Optical fiber module

Topics

How to describe optical fiber?

Optical fiber types or classifications

- According to material.
- According to number of modes.
- According to refractive index profile.

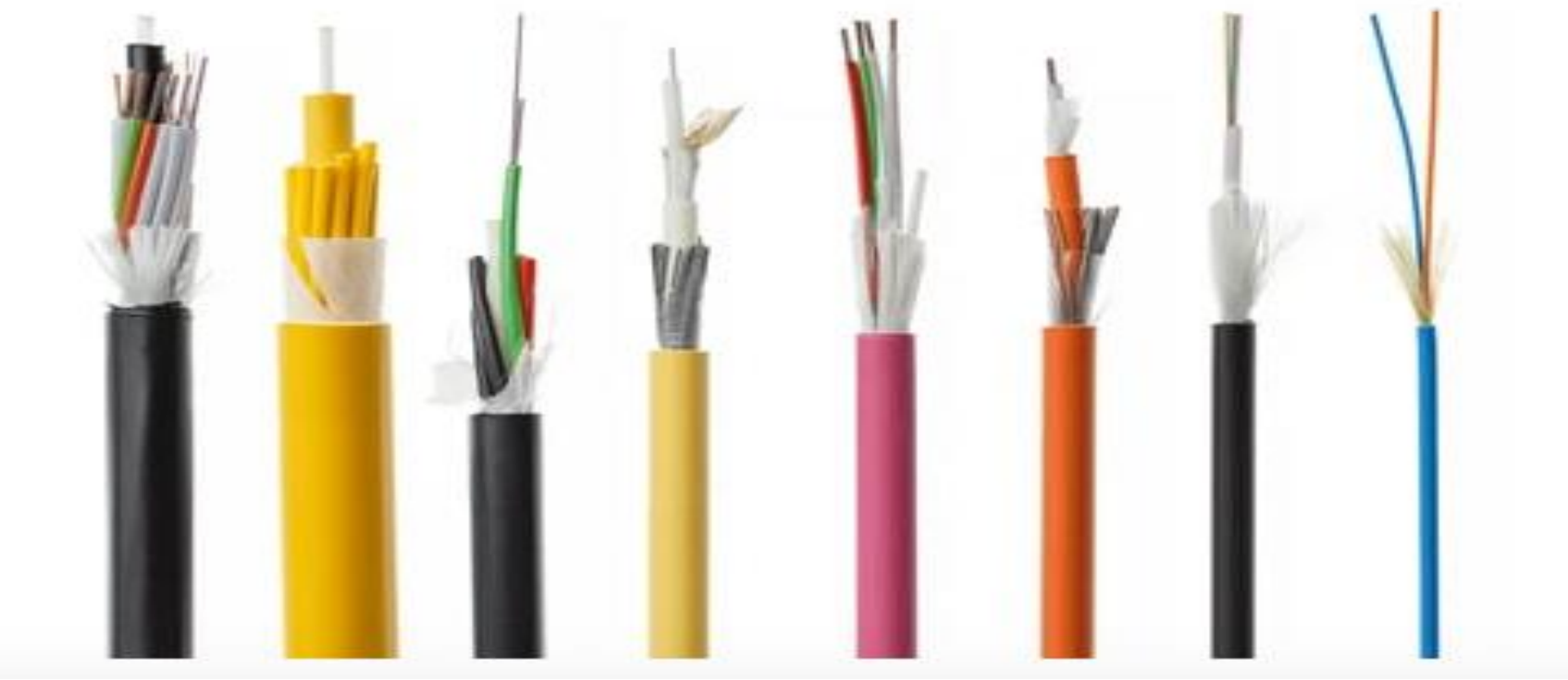
Comparison between SMF and MMF.

Coupling loss in optical fiber.

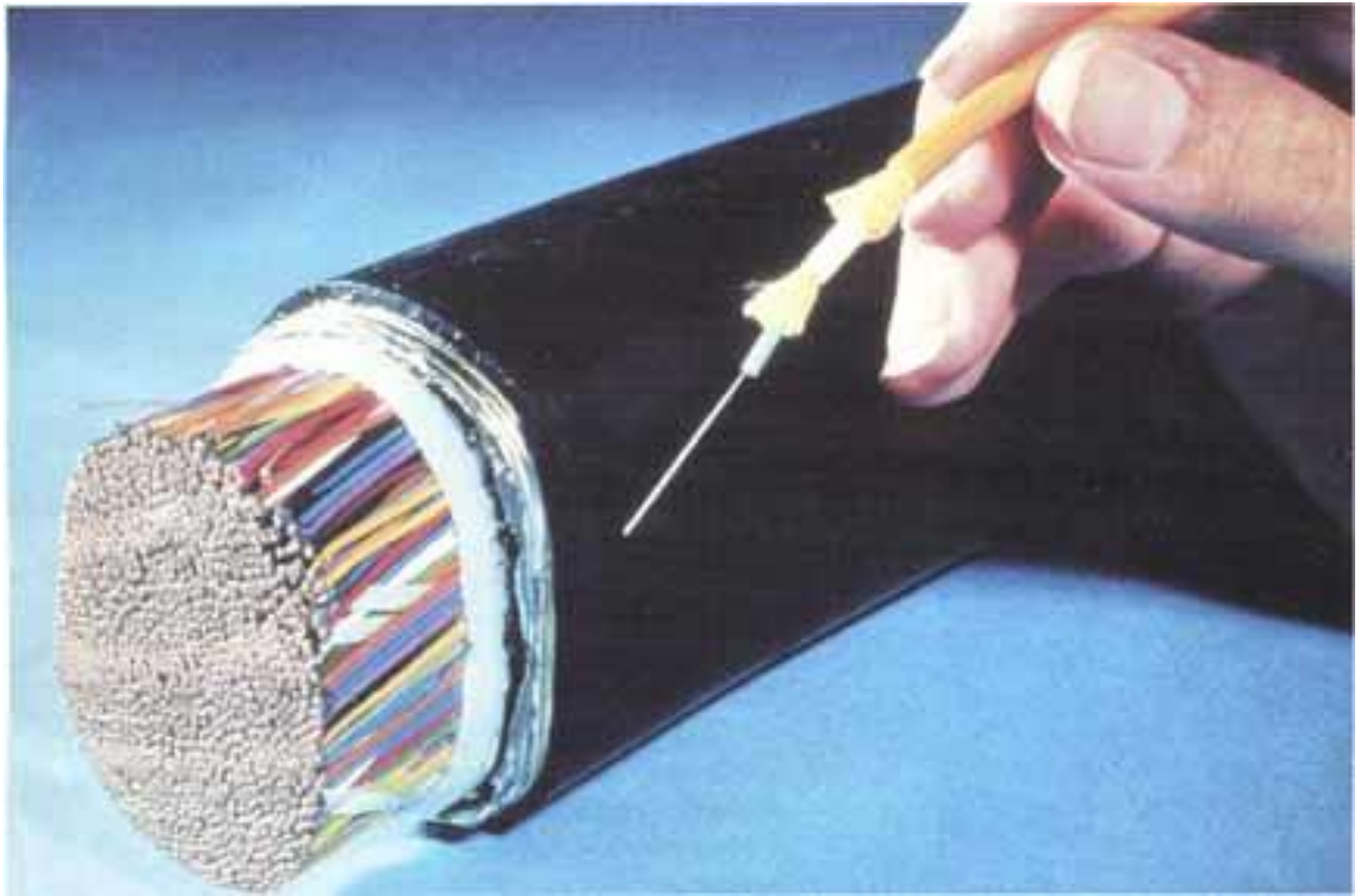
Optical fiber applications.

Multiplexing in optical fiber(WDM/DWDM)

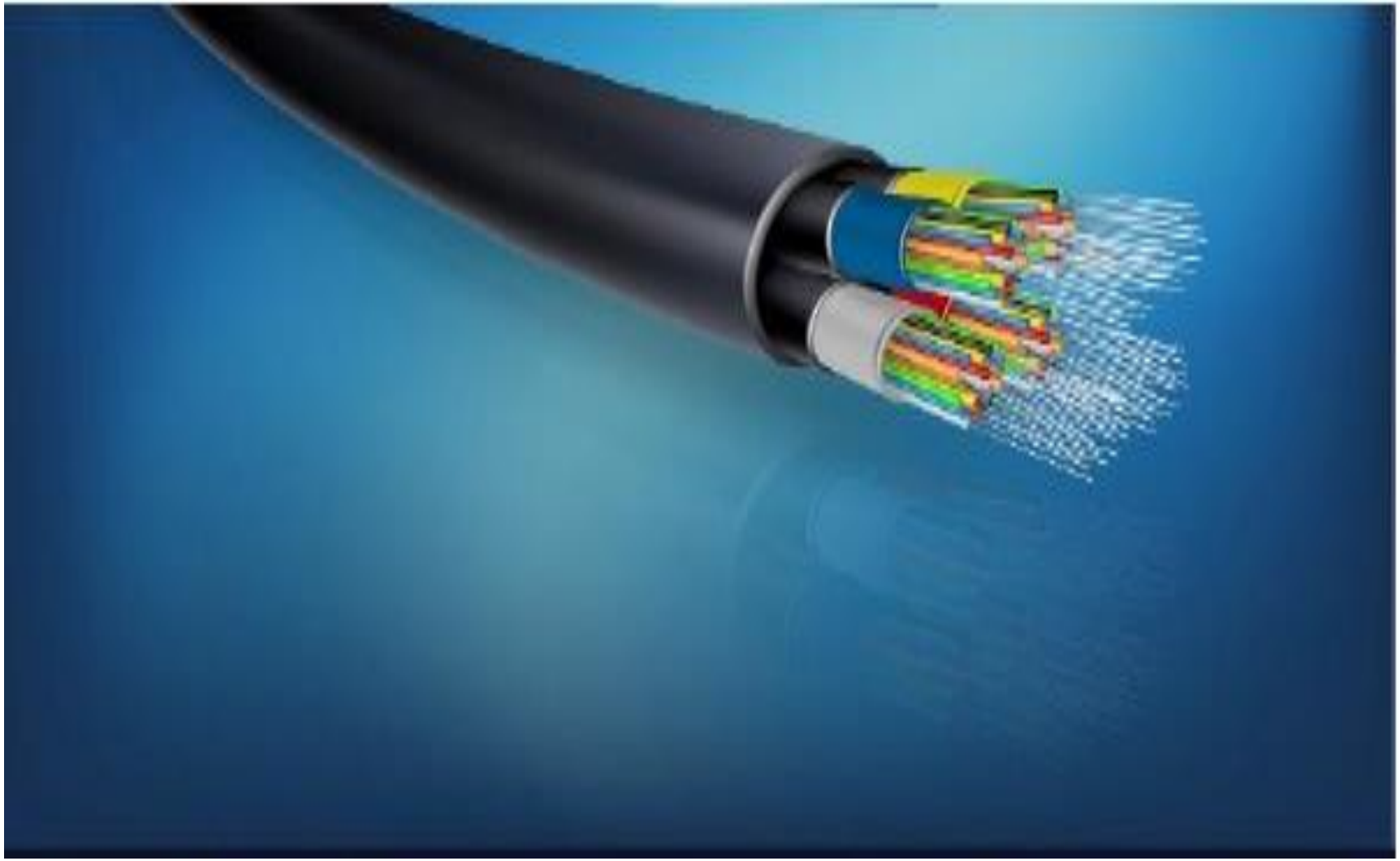
Optical fiberis described by a(b/c)
where
a is number of fibers in the cable
b is the core diameter in microns
c is the cladding diameter in microns



Optical fiber cable



Optical fiber cable



Types of Optical Fibers

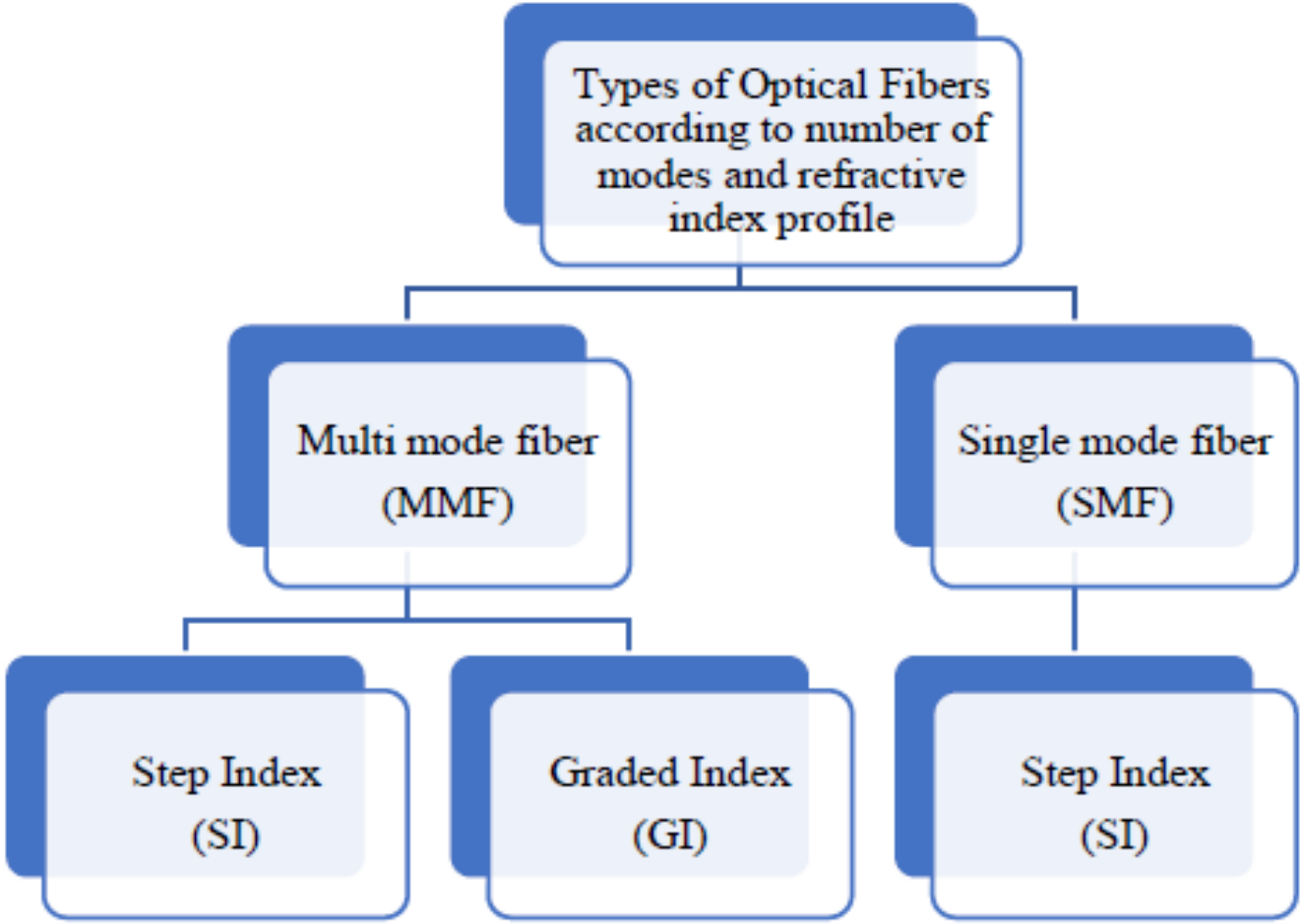
- **Types of optical fiber according the material**

Optical fiber are classified based on the materials used is as follows:

Plastic optical fibers: Poly methyl methacrylate is used as the primary material for transmitting light.

Glass optical Fiber: It is made up of very fine glass fibers.

Types of Optical Fibers



Single-Mode Fiber (SMF)

Single mode fiber (SMF) permits only one mode of light to be transmitted per time.

It has a core diameter of 8 to 10 µm.

It has a cladding diameter of 125µm

The light travels parallel to the axis, which creates little pulse dispersion. It is used for long distance up to 1,000 meters.

Multimode Fiber (MMF)

Multimode can transmit more than one modes per time.

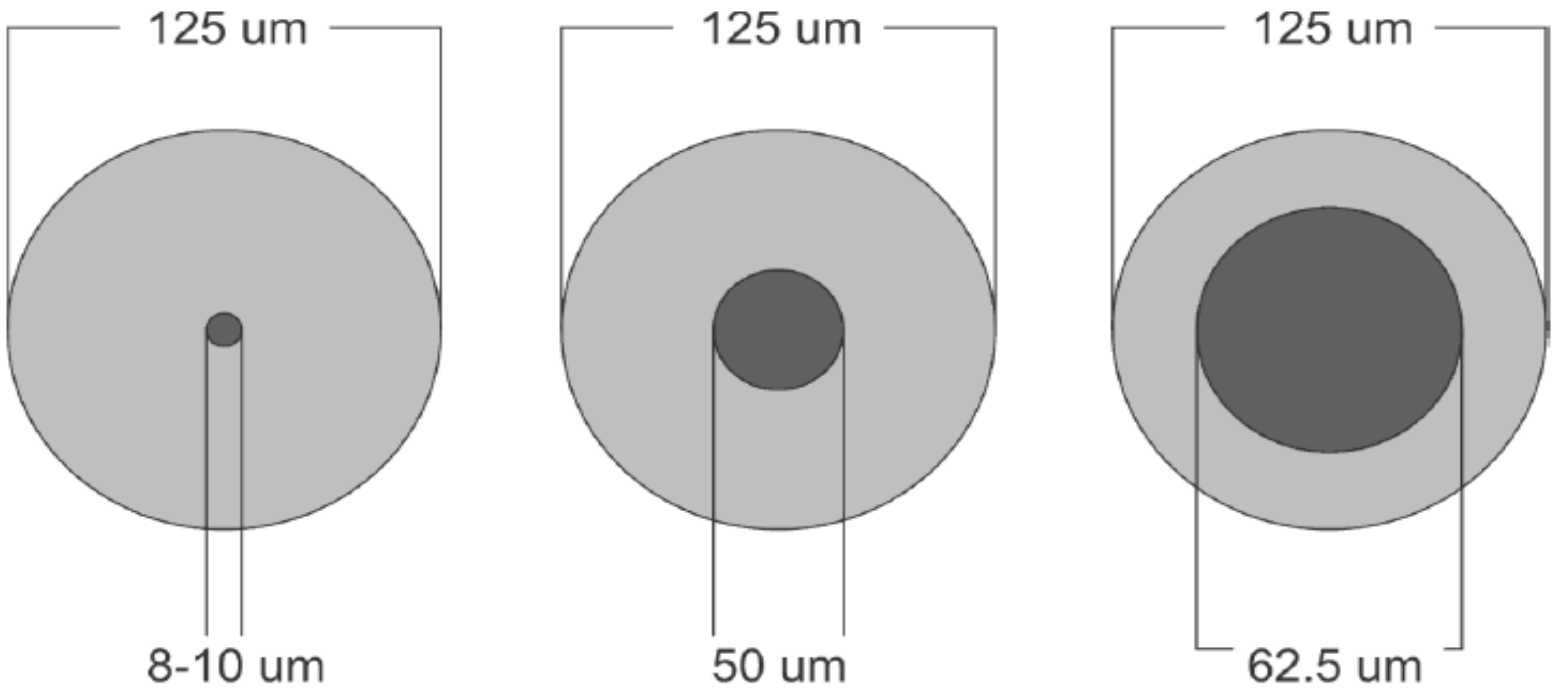
It has a bigger core from 50 microns to 62.5 microns.

It has a cladding diameter of 125µm.

Multi-mode fiber is used for short short-distance.

62.5/125 means core diameter /cladding diameter in µm is a typical multimode fiber used for telecommunication.

Types of optical fiber according to number of modes



Single Mode Fiber

Multi Mode Fiber

Types of optical fiber according to refractive index profile

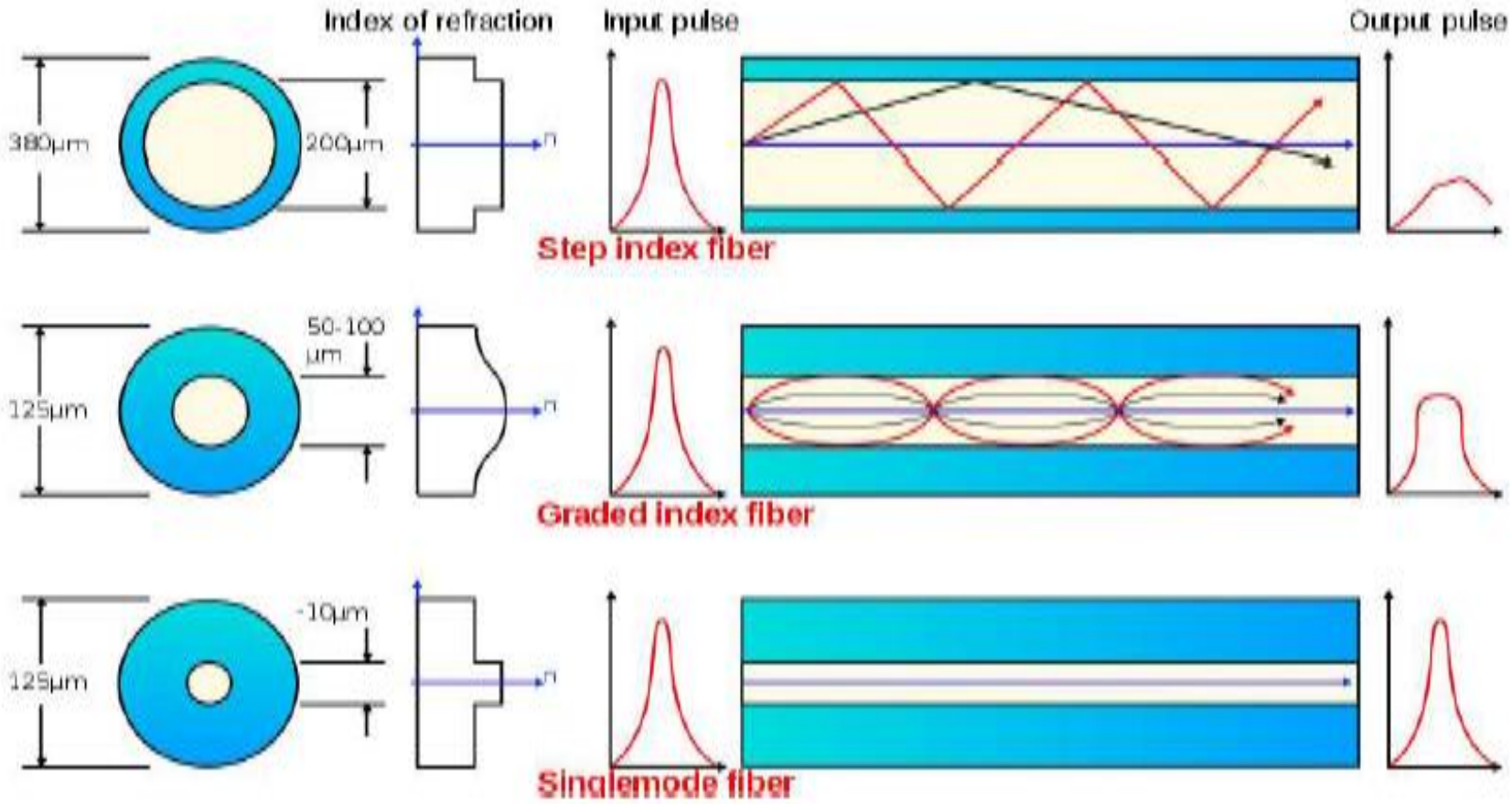
Step Index Fibers

The Refractive Index is uniform in the cladding and experiences an unexpected change at the cladding limit. Then, becomes uniform in the core.

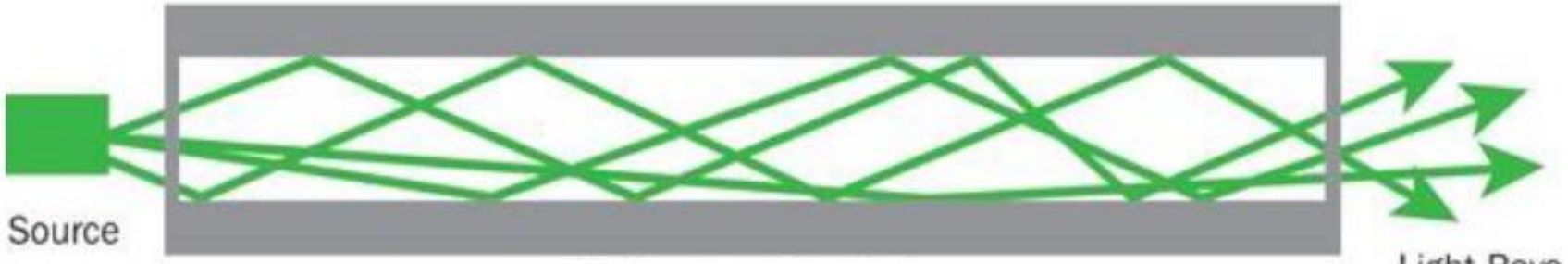
Graded Index Fibers

The Refractive Index is uniform in the cladding and increases with radial distance until it reaches maximum at the fiber center. Then, it decreases as the radial distance from the fiber axis increases i.e. away from the center of the fiber. The core refractive index varies in the form of a parabolic manner. It offers hundreds of times more bandwidth than step index fiber.

Types of optical fiber according to number of modes and refractive index profile



Types of optical fiber according to number of modes and refractive index profile

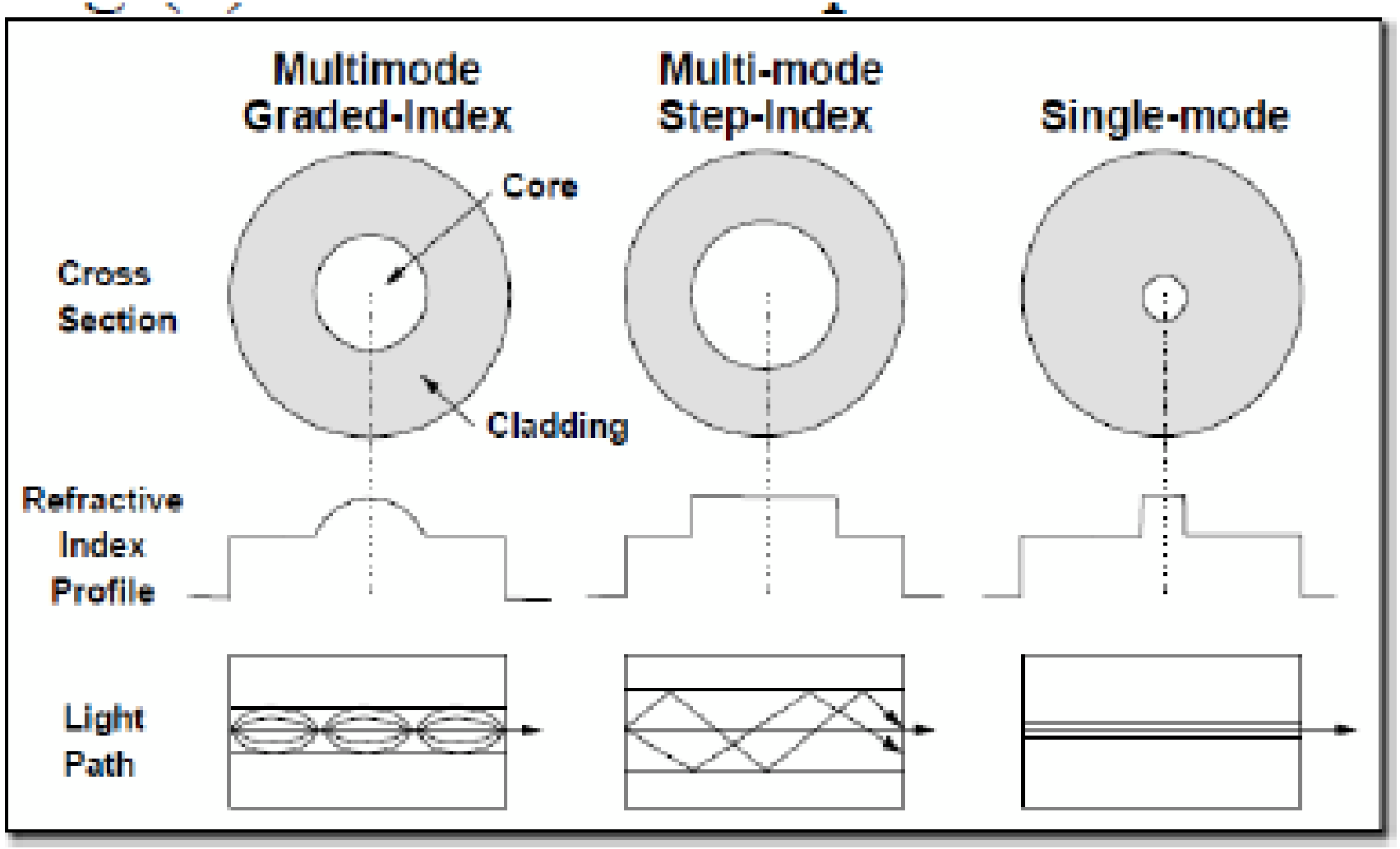


Multi-Mode Step-Index O.F.

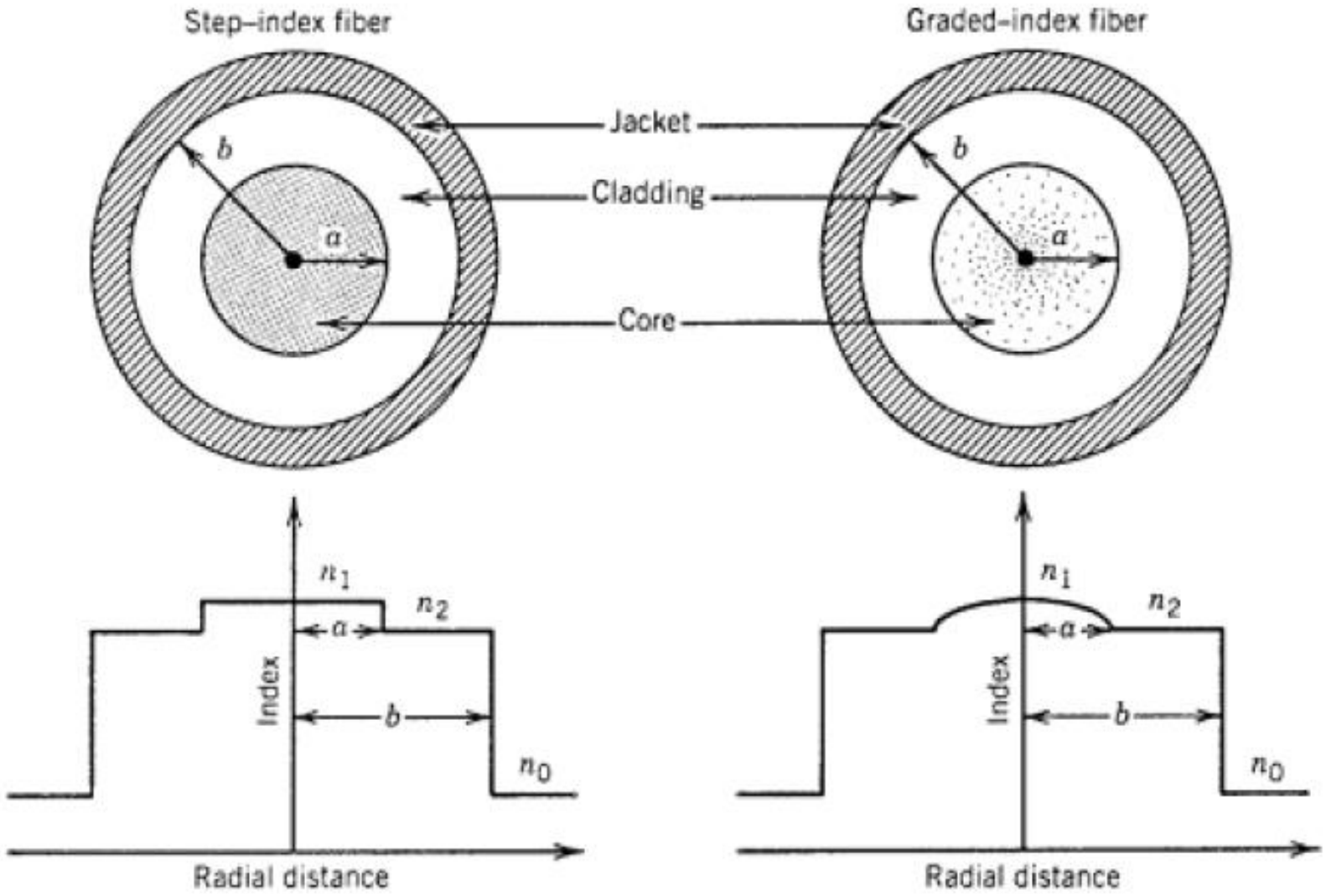
Multi-Mode Graded-Index O.F.

Single-Mode Step-Index O.F.

Types of optical fiber according to number of modes and refractive index profile



Types of optical fiber according to refractive index profile



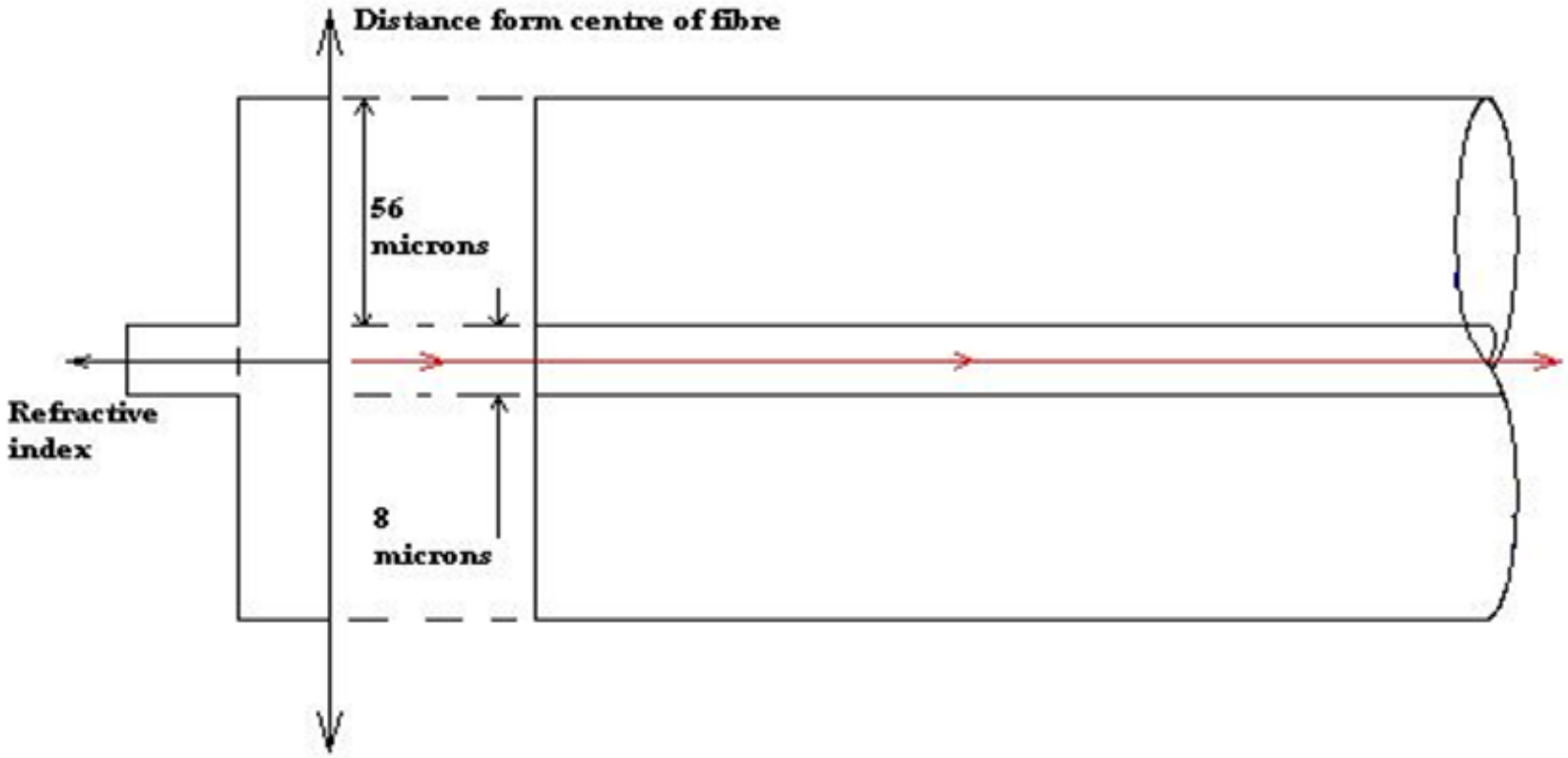
Types of optical fiber according to number of modes and refractive index profile

Thus, we have the following types

- Step index(SI)-single mode fibers(SMF)
- Step index(SI)-Multimode fibers(MMF)
- Graded index(GI)-Multimode fibers(MMF).

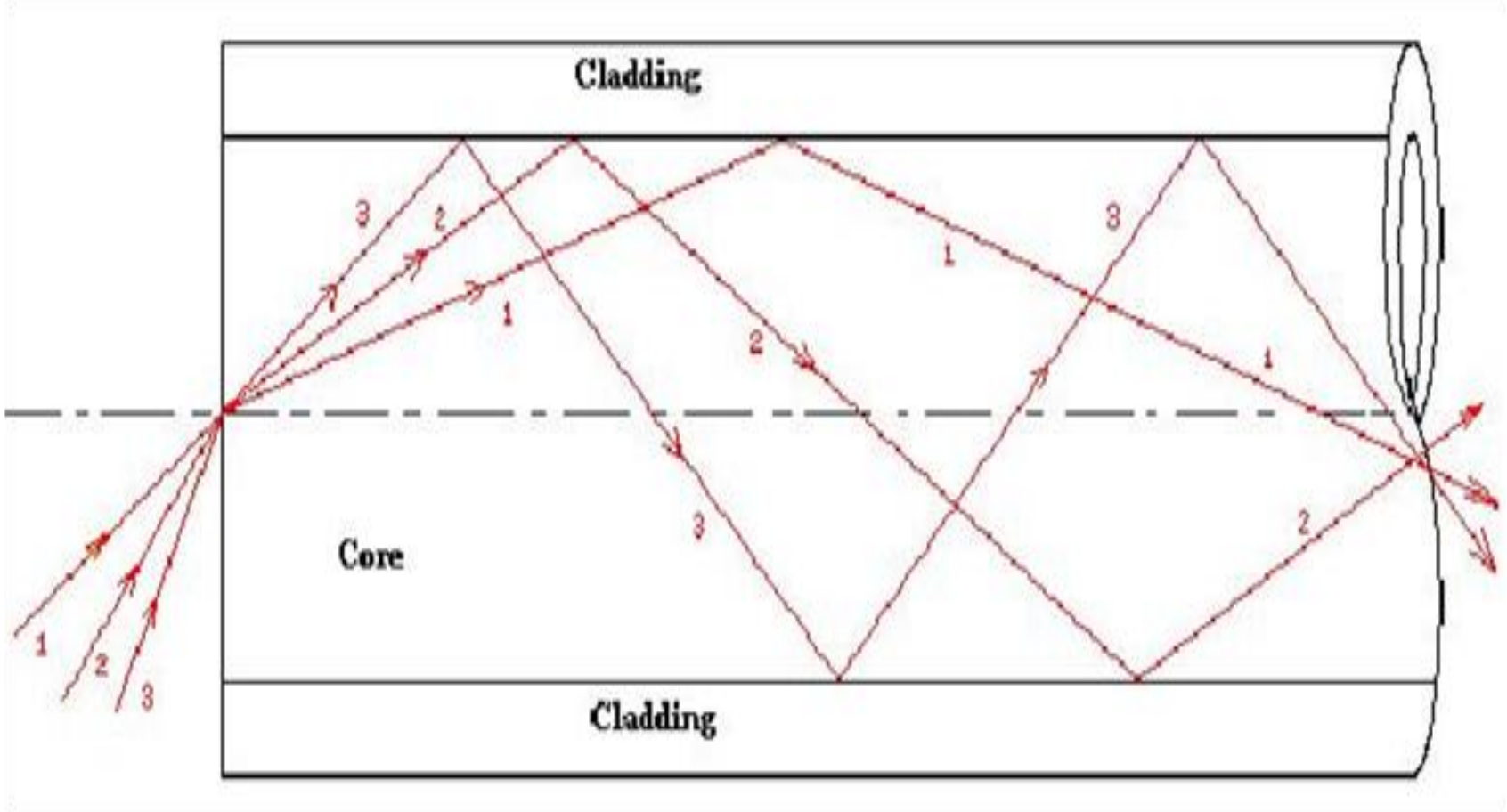
Single-Mode Fibers(SMF)

Step Index (SI)

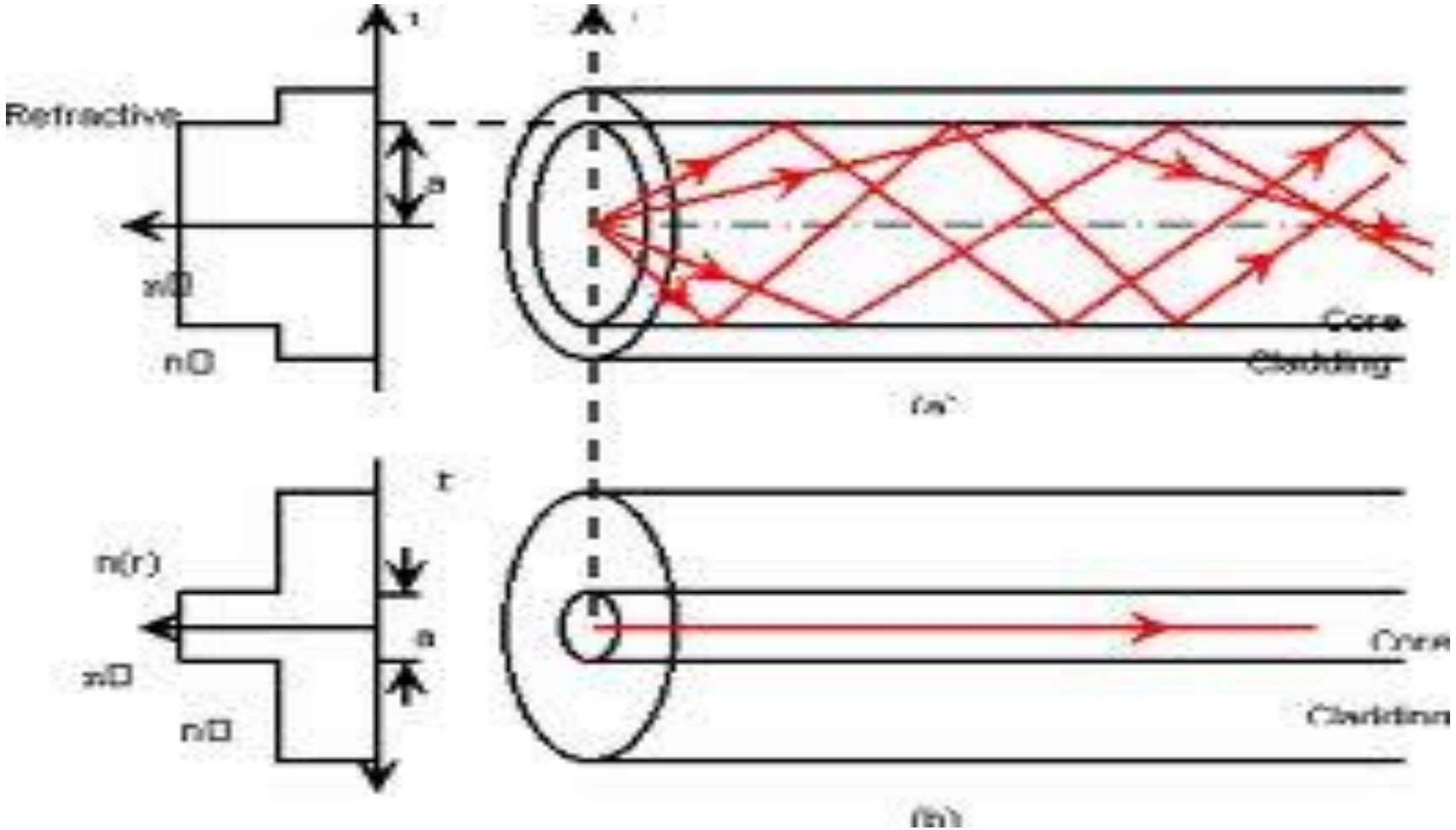


Multi-Mode Fibers (MMF)

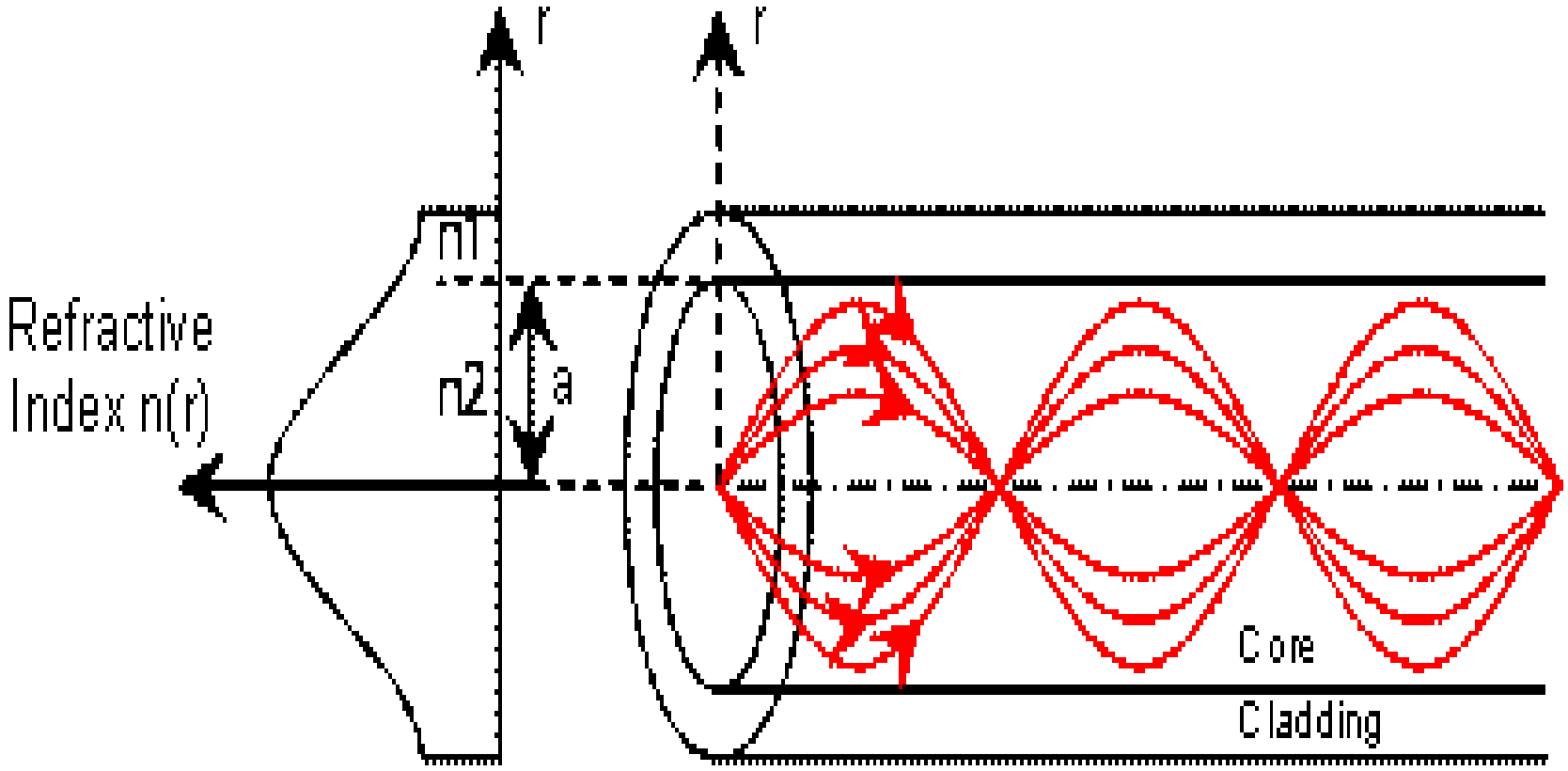
Step Index (SI)



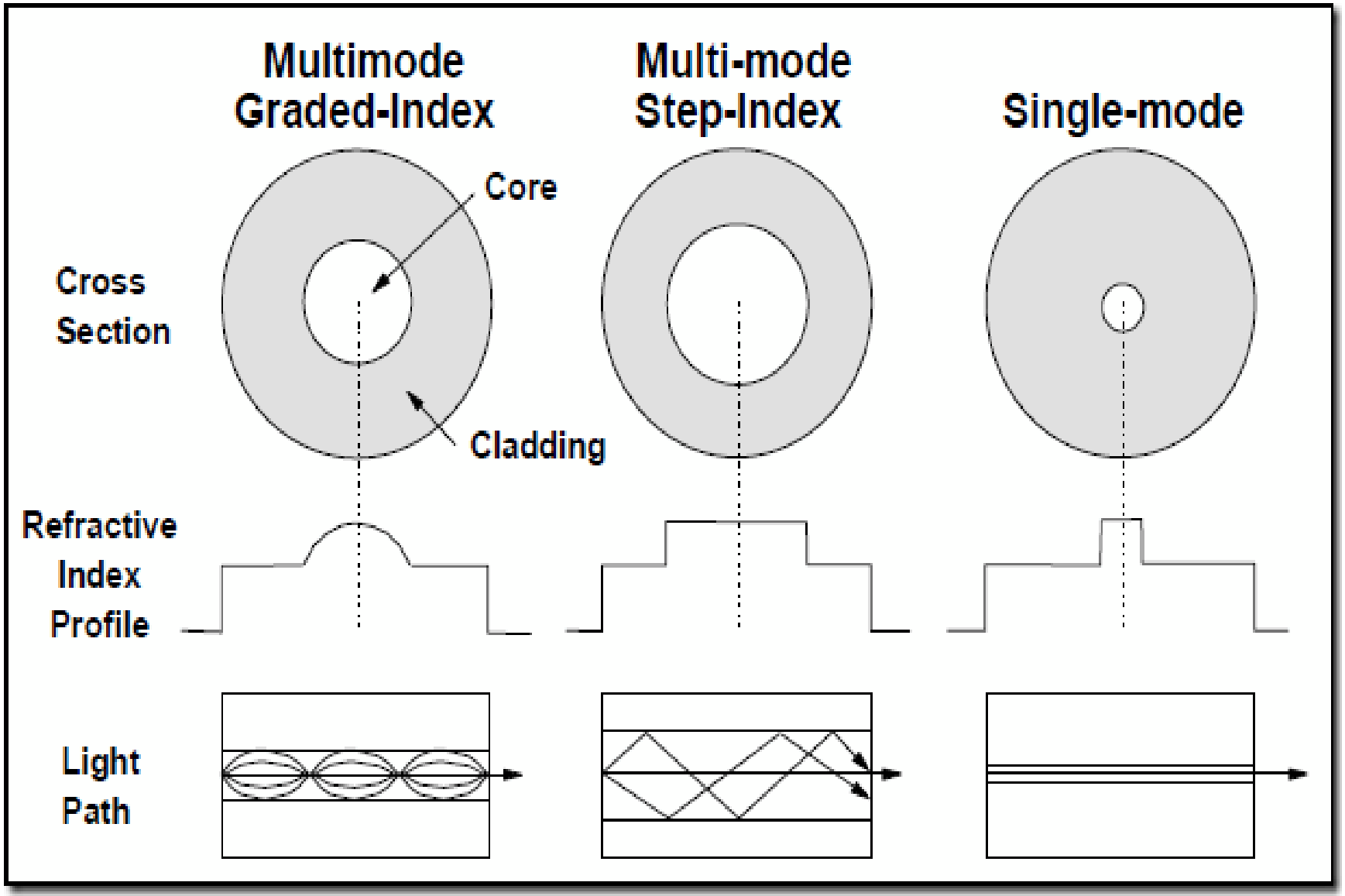
step index optical fiber



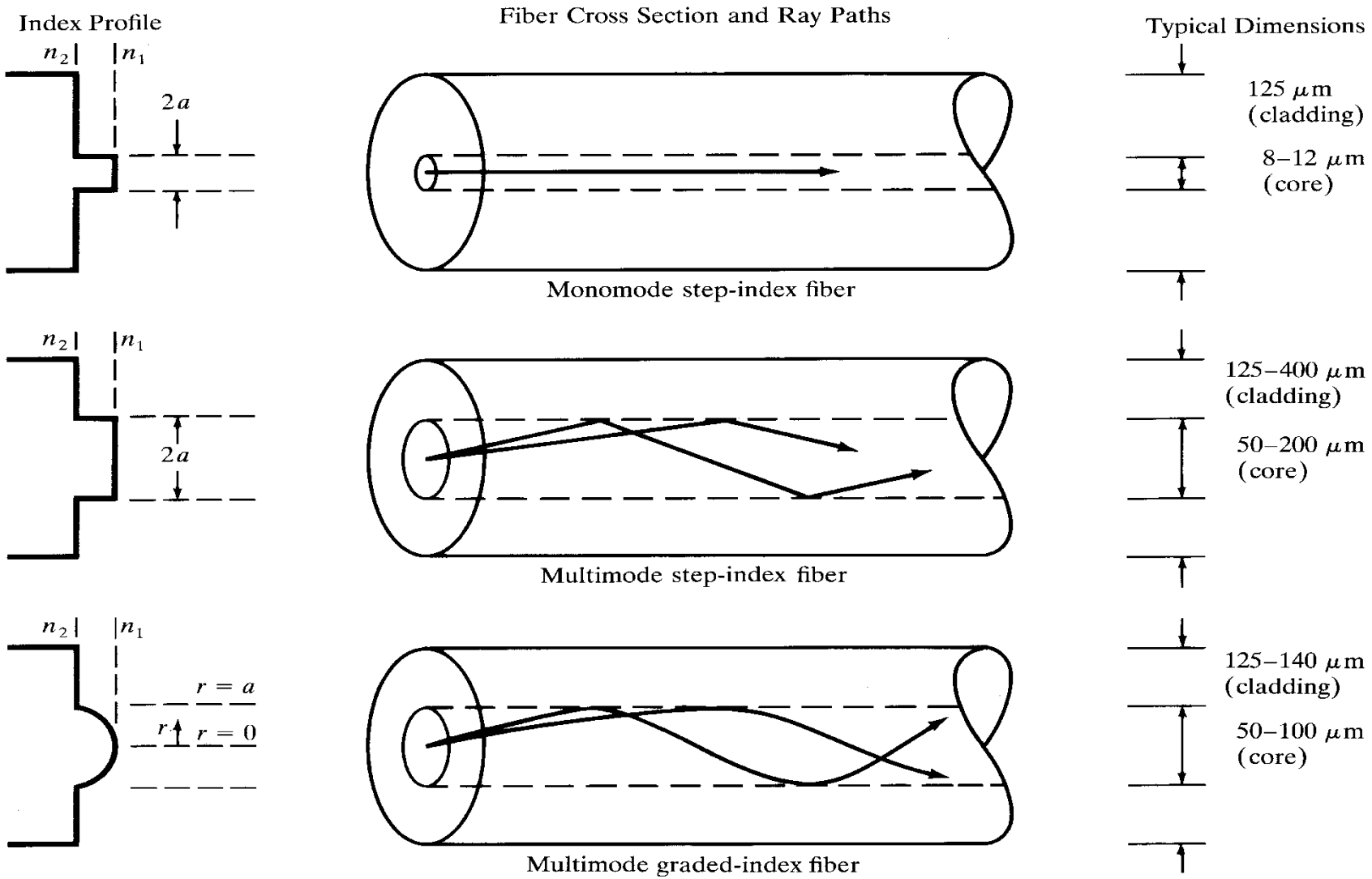
Graded index optical fiber



Optical fiber types



Optical fiber types



single mode fiber (SMF) step index (SI) Features

Advantages

- Permit utilize high power laser source.
- Low dispersion, and high bandwidth.
- Low loss (0.1 dB/km).

Disadvantages

- Cost (costly).
- Difficult to make.
- Difficult to couple light .
- A deeply directive light source (laser) is required to couple light.

Multimode fiber (MMF) step index (SI) Features

- A step change in index from core to cladding
- It has a high dispersion,
- Low bandwidth (50 MHz)
- Data rate is low for transmission of signal
- Signal is propagate in zigzag path.
- Its cost is lower than graded index.

Multimode fiber (MMF) graded index(GI) Features

- A gradual change of index form core to cladding is done.
- It has less dispersion.
- Low bandwidth (100 to 370 MHz),
- Data rate is high according to step index,
- Signal will follow predictable path .
- Its cost is higher than step index.

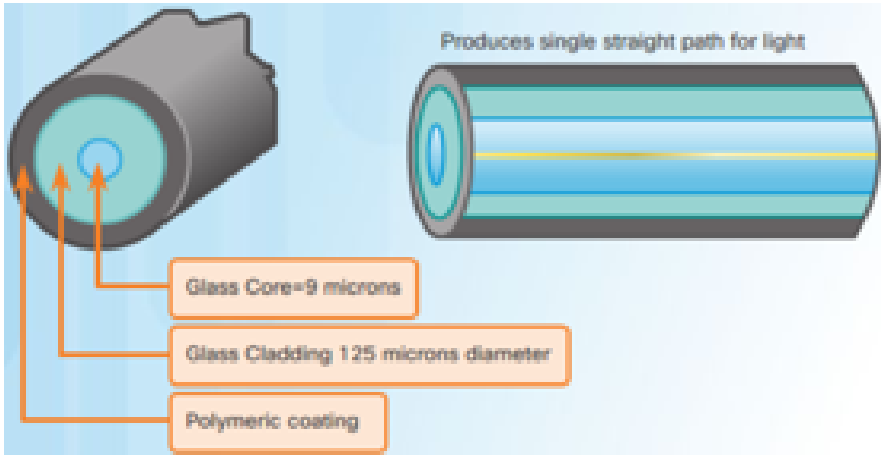
Comparison between single mode fiber (SMF) and multimode fiber (MMF)

SMF	MMF
Only one mode propagate via the core	Many or several modes (paths) propagate via the core
8:10 µm core diameter/125µm cladding diameter. Core diameter is small (8:10 µm)	50:62.5µm core diameter/125µm cladding diameter Core diameter is large (50:62.5 µm)
Laser diode (LD) is used as a photo source due to small core diameter	Light emitting diode(LED) is used as photo source due to large core diameter
It is used for longer distances.	It is used for shorter distance up to 4 Km
It support higher data rate. (5GHz.Km bandwidth distance product)	It support lower data rate. (100MHz.Km bandwidth distance product)
Expensive, difficult to maintain and difficult to couple light into and out of it	Cheap, simple to manufacture and easy to couple light into and out of it

Types of optical fiber

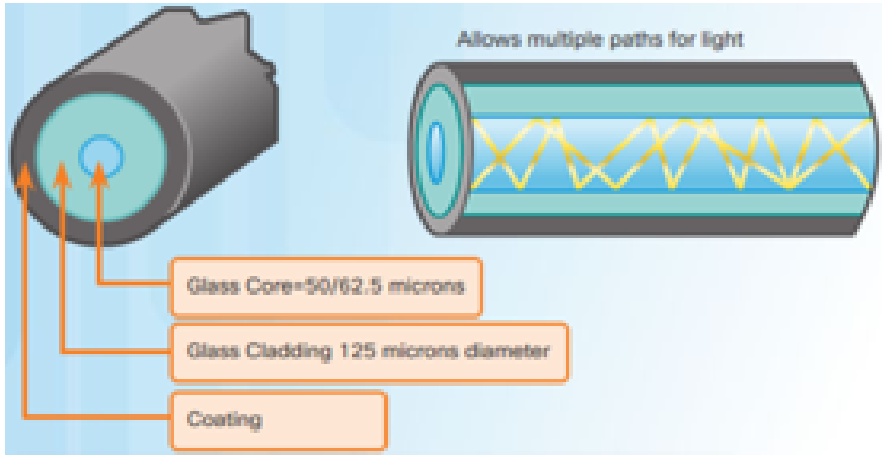
Types of Fiber Media

Single-Mode Fiber



- Very small core
- Uses expensive lasers
- Long-distance applications

Multimode Fiber



- Larger core
- Uses less expensive LEDs
- LEDs transmit at different angles
- Up to 10 Gbps over 550 meters

Coupling loss in optical fiber

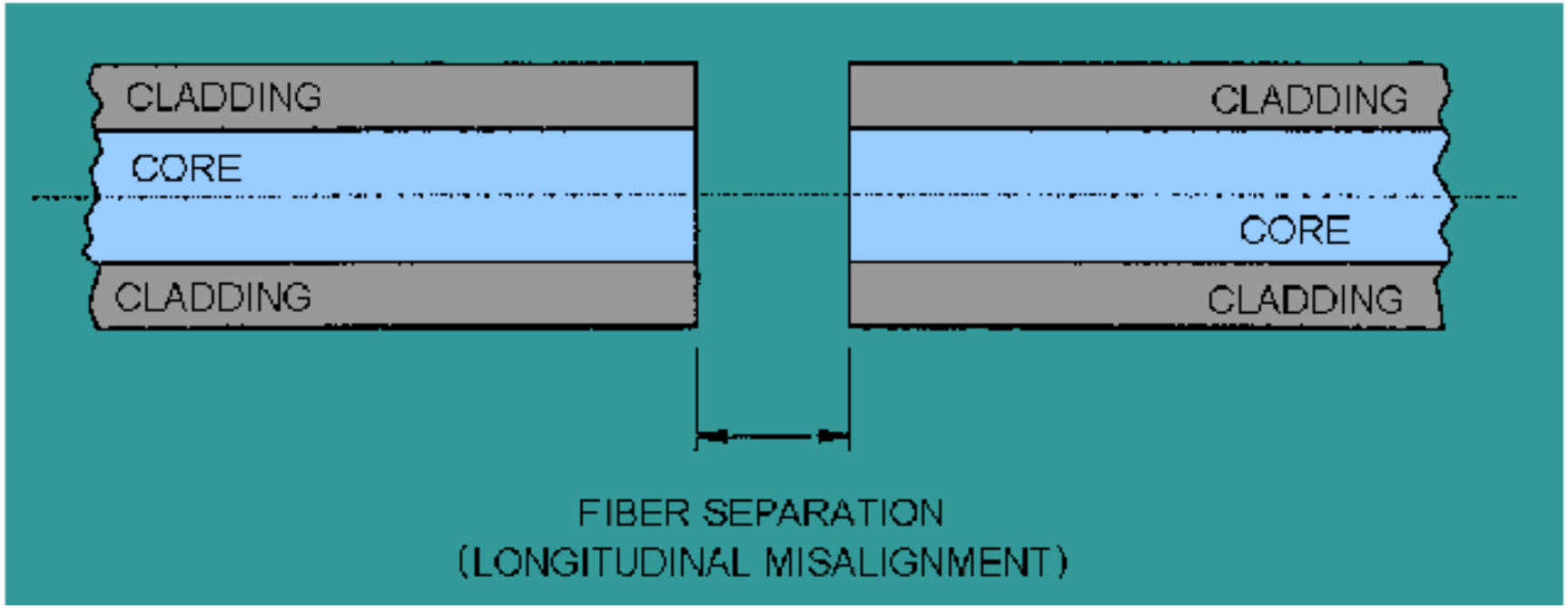
Extrinsic coupling loss

it includes the following:

- Longitudinal misalignment loss.
- Lateral misalignment loss.
- Angular misalignment loss.
- Surface edge irregulaities

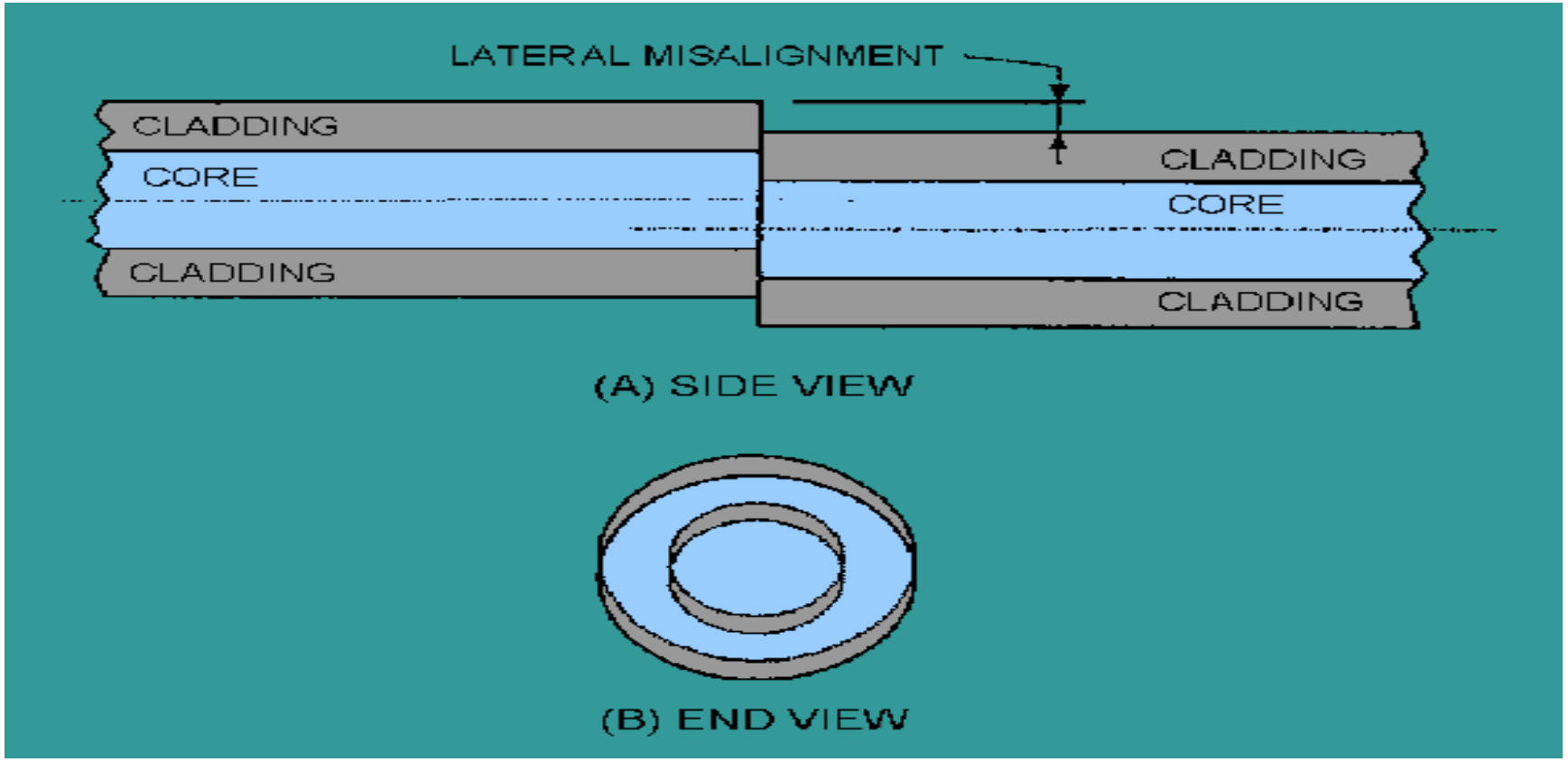
Longitudinal misalignment

when connecting two fiber, it occurs when the two fiber have the same axis but have a gap between their end faces.



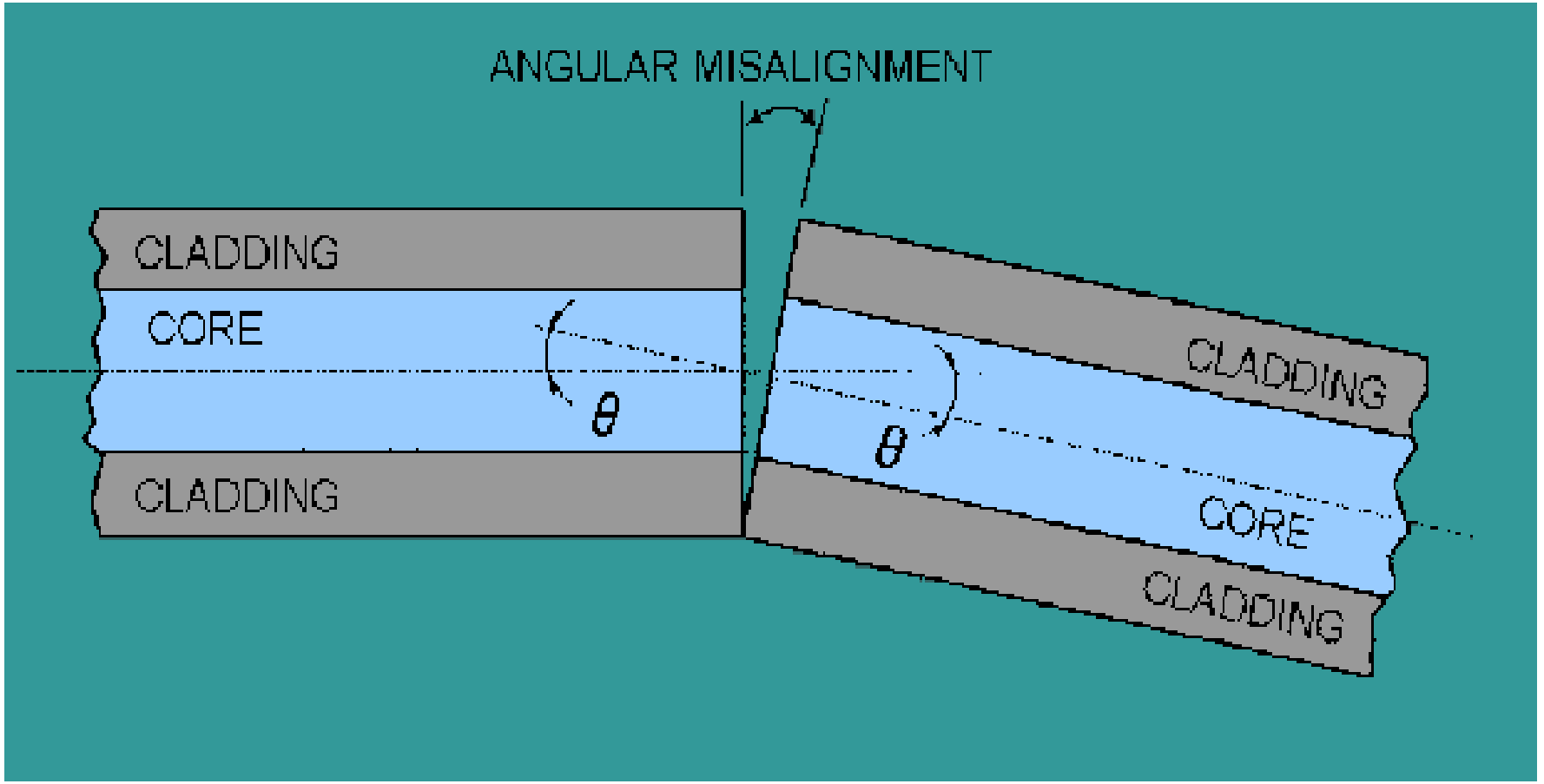
Lateral misalignment

when connecting two fiber, it occurs when the axes of the two fiber is separated by a distance d



Angular misalignment

When connecting two fibers, it occurs when the axes of the two fiber form an angle.



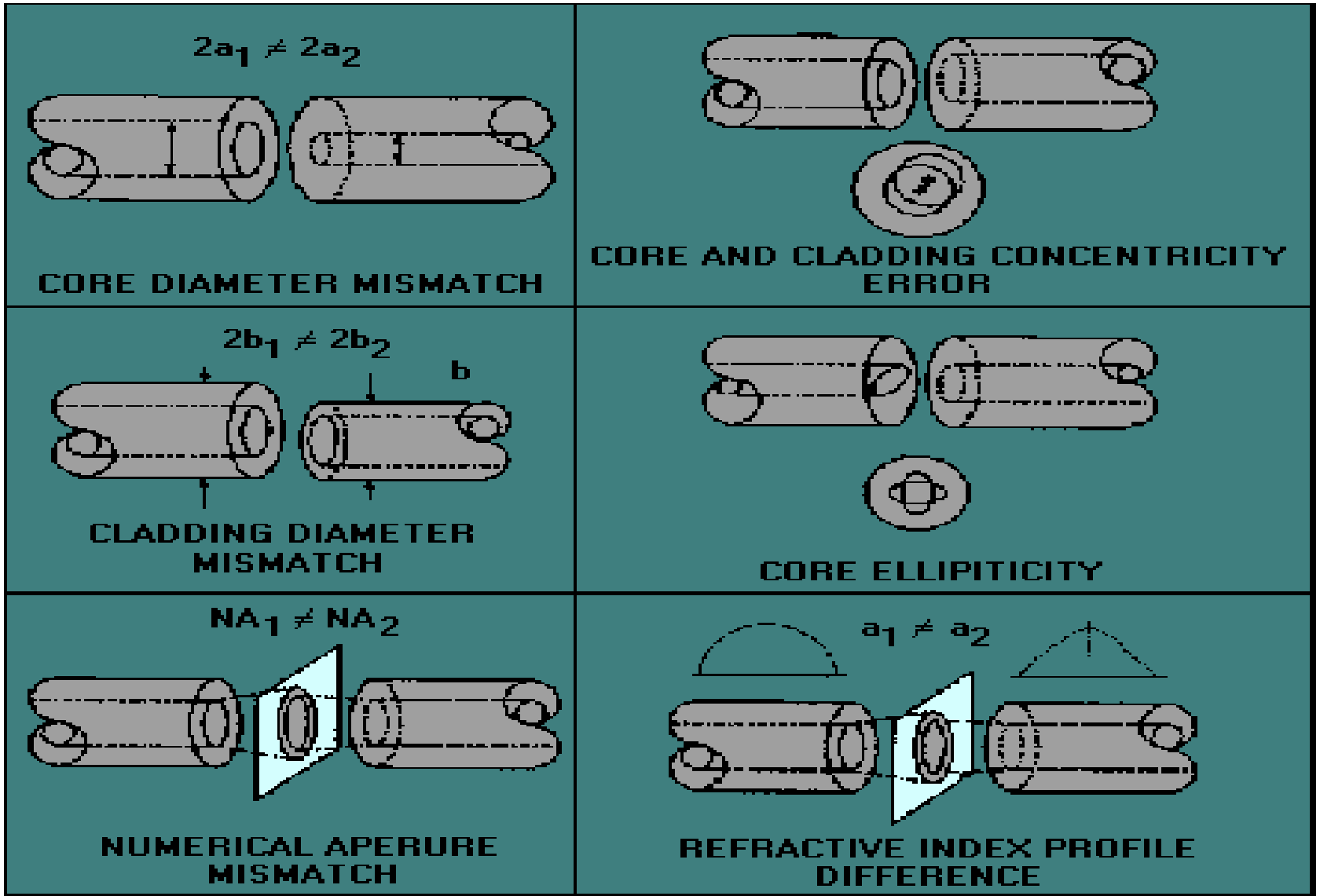
Coupling loss in optical fiber

intrinsic coupling loss.

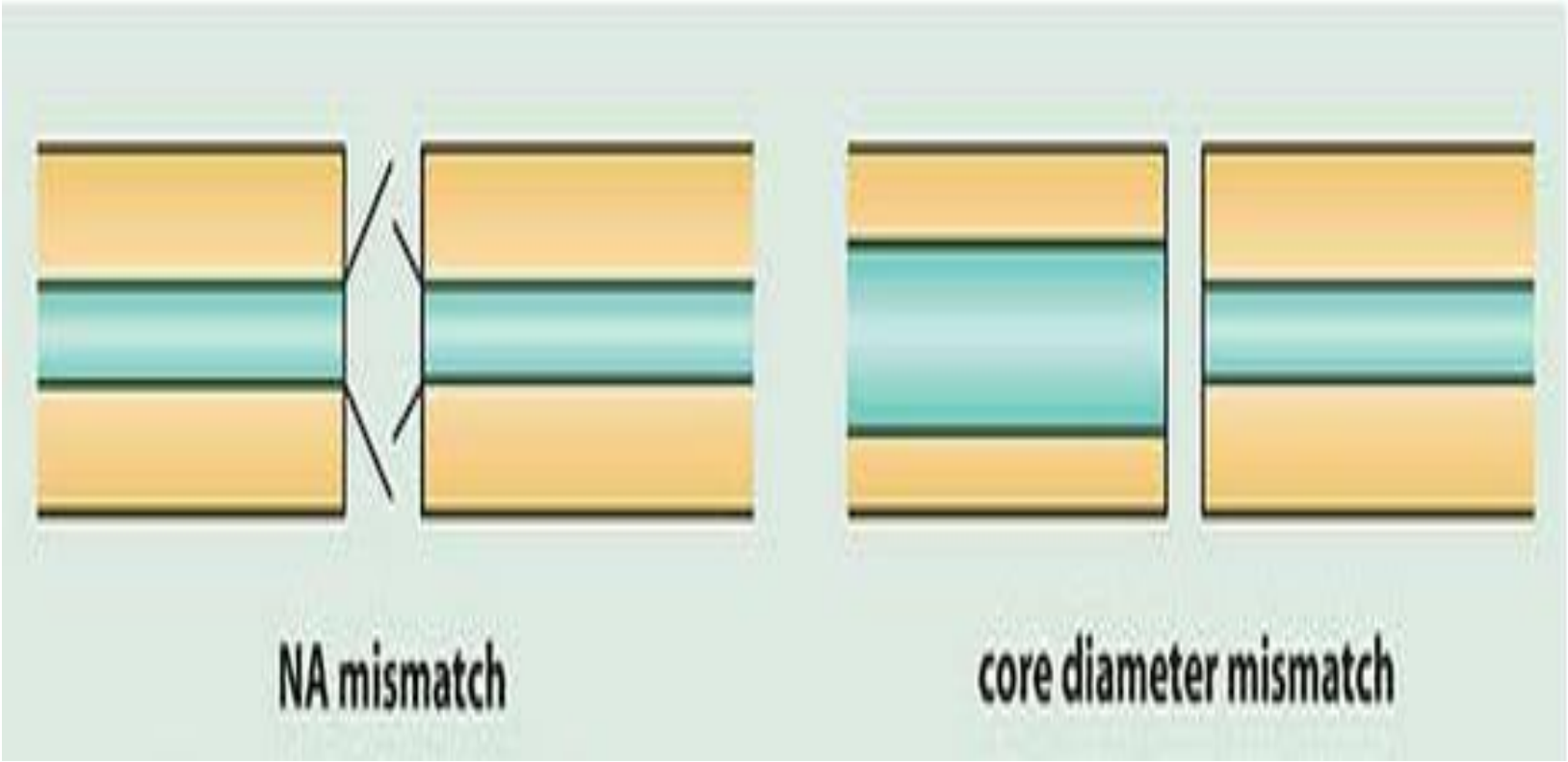
It include fiber geometry mismatches such as

- Core diameter mismatch.
- Cladding diameter mismatch.
- Numerical aperture (NA) mismatch.
- Core-cladding concentricity differences.
- Core ellipticity, and
- Rrefractive index profile difference

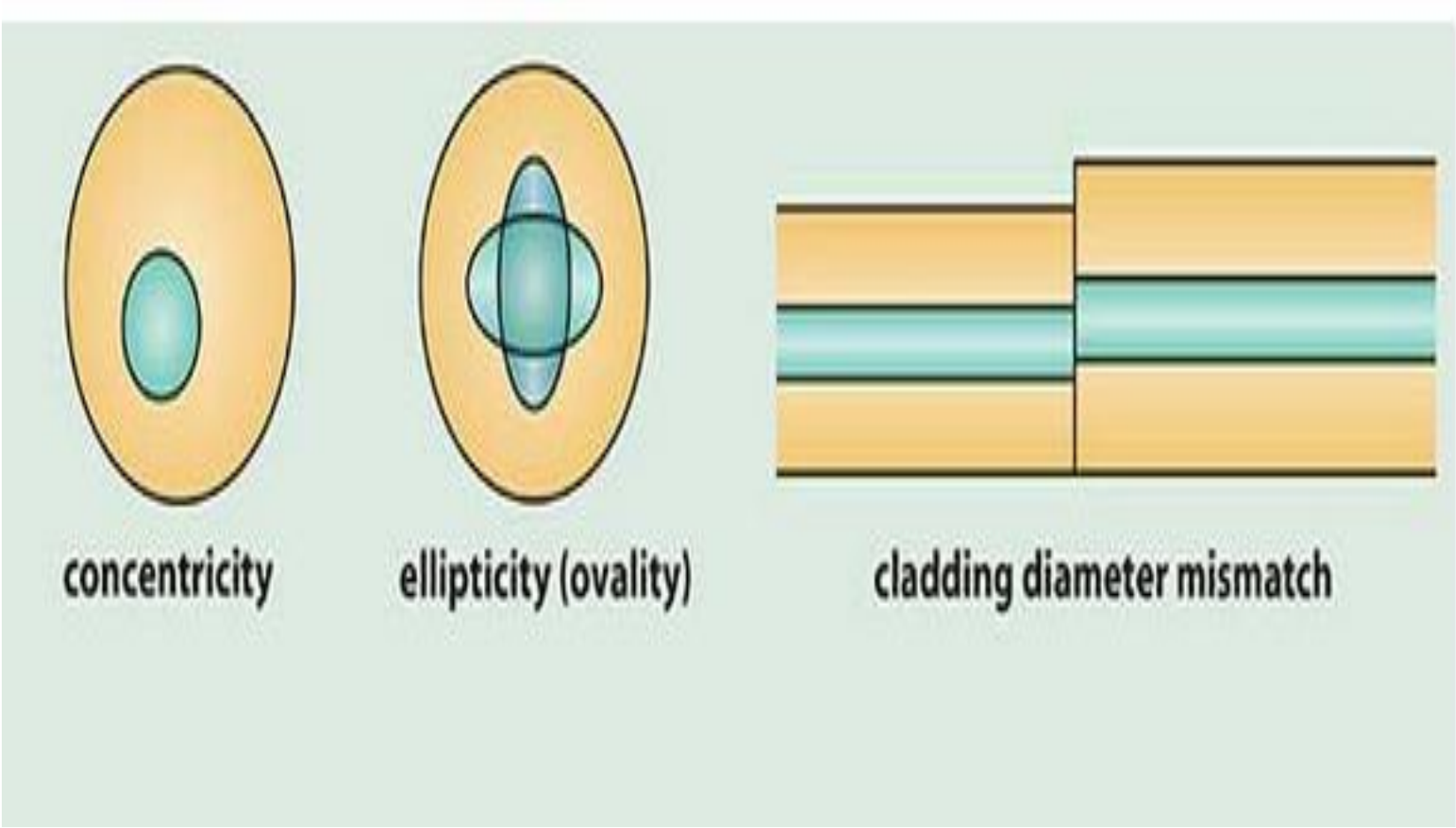
Coupling loss in optical fiber



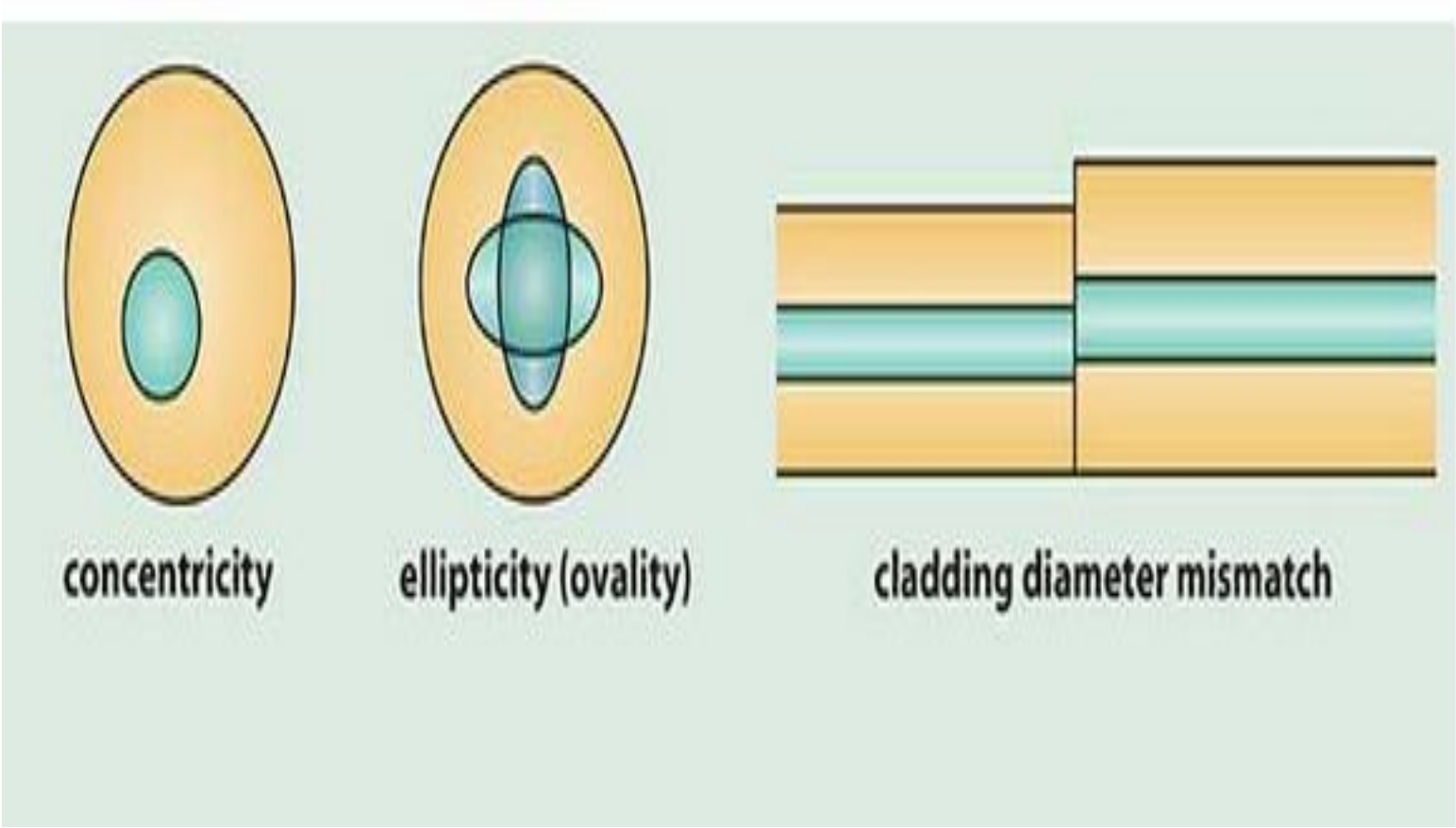
Coupling loss in optical fiber



Coupling loss in optical fiber



Coupling loss in optical fiber



Optical fiber connectors

There are four types of fiber-optic connectors:

- Straight-tip (ST) Connectors
- Subscriber Connector (SC) Connectors
- Lucent Connector (LC) Simplex Connectors
- Duplex Multimode LC Connectors

Optical fiber connectors

Fiber-Optic Connectors

Straight-Tip (ST) Connectors

Lucent Connector (LC) Simplex Connectors

Subscriber Connector (SC) Connectors

Duplex Multimode LC Connectors

Optical fiber patch cords

Fiber-optic patch cords include SC-SC multimode, LC-LC single-mode, ST-LC multimode, and SC-ST single-mode.

Optical fiber Applications

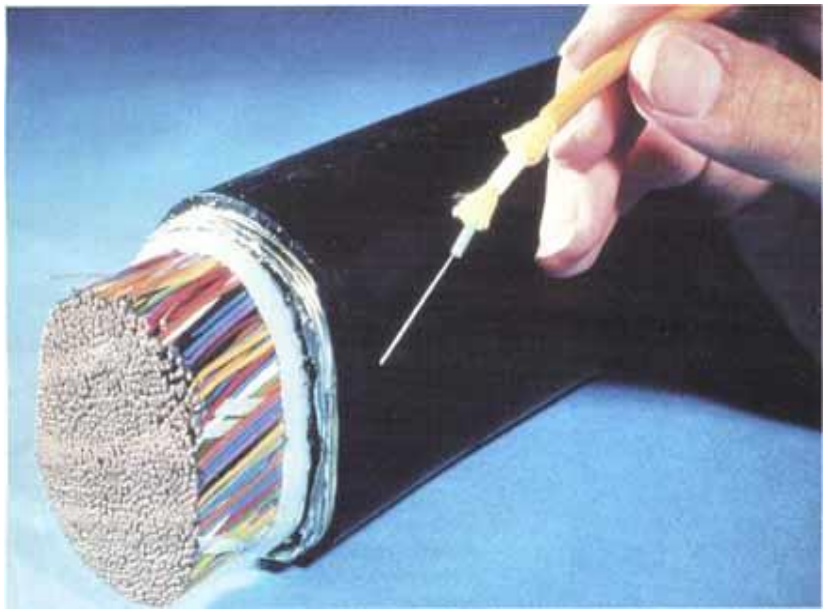
1. Long distance communication backbones.
2. Broadband applications regardless of distance (LAN).
3. Video transmission – cable TV system and online streaming.
4. Control system especially in high voltage or nuclear environment.
5. Medical application.

Fiber optic applications

Almost all guided systems use optical fiber cables

- long hauls.
- intercity.
- metropolitan area.
- LAN.

-New local loops using FTTx technology.



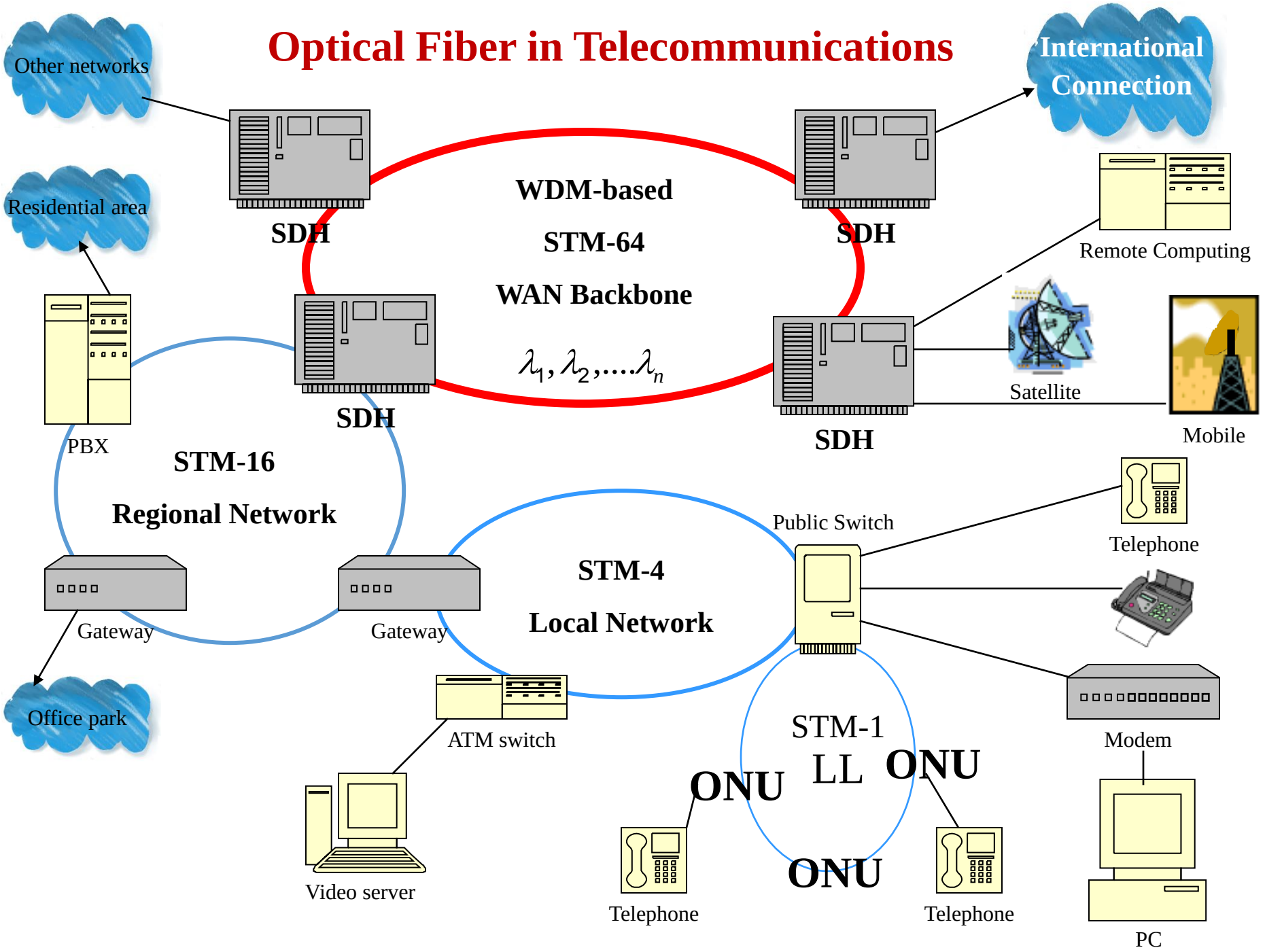
Fiber optic Applications

- **Short distance low bit rate:**

Use step index (SI) Multi mode fiber (MMF)

- **Short distance high bit rate**
  - Graded index (GI) profile Single Mode fiber (SMF) :better system maintenance.
  - Graded index (GI) multi mode fiber (MMF) : better system running cost than single mode fiber
- **Very high bit rate regardless of the distance**
  - Step index (SI) Single Mode fiber (SMF)
- **Very high bit rate, long haul communications**
  - DSF fiber with EDFA

Optical Fiber in Telecommunications



Multiplexing in optical fiber(WDM/DWDM)

- In optical fiber systems, multiplexing occurs. **Multiplexing** means transmission of several signal simultaneously over the same channel.
- There are **WDM** **W**avelength **D**ivision **M**ultiplexing for smaller number of wavelengths and **DWDM** **D**ense **W**avelength **D**ivision **M**ultiplexing for higher number of wavelengths.

Multiplexing in optical fiber

- **SONET** means **S**ynchronous **O**ptical **NET**work. It is American standard.
- **SDH** means **S**ynchronous **D**igital **H**ierarchy. It is European counterpart standard of SONET.
- Both SDH and SONET are compatible with each other.

Multiplexing in optical fiber

- **STM -1** means **s**ynchronous **t**ransport **m**odule-level 1. It is the basic signal of the SDH and has data rate **155.52 Mbps**. Higher rate signal are multiple of this rate.
- **STS-1** means **s**ynchronous **t**ransport **s**ignal level-1 and has data rate **51.84** Mbps. STS-N is obtained by byte interleaving of N STS-1

Multiplexing in optical fiber

The SONET and SDH standards

SONET	**SDH**	Data rate (Mbps)
STS-3	STM-1	155.52
STS-12	STM-4	622.08
STS-48	STM-16	2488.32
STS-192	STM-64	9953.28

Multiplexing in optical fiber

- **Optical Network Unit (ONU)/Optical Network Termination (ONT)** converts optical signals transmitted via fibers to electrical signals.
- ONU /ONT refer to the consumer end equipment in an optical Fiber to the Home (FTTH) link.
- Sometimes ONU and ONT are the same devices. The only difference is that ONT is always placed in the user's home, while ONU can be placed in either the user's home or in the provider's central office.