## 2.12Types of Optical Fibre Based on the materials

1. Glass fibre
2. Plastic fibre

**Based on the mode**

1. Single mode fibre
2. Multi-mode fibre

**Based on the refractive index**

1. Step index fibre
2. Graded index fibre

**Glass fibres**

The fibres are made up of mixture of metal oxides and silica glasses. The glass fibres can be made by any one of the following combinations of core and cladding.

1. **Core:** $SiO_2$; **Cladding:** $P_2O_3 - SiO_2$
2. **Core:** $GeO_2 - SiO_2$ **Cladding:** $SiO_2$

**Plastic fibres**

If the fibres are made up of plastics which can be handled without any care due to its toughness and durability it is called plastic fibre. The plastic fibres are made by any one of the following combinations of core and cladding.

1. **Core:** Polymethyl methacrylate;
   **Cladding:** Co-polymer
2. **Core:** Polystyrene;
   **Cladding:** Methyl methacrylate

In general, the single mode fibres are step index fibres. These types of fibres are made from doped silica. It has a very small core diameter so that it can allow only one mode of propagation and hence called single mode fibres. The cladding diameter must be very large

compared to the fore diameter. Thus in the case of single mode fibre, optical loss is very much reduced. The structure of a single mode fibre is as shown in figure.


Fig 2.12.1 Single mode fibres

**Structure**

Core Diameter : 5- 10 µm

Cladding Diameter : Generally, around 125 µm

Protective layer : 250 to 1000µm Numerical

Aperture : 0.08 to 0.10

Band Width : More than 50 MHz km

**Application**

Because of its high band width, they are used in long haul communication systems.

**Multi-Mode fibres**

The multimode fibres are useful in manufacturing both for the step index and graded index fibres. The multimode fibres are made by multi-component glass compounds such as Glass-clad Glass, Silica-clad Silica, doped silica etc. Here the core diameter is very large compared to single mode fibres, so that it can allow many modes to

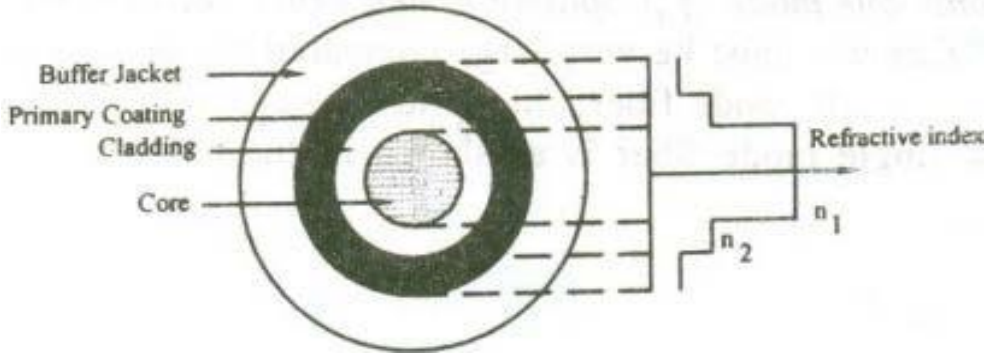



Fig 2.12.2Multi mode fibres

propagate through it and hence called as multi-mode fibres. The cladding diameter is also larger than the diameter of the single mode fibres. The structure of the multimode fibre is as

shown in figure.

**Structure**

Core Diameter : 50 - 350 μm

Cladding Diameter : 125 -500 μm

Protective layer : 250 to 1100μm

Numerical Aperture : 0.12 to 0.5

Band Width : Less than 50 MHz km

**Application**

Because of its less band width it is very useful in short haul communication systems.

**Differences between Single and Multimode Fibre**

| S.No | Single mode fibre | Multi-mode fibre |
|---|---|---|
| 1. | In single mode fibre only one mode can be propagated. | Large number of modes for light to pass through it. |
| 2. | The single mode fibre has a smaller core diameter. and | The core diameter is large. |
| 3 | Difference in refractive index of core and cladding is small. | The core and cladding refractive indices difference is large |
| 3. | No dispersion | Dispersion is more |
| 4. | Information can be carried to longer distances only. | Information can be carried to shorter distances only. |
| 5. | Launching of light and connecting two fibres are difficult. | Launching of light and also connecting two fibres is easy. |
| 6. | Installation is more costly. | Installation cost is low. |

## Step index fibre

### Single mode fibre

A single mode step index fibre consists of a very thin core of uniform refractive index surrounded by a cladding of refractive index lower than that of core. The refractive

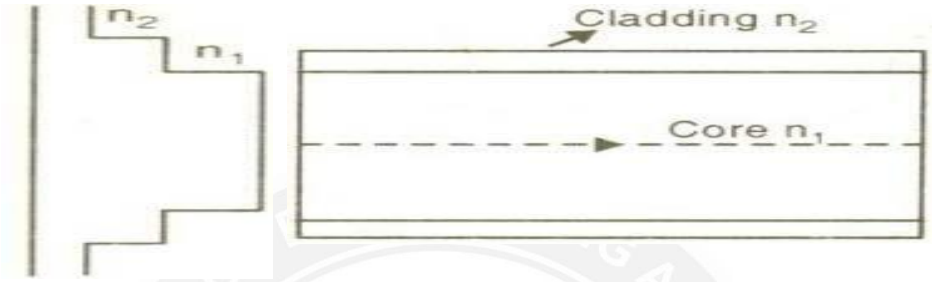
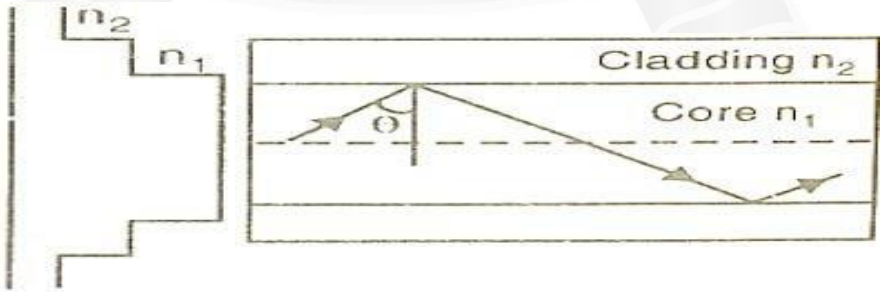



Fig 2.12.3 Step index fibre Single mode fibre

index abruptly changes at the core cladding boundary. Light travels along a side path, i.e., along the axis only. So zero order modes are supported by Single Mode Fibre.

### Multi-mode fibre

A multimode step index fibre consists of a core of uniform refractive index surrounded by cladding of refractive index lower than that of the core. The refractive index abruptly changes at the core cladding boundary. The core is of large diameter. Light follows zigzag paths inside the fibre. Many such zigzag paths of propagation are permitted in multi-mode fibre. The numerical aperture of a multi-mode fibre is larger as the core diameter of the fibre is larger.




2.12.4 Step index fibre Multi mode fibre

### Graded index fibre

GRIN fibre is one in which refractive index varies radially, decreasing continuously in a parabolic manner from the maximum value of $n_1$, at the centre of the core to a constant value of

$n_2$ at the core cladding interface.

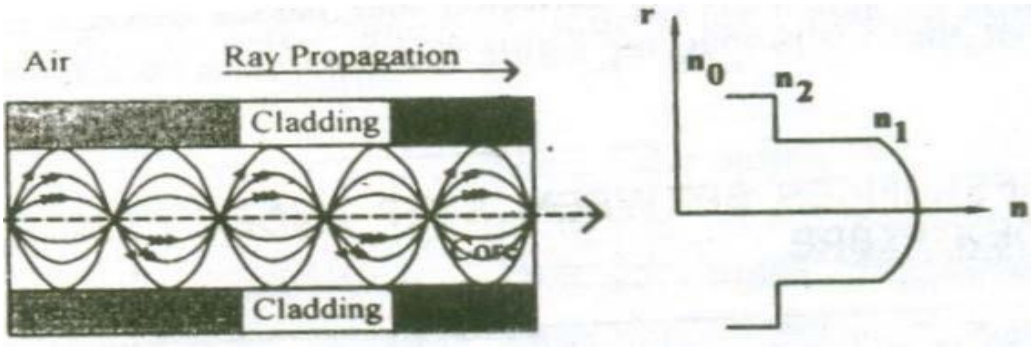



Fig 2.12.5 Graded index fibre

In graded index fibre, light rays travel at different speeds in different parts of the fibre because the refractive index varies throughout the fibre. Near the outer edge, the refractive index is lower. As a result, rays near the outer edge travel faster than the rays at the centre of the core.

Because of this, rays arrive at the end of the fibre at approximately the same time. In effect light rays arrive at the end of the fibre are continuously refocused as they travel down the fibre. All rays take the same amount of time in traversing the fibre. This leads to small pulse dispersion.

**Propagation of light in GRIN fibre**

Let $n_a$, $n_b$, $n_c$, $n_d$ etc. be the refractive indices of different layers in the graded index fibre with $n_a > n_b > n_c > n_d$ etc. Then the propagation of light through the graded index fibre is as shown in figure.

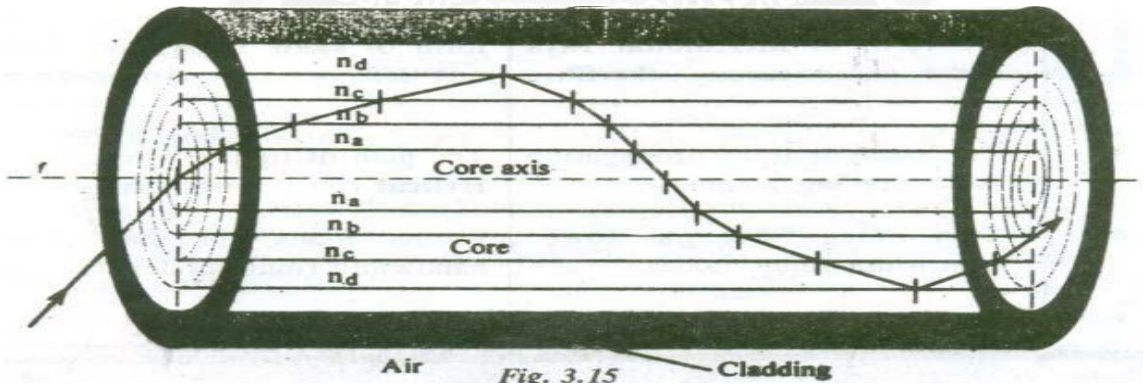



Fig 2.12.6 Propagation of light in GRIN fibre

Here, since $n_a > n_b$ the ray gets refracted. Similarly, since $n_b > n_c$, the ray gets refracted. In a similar manner, due to decrease in refractive index the ray gets gradually curved towards the upward direction and at one place, where it satisfies the condition for total internal

reflection, ($\phi > \phi_c$) it is totally internally reflected. The reflected ray travels back towards the core axis (but not crosses it) and without crossing the fibre axis, it is refracted towards downwards direction and again gets totally internally reflected and passes towards upwards direction. In this manner the ray propagates inside the fibre in a helical or spiral manner.

**Differences between Step Index Fibre and Graded Index Fibre**

| S.No | Step index fibre | Graded index fibre |
|---|---|---|
| 1. | Change in refractive index is abruptly at the core and cladding interface. | Change in refractive index is gradually at the core and cladding interface. |
| 2. | Propagation light rays are in the form of meridional rays. | Propagation of light rays is in the form of skew rays. |
| 3. | The path of light propagation is in Zig-zag manner. | The path of light propagation is Helical. |
| 4. | Step index fibre has lower bandwidth. | Graded index fibre has higher bandwidth. |
| 5. | Distortion is more | Distortion is less |
| 6. | Numerical aperture is more. | Numerical aperture is less. |