EPL442: Fiber and Integrated Optics

Major Test | **Max. Marks: 40**
May 1, 2008 | **Answer all questions** | **Duration: 2 Hrs.**

1. Write down (and explain briefly) **two** important reasons for having a cladding material of slightly lower refractive index, rather than air, surrounding the core of a teleeom-grade optieal fiber. **(2)**

2. If the transmission rate of a fiber eommunication link is 2.4 Gb/s, estimate the number of voice channels that can be simultaneously transmitted through a single fiber using one wavelength. **(2)**

3. Why do communieation system engineers use the 'dB scale' to express the magnitudes of **gain** and **loss**? Explain briefly. **(2)**

4. What is meant by "Gaussian approximation of the fundamental mode" of an optical fiber? And, how is the corresponding MFD defined? Illustrate your answer with the help of relevant diagrams. Under the Gaussian approximation, obtain an expression for the fractional power earried by the mode in the core of a single-mode fiber. **(2+2)**

5. The TE modes of a symmetrie slab waveguide of thickness d is given by the solutions of the following equation:

$$\frac{d^2 E_y}{dx^2} + \left[k_0^2 n^2(x) - \beta^2\right] E_y = 0,$$

where symbols have their usual meaning.

a) Write down the expressions representing guided wavc solutions of this wavcguide. **(2)**

b) Applying appropriate boundary conditions, obtain thc eigcnvalue equations that lead to symmetric and antisymmetric modcs. **(3)**

6. Consider two symmetric planar wavcguides, separated by a distance d, forming a *directional coupler*.

a) What is meant by 'coupling lcngth' of a directional couplcr? If the refractive index of the cladding is reduced (with respect to the core), will the coupling length increase or decrcase? And why? **(2)**

b) What other means can be employed to alter the coupling length at a given wavelength of operation? **(1)**

c) Explain briefly the principle of operation of a WDM coupler. **(2)**

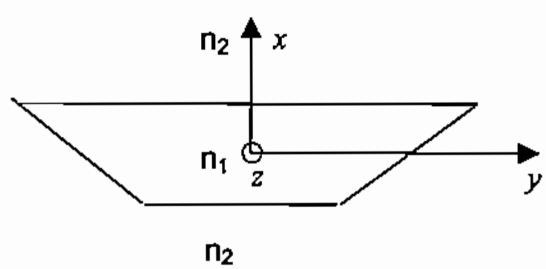

Fig.1

7. Consider a uniform (two-dimensional) buried waveguide of cross-section shown in Fig.1; z is the direction of propagation. If you were to apply the *effective index method* to obtain thc modcs of the above waveguide, what is the methodology that you would follow? Assume that the waveguide supports only the E_{00}^{y} mode. Explain only thc steps involved. **(4)**

8. You are required to design an optimum periodie deformer-pair to realize a pressure sensor based on mierobending loss in a parabolie-index multimode optieal fiber. Assume that the propagation constants of guided modes in a parabolie index fiber are given by

$$\beta_{mn} = k_0 n_1 - \frac{(m+n+1)}{a}\sqrt{2\Delta}$$

where m and n (=1,2,3,..) are mode numbers, and other symbols have their usual meaning. Assuming a relative index difference of 1% between the core and the cladding, and core diameter of 50 μm, calculate the required period of the deformer. **(4)**

9. a) Derive an expression for material dispersion $\Delta\tau_m$ for pulse propagation in a dispersive medium. **(3)**

b) A DFB laser of (source) linewidth 1 MHz and operating at 1550 nm is externally modulated to generate Gaussian pulses of 100 ps pulse-width at a certain repetition rate. Calculate the material dispersion (in units of ps) in propagating through a distance of 10 km in pure silica. Given:

$$\text{For pure silica, } \frac{d^2 n}{d\lambda_0^2} \approx 0.004\ \mu\text{m}^{-2}$$ **(4)**

10. What is meant by *–ve dispersion* (i.e. negative value of the dispersion coefficicnt *D*)? How is it different from *+ve dispersion*? If identical in magnitude, do they cancel each other? Illustrate your answers with the help of relevant diagrams. Also, discuss bricfly its relevance in high-speed long-haul optical fiber communication systems. **(5)**