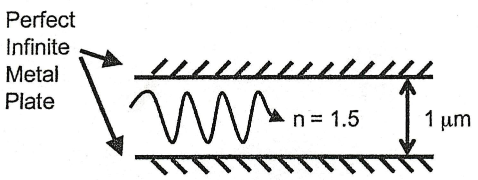
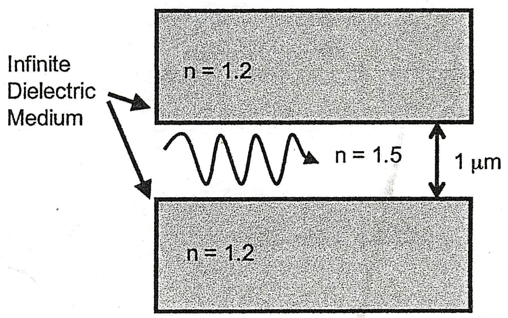
2012 秋季 光電所博士班資格考題 光電子學 II　　共 4 頁 9 題　總分 100

1.

(10%) What is the cut-off wavelength for the metallic waveguide and dielectric waveguide, respectively? Suppose the wave propagate from the left to the right and the polarization is perpendicular to the paper.





2. (10%)

The propagation constant β of an LP_{0m} mode for a weakly-guiding step-index fiber satisfies

$$\kappa a\, J_1(\kappa a)/J_0(\kappa a) = \gamma a\, K_1(\gamma a)/K_0(\gamma a)$$

where κ and γ are defined by $\kappa = (k_0^2 n_1^2 - \beta^2)^{1/2}$ and $\gamma = (\beta^2 - k_0^2 n_2^2)^{1/2}$;

a is the radius of the fiber core ;

J_0 , J_1 are Bessel functions of the first kind, and K_0 ,K_1 are modified Bessel functions of the second kind.

At cutoff, the normalized frequency V, defined as $k_0 a\,(n_1^2 - n_2^2)^{1/2}$, is equal to κa, because γa is 0.

Find the value of V at cutoff, i.e., the cutoff value of V , for LP_{01} and LP_{02} modes.

Note: $K_1(x) \rightarrow 1/x$, and $K_0(x) \rightarrow -[\ln(x/2)+0.5772]$, as $x \rightarrow 0$.

Zero points of $J_0(x)$ are x= 2.405, 5.520, 8.654, ….

Zero points of $J_1(x)$ are x= 0, 3.832, 7.016, 10.173, ….

3.

(10%) Give the precise physical meaning of the following terms: (a) inhomogeneous broadening of the lineshape function (b) blackbody radiation (c) Raman scatter.

4.

(10 %) Please answer the following questions briefly:

(a) What are the main differences between laser amplifiers and lasers?

(b) Under what conditions can hole burning occur?

(c) Is it possible to have a two-level pumping scheme? If any, how does it work?

(d) Please draw the energy levels and all the corresponding rates of decays, pumping, absorption, and emission according to the following rate equations.

$$\frac{dN_2}{dt} = R_2 - \frac{N_2}{\tau_2} - (N_2 - N_1)W_i$$

$$\frac{dN_1}{dt} = -R_1 - \frac{N_1}{\tau_1} + \frac{N_2}{\tau_{21}} + (N_2 - N_1)W_i$$

5.

a. (1) Explain how the gain condition of a laser makes a short wavelength laser more difficult to lase. (3%) (2) Describe how the phase condition of a laser affects the output frequency of a laser. (2%)

b. Explain how an intra-cavity etalon allows a laser to operate with a single longitudinal mode. Is there a condition between the free spectral range of the etalon and that of the laser cavity for this mode selection scheme to work? (5%)

c. A mode-locked laser employs a linear laser cavity. Given a pulse rate of 3 GHz at the output, what is the optical path length of the cavity? (1%) How many longitudinal modes in the laser spectrum are required to generate a 10 fs laser pulse width at the output? (2%) Describe possible ways to mode lock a laser. (2%)

6. (10%)

Given the Fermi-Dirac probability distribution function, $f(E_C)=\dfrac{1}{1+e^{\frac{E_C-E_f}{kT}}}$,

explain,

(a) what is significance of this function?

(b) what are the definitions of E_c and E_f ? estimate what is the value of E_f for an intrinsic GaAs (Eg=1.43eV), and

(c) estimate what is the probability that a state at the conduction band edge of intrinsic GaAs is occupied at room temperature?

7.

The double heterostructure (DH) can provide the electrical and optical confinement effects for semiconductor lasers. How does this DH provide both the confinement effects? (10%)

8.

An electrically controlled directional coupler is shown in Figure 1. The power-transfer ratio is $T\equiv\dfrac{P_2(L)}{P_1(0)}=\left(\dfrac{\pi}{2}\right)^2\text{sinc}^2\left[\dfrac{1}{2}\sqrt{1+\left(\dfrac{\Delta\beta\cdot L_0}{\pi}\right)^2}\right]$, where $\text{sinc}(x)\equiv\dfrac{\sin(\pi x)}{\pi x}$, $\Delta\beta=\dfrac{2\pi\cdot\Delta n}{\lambda_0}$ is the mismatch of the propagation constants, Δn is the difference between the refractive indices of the 2 waveguides, λ_0 is the operating wavelength.

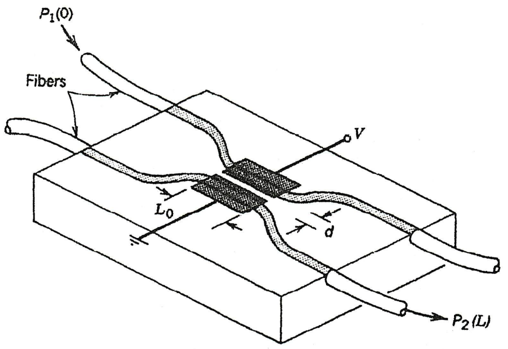


Figure 1.

a) (10%) Describe how to switch the optical power between the two waveguides.

b) (5%) What problem(s) will arise when a short pulse is sent into the directional coupler?

9.

a. Given a 2nd-order nonlinear optical material with known dispersion and a pump wavelength λ_p, how do you calculate the signal and idler wavelengths, λ_s and λ_i, respectively? Assume birefringence phase matching. (4%)

b. For the quasi-phase-matched second harmonic generation (SHG) in lithium niobate using the d_{33} coefficient, what is the first-order phase matching condition for a nonlinear grating period of Λ in the crystal? Compare its output power efficiency with birefringence phase matched SHG using the d_{31} coefficient. In your answers, specify the refractive indices for the e-wave and o-wave as n_e and n_o, and use the subscripts ω and 2ω to denote parameters associated with the fundamental and SHG waves, respectively. (6%)