fiber optic waveguides can be affected by environmental conditions: strength, attenuation and resistance to losses caused by micro bending. External fiber optic coatings protect glass optical fiber from environmental conditions that can affect the fiber’s performance and long-term durability. On the inside, coatings ensure the reliability of the signal being carried and help minimize attenuation due to micro bending.**

Telecommunication and computer networking

**Optical fiber can be used as a medium for telecommunication and computer networking because it is flexible and can be bundled as cables. It is especially advantageous for long-distance communications, because light propagates through the fiber with little attenuation compared to electrical cables. This allows long distances to be spanned with few repeaters. Additionally, the per-channel light signals propagating in the fiber have been modulated at rates as high as 111 gigabits per second by NTT, although 10 or 40 Gigabit/s is typical in deployed systems. Each fiber can carry many independent channels, each using a different wavelength of light (wavelength-division multiplexing (WDM)). The net data rate (data rate without overhead bytes) per fiber is the per-channel data rate reduced by the FEC overhead, multiplied by the number of channels (usually up to eighty in commercial dense WDM systems as of 2008). As of 2011 the record for bandwidth on a single core was 101 T bit/sec (370 channels at 273 Gigabit/sec each).The record for a multi-core fiber as of January 2013 was 1.05 p bits per second.  In 2009, Bell Labs broke the 100 (P bit per second)×kilo meter barrier (15.5 T bit/s over a single 7000 km fiber).**

**For short distance application, such as a network in an office building, fiber-optic cabling can save space in cable ducts. This is because a single fiber can carry much more data than electrical cables such as standard category 5 Ethernet cabling, which typically runs at 100 M bit/s or 1 G bit/s speeds. Fiber is also immune to electrical interference; there is no cross-talk between signals in different cables, and no pickup of environmental noise. Non-armored fiber cables do not conduct** **electricity, which makes fiber a good solution for protecting communications equipment in high voltage environments, such as power generation facilities, or metal communication structures prone to lightning strikes. They can also be used in environments where explosive fumes are present, without danger of ignition. Wiretapping (in this case, fiber tapping) is** **more difficult compared to electrical connections, and there are concentric dual core fibers that are said to be tap-proof.**

Fiber optic sensors

**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 reflector meter*.**

**Optical fibers can be used as sensors to measure strain, temperature, pressure and other quantities by modifying a fiber so that the property to measure modulates the intensity, phase, polarization, wavelength, or transit time of light in the fiber. Sensors that vary the intensity of light are the simplest, since only a simple source and detector are required. A particularly useful feature of such fiber optic sensors is that they can, if required, provide distributed sensing over distances of up to one meter.**

**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. A major benefit of extrinsic sensors is their ability to reach otherwise inaccessible places. An example is the measurement of temperature inside aircraft jet engines by using a fiber to transmit radiation into a radiation pyrometer outside the engine. Extrinsic sensors can be used in the same way to measure the internal temperature of electrical transformers, where the extreme electromagnetic fields present make other measurement techniques impossible. Extrinsic sensors measure vibration, rotation, displacement, velocity, acceleration, torque, and twisting. A solid state version of the gyroscope, using the interference of light, has been developed. The *fiber optic gyroscope (FOG)* has no moving parts, and exploits the *Sagnac effect* to detect mechanical rotation.**

**Common uses for fiber optic sensors includes advanced intrusion detection security systems. The light is transmitted along a fiber optic sensor cable placed on a fence, pipeline, or** **communication cabling, and the returned signal is monitored and analyisd for disturbances. This return signal is digitally processed to detect disturbances and trip an alarm if an intrusion has occurred.**

Other uses of optical fibers

**Optical fiber is also used in imaging optics. A coherent bundle of fibers is used, sometimes along with lenses, for a long, thin imaging device called an endoscope, which is used to view objects through a small hole. Medical endoscopes are used for minimally invasive exploratory or surgical procedures. Industrial endoscopes (see fiberscope) are used for inspecting anything hard to reach, such as jet engine interiors. Many microscopes use fiber-optic light sources to provide intense illumination of samples being studied.**

**In spectroscopy, optical fiber bundles transmit light from a spectrometer to a substance that cannot be placed inside the spectrometer itself, in order to analyze its composition. A spectrometer analyzes substances by bouncing light off of and through them. By using fibers, a spectrometer can be used to study objects remotely.**

**An optical fiber doped with certain rare earth elements such as erbium can be used as the gain medium of a laser or optical amplifier . Rare-earth doped optical fibers can be used to provide signal amplification by splicing a short section of doped fiber into a regular (un doped) optical fiber line. The doped fiber is optically pumped with a second laser wavelength that is coupled into the line in addition to the signal wave. Both wavelengths of light are transmitted through the doped fiber, which transfers energy from the second pump wavelength to the signal wave. The process that causes the amplification is stimulated emission.**

**Optical fibers doped with a wavelength shifter collect scintillation light in physics experiments**

**Optical fiber can be used to supply a low level of power (around one watt) to electronics situated in a difficult electrical environment. Examples of this are electronics in high-powered antenna elements and measurement devices used in high voltage transmission equipment.**

**The iron sights for handguns, rifles, and shotguns may use short pieces of optical fiber for contrast enhancement.**

* **Much higher bandwidth(Gbps) - Thousands of channels can be multiplexed together over one strand of fiber**
* **Immunity to noise - Immune to electromagnetic interference (EMI).**
* **Saftey-Doesn’t transmit electrical signals, making it safe in environments like a gas pipeline.**
* **Security - Impossible to “tap into.”**
* **Attenuation –It is a term that refers to the reduction in the strength of a signal. (fibers can be made to have only 0.2 dB/km of attenuation)**
* **Reliability - More resilient than copper in extreme environmental conditions.**
* **Size- Lighter and more compact than copper. Unlike impure, brittle glass, fiber is physically very flexible.**

**Disadvantages include the cost of interfacing equipment necessary to convert electrical signals to optical signals. (optical transmitters, receivers) splicing fiber optic cable is also more difficult.**

* **Expensive over short distance**
* **Requires highly skilled installers**
* **Adding additional nodes is difficult**

**A huge amount of development can be made by making further research and work on fiber optics .We need it for a faster and more sophisticated infrastructure which would be the prime demand of the ever growing population of tomorrow.**

**At present there are many optical fibre communication links throughout the world without using optical soliton. When we introduce optical solitons as light pulses through the fibres, we can achieve high quality telecommunication at a lower cost. We can expect a great revolution in optical fibre communication within a few years by means of solitons.**

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