A PRESENTATION
ON
SPACE DIVISION MULTIPLEXING

A NEW MILESTONE IN THE EVOLUTION OF FIBER OPTIC COMMUNICATION

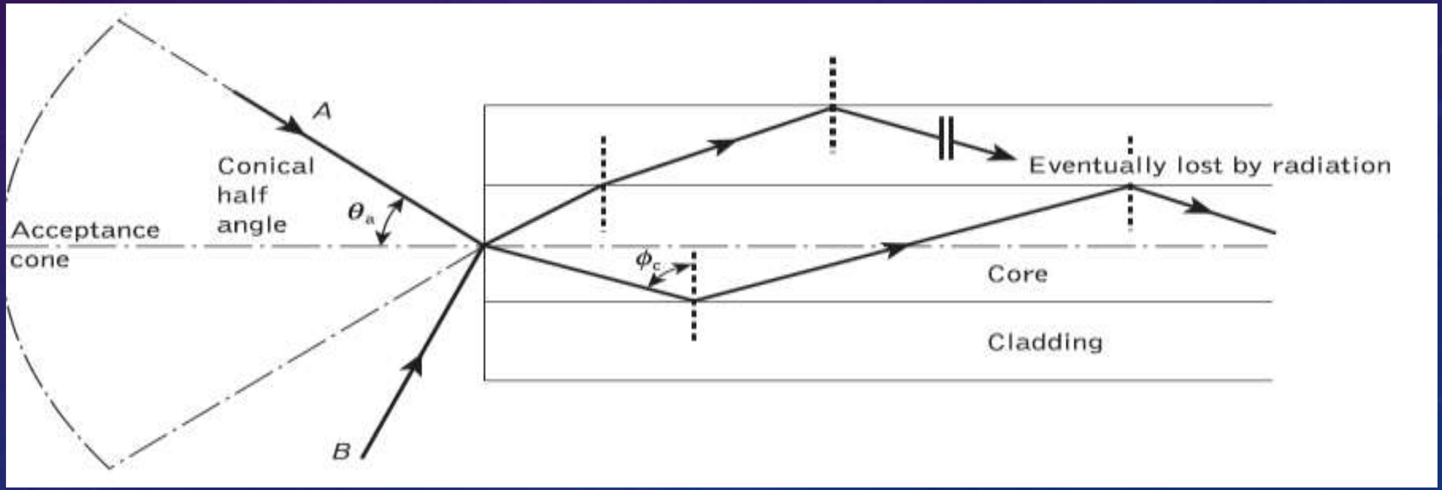
Md. Mahmudul Hasan
Ahmed Saif Muntaseer
Rekha Saha
Electronics & Communication Engineering Discipline
Khulna University, Khulna, Bangladesh

Contents

Fiber parameters

Acceptance angle

- Defined by the conical half angle θa



Optical fiber communication

Numerical aperture

- Equation of numerical aperture

$$NA = (n_1^2 - n_2^2)^{1/2}$$

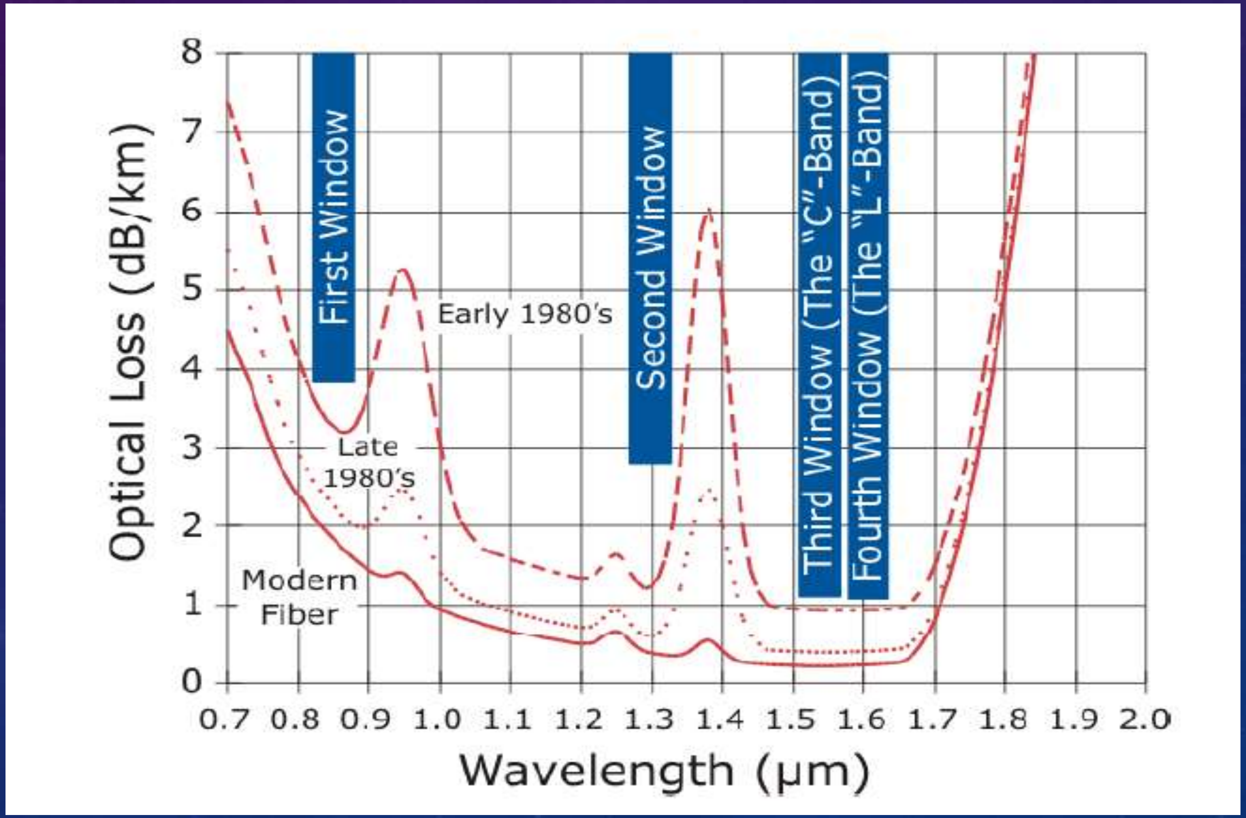
- Numerical aperture of step index fiber is given as

$$NA = n_1 \sqrt{2\Delta}$$

Where, $\Delta = \frac{n1^2 - n2^2}{n1}$, and is called fractional index change

Optical window

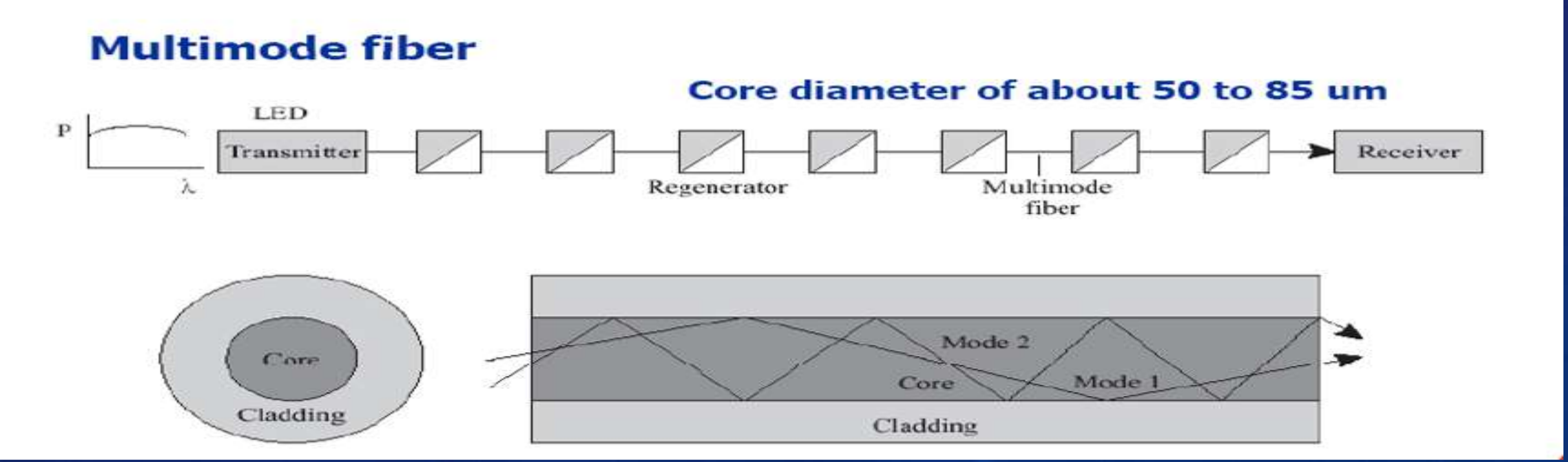
Most commonly three types of optical windows is used in optical fiber communication



Optical fiber evolution

First generation optical fiber

- Multimode optical fibers
- LED sources
- Operated in the 850 nm wavelength region.



Optical fiber evolution (cont.)

Advantage of the multimode fiber

- Large core
- High numerical aperture

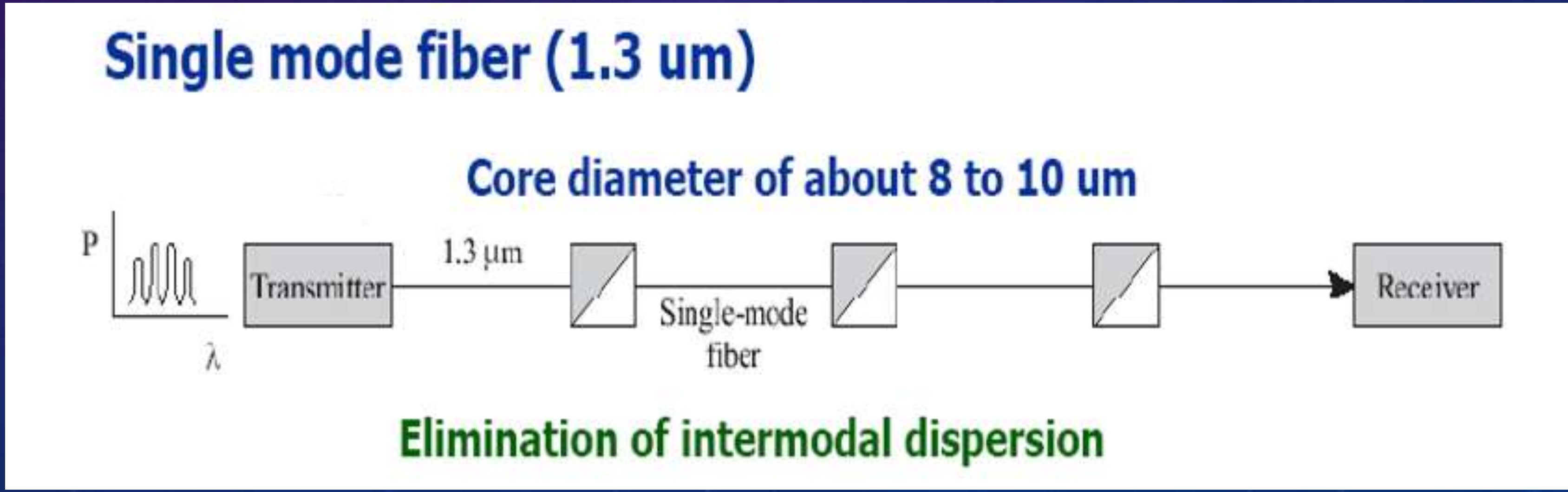
Disadvantage

- Intermodal dispersion.

Optical fiber evolution (cont.)

Second generation optical fiber

- Single mode fiber
- Single mode lasers
- Uses 1300 nm wavelength region.



Optical fiber evolution (cont.)

Advantage

- Attenuation is less than that in 850 nm.
- Nearly zero dispersion

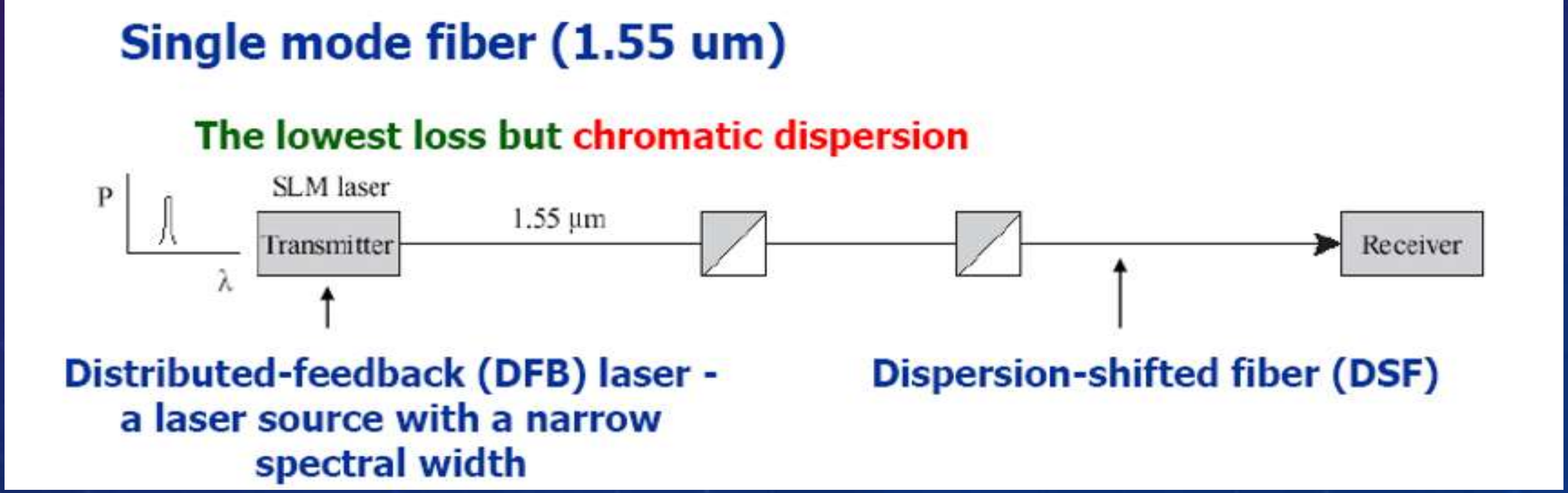
Disadvantage

- Exhibit attenuation

Optical fiber evolution (cont.)

Third generation optical fiber

- Uses 1550nm wavelength region
- For minimizing chromatic dispersion, Dispersion Shifted Optical fiber (DSF) was implemented.



Optical fiber evolution (cont.)

Advantage

- Attenuation is lowest in 1550nm window

Disadvantage

- Very large Chromatic dispersion

Space division multiplexing

Space

- ❖ Several parallel spatial paths usually at the same time,
  - ❑ data buses
  - ❑ ribbon cables and twisted pair cables

A method by which optical transmission media are physically separated by waveguides or space in order to maintain channel separations.

Why space division multiplexing

There are several ways to increase optical transmission capacity over a fixed bandwidth, These are-

- Modulation using different amplitude levels
- Polarization
- Frequency is used in Wavelength Division Multiplexing

And most of them are already being used

Multiplexing techniques

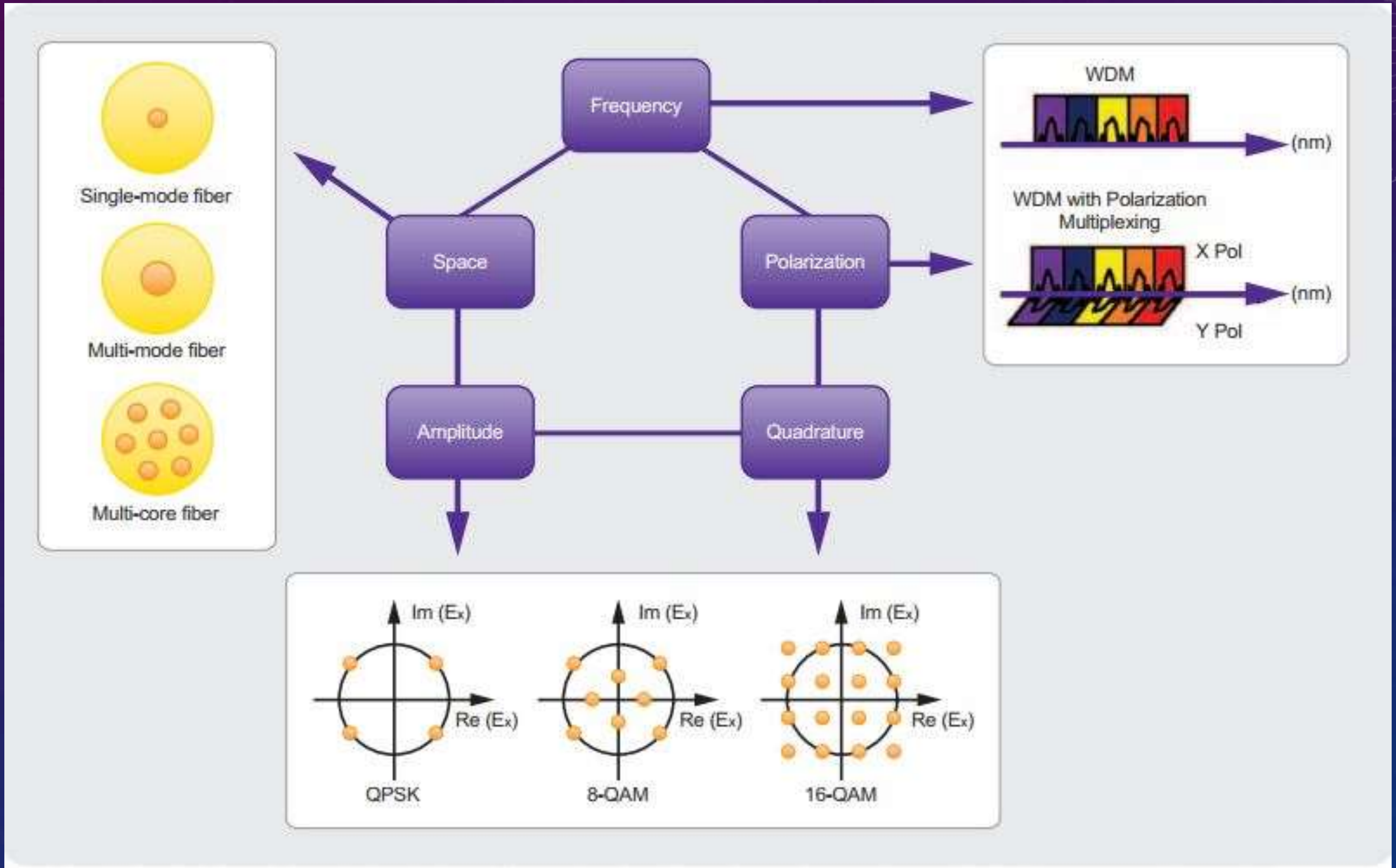


Fig: Ways to modulate and multiplex channels to increase system capacity in optical transmission.

Space division multiplexing types

In fact, the only remaining unused dimension is space, and there are two basic strategies for achieving spatial separation within a fiber

- Few mode fiber
- Multi core fiber

Few mode fiber

In few-mode fibers (FMFs) the size and the refractive index of a single fiber core is chosen such that several propagation modes are supported by the fiber.

- allows several modes
- its core needs to be quite larger micrometers
- large numerical aperture
- these modes act as individual communication channels

Few mode fiber significance

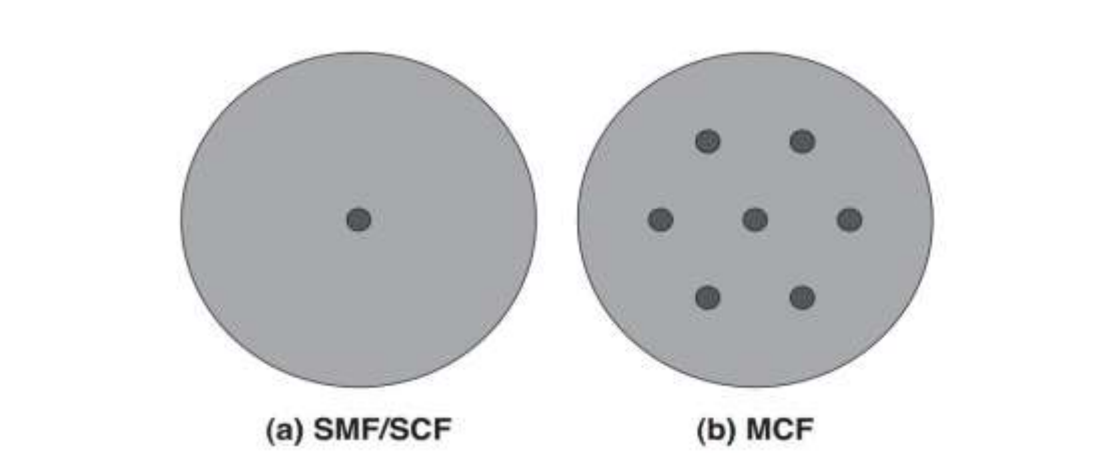
- Few-mode fibers (FMFs) can have the same performance as single-mode fibers in terms of dispersion and loss

- It is possible to use these fibers in the single-mode operation where all the data is carried in only one of the spatial modes throughout the fiber.

Multi core fiber (cont.)

- Have several cores
- Within same cladding

Two cross-sectional view is shown here



Multi core fiber (cont.)

- Fiber parameters and cross sectional view of a 19 core fiber

^=core-to-core distance (core pitch)
D=cladding diameter
Δ=Refractive index difference between core
T=outer cladding thickness

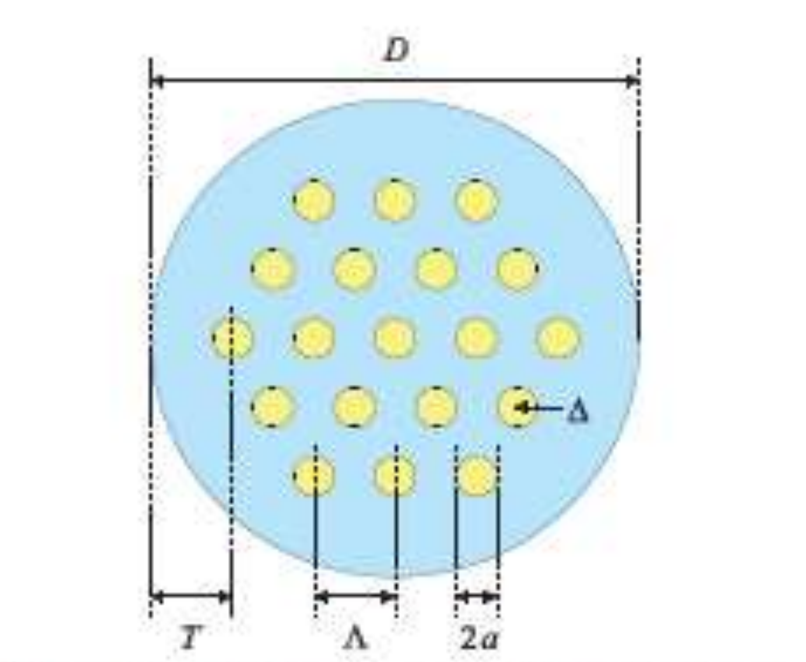


Fig. 1. Schematic cross-section of a multicore fiber.

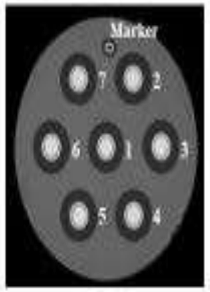
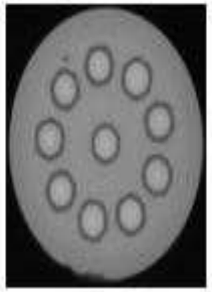
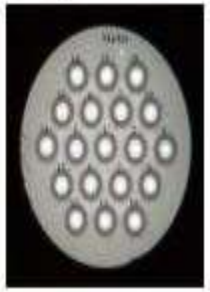
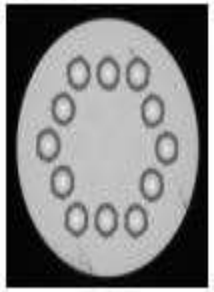
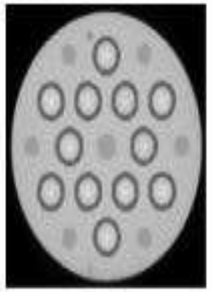
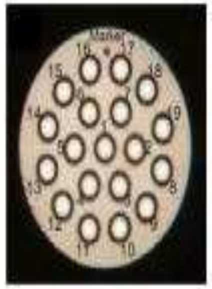
Fiber design consideration

Fundamental consideration

- Crosstalk suppression,
- Core-density improvement
- Core-arrangement optimization

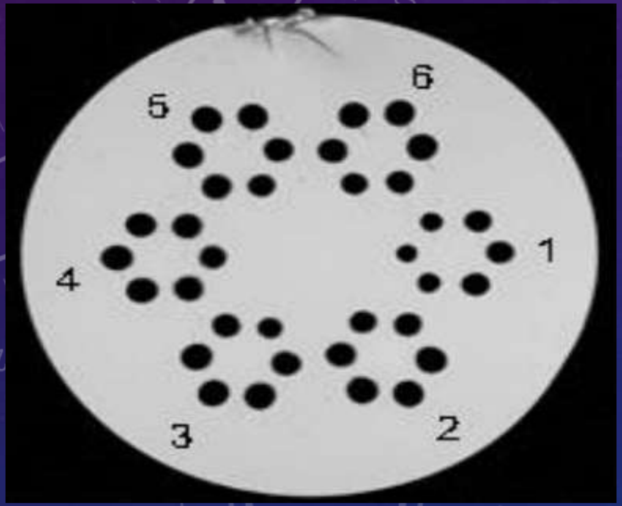
Different core arrangement

Different core arrangement

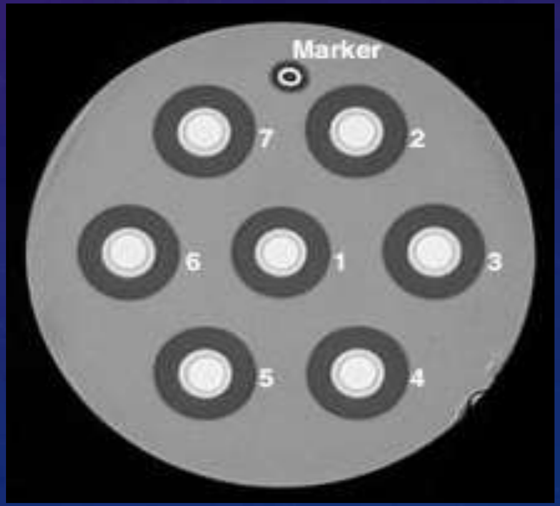
Reference	Mar. 2011	Dec. 2011	Mar. 2012	Dec. 2012	July 2013	Sept. 2013
Cross-sectional view of trench-assisted single-mode multicore fiber						
Core arrangement	HCPS	TPS	HCPS	ORS	DRS	Modified HCPS
Core count	7	10	19	12	12	19
Core pitch [μm]	45	40.5[3]	35	36.8	44.6	38.0-39.0
Cladding diameter [μm]	150	204.4	200	225	230	220
Atteneuation[1] [dB/km]	<0.18	0.242[4]	0.227[2]	0.199[2]	0.186[2],[5]	0.285[2]

Crosstalk minimization concept

Different core arrangement is proposed for minimizing crosstalk of a MCF



Hole assisted MCF



Trench assisted fiber

Advantages

- Gives better utilize of individual optical channels.
- Provides Pb/s data rate

Limitations

- Inter-core crosstalk
- Compatibility problem
- Costly equipment
- Requires complex Digital signal processing, and MIMI techniques.


Thank
You