OPTICAL FIBER JOINTS & CONNECTOR-II

OPTICAL FIBER JOINTS

- Technical requirement for both jointing & termination of transmission media

- **Number of Joints or Connections**
  - Link length between repeaters
  - Continuous length of fiber
  - Length of fiber cable practically or conveniently installed as continuous length

- **Repeaters Spacing** (A continuously increasing parameter)
  - Ranges from ≈ 40-60 km at 400 Mbits/s
    ≈ 100 km at 2.4 Gb/s
    ≈ 300 km at 1.7-10 Gb/s using SMDSFs

FIBER JOINTS

- **Source- Fiber**
- **Fiber- Fiber**
- **Fiber- Detector**

❖ Manufacturers supply ***Electro-optical devices*** (Sources and Detectors) with fiber optic ***pigtail*** to facilitate direct fiber-fiber connection

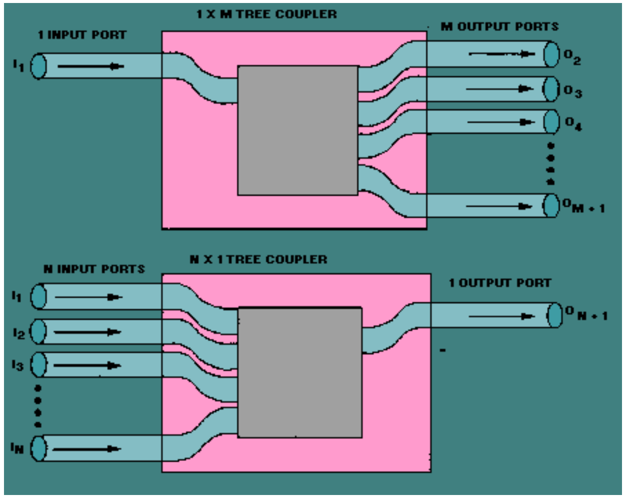
❑ **IMPORTANT ASPECT IS FIBER-TO- FIBER CONNECTION WITH LOW LOSS AND MINIMUM DISTORTION**

Two major categories of fiber joints

- **FIBER SPLICES:** Permanent or Semi-permanent joints
  - ✓**Soldering**

- **FIBER CONNECTORS:** Demountable or Removable joints
  - ✓Plugs or Sockets

- **FIBER COUPLERS:** Branching devices
  - Splitters or Combiners
  - Importance in Networks

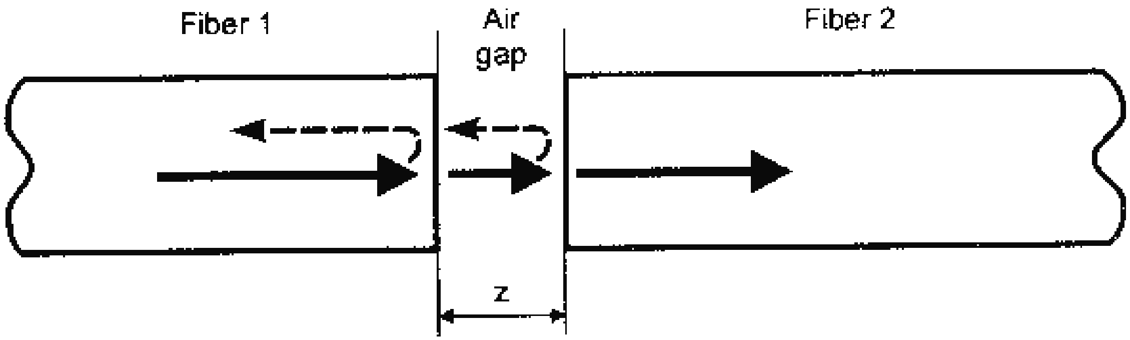


LOSS MECHANISMS AT JOINTS

1. Fresnel Reflection

- **Optical Loss encountered at the interfaces** (Even when two fiber ends are smooth, perpendicular to fiber axes and perfectly aligned)
- **A small proportion of light may be reflected back into transmitting fiber causing attenuation at the joint.**

***Fresnel Reflection**



Reflection Loss

- **Occurs due to step changes in refractive index at jointed interface**

Glass – Air - Glass

Fraction of light reflected at a single interface

$$r = \left(\frac{n_1 - n}{n_1 + n} \right)^2$$

n_1 : R.I. of core, n : R.I. of interfacing medium (= 1 for air)

Loss in decibel due to FR at single interface

$$\text{Loss}_{\text{Fres}} = -10 \log_{10}(1-r)$$

- **Can be reduced to a very low level using index matching fluid in the gap between jointed fibers.**

2. Deviation in Geometrical & Optical Parameters

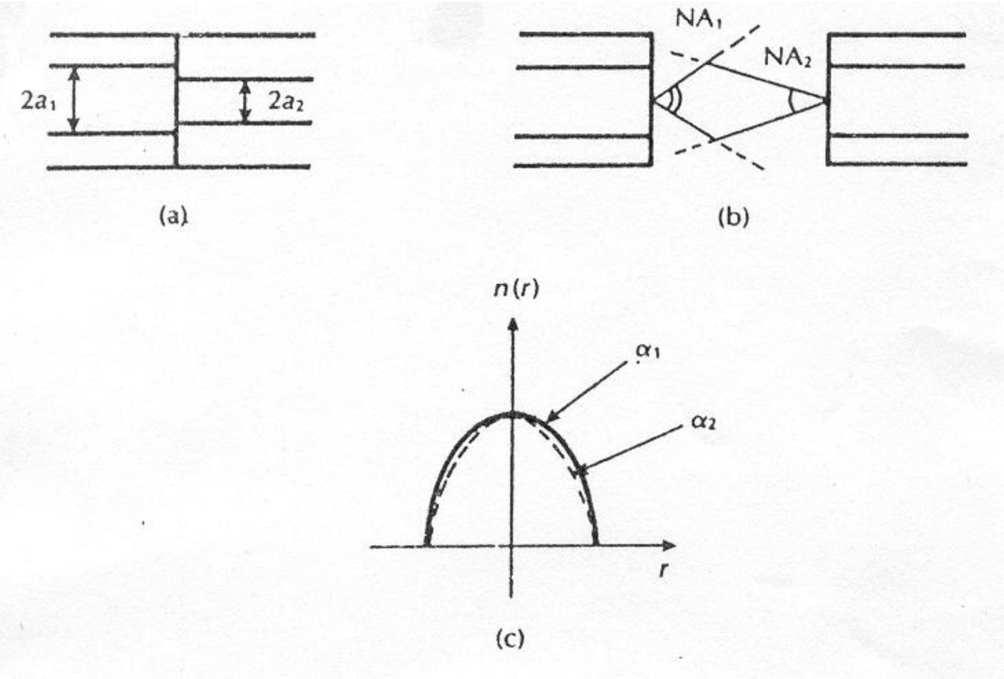
- All light from one fiber is not transmitted to another fiber ; **Because of mismatch of mechanical dimension**

Three major cases :

a) **Core mismatch**

b) **NA mismatch**

c) **Index Profile**



Intrinsic Losses

Losses due to:

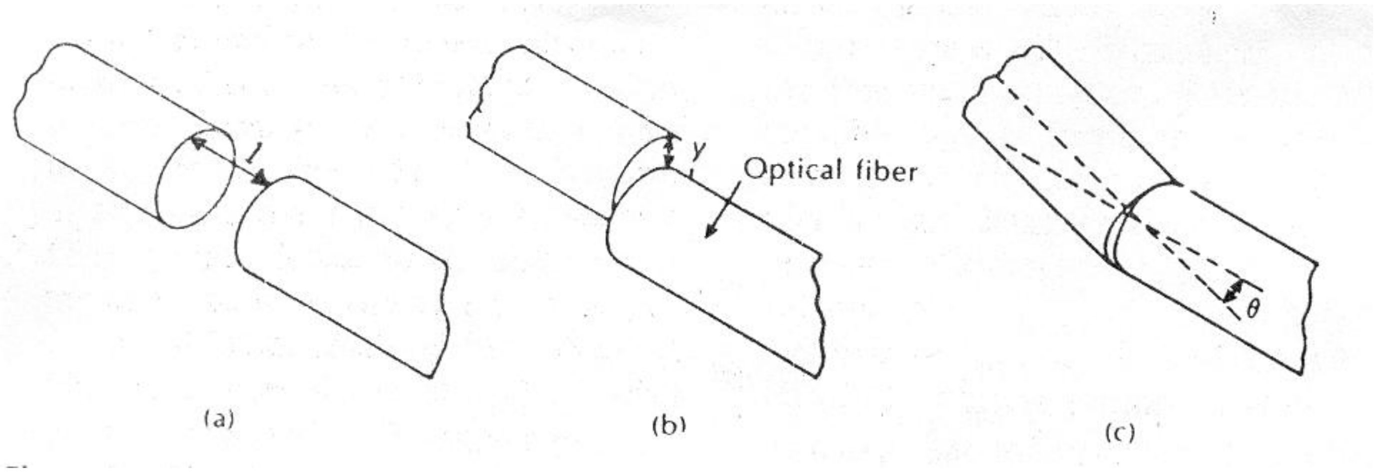
- Fresnel Reflection
- Deviation in Geometrical & Optical parameters

- **Minimized using fibers manufactured with lowest tolerance i.e.(same fiber)**

Extrinsic Losses

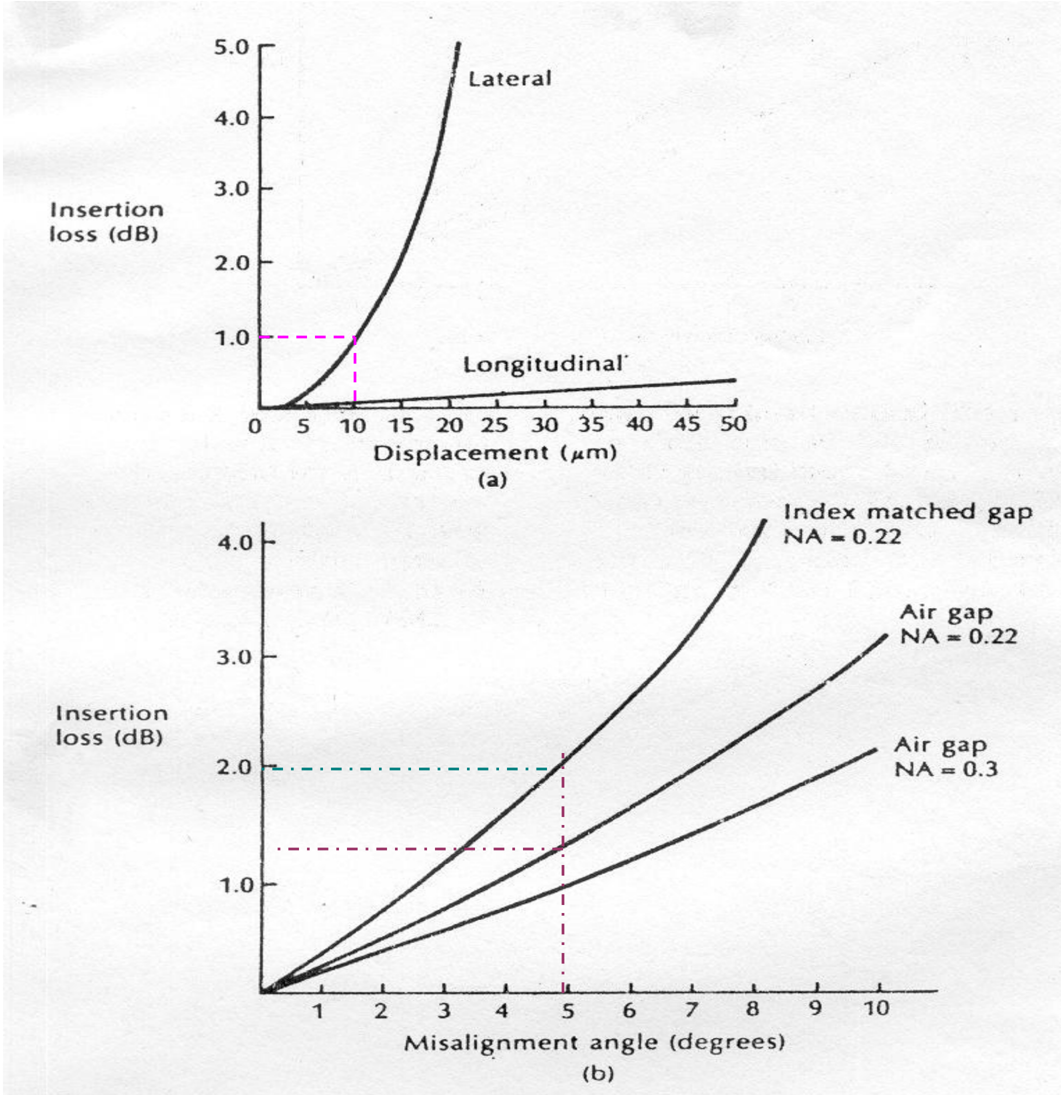
- **Losses due to some imperfection in splicing**

  -Caused by Misalignment



Three possible types of misalignment at joint

(a) Longitudinal misalignment
(b) Lateral misalignment;
(c) Angular misalignment



(a) Loss due to lateral and longitudinal misalignment for a 50 μm core diameter GI fiber; (b) insertion loss due to angular misalignment for joints in two MMSI fibers with NA of 0.22 and 0.3.

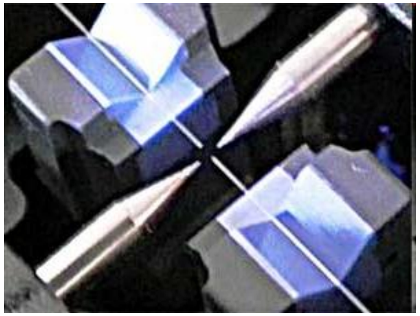
FIBER SPLICES

- **A permanent joint formed between two fibers**

TWO BROAD CATEGORIES

- **Fusion Splicing or Welding**

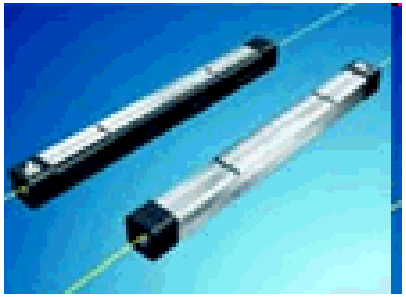
  Accomplished by applying localized heating (a flame or an electric arc) at the interface between two butted, prealigned fiber ends causing them to soften and fuse.



- **Mechanical Splicing**

  Fibers are held in alignment by some mechanical means

  - **Achieved by various methods;**
    - **Tube Splices**
    - **Groove Splices**



FIBER CONNECTORS

❑ Demountable fiber connectors

- ➢ More difficult to achieve than fiber splices

- Must maintain similar tolerance requirements, but in a ***removable fashion.***
- Must allow for repeated connection and disconnection without problems for fiber alignment - ***without degradation in performance***.
- Must protect the fiber ends from damage – due to handling
- Must be insensitive to environmental factors (e.g. moisture & dust)
- Must cope with tensile load on the cable and can be fitted with relative ease.
- Should ideally be a ***low cost component***,

Three Major Parts

- **Fiber Termination** : protects and locates the fiber ends
- **Fiber end Alignment :** provide optimum optical coupling
- **Outer shell** : maintains the connection and fiber alignment, protects the fiber ends from the environment and provides adequate strength at the joint.

➢ **Losses in the range 0.2 to 0.3 dB**

Butt Jointed Connectors

- Alignment of two prepared fiber ends in close proximity (butted) to each other so that the fiber axes coincide.

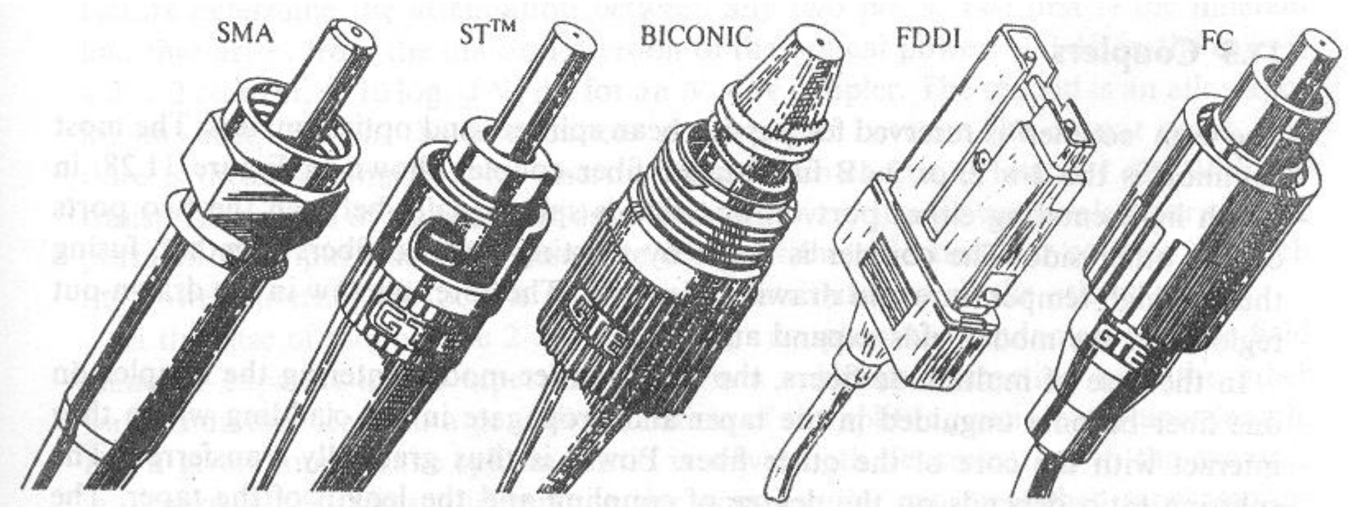


Figure 11.26 An illustration of some of the more common types of connector.

Expanded-Beam Connectors

➢ **Collimating and refocusing the light from one fiber into the other.**

- Utilize interposed optics at the joint in order to ***expand*** the beam from the transmitting fiber end before ***reducing*** it again to a size compatible with the receiving fiber end.

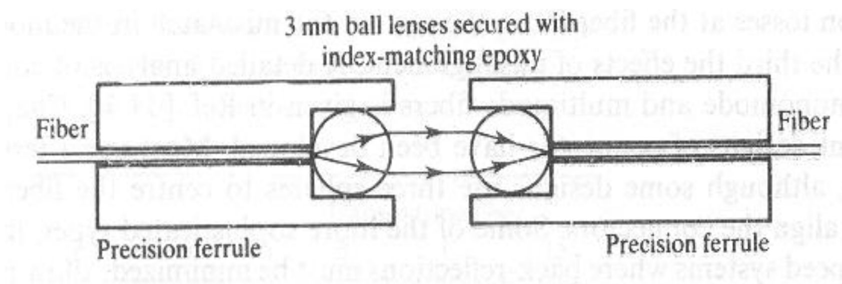
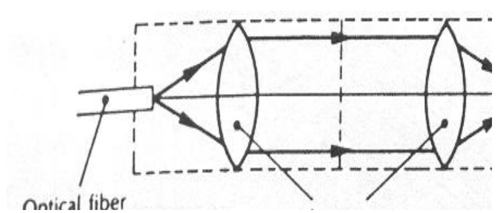
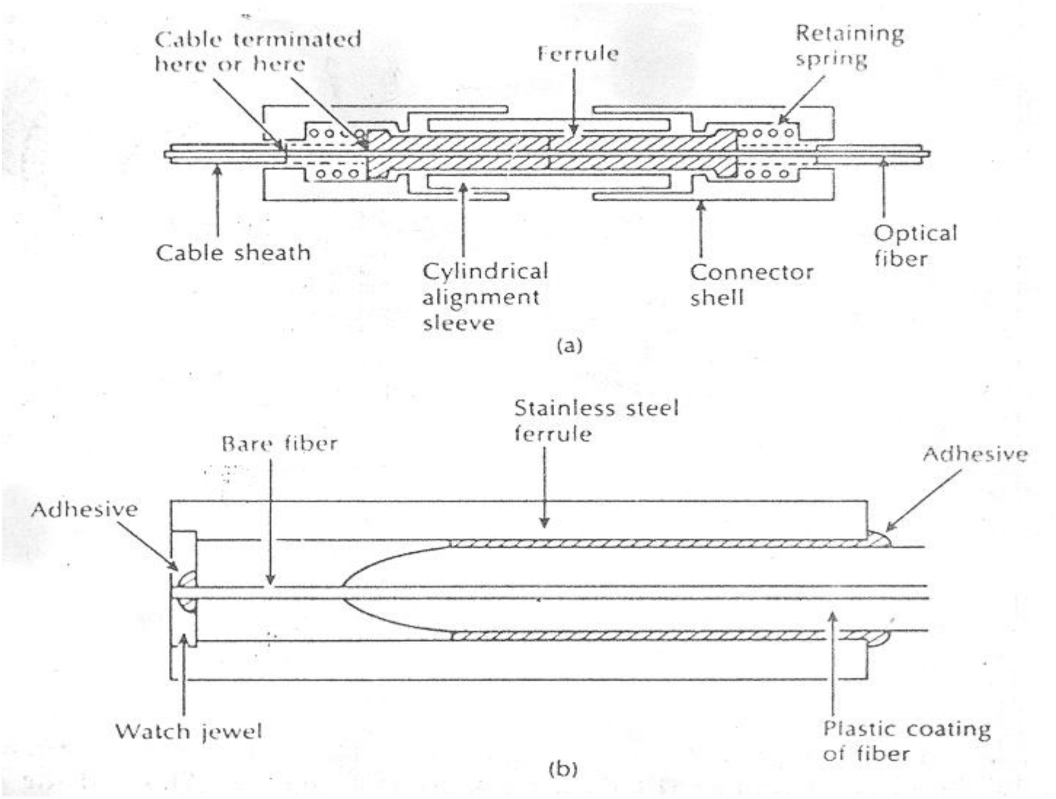


Figure 11.27 An expanded-beam connector.



Cylindrical Ferrule Connector

- **Glass Ferrules with central drilled hole**
- **Concentric alignment sleeve**

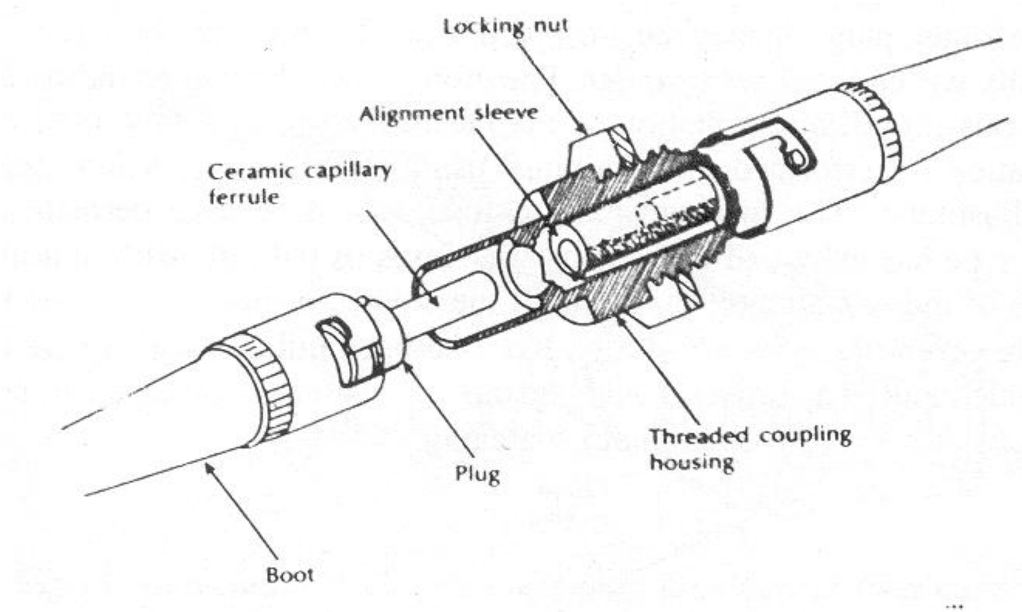


- **Preparation of fiber ends before fixing the ferrules**
- **Insertion Losses** ≈ 1 to 2 dB with MMSIF
- **Watch jewel for close end approach and tolerance requirement**

Ferrule Connectors: (a) structure of a basic ferrule connector;
(b) structure of a watch jewel connector ferrule.

Ceramic Capillary Ferrules

- Ferrules made from ceramic material
- End preparation after fixing ceramic ferrules



ST series multimode fiber connector using ceramic capillary ferrules.

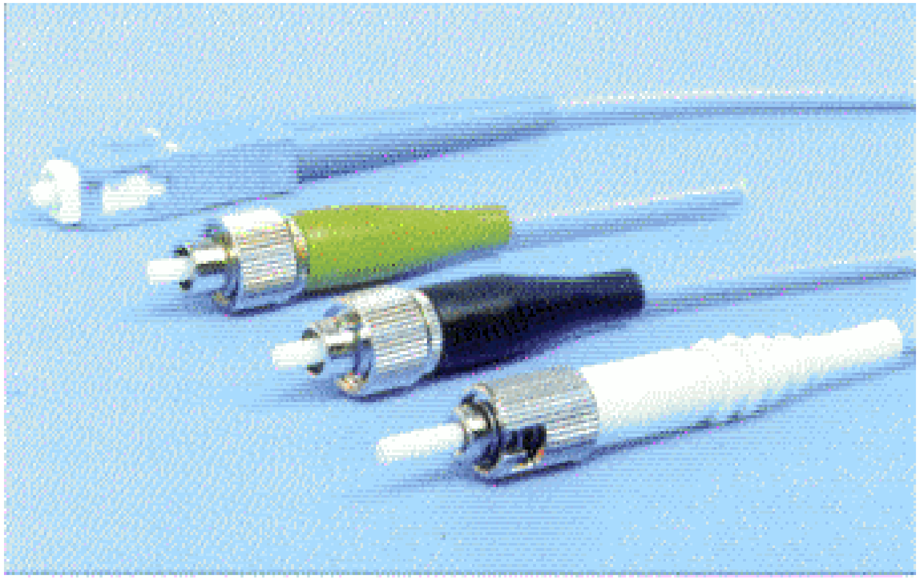
❑ **Outstanding**

- Thermal,
- Mechanical
- Chemical Resistance

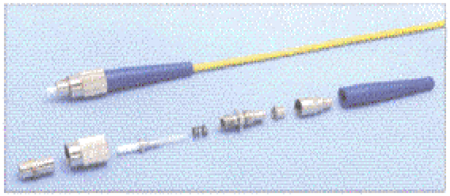
❑ **Average Losses**

≈ 0.2 dB with MMGI

≈ 0.3 dB with SMF

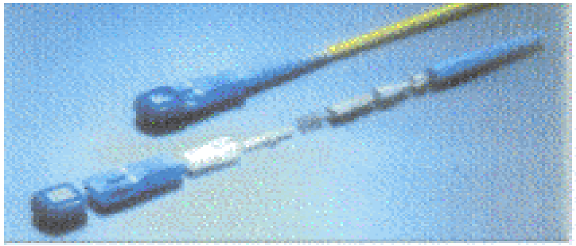


Commonly Used Connectors

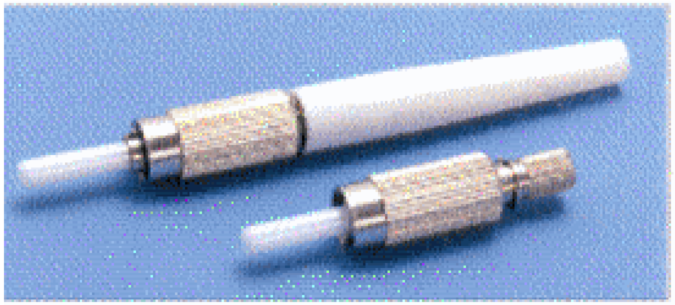


FC Connectors

ST Connectors

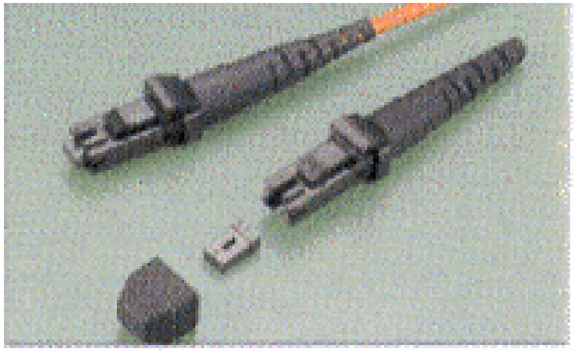


SC Connector



DIN Connectors

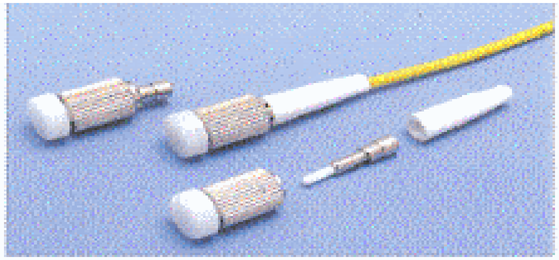
(Spring loaded free-floating Zirconia ceramic ferrule)



MTRJ Connector

SMA Connector

Biconic Connectors



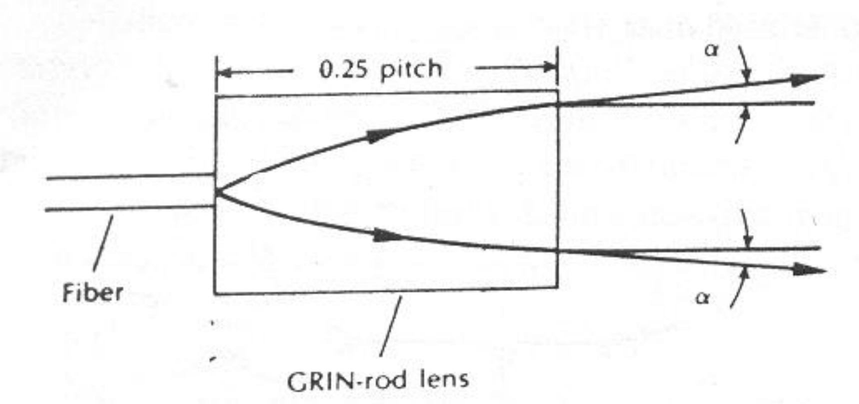
D4 Connectors

GRIN-rod Lenses

An alternative lens geometry to facilitate efficient beam expansion and collimation

- Arose from development of GI fiber waveguides
- A cylindrical glass rod 0.5 to 2 mm in diameter with parabolic refractive index profile.
- Light propagation is determined by the lens dimension and wavelength of the light.
- Produce a collimated output beam with divergent angle of 1^o to 5^o from light source.onto the opposite face of lens
-

GRIN-rod Lenses



- **Ray propagation determined by paraxial ray equation**

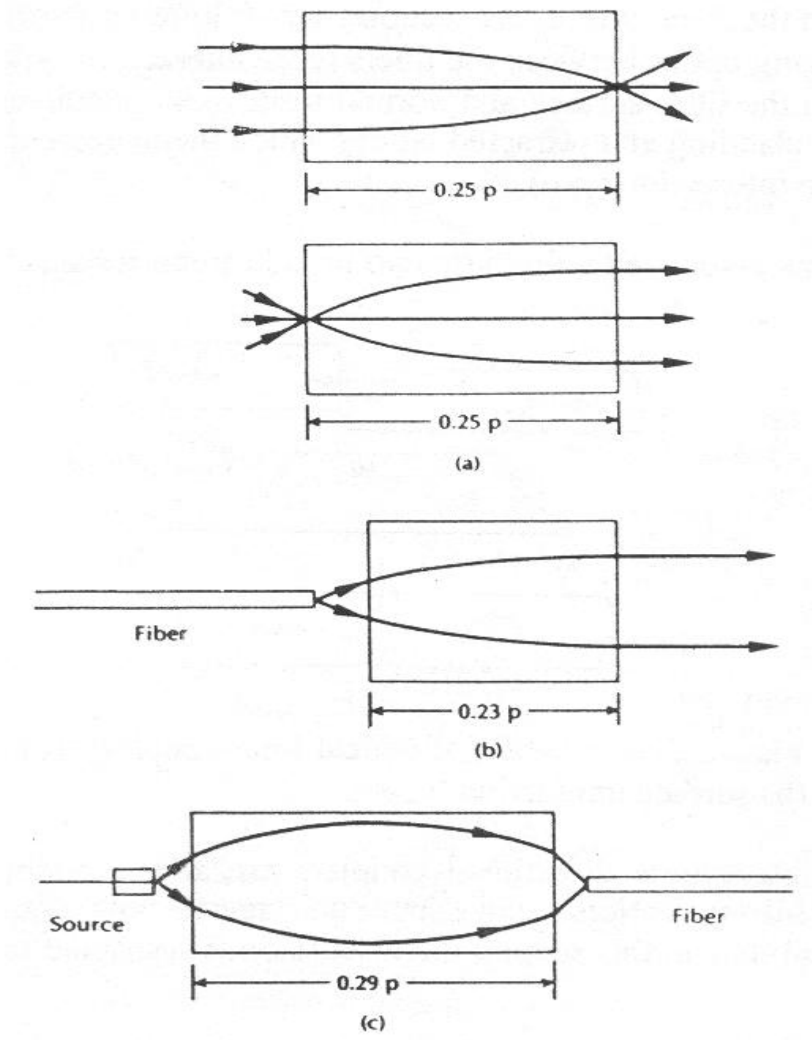
$$\frac{d^2 r}{dz^2} = \frac{1}{n}\frac{dn}{dr}$$

  - **Solution is**

$$r = k_1 \cos A^{1/2} r + k_2 \sin A^{1/2} r \;:\longrightarrow$$ **A sinusoidal path**

- Traversing of one sinusoidal period : **one full pitch**

Various fractional pitch GRIN-rod lenses



- **0.25, 0.23, 0.29 etc.**

➢ **SELFOC from Nippon Sheet Glass Co. Ltd.**

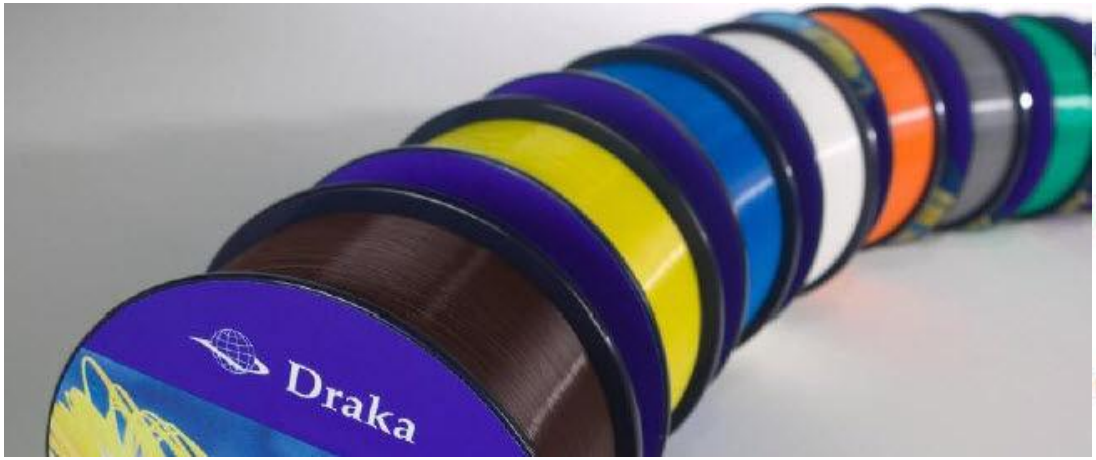
Losses ≅ 1 dB

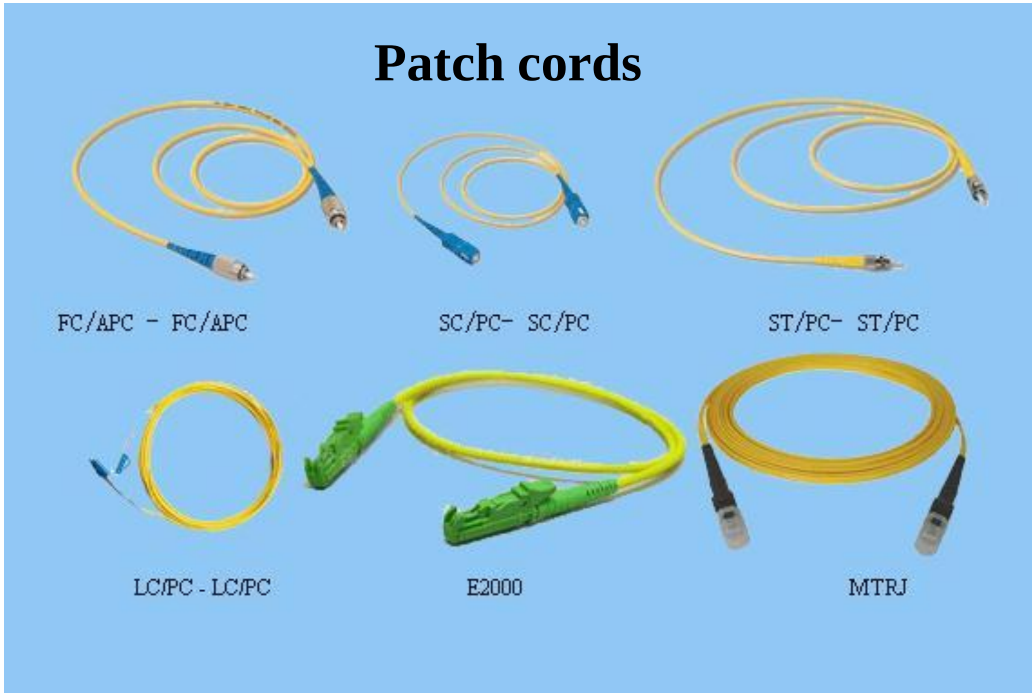
Average Losses

≈ 0.2 dB with MMGI

≈ 0.3 dB with SMF

Fiber Reels, Connectors & Patch cords





THANK YOU