PHYSICAL SCIENCE

STUDY OF FIBER MATERIAL AND ITS TYPE

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Abstract:- Modern technology applies fiber optics in many industries. In a many kinds of applications, military, medical, telecommunication, data storage, networking, Industrial and broad cast industries have all found ways to utilize this versatile fiber. Without a backbone of an optical fiber network, it would be almost impossible to have all the current facilities of communication and information transformation. The true age of optics is here with us and is expected in making 21^{st} century the century of **photonics and fibered world**.

Keyword: -Optical fiber, Fiber optics, Data storage, Photonics, Information transformation

Introduction :- The basic material for glass fibers is silicon dioxide that are quite abundant on earth. Optical fibres are also made of transparent plastic. This is also readily available material. Compared their cost with the wire cables in regard to per unit of information transfer then they are cheaper than their wire equivalents. Apart from these fiber cables are strong and flexible. They have smaller and lighter weight compared to their wire equivalents. They do not break even if wrapped in curves of very small radius. This helps in their transportation and installation. Techniques have been evolved for the manufacture of fibers with very low transmission losses. Optical fibers have ability to carry large amount of information in either digital or analog form. In a recently developed fiber optic system it has been possible to send 140 Mbits/sec. information through a 220 km link of one optical fiber which is equivalent to about 450,000 voice channel-km. Bandwith of optic fiber is higher than that of an equivalent wire transmission line. Optical fibers, glass or plastic are insulators, so a fiber is well protected from interference. It also protects from coupling with other communication channels.

An optical fiber is a flexible, clear fiber made of extruded glass or plastic. These are somewhat thicker than a human hair. This thicker human hair acts as wave guide, sometimes named as a “light pipe” to transmit light between the two ends of the fibers. The field of applied science and engineering related with the design shape and application of optical fibers is named as fiber optics. Two main constituents of an optical fiber are its core and cladding. The core or the axial parts of the optical fibers are made of silica glass, which acts as the light transmission area of the fiber. It may sometimes be treated with a doping element to change its refractive index . Thus the velocity of the optical wave can be changed in side the optical fiber.

In the data transmission, copper wires have been used since the invention of telephone in 1876. As the demand increased the use of copper wires consistently got reduced. This is due to the reasons such as low bandwidth, short transmission length and its inefficiency.

Optical fiber communications are extensively used in fiber optics that allows transmission over longer distances and at higher bandwidth than other forms of communication.

Development :- In choosing matters for optical fibers, a number of demands must be contended. For example: It must be possible to make long, thin, flexible fibers from the material. The material must be transparent at a particular optical wavelength in order for the fiber to guide optical wave efficiently. Actually united materials that have moderately different refractive indices for the core and cladding must be obtainable.

Matters that fulfil these demands are glasses and plastics. The majority of fibers are made of glass consisting of either silica (SiO_2) or a silicate. The diversity of obtainable glass fibers fluctuate from moderate-loss fibers with large cores used for low communication distances to very clear (low-loss) fibers engaged in long-haul uses. Plastic fibers are less extensively used because of their largely higher fading than glass fibers. The main use of plastic fibers is in low range applications (several hundred meters) and in bad surroundings, where the higher mechanical power of plastic fibers provide and merits over the use of glass fibers.

Fiber Type

Glass Fibers

Glass is made by fusing mixtures of metal oxides, sulfides, or selenides. The derived material is a irregularly fixed molecular system rather than a well-defined determined arrangement as found in crystalline materials. A result of this irregular order is that glasses do not have well-defined melting points. When glass is heated up from room temperature, it remains a hard solid up to several hundred degrees centigrade. As the temperature increases further, the glass gradually begins to soften until at very high temperatures it becomes a viscous liquid.

Here, the notation GeO_2-SiO_2, for example, denotes a GeO_2-doped silica glass.

Active Glass Fibers

Including rare-earth elements (atomic numbers 57-71) into a generally passive glass gives the resulting matter new optical and magnetic merits. These new merits allow the material to perform amplification, attenuation, and phase retardation on the optical wave passing through it. Doping can be followed up for silica, tellurite, and halide glasses.

Plastic Optical Fiber

The increasing demand for producing high-speed services directly to the workstation has led fiber constructors to create high-bandwith graded-index polymer (plastic) optical fibers (POF) for use in a consumer places. The core of these fibers is either polymethylmethacrylate or a perfluorinated polymer. These fibers are hence referred to as PMMA POF and PF POF, respectively. Although they exhibit considerably greater optical signal attenuations than glass fibers, they are tough and durable. Compared with silica fibers, the core diameters of plastic fibers are 10-20 times larger, which allows a relaxation of connector tolerances without sacrificing optical coupling efficiencies. Thus, inexpensive plastic injection-molding technologies can be used to fabricate connectors, splices and transceivers - the main constituents of optical fiber communications link. Table-A gives sample characteristics of PMMA and PF polymer optical fibers.

Table-A :

Sample characteristics of PMMA and PF polymer optical fibers.

Characteristic	PMMA POF	PF POF
Core diameter	0.4 mm	0.125 – 0.30 mm
Cladding diameter	1.0 mm	0.25 – 0.60 mm
Numerical aperture	0.25	0.20
Attenuation	150dB/km at 650nm	<40 dB/km at 650-1300nm
Bandwidth	2.5Gb/s over 200m	2.5Gb/s over 550 m

Photonic Crystal Fiber

In the early 1990s researchers envisioned and demonstrated a new optical fiber structure known as a photonic crystal fiber (PCF) or a microstructured fiber. The difference between this new structure and that of a conventional fiber is that the cladding and, in some cases, the core regions of a PCF contain air holes, which run along the entire length of the fiber. Whereas the material properties of the core and cladding define the light-transmission characteristics of conventional fibers, the structural arrangement in a PCF creates an internal microstructure, which offers another dimension of light control in the fiber.

The size and spacing (known as the pitch) of the holes in the microstructure and the refractive index of its constituent material determine the light-guiding characteristics of photonic crystal fibers. The two basic PCF categories are index-guiding fibers and photonic bandgap fibers. The light transmission mechanism in an index-guiding fiber is similar to that in a conventional fiber, since it has a high-index core surrounded by a lower-index cladding. However, for a PCF the effective refractive index of the cladding depends on the wavelength and the size and pitch of the holes. In contrast, a photonic bandgap fiber has a hollow core which is surrounded by a micro structured cladding. This class of fibers guides optical wave by means of a photonic bandgap effect.

Index-Guiding PCF

The fiber has a solid core that is surrounded by a cladding region which contains air holes running along the length of the fiber. The holes have a diameter d and a pitch A. Although the core and the cladding are made of the same material (for example, pure silica), the air holes lower the effective index of refraction in the cladding region, since refractive index n =1 for air and 1.45 for silica. Consequently, the microstructure arrangement creates a step-index optical fiber.

The fact that the core can be made of pure silica, gives the PCF a number of operational advantages over conventional fibers, which typically have a germaniumdoped silica core. These include very low losses, the ability to transmit high optical power levels, and a high resistance to darkening effects from nuclear radiation. The fibers can support single-mode operation over wavelengths ranging from 300 nm to more than 2000nm. The mode field area of a PCF can be greater than 300 μm^2 compared to the 80 μm^2 area of conventional single-mode fibers. This permits the PCF to go through high optical power levels without affecting the nonlinear effects shown by standard fibers.

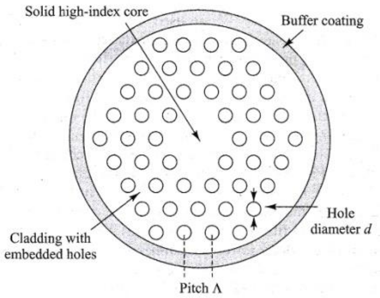

Fig. 1 : Cross-sectional end view of the structure of an index guiding photonic crystal fiber (PCF).

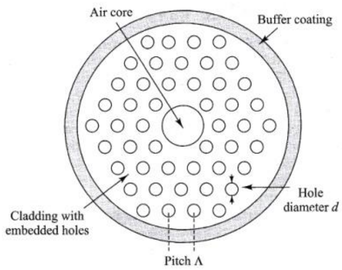

Fig. 2 : Cross-sectional end view of the structure of a photonic bandgap fiber (PBF).

Photonic Bandgap Fiber

In contrast to an index-guiding PCF, here the fiber has a hollow core that is surrounded by a cladding region which contains air holes running along the length of the fiber. Again the holes in the cladding region have a diameter d and a pitch A.

The functional principle of a photonic handgap fiber is analogous to the role of a periodic crystalline lattice in a semiconductor, which blocks electrons from occupying a badgap region. In a PBG fiber the hollow core acts as a defect in the photonic bandgap structure, which creates a region in which the optical wave can propagate.

Specialty fiber

Specialty fibers are designed to interact with light and thereby control some characteristics of an optical signal. This fibers may be of either a multimode or a single mode type.

Table 'B' gives a summary of specialty fibers and their applications:-

Fiber Type	**Application**
Erbium-doped fiber	Gain medium for optical fiber amplifiers
Photo sensitive fibers	Fabrication of fiber Bragg gratings
Bend-insensitive fibers	Tightly looped connections in device packages
Termination Fibers	Termination of open optical fiber ends.
Polarization-preserving Fibers	Pump laser, polarization-sensitive devices, sensors.
High Index Fibers	Fused couplers, sort-λ sources, DWDM devices.

There are three classifications of multimode fibers in terms of bandwidth.

OM1 grade Fiber is the original multimode fiber that was designed to be used with LEDs. The bandwidth of the fibers is 200 MHz-kilometers at 850 nm and 500 MHz – km at 1310 nm. The data rates with LEDs are limited to about 100 Mb/s.

OM2 grade Fiber has an improved bandwidth and can be used to expand networks that contain exiting legacy 50-µm core diameter fiber. If only this fiber is used, then at 850 nm it is possible to send 1-GB/s signals over about 750 m distances and 10 GB/s over 82 m.

OM3 grade Fiber has the highest bandwidth and can support 10-GB/s data rates over distances upto 300 m. further improvements in fiber performance enable the distance for 10 GB/s transmission to be a maximum of 550 m at an 850 nm wavelength.

Result and Discussion :- The huge group of optically clear glasses from which optical fibers are made up are oxide glasses. Of these, the most common is silica (SiO_2). This has a refractive index of 1.458 at 850mm. To construct two alike materials that have moderately different indices of refraction for the core and cladding, either fluorine or various oxides (referred to as dopants), such as B_2O_3, GeO_2, or P_2O_5, are added to the silica. As shown in Fig. 3 the addition of GeO_2 or P_2O_5 increases the refractive index, whereas doping the silica with fluorine or B_2O_3 decreases it. Since the cladding must have a minor index than the core, examples of fiber configurations are

1. GeO_2-SiO_2 core: SiO_2 cladding
2. P_2O_5 – SiO_2 core : SiO_2 cladding
3. SiO_2 core : B_2O_3-SiO_2 cladding
4. GeO_2-B_2O_3-SiO_2 core: B_2O_3-SiO_2 cladding

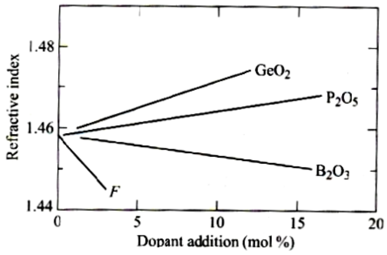

Fig. 3: Variation in refractive index as a function of doping concentration in silica glass.

Conclusion :- The ionic gathering of the rare-earth elements are low (on the order of 0.005 -0.05 mole percent) to avoid gathering effects. By examining the absorption and fluorescence spectra of these materials, we can use an optical source which emits at an absorption wavelength to excite electrons to higher energy levels in the rare-earth dopants. When these excited electrons are stimulated by a photon to drop to lower energy levels, they emit light in a narrow optical spectrum at the fluorescence wavelength. The principal raw material for silica is high-purity sand. Glass collected of pure silica is mentioned to as either silica glass, fused silica, or vitreous silica. Refractive index of the fiber materials vary with dopping concentration.

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