Lecture 16 - Dielectric Waveguides/Photonic Crystals - Outline

- **Dielectric optics** (guiding, confining, manipulating light)
  - Slab waveguides
  - Cylindrical waveguides (wires for light)
  - Rectangular waveguides
  - Coupled rectangular waveguide structures
    - Couplers, Filters, Switches
- **Photonic crystals**
  - History: Optical bandgaps and Eli Yablonovich, to the present
  - One-dimensional photonic crystals
    - Distributed Bragg reflectors
      - periodic grating of length L
      - grating with phase shift at L/2; at L/2 ± fΛ/2
    - Photonic fibers; perfect mirrors
  - Two-dimensional photonic crystals
    - Guided wave optics structures
    - Defect levels
  - Three-dimensional photonic crystals

Cylindrical dielectric waveguides

- **Glass and plastic fibers**

Some important characteristics of glass fibers

(Images deleted)

See Figures 5-12 and 5-14 in Palais, Joseph C. *Fiber Optic Communications.* 4th ed. Upper Saddle River, N.J. : Prentice Hall, 1998.

Apparatus for pulling a glass fiber from a preform

Loss specturm of a plastic fiber –>

Slab dielectric waveguides

- **Mode patterns and charts for symmetric and asymmetric slabs**

(Images deleted)

See Figures 4-5, 4-7, 4-8, and 4-9 in Palais, Joseph C. *Fiber Optic Communications.* 4th ed. Upper Saddle River, N.J. : Prentice Hall, 1998.

Achieving compact rectangular waveguide layouts

- **Bends**

Calculated transmisson:

a. 30%

b. 60%

c. 98.5%

d. 98%

(Image deleted)

See C. Manolatou, S.G. Johnson, S. Fan, P.R. Villeneuve, H.A. Haus, and J.D. Joanopolous, "High-Density Integrated Optics," IEEE J. Lightwave Technology, 17 (1999) 1682-1692.

Achieving compact rectangular waveguide layouts

- **Splitting Tees**

Calculated transmisson:

a. 30% (15 %/side)

b. 99% (> 49%/side)

(Image deleted)

See C. Manolatou, S.G. Johnson, S. Fan, P.R. Villeneuve, H.A. Haus, and J.D. Joanopolous, "High-Density Integrated Optics," IEEE J. Lightwave Technology, 17 (1999) 1682-1692.

Planar waveguide integrated optics components

- **Resonant ring couplers and channel dropping filters**

Then

(Images deleted)

See Figs. 1 and 12 in E.A.J. Marcatili, "Bends in Optical Dielectric Guides," Bell Syst. Tech. J. 48 (1969) 2103-2132.

Now

(Image deleted)

See B.E. Little et al, "Vertically Coupled Glass Microring Resonator Channel Dropping Filters," IEEE Photonics Tech. Lett. 11 (1999) 215.

(Image deleted)

See S.T. Chu et al, "An Eight-Channel Add-Drop Filter Using Vertically Coupled Microring Resonators over a Cross Grid," IEEE Photonics Tech. Lett. 11 (1999) 691.

Photonic crystals - Yablonvich's original proposals

- **3-dimensional structures with optical bandgaps: solids that totally reflect light in band of energy**

Photonic crystals - Axel Scherer

- **Rectangular dielectric waveguide structures:**

example of making bends using phtonic bandgap concepts

Right: structure and fabrication sequence

Below: performance

(Images deleted)

See Fig. 4 and Table II in Cheng, C. C., and A. Scherer. "Lithographic Band Gap Tuning in Photonic Bandgap Crystals." J. Vac. Sci. Technol. B 14 (1996): 4110-4114.