

Fiber Technology and Its Application in the Modern Society

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Abstract

The optical fiber refers to the waveguide and the technology associated with the transmission of information as light pulses along with a glass or plastic fiber. This technology is very useful for long-distance and high-performance data networking. There are three basic elements in an optical fiber cable such as core, cladding, and coating. The overall size of the fiber is determined by the outer diameters of its core, cladding, and coating. However, generally, the size of the fiber is estimated to be slightly thicker than a human hair. Light travels in an optical fiber cable by bouncing repeatedly on the walls of the core. Light gets incident on the medium of lower refractive index, the ray is bent away from the normal, so the exit angle is greater than the incident angle. Such reflection is commonly called "internal reflection". The minimum value of angle of an incident at which the angle of refraction will then approach 90° is called critical angle θ_c , and for incident angles greater than the critical angle there will be the total internal reflection. This article has been reported the definition of fiber optic, types, working principle and important applications in different areas.

Introduction

An optical fiber is a flexible, transparent rod made by plastic or glass having a diameter slightly thicker than a human hair [1]. Optical fibers are used to pass electromagnetic waves, data message single even light between the two ends and have wide applications at higher band widths than electrical cables. Specially designed fibers are also used for a variety of other applications, some of them being fiber optic sensors and fiber lasers [2]. Optical fibers include a core surrounded by a cladding of material having a lower refractive index. Light is kept in the core by the phenomenon of total internal reflection which causes the fiber acting as a waveguide [3]. Fibers that transmit signals through many paths are called multi-mode fibers, while those that support a single mode are called single-mode fibers. In multi-mode fibers core diameter is generally large with compared to single-mode that are used for short-distance communication links and for applications where high power must be transmitted. Being able to join optical fibers with loss, is important in fiber optic communication [4]. This is so complex than joining electrical wire or cable. The field of applied science and engineering concerned with the construction and application of optical fibers is known as fiber optics.

Working Principle

An optical fiber is a cylindrical dielectric waveguide that transmits

light along its axis by total internal reflection. The fiber consists of a core surrounded by a cladding layer, both are made of glass or plastics. To confine the optical signal in the core-cladding interface, the refractive index of the core is greater than that of the cladding. The boundary between the core and cladding may abrupt in step-index fiber and gradual, in graded-index fiber. Most of the optical fiber is weakly guiding, meaning that the difference in refractive index between the core and the cladding is very small [5].

Total internal reflection

When light traveling through a denser medium, hits a boundary at an angle greater than the critical angle, the light is completely reflected. This is called total internal reflection. This effect is used in optical fibers to confine light in the core-cladding interface. Light traveling through the core-cladding interface, many times total internal reflection, bouncing back and forth off the boundary between the core and cladding. The light that enters the fiber within a certain range of angles can travel down the fiber. This range of angles is called the acceptance angle. The size of this acceptance cone is a function of the refractive index difference between the core and cladding. In simpler terms, there is a maximum angle from the fiber axis at which light may enter the core so that it will propagate, or travel, in the core of the fiber.

Types of fiber

Multi-mode fiber

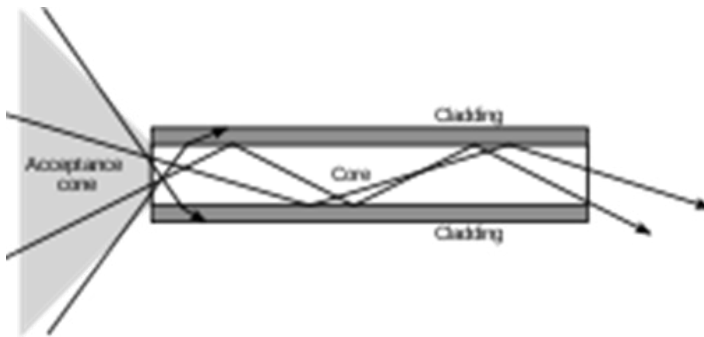


Figure 1: Light propagation through multi-mode fiber [6]

Fiber with a large core diameter of about 10 micrometers may be analyzed by geometrical optics. This fiber is called multi-mode fiber. In a step-index multi-mode fiber, rays of light are guided along with the core-cladding interface by total internal reflection. Light rays that meet the core-

cladding boundary at an angle, greater than the critical angle for this boundary, are completely reflected. The critical angle is determined by the difference of refractive index between the core and cladding. When rays that meet the boundary at a low angle are refracted from the core into the cladding. The critical angle determines the acceptance angle of the fiber that reported as a numerical aperture (NA). Numerical aperture allows light to propagate down the fiber, allowing efficient coupling of light into the fiber. The higher value of numerical aperture increases the amount of dispersion of light at different angles. In graded-index fiber, the refractive index of the core decreases continuously between the axis and the cladding.

Single-mode fiber

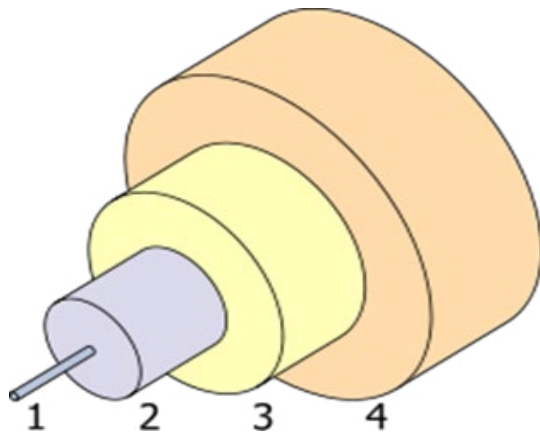


Figure 2: Schematic diagram of the typical single-mode fiber [6]

1. Core: 8 μm
2. Cladding: 125 μm
3. Buffer: 250 μm
4. Jacket: 400 μm

As an optical waveguide, the fiber cable supports one or more con-

finer transverse modes by which light can propagate along with the core-cladding interface in the fiber. Fiber propagation takes only one mode is called single-mode or mono-mode fiber. The larger-core multi-mode fiber can be modeled using the wave equation, which shows that such fiber supports many modes of propagation. The results of such modeling of multi-mode fiber agree with the predictions of geometric optics. Instead of single-mode fibers, a significant fraction of the energy in the bound mode travels in the cladding. The most common type of single-mode fiber has a core diameter of about 10 micrometers and is designed for use in the near-infrared region. The paths depend on the wavelength of the light used so that this fiber actually supports a small number of additional modes at different visible wavelengths [6].

Important applications

Communication

Fiber optic is used as a medium for telecommunication and computer technology because it is flexible and can be bundled as cables. It is especially advantageous for the process of long-distance communications because infrared light propagates through the fiber with much lower attenuation compared to electrical cables. Fiber transmission leads to electrical interference where there is no cross-talk between signals in different cables and no pickup of environmental noise. They can also be used in controlling environmental pollution where explosive fumes are present, without danger of ignition. Wiretapping is so difficult compared to electrical connections, which are concentric dual-core fibers. Fibers are also used for short-distance connections between devices. Information traveling inside the optical fiber is even immune to electromagnetic pulses generated by nuclear devices [7].

Sensors

Fibers have many applications in remote sensing. In many cases, the sensor is itself an optical fiber. Fiber optic is used to connect a non-fiber optic sensor to a measurement mechanism. It can be used because of its small size, or the fact that no electrical power is needed to the remote location, and many sensors can be elongated along the length of fiber by using different wavelengths of light, or by sensing the time delay as light passes along the fiber cable through each sensor. The delay of time can be determined using a device such as an optical time-domain reflect meter [8]. To measure modulated intensity, phase, polarization, wavelength, or transit time of light in the fiber. Sensors that vary the intensity of light are the simplest having a simple source and detector are required. In contrast, highly localized measurements can be provided by integrating sensing elements with the tip of the fiber [8]. These can be used by various micro- and nanofabrication technologies, which do not exceed the microscopic boundary of the fiber tip. A significant benefit of extrinsic sensors is their ability to reach inaccessible places. Optical sensors are used to measure the internal temperature of electrical transformers, where the extreme electromagnetic fields present make other measurement techniques impossible. The light is transmitted through fiber optic sensor used on a fence, pipeline, or communication cabling, and the returned signal is controlled and analyzed for disturbances [10].

Power transmission

Optical fiber used to transmit power using a photovoltaic cell to

convert light energy into electrical energy. While this method of power transmission is not as efficient as conventional methods, it is very useful in situations where it is desirable not to have a metallic conductor as in the case of use nearby MRI machines, having strong magnetic fields. The glass medium enhances optical interactions, and the long interaction possible by the number of processes, which is difficult for applications and fundamental investigation. Conversely, fiber nonlinearity can have deleterious effects on optical signals, and measures are essential to minimize such unwanted effects.

Conclusions

Fiber optics made of plastic or glass has been defined and classified into two types. As an optical waveguide, the fiber cable supports one or more confined transverse modes that is single mode and multi-mode by which light can propagate along with the core-cladding interface in the fiber. Optical fiber is a cylindrical dielectric waveguide that transmits light along its axis by total internal reflection. This study has been reported structure of single mode and multimode fiber, its working principle, light propagation through core-cladding interface and its important application such as communication, have many applications in remote sensing and even in power transmission using photovoltaic cell to convert light energy into electrical energy. Fiber technology has lots of potential applications in modern society and efficient tool to propagate waves, signals, data message etc. through core cladding interface by many times total internal reflection. The ability to transmit data using pulses of light has opened the door for many world-changing innovations in medical applications, remote sensors, long distance transmission, and communications. The world of fiber optics has opened many possibilities for solving technological problems and has improved human civilization

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