國 立 清 華 大 學 命 題 紙

九十九學年度第一學期 光電工程研究所 博士班研究生資格考試

科目 光電子學二 共____頁第____頁 ＊請在試卷(答案卷)內作答

1. (9%) Mr. Lin wanted to purchase a single-mode fiber for communication operating at the wavelength 1.55 μm. The following four types of step-index fibers have different specifications as listed.

Type	*core radius (μm)*	*core index*	*cladding index*
A	2	1.45	1.44
B	3	1.45	1.445
C	5	1.45	1.445
D	5	1.45	1.447

He would choose only one type. What would he choose for the best purpose of ,say 10-km communication? Explain.

2. (8 %) You have a dielectric waveguide, and you find three modes guided through it when you launch a laser light at a particular wavelength. Describe how these three modes differ. That is, give a statement to differentiate the mode field distributions, the propagation constants and any other parameters you can think of. Please specify the difference and likely draw the difference between these modes.

3. (8%) Explain why the propagation constants of guided modes are smaller than $k_o n_1$ and larger than $k_o n_2$? Here k_o is the free-space propagation constant; n_1 and n_2 are refractive indices of the guiding layer and the cladding layer.

4. (15 %) Make necessary assumptions and descriptions when answering this problem.
   (a) Design a laser of your choice. Please show the energy diagram and provide the necessary information of the laser in detail (Values are not needed. Symbols are fine).
   (b) Please write down the rate equations of the laser according to your assumptions.
   (c) By solving the rate equations, describe why the gain of the laser gets saturated when there is light presented.
   (d) The following figure shows the gain spectrum, the initial oscillation modes, the oscillation modes evolve with time, and the resolve gain spectrum when lasing, respectively. Please describe the evolution of oscillation shown in the figure.
   (e) What happen to the hatched areas? What kind of gain medium is this?

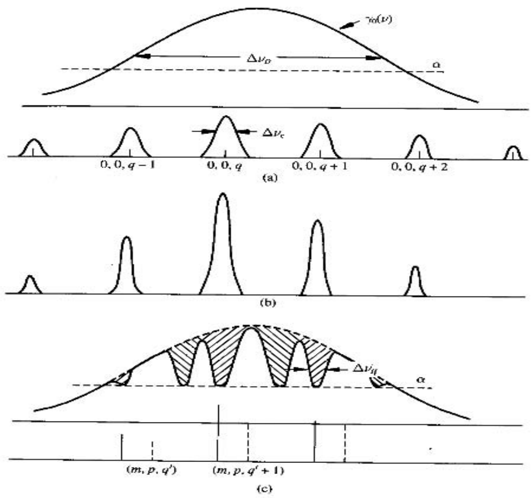

FIGURE 8.12. Evolution of oscillation in a Doppler-broadened transition.

5. (10 %) Gain switching and Q-switching are two common techniques for generating short pulses.
   (a) To describe and compare the mechanisms of these two techniques, please draw the relations of the pump, the loss, the gain (population difference), and the photon number density as they vary with time (Please mark all the critical timings clearly).
   (b) What limits the pulsewidth in these techniques?

6. (15%) If you were working in a basic research laboratory of a big company and you were assigned a job to select a semiconductor material for (a) light emitting purpose (b) light absorbing purpose for the company's future products, what aspects in the optical characteristics of the material, in general, that you would have to consider and evaluate? Discuss in detail.

7. (10%) Describe and explain the working principle of the light emitting diode(LED).

8. An electro-optic uniaxial material has the Pockels coefficients

$$\begin{bmatrix} 0 & -r_{22} & r_{13} \\ 0 & r_{22} & r_{13} \\ 0 & 0 & r_{33} \\ 0 & r_{51} & 0 \\ r_{51} & 0 & 0 \\ -r_{22} & 0 & 0 \end{bmatrix}.$$

Use such a material to design an electro-optic intensity modulator (5%) and derive its half-wave voltage (5%). In your design, specify the crystal axes and the electric field direction relative to the laser polarization and propagation directions. Assume the incident laser wavelength is λ (in vacuum), the refractive indices of the ordinary and extraordinary polarizations are n_0 and n_e, respectively, and the length (along x) and the thickness (along z) of the crystals are L and d, respectively.

1. Explain why the variation of the refractive index is shifted by 90° with respect to the electric field variation in a photorefractive material. (5%)
2. Explain why the 2nd order optical nonlinearity only exists in a material without inversion symmetry. (5%)
3. A short optical pulse is transmitted into a piece of 2nd-order nonlinear optical material and an electromagnetic pulse of its field envelope is generated at the output, as shown below. Explain the underline nonlinear optical mechanism of such a process. This technology is sometimes adopted to generate a THz electromagnetic pulse from an ultrafast laser pulse. (5%)