Fiber Optics

Fiber Optics deals with the transmission of light through fibers or thin rods of glass, or some other transparent material of high refractive index. If light is admitted at one end of a fiber, it can travel with very low loss, even if the fiber is curved.

The principle on which this transmission of light depends is that of total internal reflection: light traveling within the fiber's center, or core, strikes the outside surface at an angle of incidence greater than the critical angle, so that all the light is reflected into the fiber without loss. Thus light can be transmitted over long distances by being reflected thousands of times. In order to avoid losses through the scattering of light by impurities on the surface of the fiber, the optical-fiber core is clad with a glass layer of much lower refractive index; the reflections occur at the interface of the glass fiber and the cladding.

The simplest application of optical fibers is the transmission of light to locations otherwise hard to reach, such as the bore of a dentist's drill. Also, bundles of several thousand very thin fibers, assembled precisely side by side and optically polished at their ends, can be used to transmit images. Each point of the image projected on one face of the bundle is reproduced at the other end of the bundle, reconstituting the image, which can be observed through a magnifier. Image transmission by optical fibers is widely used in medical instruments for viewing the interior of the human body and for laser surgery, in facsimile systems, in phototypesetting, in computer graphics, and in many other applications.

Optical fibers are also used in a wide variety of sensing devices, ranging from thermometers to gyroscopes. The potential of their applications in this field is nearly unlimited, because the light sent through them is sensitive to many environmental changes, including pressure, sound waves, and strain, as well as heat and motion. The fibers can be especially useful where electrical effects could make ordinary wiring useless, inaccurate, or even hazardous. Fibers have also been developed to carry high-power laser beams for cutting and drilling.

One growing application of optical fibers is in communication, because light waves have high frequencies and the information-carrying capacity of a signal increases with frequency. Optic-optic laser systems are used in communications networks. Many long-haul fiber communications networks providing both transcontinental and transoceanic connections are in operation. One advantage of optical fiber systems is the great distances that a signal can travel before a repeater is needed to regenerate it. Optic-optic repeaters are currently separated by about 100 km (about 60 mi), compared to about 1.5 km (1 mi) for electrical systems. Newly developed optical-fiber amplifiers can extend this distance even farther.

Local area networks (LANs) are another growing application for fiber optics. Unlike long-haul communications, these systems connect local subscribers to centralized equipment such as computers and printers. This system increases the utilization of equipment and can easily accommodate new users on a network. Development of new electro-optic and integrated-optic components will further expand the capability of fiber systems.