ELECTRICAL ENGINEERING

INTELLIGENT TECHNICAL MEANS IN INDUSTRY AND DIAGNOSTICS OF OPTICAL FIBER CONDUCTORS

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ИНТЕЛЛЕКТУАЛЬНЫЕ ТЕХНИЧЕСКИЕ СРЕДСТВА В ПРОМЫШЛЕННОСТИ И ДИАГНОСТИКЕ ОПТОВОЛОКОННЫХ ПРОВОДОВ

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ABSTRACT

This article provides information on Intelligent Technical Tools and Diagnostics of Optical Fiber Conductors in Industry. Information is given on the types of optical fibers, their modification, useful properties, concentric elements, application in various fields, operation, optical and mechanical properties, chemical reactions.

АННОТАЦИЯ

В этой статье содержится информация об интеллектуальных технических средствах и диагностике оптоволоконных проводников в промышленности. Дана информация о типах оптических волокон, их модификации, полезных свойствах, концентрических элементах, применении в различных областях, эксплуатации, оптических и механических свойствах, химических реакциях.

Keywords: Optical Fiber, buffer, aligned cores, sensing elements, endoscope, fiberscope, doped fiber.

Ключевые слова: Оптическое волокно, буфер, совмещенные жилы, чувствительные элементы, эндоскоп, фиброскоп, легированное волокно.

An optical fiber (or fibre in British English) is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair. Optical fibers are used most often as a means to transmit light[a] between the two ends of the fiber and find wide usage in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths (data transfer rates) than electrical cables. Fibers are used instead of metal wires because signals travel along them with less loss; in addition, fibers are immune to electromagnetic interference, a problem from which metal wires suffer. Fibers are also used for illumination and imaging, and are often wrapped in bundles so they may be used to carry light into, or images out of confined spaces, as in the case of a fiberscope. Specially designed fibers are also used for a variety of other applications, some of them being fiber optic sensors and fiber lasers.

Optical fibers typically include a core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by the phenomenon of total internal reflection which causes the fiber to act as a wave-

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guide. Fibers that support many propagation paths or transverse modes are called multi-mode fibers, while those that support a single mode are called single-mode fibers (SMF). Multi-mode fibers generally have a wider core diameter and are used for short-distance communication links and for applications where high power must be transmitted. Single-mode fibers are used for most communication links longer than 1,000 meters (3,300 ft).[citation needed]

Being able to join optical fibers with low loss is important in fiber optic communication. This is more complex than joining electrical wire or cable and involves careful cleaving of the fibers, precise alignment of the fiber cores, and the coupling of these aligned cores. For applications that demand a permanent connection a fusion splice is common. In this technique, an electric arc is used to melt the ends of the fibers together. Another common technique is a mechanical splice, where the ends of the fibers are held in contact by mechanical force. Temporary or semi-permanent connections are made by means of specialized optical fiber connectors.

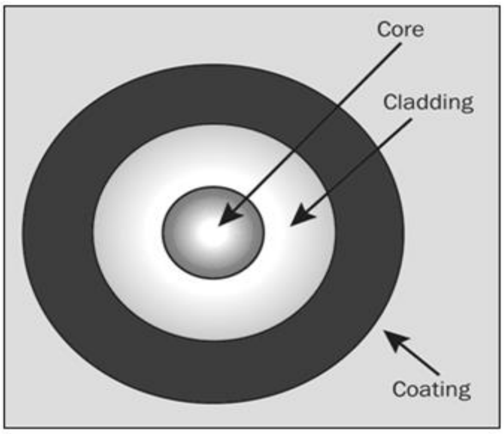

Figure 1. An optical fiber consists of a core, cladding, and coating

An optical fiber consists of three basic concentric elements: the core, the cladding, and the outer coating (Figure 1).

The core is usually made of glass or plastic, although other materials are sometimes used, depending on the transmission spectrum desired.

Optical fibers can be used as sensors to measure strain, temperature, pressure, and other quantities by modifying a fiber so that the property being measured 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. In contrast, highly localized measurements can be provided by integrating miniaturized sensing elements with the tip of the fiber.

These can be implemented by various micro- and nanofabrication technologies, such that they do not exceed the microscopic boundary of the fiber tip, allowing for such applications as insertion into blood vessels via hypodermic needle.

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 or bores cope) are used for inspecting anything hard to reach, such as jet engine interiors.

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 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 fiber is also widely exploited as a nonlinear medium. The glass medium supports a host of nonlinear optical interactions, and the long interaction lengths possible in fiber facilitate a variety of phenomena, which are harnessed for applications and fundamental investigation. Conversely, fiber nonlinearity can have deleterious effects on optical signals, and measures are often required to minimize such unwanted effects.

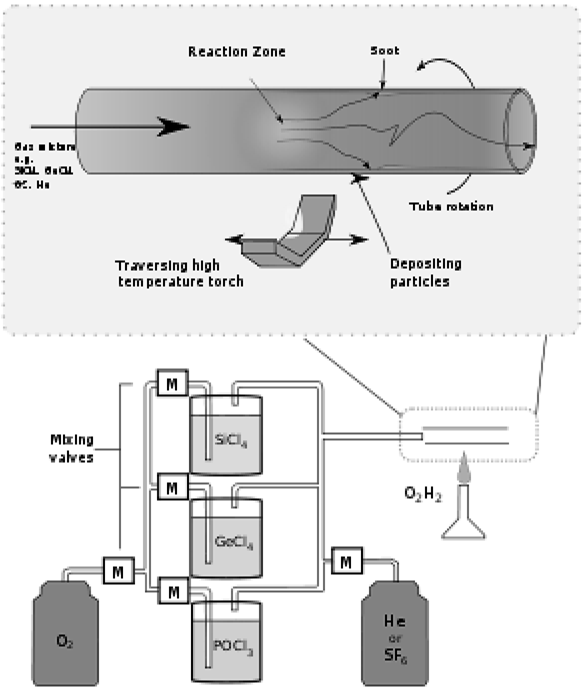

Figure 2. Illustration of the modified chemical vapor deposition (inside) process

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

Typical communications fiber uses a circular preform. For some applications such as double-clad fibers another form is preferred.[74] In fiber lasers based on double-clad fiber, an asymmetric shape improves the filling factor for laser pumping.

Because of the surface tension, the shape is smoothed during the drawing process, and the shape of the resulting fiber does not reproduce the sharp edges of the preform. Nevertheless, careful polishing of the preform is important, since any defects of the preform surface affect the optical and mechanical properties of the resulting fiber. In particular, the preform for the test-fiber shown in the figure was not polished well, and cracks are seen with the confocal optical microscope.

Fiber optic coatings are applied in concentric layers to prevent damage to the fiber during the drawing application and to maximize fiber strength and microbend 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.

The thickness of the coating is taken into account when calculating the stress that the fiber experiences under different bend configurations. When a coated fiber is wrapped around a mandrel, the stress experienced by the fiber is given by

$$\sigma = E\frac{d_f}{d_m + d_c}$$

Where "E" is the fiber's *Young's modulus*, "d_m" is the diameter of the mandrel, "d_f" is the diameter of the cladding and "d_c" is the diameter of the coating.

In a two-point bend configuration, a coated fiber is bent in a U-shape and placed between the grooves of two faceplates, which are brought together until the fiber breaks. The stress in the fiber in this configuration is given by

$$\sigma = 1.198E\frac{d_f}{d - d_c}$$

Where "d" is the distance between the faceplates. The coefficient 1.198 is a geometric constant associated with this configuration.

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 microbending. External *optical fiber cable* jackets and buffer tubes 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 microbending.

Cable construction

Figure 3. An optical fiber cable

In practical fibers, the cladding is usually coated with a tough "*resin*" coating and an additional "*buffer*" layer, which may be further surrounded by a "jacket" layer, usually plastic. These layers add strength to the fiber but do not contribute to its optical wave guide properties. Rigid fiber assemblies sometimes put light-absorbing ("dark") glass between the fibers, to prevent light that leaks out of one fiber from entering another. This reduces "*crosstalk*" between the fibers, or reduces "*flare*" in fiber bundle imaging applications.

Modern cables come in a wide variety of sheathings and armor, designed for applications such as direct burial in trenches, high voltage isolation, dual use as power lines, installation in conduit, lashing to aerial telephone poles, submarine installation, and insertion in paved streets. Multi-fiber cable usually uses colored coatings and/or buffers to identify each strand. The cost of small fiber-count pole-mounted cables has greatly decreased due to the high demand for "*fiber to the home*" (FTTH) installations in Japan and South Korea.

References:

1. "Optical Fiber". www.thefoa.org. The Fiber Optic Association. Retrieved 17 April 2015.
2. Senior, John M.; Jamro, M. Yousif (2009). "Optical fiber communications: principles and practice. Pearson Education. pp." 7–9. ISBN 978-0130326812.
3. "Birth of Fiberscopes". www.olympus-global.com. Olympus Corporation. Retrieved 17 April 2015.
4. Pearsall, Thomas (2010). Photonics Essentials, 2nd edition. McGraw-Hill. ISBN 978-0-07-162935-5.
5. The Optical Industry & Systems Purchasing Directory. Optical Publishing Company. 1984.