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.

Photonic crystals - Yablonvich's original proposals

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

(E. Yablonovich, 1992)

Photonic crystals - Axel Scherer

- **Rectangular dielectric waveguide structures:**

example of making bends using phtonic bandgap concepts

(Fig. 4. Image removed)

(Table II. Image removed)

Right: structure and fabrication sequence

Below: performance

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