2. Structure of optical fiber

Constructionally, an optical fiber is a solid cylindrical glass rod called the core, through which light in the form of light or optical signal propagates. This is surrounded by another coaxial cylindrical structure made of glass of lower refractive index called the cladding. This basic arrangement that guides light over long distances is shown in figure 1.

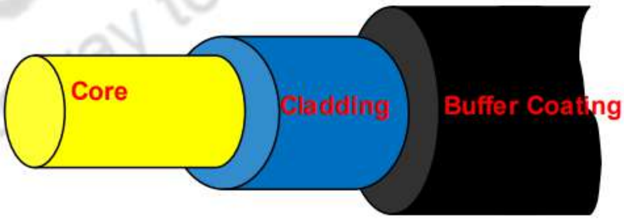

Figure 1. Constructional details of optical fiber

Optical fiber has diameter of the cladding is of the order of 125 μm and the diameter of the core even smaller than that. Thus it is a very fine and brittle glass rod. In order to provide mechanical strength to this core-cladding arrangement, other coaxial surrounding called the buffer coating and jacketing layers are provided. They do not play any role in the propagation of light through the optical fiber, but are present solely for providing mechanical strength and support to the fiber.

3. Propagation of light through optical fiber

Propagation of light energy in the form of optical signals inside the core-cladding arrangement and throughout the length of the fiber takes place by a phenomenon called the Total Internal Reflection (TIR) of light. This phenomenon occurs only when the refractive index of core is greater than the refractive index of cladding and so the cladding is made from glass of lower refractive index. By multiple total internal reflections at the core-cladding interface the light propagates throughout the fiber over very long distances with low attenuation.

The essential requirements of the propagation of light through an optical fiber, over long distances with minimum loss, are discussed in detail.

Figure 2 shows a section of the core of an optical fiber. If a ray of light is incident on the core of an optical fiber from the side, the ray of light simply refracts out from the fiber on the other side. The ray shown in figure 2 (in blue) demonstrates the situation.

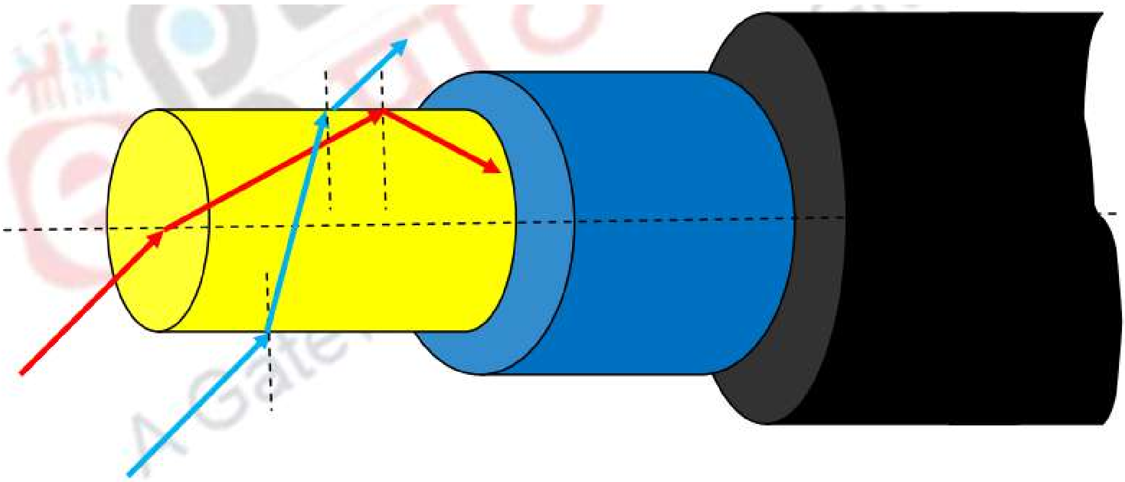

Figure 2. Launching light into optical fiber

Any light that enters the optical fiber from the side does not propagate along the fiber. Therefore, one has to launch the light through the tip of the fiber. That is, in order to guide light along the fiber, the light must be incident from the tip of the optical fiber. The red ray of light in figure 2 explains this situation. In other words, if the tip of the optical fiber is not exposed to light, no light will enter the fiber. Although there may be ambient light, as long as the tip is protected, no light from the sides propagates along the fiber. Equivalently, if there was propagation of light through the fiber, no light would emerge from the sides of the fiber. This characteristic of the optical fiber imparts the advantage of information security to the Optical Fiber Communication Technology.

Partial reflection at the core-cladding interface does not suffice the propagation of light along the fiber over long distances. The reason is that, at each reflection a part of the optical energy launched into the optical fiber would be lost and after a certain distance along the length of the fiber the optical power would be negligibly low to be of any use. Thus total internal reflection is an absolute necessity at each reflection for a sustained propagation of optical energy over long distance along the optical fiber. This precisely is the sole reason of launching light into the fiber at particular angles so that light energy propagates along the fiber by multiple total internal reflections at the core-cladding interface. The Ray-Model of light obeys the Snell's laws. Figure 4 depicts a situation of a typical refraction phenomenon taking place at the interface of two optically different media having refractive indices n_1 and n_2:

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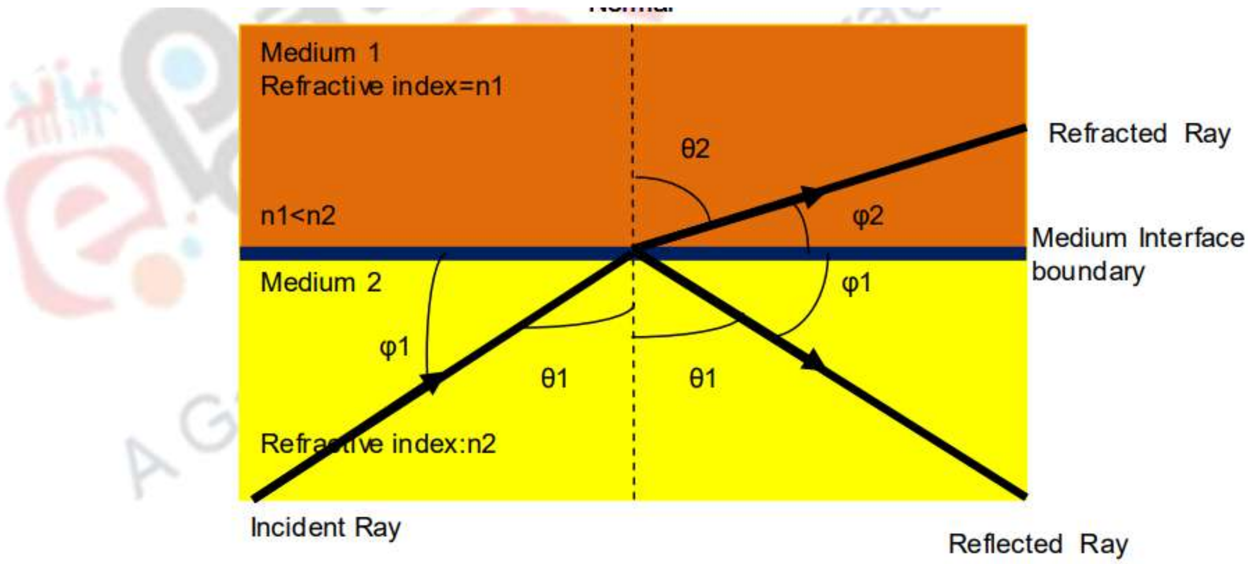

$n1 \sin \theta 1 = n2 \sin \theta 2$ **(Snell's law)**

Figure 4 Refraction of light at medium interface boundary

The angles measured in the expression for Snell's law are measured with respect to the normal to the media interface at the point of incidence. If n2 > n1 , then the angle of refraction is greater than the angle of incidence and the refracted ray is said to have planes and consequently the rays lying in a meridional-plane are called meridional-rays. Meridional rays always remain in the respective meridional plane.

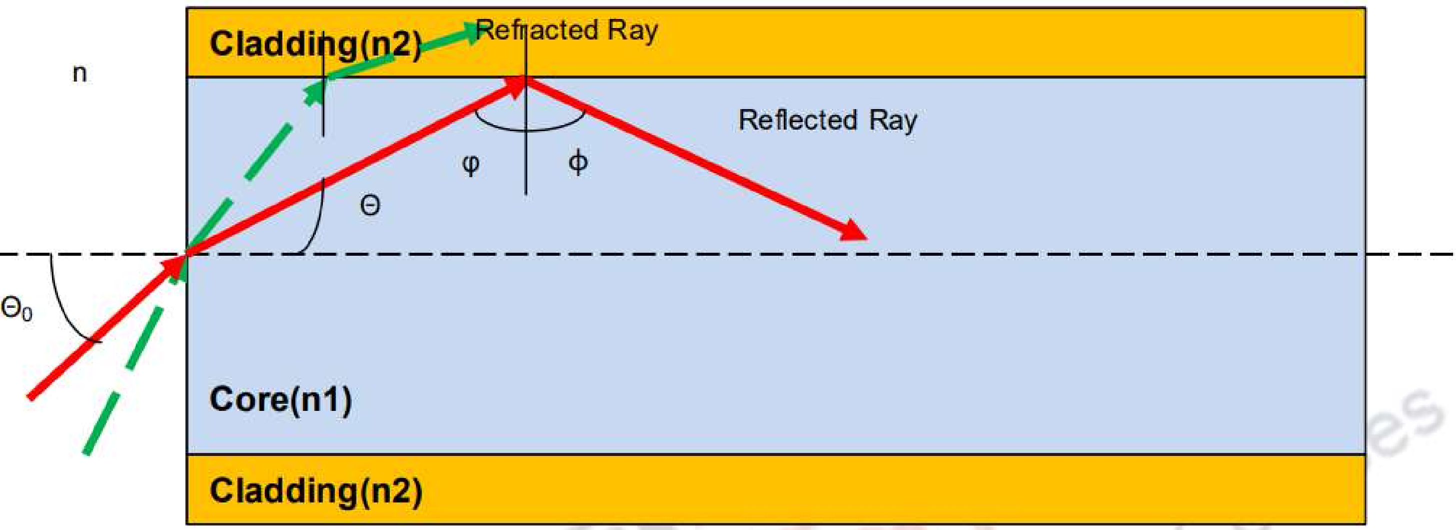

Figure 5 Launching the light into optical fiber

Infinite number of planes can pass through the axis of the fiber and an infinite number of meridional planes. This proves that there are an infinite number of meridional rays too, which are incident on the tip of the fiber making an angle with the fiber-axis as shown in the above figure 5.

These meridional rays after total internal reflection at the core-cladding boundary meet again at the axis of the optical fiber as shown in the figure 6. Consider the meridional plane is the plane of the paper which passes through the axis of the fiber and the incident rays, refracted rays and the reflected rays lie on the plane of the paper.

For the sake of simplicity and clarity only two rays are shown in the figure . However in practice there would be a number of rays that would be convergent at the same point. One can classify these Meridional rays as bound and unbound rays.

The rays that undergo TIR inside the fiber core remain inside the core at all times along the propagation and are called as bound rays. The red ray in the Figure 5 is bound ray. The rays

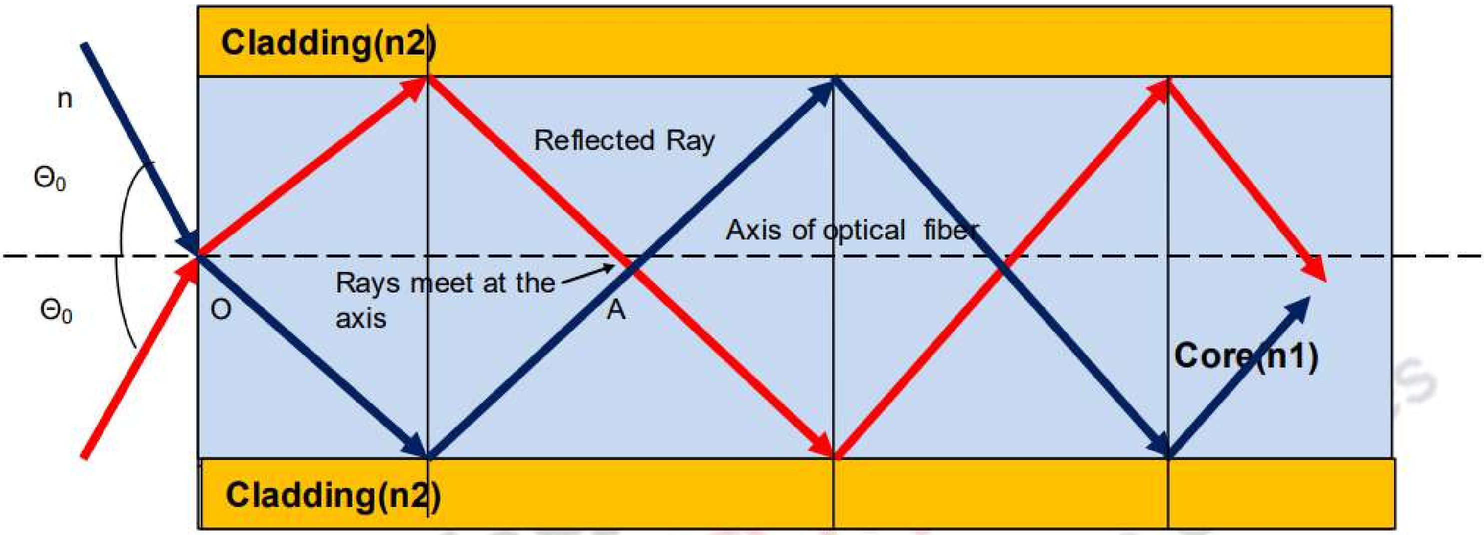

Figure 6 Propagation of meridional rays along the fiber axis