光電所 98 學年度第二學期博士班資格考 光電子學 II 考題
總共三頁　九題　一百分

1. A step-index fiber has the following parameters:
a : 4 μm　(core radius)
n_1 , n_2 : 1.45, 1.448
(a) Determine the single-mode cutoff wavelength λc, i.e., the critical wavelength for single-mode operation. (6%)
(b) Is this fiber single-moded for the wavelength 1.55 μm ? Give your explanation. (7%)

2. T he normalized frequency V is defined to be $2\pi h (n_1^2 - n_2^2)^{0.5}/\lambda$ for a symmetric optical slab waveguide, where h is the thickness of the guiding layer ,n_1 and n_2 are the refractive indices of the guiding layer and the claddings, respectively. For TE modes the cutoff value of V for TE_0, TE_1, TE_2,…,TE_N modes are $0, \pi, 2\pi, \cdots, N\pi$.
(a) What is the required h for this waveguide to be single-moded ? (6%)
(b) How many TE modes exist for h= 10 μm, n_1 =1.5, n_2 = 1.45, and λ =1.55 μm ? (6%)

3. (15 %)Assuming you are talking to someone not in the field of photonics. He/She knows nothing about lasers and wants to learn something about pulse generations. Answer the following questions in detail. (The more comprehensive the higher score)

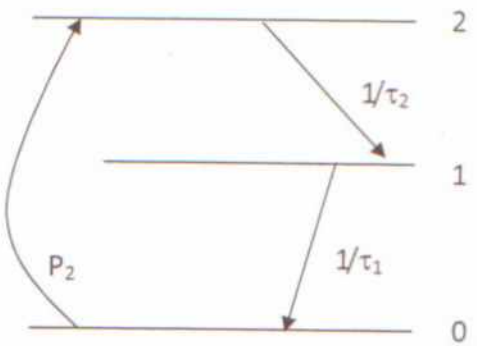
(a) What is "mode-locking"?

(b) What is "Q-switching"?

(c) What are the differences between them?

4. (10 %) In the diagram shown below, the pump P_2 excites atoms from state 0 to state 2, nothing to state 1. To make the problem simple and tractable, assume state 0 is

not depleted to any significant extent for any time (i.e., $dN_0/dt = 0$) and $N_2(0)$and $N_1(0)$ are 0 initially; use the simple decay route indicated; neglect stimulated emission; assume $\tau_2 = 1$ μs and $\tau_1 = 2$ μs; and let $P_2 = 10^{20}$ cm^{-3} s^{-1}. Use symbols for (a) and (b) and find numerical values for (c) and (d).



(d) What are the rate equations for states 2 and 1?

(e) Give an expression for the densities $N_{2,1}$ as a function of time.

(f) What are the steady-state populations in 2 and 1?

(g) Over what time interval, δt, is the population difference N_2-$N_1 > 0$?

5. Explain in detail why the semiconductor with indirect band gap is considered to be a poor light emitter? (7%)

6. Formulate an expression that relates the Fermi function and the density of states to the spontaneous emission rate. If the material is lightly doped, derive the spectral intensity of the direct band to band spontaneous emission rate at thermal equilibrium and plot it as a function of frequency, interpret your result. (10%)

7. Explain the basic working principle of the light emitting phenomenon in a

forward biased p-n junction photodiode. (8%)

8. (3%) (A) You want to fabricate a transverse optical phase modulator for a low-speed data encoding system. Two distinct optical phase changes of (0 and π) via the modulator are used to encode your data. You are given two crystals with equal physical dimensions. However, they have different Pockels coefficients (γ_1, $\gamma_2=3\gamma_1$) and refractive indices (n_1, $n_2=0.5n_1$). Based on the information, discuss which crystal is preferred for a real system, where less electrical driving power is desired. Your reasoning should be in conjunction with certain mathematical formulations.

(4%) (B) What is the major design difference between high-speed (say, 10-GHz) EO modulators from the low-speed modulator considered in (A)?

(3%) (C) Is it possible to obtain higher frequency optical output by driving an intensity modulator using a lower frequency electrical source? You need to prove your answer pictorially or theoretically.

9. (15%) Can you give a description on the optical solitons and the spatial solitons? What are the required conditions to generate optical solitons and spatial solitons, respectively?