# Optical Communications

## Couplers and Connectors

Part8

**Fiber Optic Communications**

**Joseph C. Palais**

**Fourth Edition PRENTICE HALL**

Dr. Abdel-Rahman Al-Qawasmi

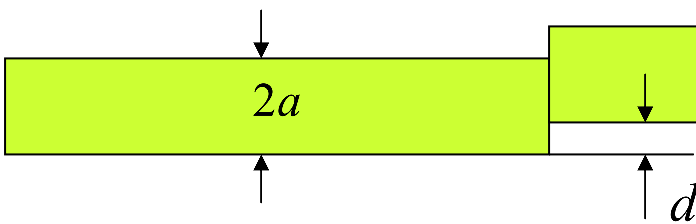
# Couplers and Connectors

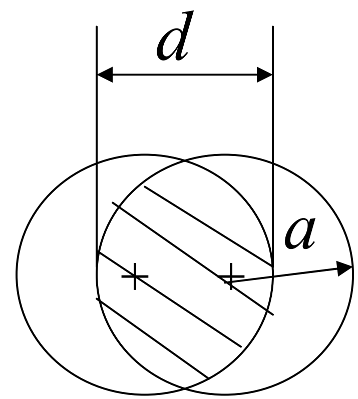
Fiber-to-fiber connections are needed to be spliced together for links of more than a few kilometers because fibers have limited lengths from manufactures.

## Connector Principles:

Losses in fiber-to-fiber arise in a number of ways:

**Lateral Misalignment: multimode SI fiber**




Overlap of transmitting and receiving fibers.

$\eta$ — The coupling efficiency is the ratio of the overlapping are to the core area

$$\eta = \frac{2}{\pi}\left\{\cos^{-1}\frac{d}{2a} - \frac{d}{2a}\sqrt{\left[1-\left(\frac{d}{2a}\right)^2\right]}\right\}$$

# Couplers and Connectors

The inverse cosine is calculated in radians. The corresponding loss in dB is

$$L = -10\log\eta$$

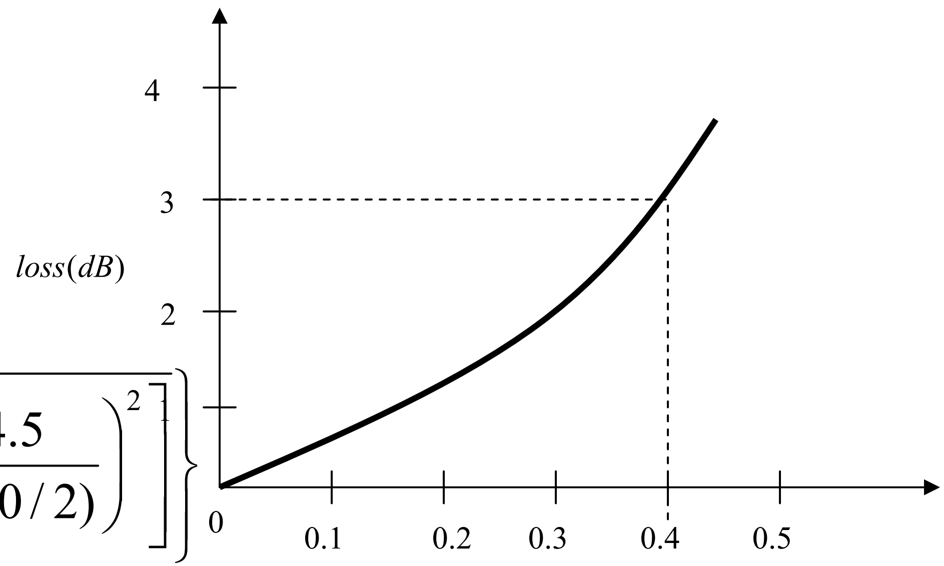
**Example**:

Find the allowable axial displacement if the coupling loss is to be less than 3 dB and a=50 micrometers. Find the loss in dB if d=4.5 micrometers.

Solution: using graph

$$d/2a = 0.4$$

then $d = 2a(0.4) = 40\,\mu m$




$$\eta = \frac{2}{\pi}\left\{\cos^{-1}\frac{4.5}{2(50/2)} - \frac{4.5}{2(50/2)}\sqrt{\left[1-\left(\frac{4.5}{2(50/2)}\right)^2\right]}\right\}$$

$$\eta = \frac{2}{\pi}(1.4807 - 0.0896) = 0.886 \qquad L = -10\log\eta = 0.525dB$$

# Couplers and Connectors

**Lateral Misalignment of single-mode fibers**

$$L = -10\log\left\{\exp\left[-\left(\frac{d}{w}\right)^2\right]\right\}$$

$w$ → Spot size

**Example:**

Compute the coupling loss in single mode fiber with n1=1.465 and n2=1.46 due to lateral misalignment at wavelength 1250 nm

Solution

First we find a $$a = \frac{\lambda.2.405}{2\pi\sqrt{n_1^2 - n_2^2}} = 3.96\mu m$$

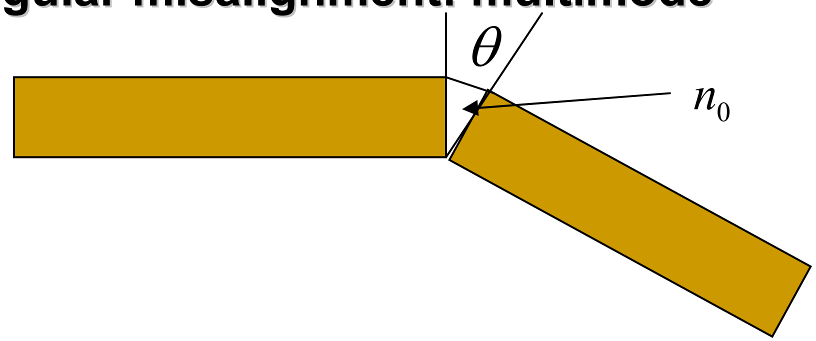
$$V = \frac{2\pi a}{\lambda}\sqrt{n_1^2 - n_2^2} = \frac{2\pi(3.96)}{1.25}\sqrt{1.465^2 - 1.46^2 =} = 2.4$$

$$\frac{w}{a} = 0.65 + 1.69V^{-3/2} + 2.879V^{-6} = \frac{w}{3.96} = 0.65 + 1.69(2.4)^{-3/2} + 2.879(2.4)^{-6}$$

$$w = 4.43\mu m$$

$$L = -10\log\left\{\exp\left[-\left(\frac{d}{w}\right)^2\right]\right\} = -10\log\left\{\exp\left[-\left(\frac{5}{4.43}\right)^2\right]\right\} = 5.53dB$$

**Angular misalignment: multimode**




$$L = -10\log = 1 - \frac{n_0\theta}{\pi NA}$$

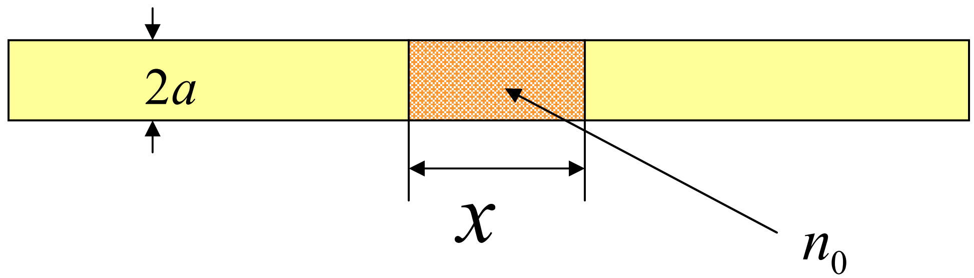
$\theta$ In radians

**Angular misalignment: single mode**

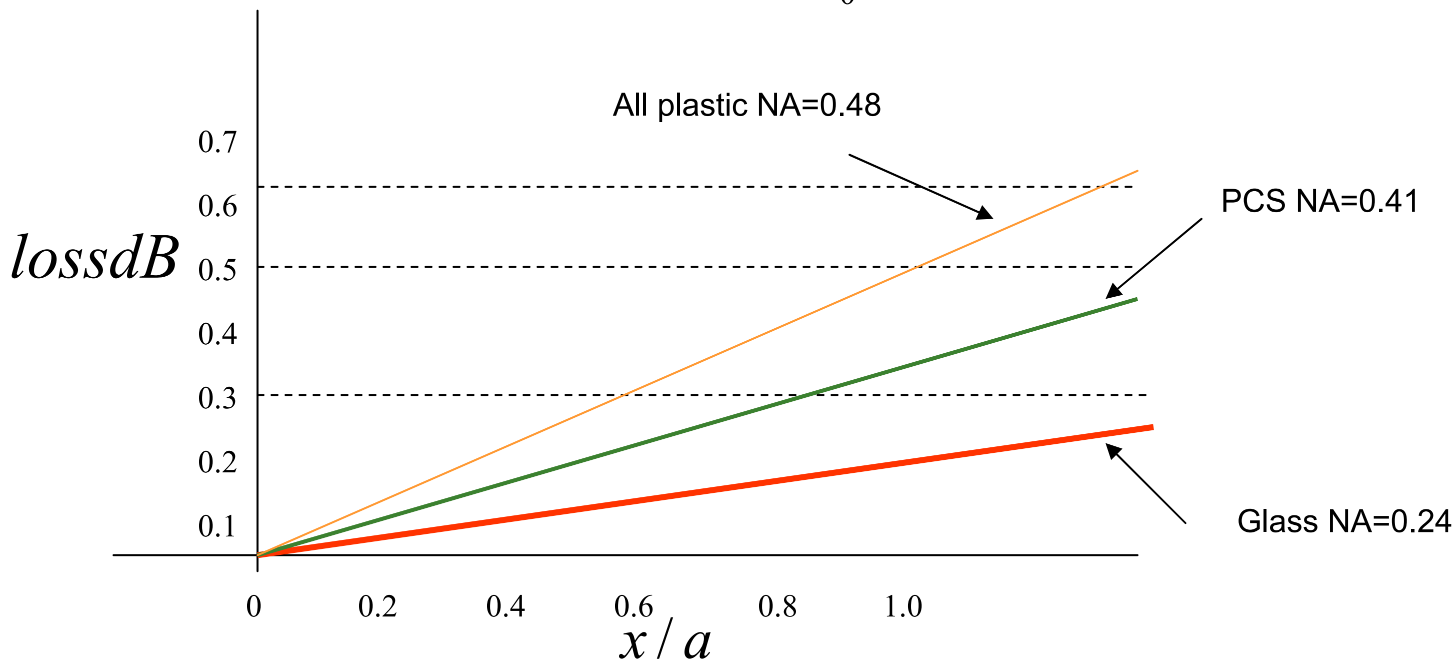
$$L = -10\log\left\{\exp\left[-\left(\frac{\pi n_2 w\theta}{\lambda}\right)^2\right]\right\}$$

# Couplers and Connectors

## End separation



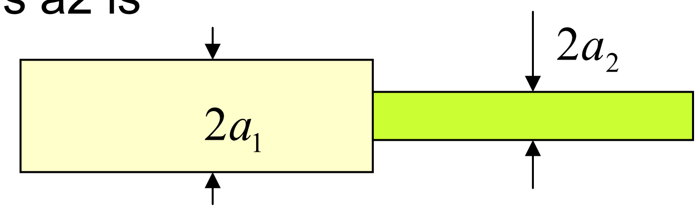

$$L = -10\log\left(1 - \frac{x.NA}{4an_0}\right)$$



# Couplers and Connectors

**Connecting Different Fibers:**

The loss when transmitting from a fiber of core radius a1 to one having core radius a2 is




$$L = -10\log\left(\frac{a_2}{a_1}\right)^2$$

The loss when transmitting from a higher to a lower numerical aperture:

$$L = -10\log\left(\frac{NA_2^2}{NA_1^2}\right)$$