Optical Fibers

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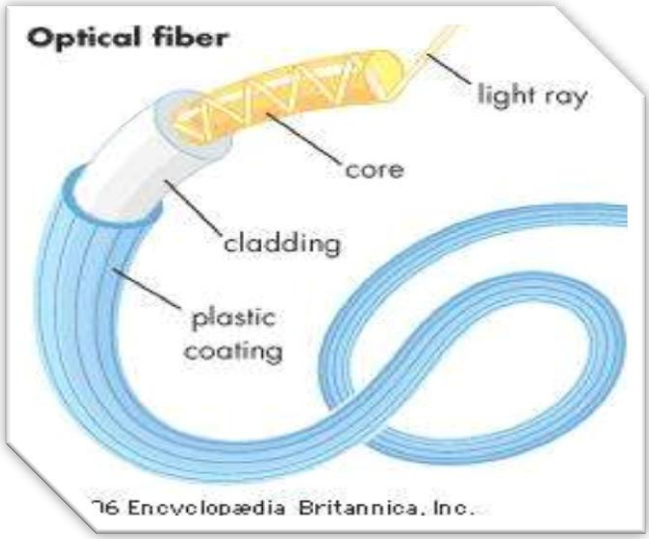


Introduction

An optical fiber is a flexible, transparent strand of very pure glass that acts as a light pipe to transmit light between two ends of the fiber and find wide usage in fiber-optic communications, where it permits transmission over longer distances and at higher bandwidths (data rates) than electrical cables. Optical fibers have a core surrounded by a cladding layer made of dielectric material. The optical signals in the core confined by establishing a refractive index that is greater than the cladding. A fiber optic cable can contain a varying number of glass fibers -- from a few up to a couple hundred.

Because they have three very big advantages over old-style copper cables:

1) **Less attenuation**: (signal loss) Information travels roughly 10 times further before it needs amplifying which makes fiber networks simpler and cheaper to operate and maintain.
2) **No interference**: Unlike with copper cables, there's no "crosstalk" (electromagnetic interference) between optical fibers, so they transmit information more reliably with better signal quality
3) **Higher bandwidth**: As we've already seen, fiber-optic cables can carry far more data than copper cables of the same diameter.

Basic Structure Of An Optical Fiber

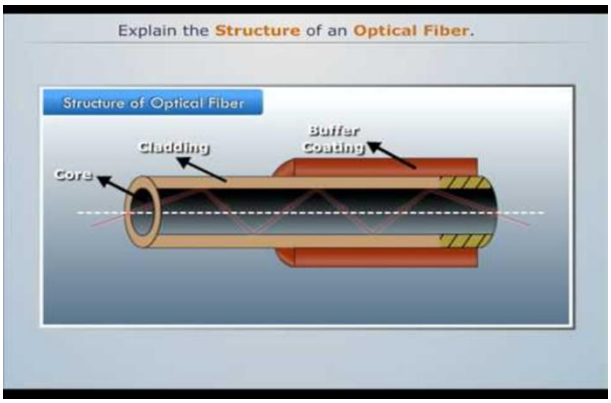
The basic structure of an optical fiber consists of three parts; the **core**, the **cladding**, and the **coating** or **buffer** as shown in figures ١.

- The **core** is a cylindrical rod of dielectric material. Dielectric material conducts no electricity. Light propagates mainly along the core of the fiber. The core is generally made of glass. The **core** is described as having a radius of (a) and an index of refraction n_1. The core is surrounded by a layer of material called the **cladding**. Even though light will propagate along the fiber core without the layer of cladding material, the cladding does perform some necessary functions. The light is "guided" down (see Figure 2) the core of the fiber by the optical "cladding" which has a lower refractive index (the ratio of the velocity of light in a vacuum to its velocity in a specified medium) that traps light in the core through "total internal reflection."
- The **cladding** layer is made of a dielectric material with an index of refraction n2. The index of refraction of the cladding material is less than that of the core material. The cladding is generally made of glass or plastic. The cladding performs the following functions:
  - Reduces loss of light from the core into the surrounding air
  - Protects the fiber from absorbing surface contaminants
  - Reduces scattering loss at the surface of the core
  - Adds mechanical strength

For extra protection, the cladding is enclosed in an additional layer called the coating or buffer

- The **coating** or **buffer** is a layer of material used to protect an optical fiber from physical damage. The material used for a buffer is a type of plastic. The buffer is elastic in nature and prevents abrasions. The buffer also prevents the optical fiber from scattering losses caused by microbends. Microbends occur when an optical fiber is placed on a rough and distorted surface.

Figure



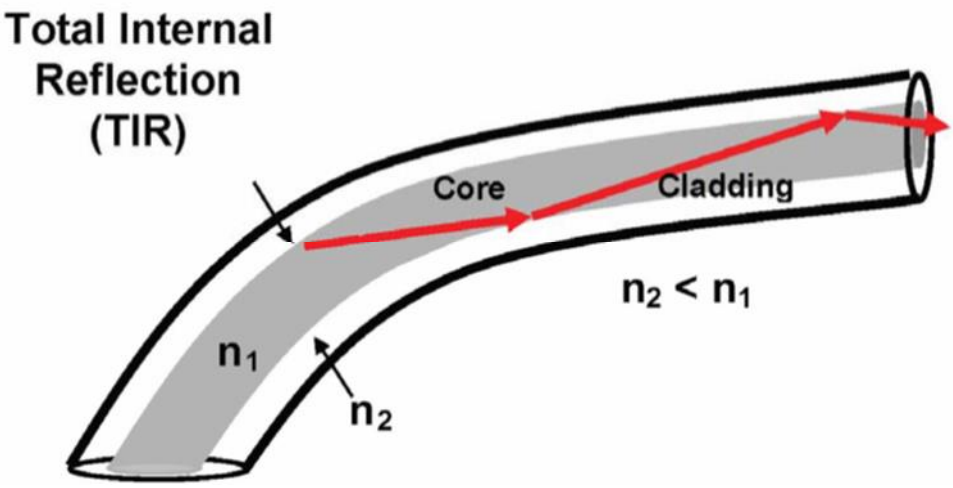


Figure.2 .Total Internal Reflection

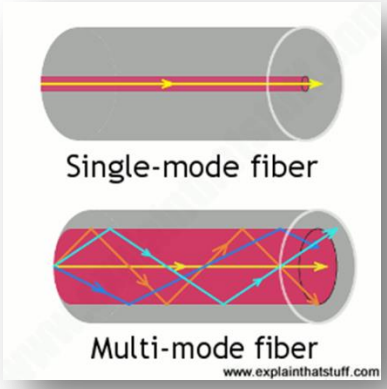
Light travels down a fiber-optic cable by bouncing repeatedly off the walls as shown in figure.3. Each tiny photon (particle of light) bounces down the pipe like a bobsleigh going down an ice run. Now you might expect a beam of light, traveling in a clear glass pipe, simply to leak out of the edges. But if light hits glass at a really shallow angle (less than 42 degrees), it reflects back in again as though the glass were really a mirror. This phenomenon is called total internal reflection. It's one of the things that keeps light inside the pipe. The other thing that keeps light in the pipe is the structure of the cable, which is made up of two separate parts. The main part of the cable in the middle is called the core and that's the bit the light travels through. Wrapped around the outside of the core is another layer of glass called the cladding. The cladding's job is to keep the light signals inside the core. It can do this because it is made of a different type of glass to the core. (More technically, the cladding has a lower refractive index.)

Types of optical fibers:

Optical fibers carry light signals down them in what are called **modes**. That sounds technical but it just means different ways of traveling: a mode is simply the path that a light beam follows down the fiber. One mode is to go straight down the middle of the fiber. Another is to bounce down the fiber at a shallow angle. Other modes involve bouncing down the fiber at other angles, more or less steep.

single-mode. It is the simplest type of optical fiber. It has a very thin core about 5-10 microns (millionths of a meter) in diameter. In a single-mode fiber, all signals travel straight down the middle without bouncing off the edges (yellow line in diagram). Cable TV, Internet, and telephone signals are generally carried by single-mode fibers, wrapped together into a huge bundle. Cables like this can send information over 100 km (60 miles).

multi-mode. Each optical fiber in a multi-mode cable is about 10 times bigger than one in a single-mode cable. This means light beams can travel through the core by following a variety of different paths (yellow, orange, blue, and cyan lines) in other words, in multiple different modes. Multi-mode cables can send information only over relatively short distances and are used (among other things) to link computer networks together.



Optical fibers applications:

- **Medical industry.** Because of the extremely thin and flexible nature, it used in various instruments to view internal body parts by inserting into hollow spaces in the body. It is used as lasers during surgeries, endoscopy, microscopy and biomedical research.
- **Communication.** Telecommunication to copper wires, fiber optics cables are has major uses of optical fiber cables for transmitting and receiving purposes. It is used in various networking fields and even increases the speed and accuracy of the transmission data. Compared
- **Defense Purpose.** Fiber optics are used for data transmission in high level data security fields of military and aerospace applications. These are used in wirings in aircrafts, hydrophones for SONARs and Seismic applications.

- **Lightening and Decorations.** By now, we got a fair idea of what is optical fiber and it also gives an attractive, economical and easy way to illuminate the area and that is why, it is widely used in decorations and christmas trees.
- **Mechanical Inspections.** On-site inspection engineers use optical fibres to detect damages and faults which are at hard to reach places. Even plumbers use optical fibres for inspection of pipes.

Who invented fiber optics?

- 1840s: Swiss physicist **Daniel Colladon** (1802–1893) discovered he could shine light along a water pipe. The water carried the light by internal reflection.
- 1870: An Irish physicist called **John Tyndall** (1820–1893) demonstrated internal reflection at London's Royal Society. He shone light into a jug of water. When he poured some of the water out from the jug, the light curved round following the water's path. This idea of "bending light" is exactly what happens in fiber optics. Although Colladon is the true grandfather of fiber-optics, Tyndall often earns the credit.
- 1930s: **Heinrich Lamm** and **Walter Gerlach**, two German students, tried to use light pipes to make a gastroscope—an instrument for looking inside someone's stomach.
- 1950s: In London, England, Indian physicist **Narinder Kapany** (1927–) and British physicist **Harold Hopkins** (1918–1994) managed to send a simple picture down a light pipe made from thousands of glass fibers. After publishing many scientific papers, Kapany earned a reputation as the "father of fiber optics."
- 1957: Three American scientists at the University of Michigan, **Lawrence Curtiss**, **Basil Hirschowitz**, and **Wilbur Peters**, successfully used fiber-optic technology to make the world's first gastroscope.
- 1960s: Chinese-born US physicist Charles Kao (1933–2018) and his colleague George Hockham realized that impure glass was no use for long-range fiber optics. Kao suggested that a fiber-optic cable made from very pure glass would be able to carry telephone signals over much longer distances and was awarded the 2009 Nobel Prize in Physics for this ground-breaking discovery.
- 1960s: Researchers at the Corning Glass Company made the first fiber-optic cable capable of carrying telephone signals.
- ~1970: Donald Keck and colleagues at Corning found ways to send signals much further (with less loss) prompting the development of the first low-loss optical fibers.
- 1977: The first fiber-optic telephone cable was laid between Long Beach and Artesia, California.
- 1988: The first. 2018: According to Telegraphy, there are currently around 450 fiber-optic submarine cables (carrying communications under the world's oceans), stretching a total of 1.2 million km (0.7 million miles).

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