Types of Fibers

CLASSIFICATION BASED ON MATERIALS

1. **Glass fiber:** Made by fusing mixtures of metal oxides and silica glasses.

Ex: GeO_2-SiO_2 core, SiO_2 cladding

SiO_2 core, P_2O_3-SiO_2 cladding

2. **Plastic fiber:** Made up of plastic polymers and is of low cost and flexible. Can be handled without any special care due to its toughness and durability.

Ex: Polysterene core, Methyl methacrylate cladding

Polymethyl methacrylate core and co-polymer cladding

CLASSIFICATION BASED ON NUMBER OF MODES

Number of modes

- Optical fiber is a dielectric waveguide.
- Energy in the fiber is propagated by electric and magnetic field vectors of electromagnetic wave; which can be analysed by Maxwell's field equations.
- Maxwell's equations have discrete sets of solutions called the modes.
- Number of modes propagating in an optical fiber can be determined by a factor known as "horizontal wave number" (V).

$$\boxed{V = \frac{2\pi a}{\lambda} NA}$$

$a \rightarrow$ radius of the core

❖ Maximum number of modes supported by a step index fiber is:

$$N_m = \frac{1}{2} V^2$$

❖ Maximum number of modes supported by a graded index fiber is:

$$N_m = \frac{1}{4} V^2$$

❖ For V < 2.405: Only one mode is supported (single mode fiber)

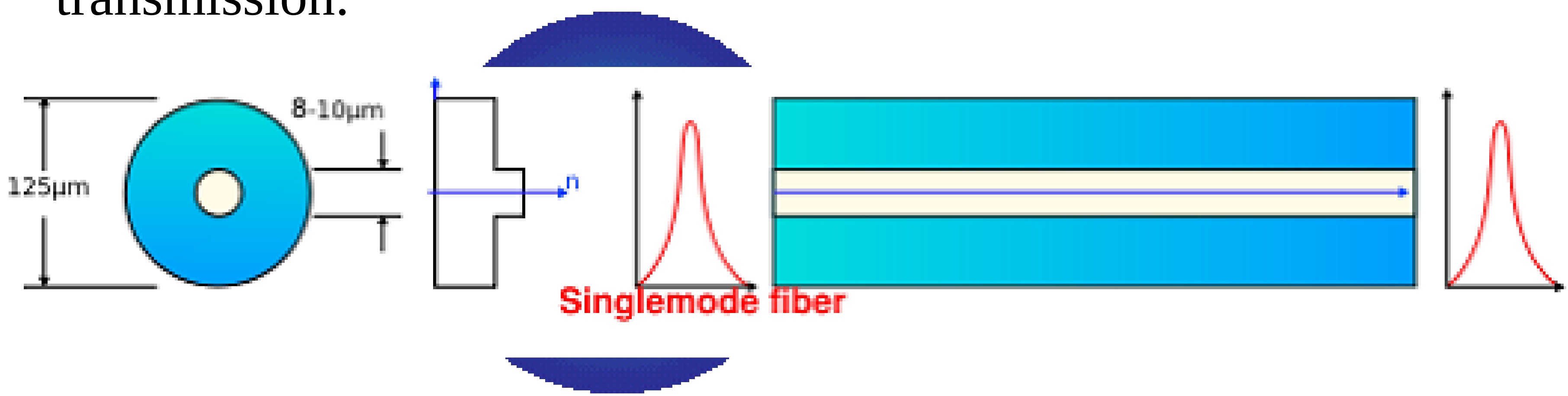
❖ For V > 2.405: Can support more than one mode (Multimode fiber)

❖ The wavelength corresponding to V = 2.405 is known as the cut-off wavelength of the fiber.

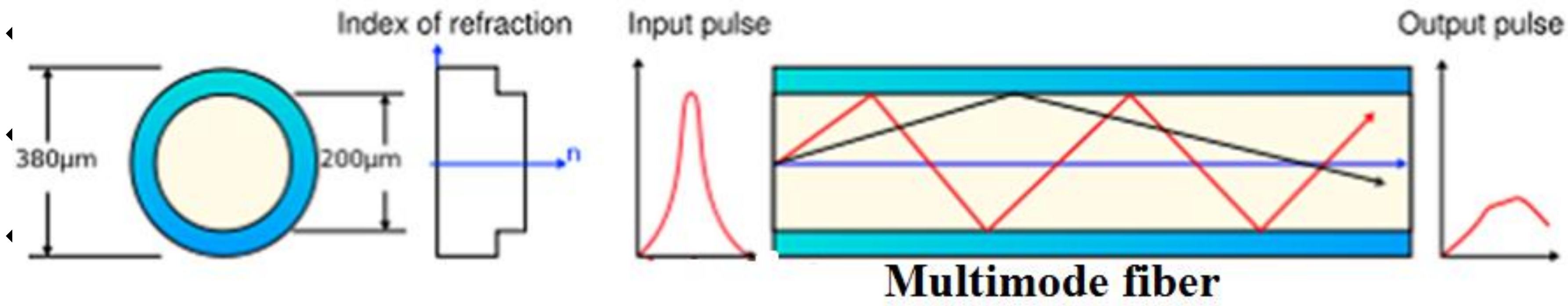
$$\lambda_c = \frac{\lambda V}{2.405}$$

SINGLE MODE FIBER

- These fibers have very narrow core (~ 10 µm in diameter).
- Hence allow only one mode (TE, TM or TEM) to pass through it.
- NA and acceptance angles are small for these fibers which allows only the transmission of fundamental modes.
- Amount of dispersion is very less.
- Used for very high speed, large bandwidth and long distance transmission.



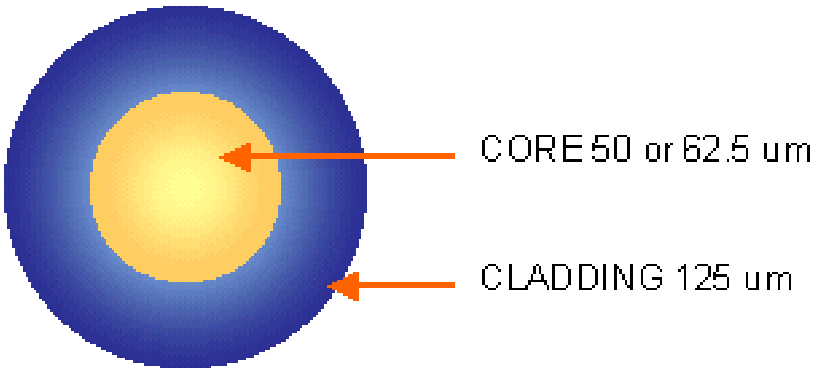
MULTI MODE FIBER

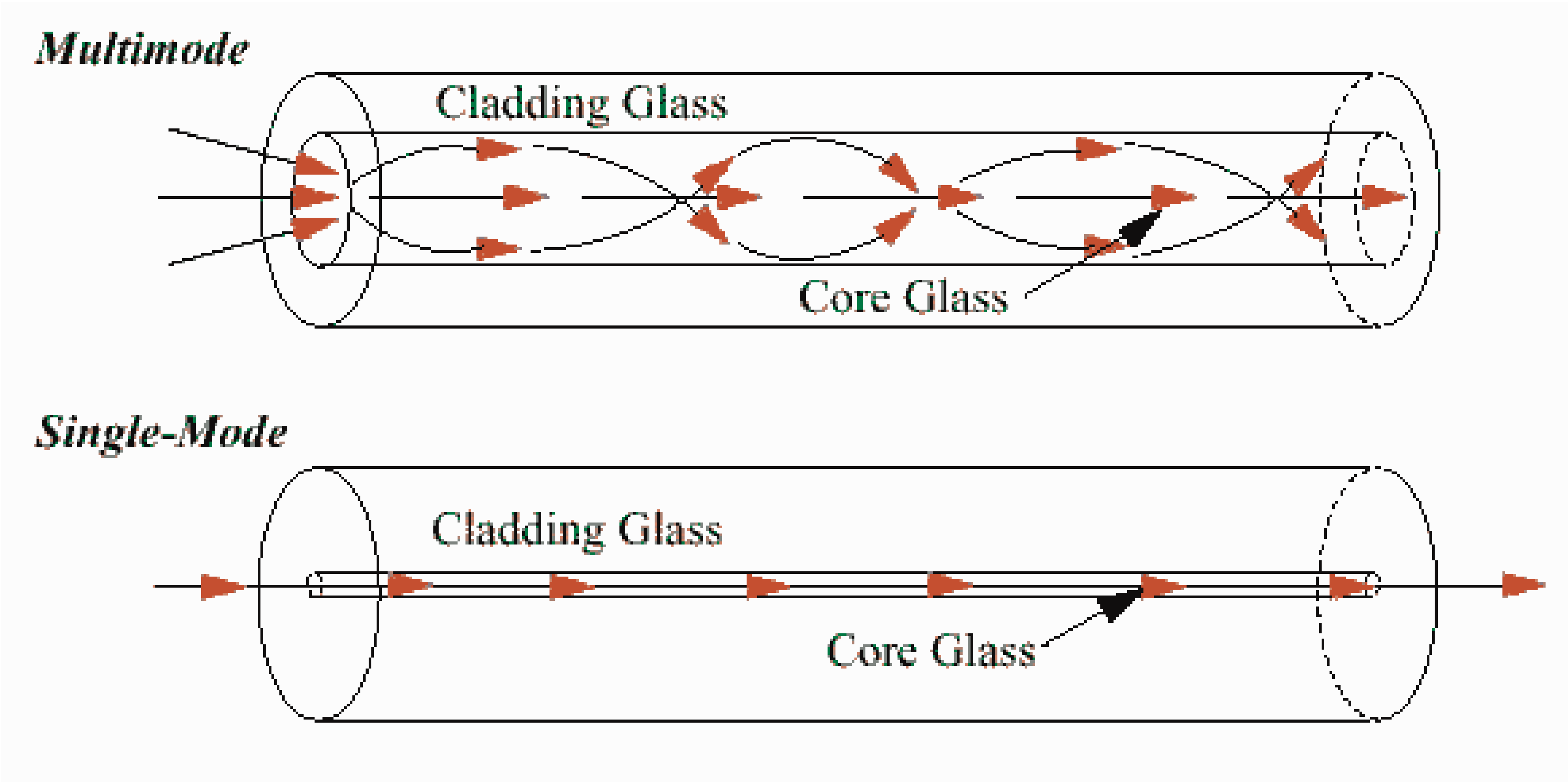


and marginal ray (near the fiber surface).

- ❖ Marginal ray travels longer distance than the axial ray.
- ❖ This time delay causes distortion in the pulse leading to dispersion.
- ❖ Results in broadening of light pulses reducing the transmission speed and transmission bandwidth.

Best designed for short transmission distances and is suited for use in LAN systems and video surveillance

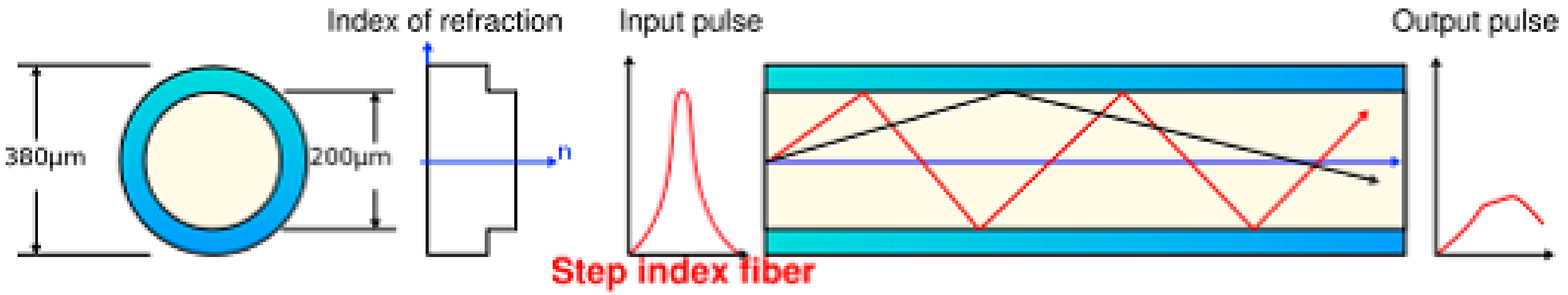



Multimode
Cladding Glass
Core Glass
Single-Mode
Cladding Glass
Core Glass

Classification Based on Refractive Index Profile

Step-Index Fiber

❖ Refractive index of the core is uniform throughout and undergoes an abrupt change (step) at the cladding boundary.



Multimode step-index fiber

GRADED-INDEX FIBER

- Core refractive index is made to vary as a function of the radial distance from the center of the fiber. Also known as inhomogeneous core fibers.

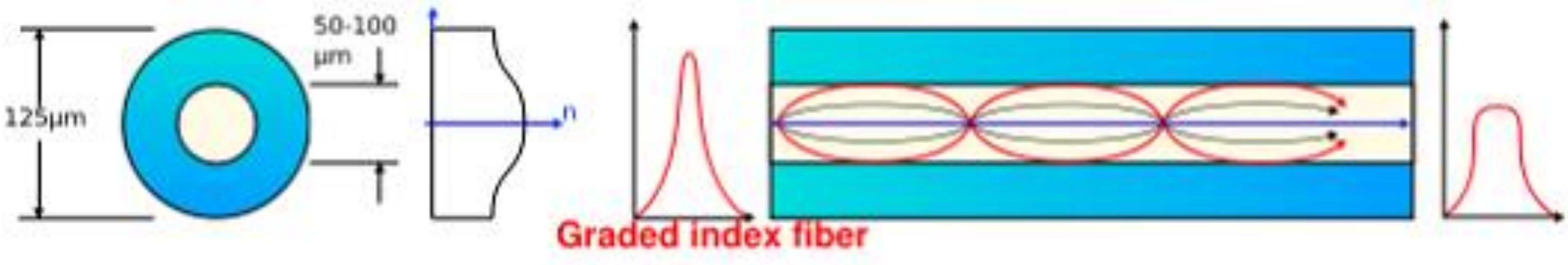
$$n(r) = n_1\left[\left(1-2\Delta\left(\frac{r}{a}\right)^{\alpha}\right)\right]^{1/2}$$ For $r < a$, Core

$$n(r) = n_1(1-2\Delta)^{1/2} = n_2$$ For $r >= a$, Cladding

$\Delta \rightarrow$ Relative refractive index difference

$\alpha \rightarrow$ Profile parameter (Gives the characteristic refractive index of core)

= **1 (triangular profile), 2 (parabolic), ∞ (step-index)**



❖ Graded index profiles, giving best result for multimode optical propagation have nearly parabolic refractive index profile.

❖ In this case, the pulse dispersion is less than that in step-index fiber.