Special lecture on Fiber Optics

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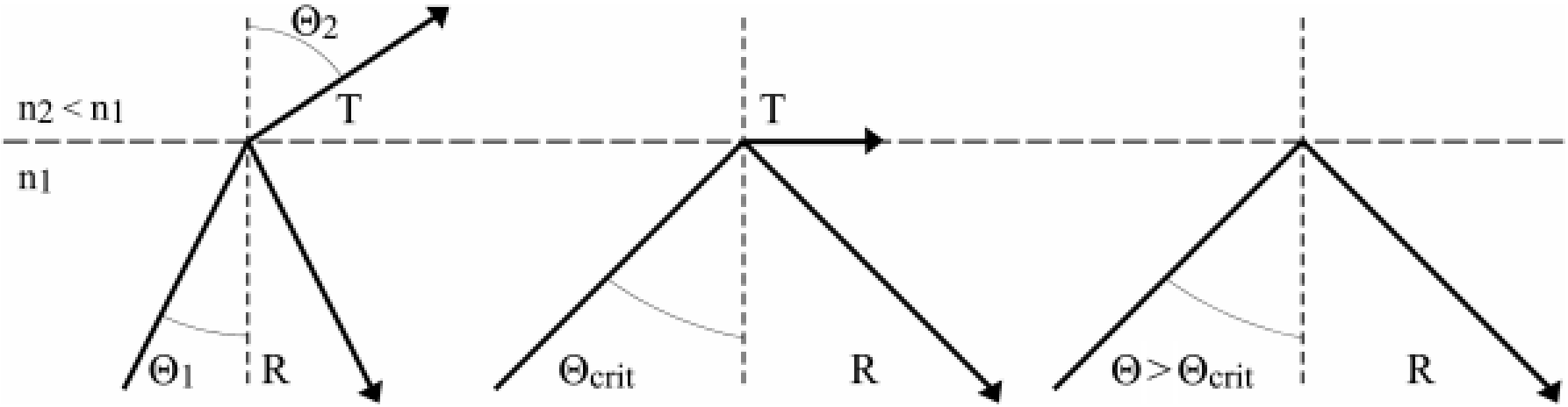
FIBER OPTICS

- Fiber optics deals with the
  emission,
  transmission &
  detection
  of light waves using optical fibers.

- Principle: Total Internal Reflection
- The refractive index, $n = \sin i / \sin r = c/v$
- Fiber is structured with materials of varying n.(n core › n cladding)
- Fiber acts as a cylindrical dielectric(Silica) wave guide.
- Light entering the fiber total internal reflection & comes out through the other end with min(zero) energy loss.

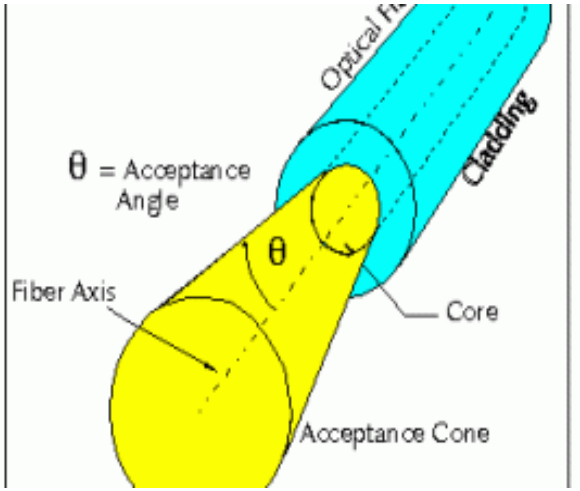
Total Internal Reflection



Important Parameters

- Acceptance angle: The angle with which the incident ray from the source is launched into the fiber so as to produce total internal reflection.
- Numerical aperture: It is the measure of the amount of light rays that can be accepted by the fiber. NA is represented in terms of n_1 & n_2.(n of core & cladding)
- Relation connecting AA & NA

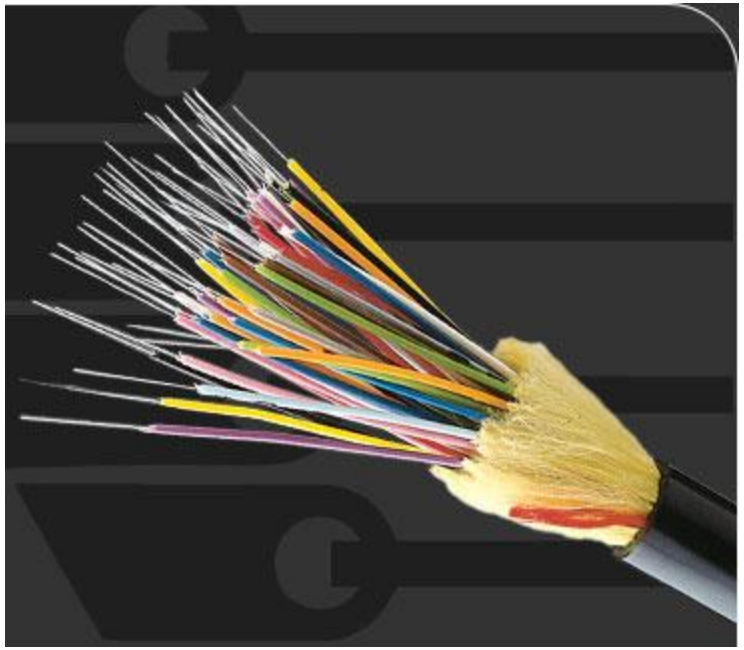
$$\sin(\phi_A) = NA = \sqrt{(n_1^2 - n_2^2)}$$



Structure of optical fiber

Basic components of an optical fiber

1. Core
2. Cladding
3. Primary coating
4. Buffer jacket
5. Strength member
6. Outer jacket
7. Filler material



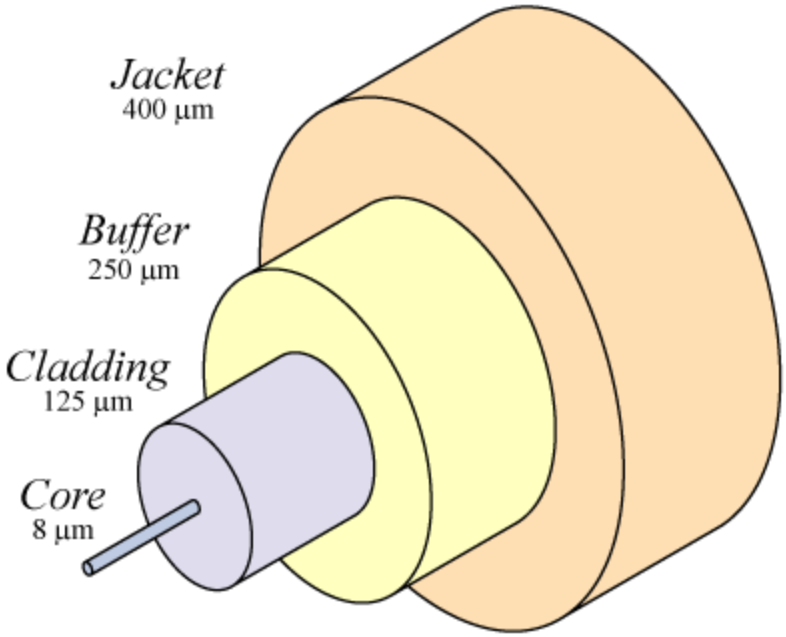
Structure of optical fiber

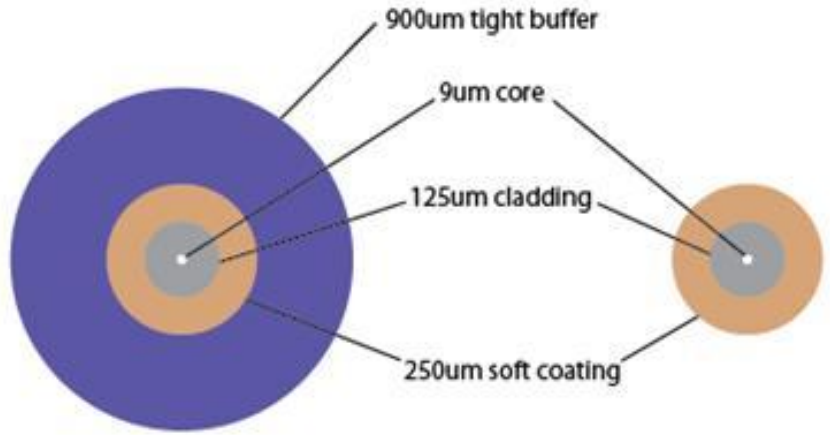
- 1&2. Core & cladding:
  - Silica/silicates/ ultra pure glass rods(preforms)
  - n=1.458 & can be varied by changing dopant concentration
  - GeO_2,P_2O_5 to increase n & B_2O_3 to decrease n
  - Toughness & durability are important
- 3. Primary coating:
  - A thin polymer coat over cladding by dipping or spraying technique
  - Gives additional strength to fiber & prevents chemical attack
  - KYNAR –Vinylidene Fluoride Polymer is used
- 4. Buffer Jacket:
  - To avoid micro bends(to reduce bending stress)
  - Designed based on indoor or out door applications

Structure of optical fiber

- 5. Strength member:
  - To provide flexibility
  - To avoid elongation/contraction of fibers
  - Aromatic polymers, Nylon, Glass fibers
- 6. Outer jacket:
  - To give productive outer layer
  - To increase mechanical strength of fibers
  - To provide water resistance effects
  - Poly ethylene, Polyurethane
- 7.Filler materials
  - To give stiffness & to provide moisture resistance
  - Specially formulated Silicone Rubber

Structure of optical fiber





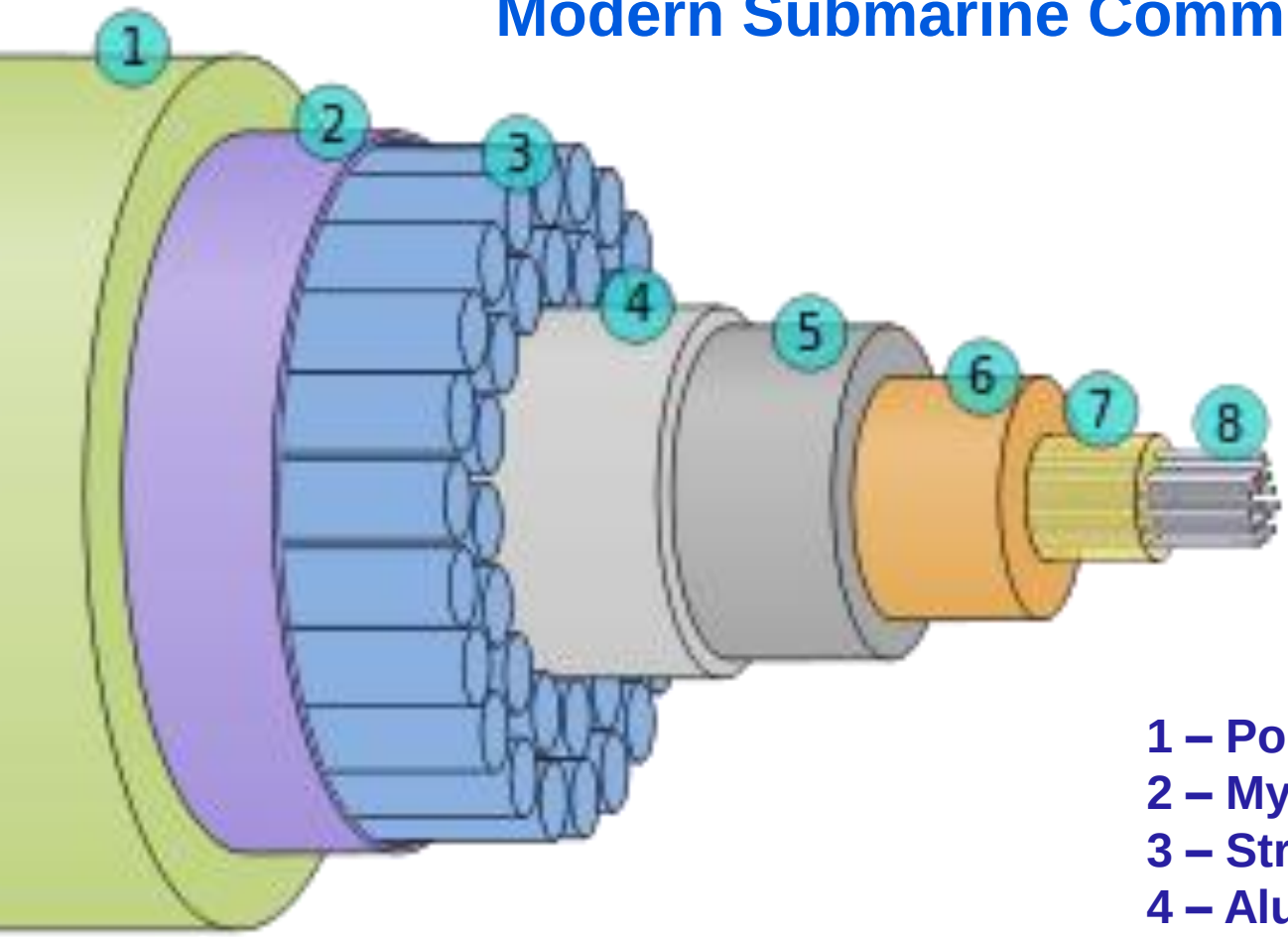
900um Tight Buffered Fiber

250um Coated Fiber

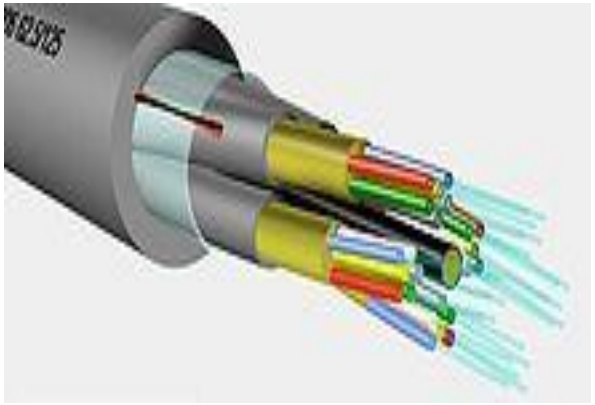
Note: Coated fiber is also called "bare fiber"

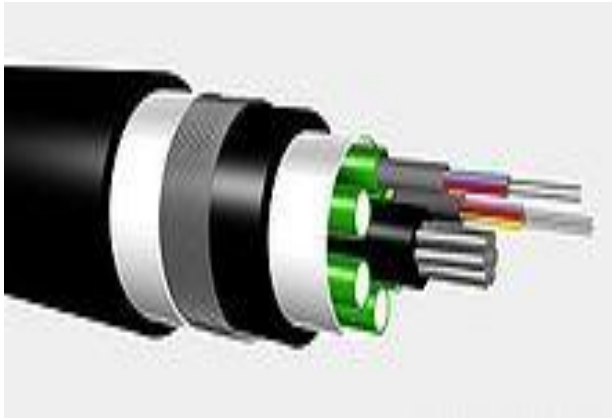
The Difference Between Tight Buffered Fiber and Coated Fiber

Modern Submarine Communications Cable



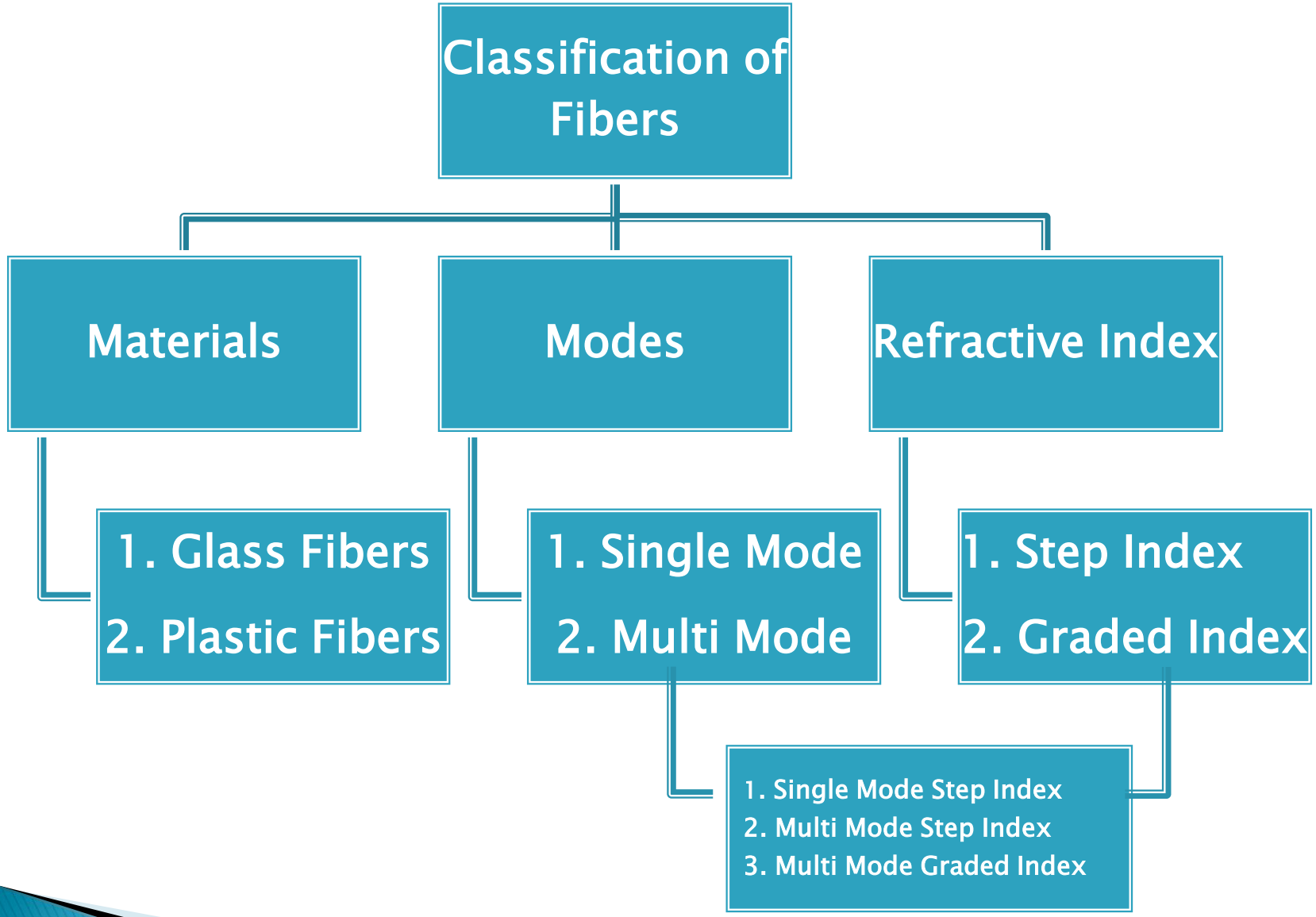
1 – Polyethylene
2 – Mylar tape
3 – Stranded steel wires
4 – Aluminium water barrier
5 – Polycarbonate
6 – Copper or Aluminium tube
7 – Petroleum jelly
8 – Optical fibers

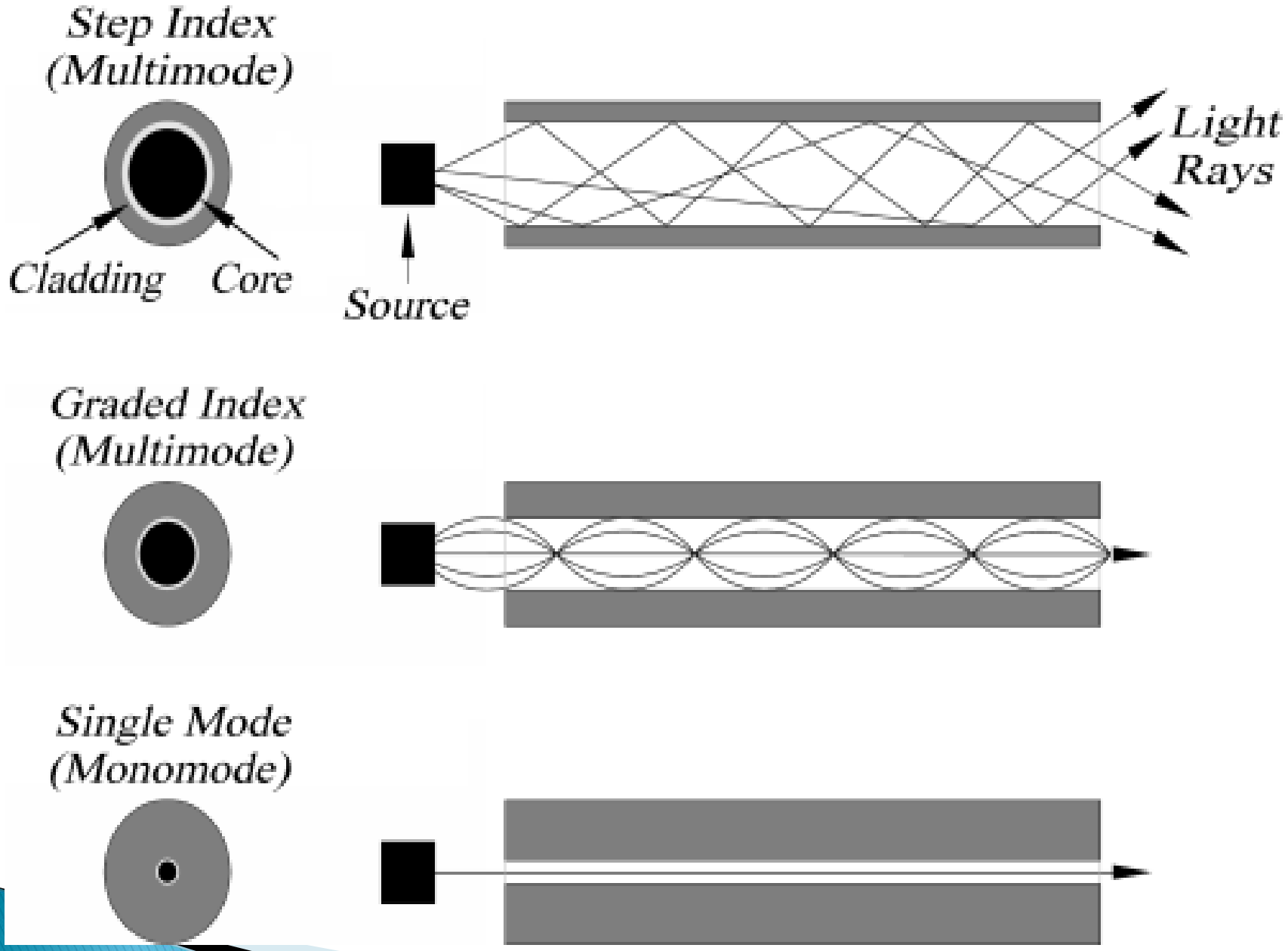


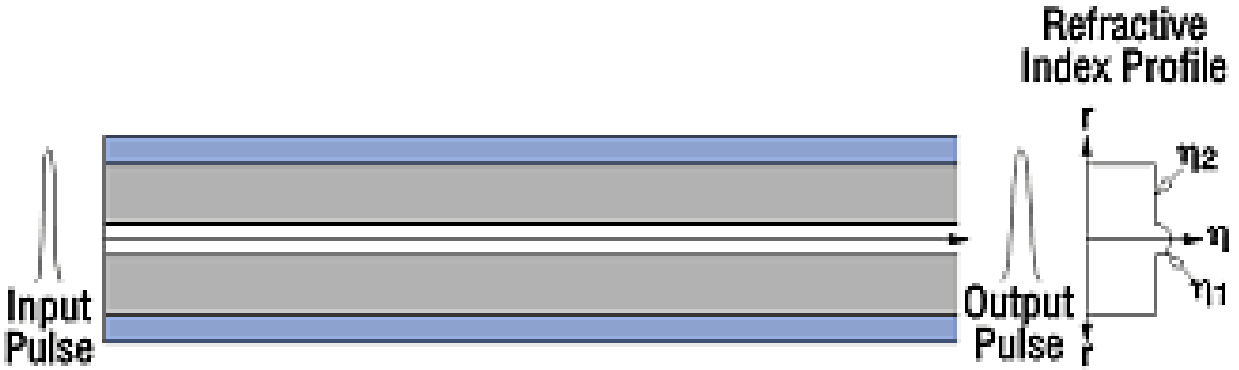


Color coding of Premises Fiber Cable

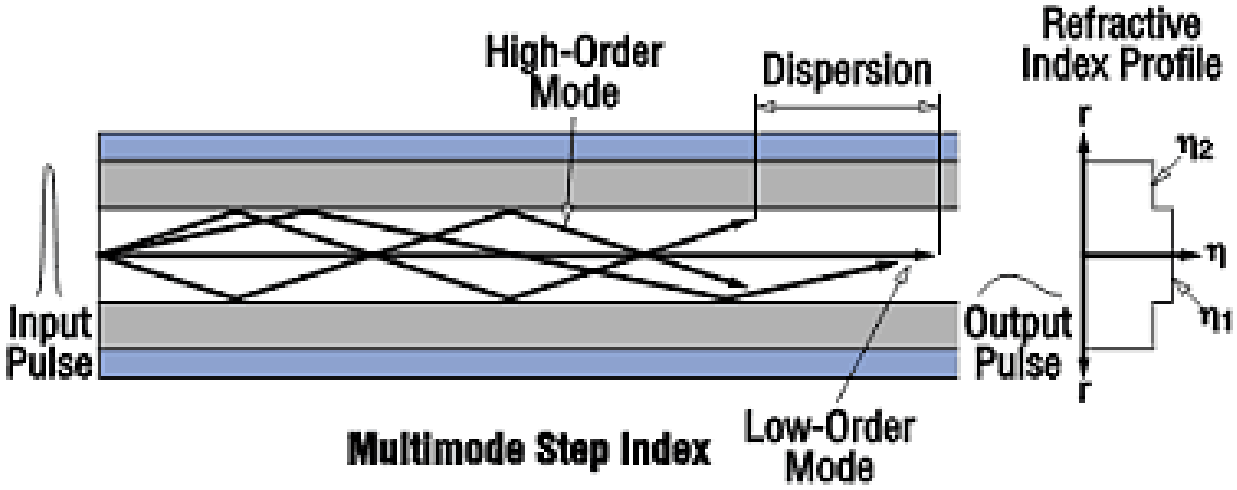
Fiber Type / Class	Diameter (µm)	Jacket Color
Multimode 1a	50/125	Orange
Multimode 1a	62.5/125	Slate
Multimode 1a	85/125	Blue
Multimode 1a	100/140	Green
Singlemode IVa	All	Yellow
Singlemode IVb	All	Red


Classification of Fibers
Materials
Modes
Refractive Index
1. Glass Fibers
2. Plastic Fibers
1. Single Mode
2. Multi Mode
1. Step Index
2. Graded Index
1. Single Mode Step Index
2. Multi Mode Step Index
3. Multi Mode Graded Index


Step Index
(Multimode)
Cladding
Core
Source
Light
Rays
Graded Index
(Multimode)
Single Mode
(Monomode)



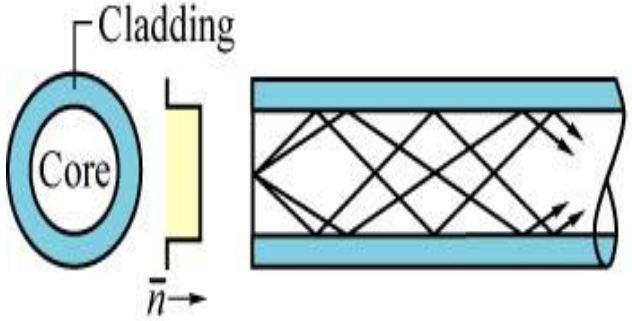
Single-Mode Step Index



Multimode Step Index

(a) ***Step-index multimode fiber***

Simple coupling; large modal dispersion

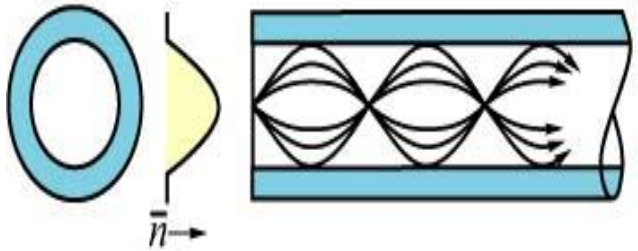


Typical diameters and refractive indices

Core/cladding diameter	62.5/125, 100/140, ... , 1000/1200 μ
Core index	1.45
Index difference	1 % – 2 %

(b) ***Parabolically-graded-index multimode fiber***

Simple coupling; difficult fabrication; low or zero modal dispersion



Core/cladding diameter	50/125, 62.5/125, 85/125
Core index at center	1.45
Index difference	1 % – 2 % in graded index profile

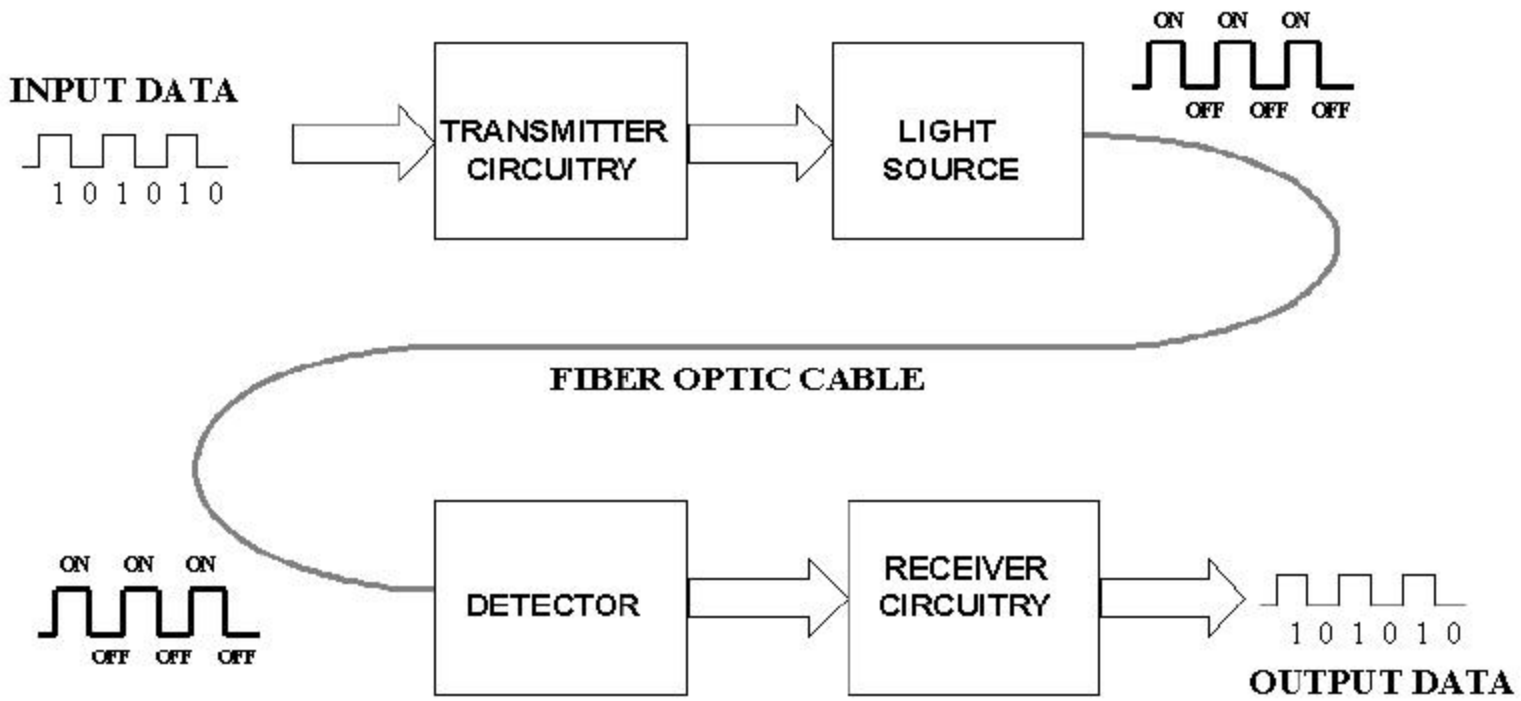
FIBER OPTIC COMMUNICATION

- In the field of communication to transmit
  Voice signals(audio)
  Picture signals(video)
  Data signals(digital)
  from one place to another fibers can be used.
- Tried by John Tyndall in 1870 & practiced from1927
- The information carrying capacity is $\propto$ to γ of light used.
  Cu wire: 48 independent signals
  Fiber : 15,000 or more simultaneously
- Principle: Total internal reflection

Advantages of fiber optic communication

1. Wider bandwidth
2. Low transmission loss
3. Electrical isolation
4. Immunity to cross talk
5. No electro magnetic interference
6. Signal security
7. Small size & lesser weight
8. Flexibility& ruggedness
9. System reliability
10. Low cost

FIBER OPTIC COMMUNICATION



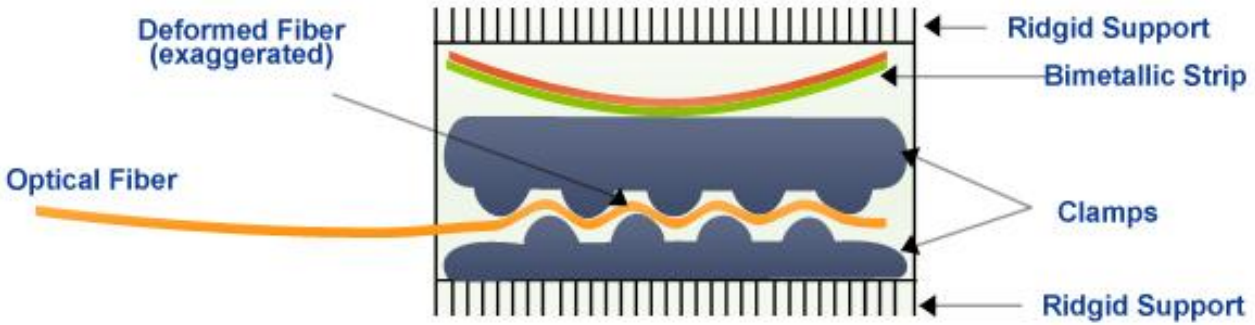
Applications of fiber optic communication

- Best communication devices–larger bandwidth
- Defence communications–signal security
- Digital data transfer– huge data transfer
- Safety devices/Alarms– immunity to cross talk & electrical isolation
- Electronic instrumentation/automated instruments– reliability

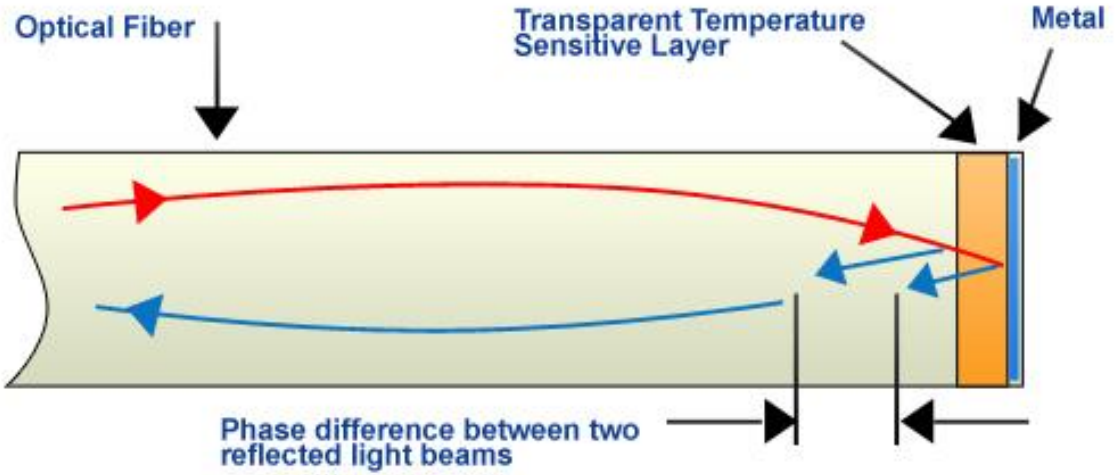
Applications of fiber optic communication

- **Fiber Optic Sensors:**
  - Intensity modulated sensors–variation of light intensity
  - Phase sensors–phase variations in signal
  - Diffraction grating sensor– changes in diffraction pattern
  - Pressure & displacement sensors
  - Presence sensors

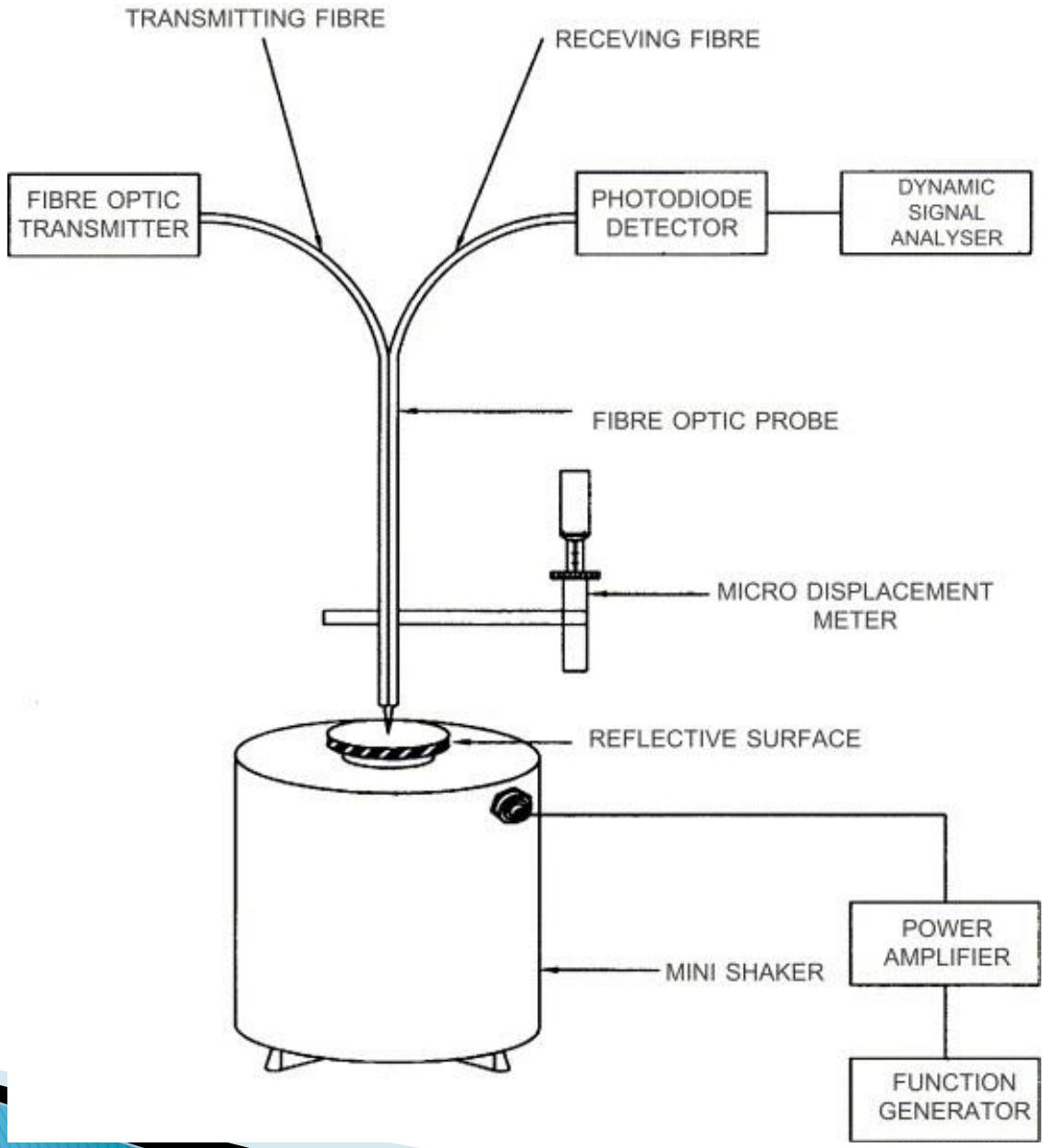
Fiber Optic Temperature Sensor Using Fiber Deformation



Fiber Optic Temperature Sensor Using Phase Interference



Displacement Sensor



Thank You