1. (10%) Calculate the quasi-Fermi levels ($E_{fn} - E_i$ and $E_i - E_{fp}$) at 300K (room temperature) for a semiconductor with $N_a = 10^{16}\text{cm}^{-3}$, $\tau_n = 10\mu\text{s}$, $n_i = 10^{10}\text{cm}^{-3}$, and $G_L = 10^{18}\text{cm}^{-3}\text{s}^{-1}$. kT=0.026eV.

2. (10%) Sketch the electric field diagram for the charge distribution shown in Fig.P2.

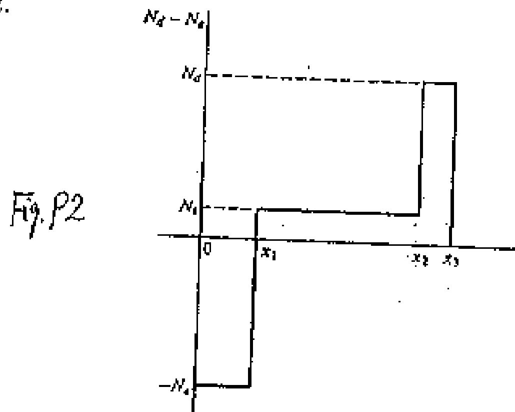


Fig.P2

3.
(5%) (a) A p^+n diode is reverse-biased with V_R, and the charge stored in either half of the junction is

$$Q = qAN_dx_d = A\sqrt{2qK_s\epsilon_o(\psi_o + V_R)N_d}.$$

Show the depletion-layer capacitance can be written

$$\frac{1}{C^2} = \frac{2}{qK_s\epsilon_oN_dA^2}(V_R + \psi_o)$$

(5%) (b) Explain how to obtain the donor density N_d and the built-in voltage ψ_o from this $\frac{1}{C^2}$ versus V_R plot?

4.
(5%) (a) Sketch the energy-band diagram for an n^+pn transistor at equilibrium and under the normal active mode of operation.
(5%) (b) Sketch the minority-carrier density in the base at (i) normal, and (ii) saturation.

5.
(5%) (a) Let's consider a thin layer of charge Q_o per unit area located at x from the metal as shown in Fig.P5. Note that the Q_o induces charges in metal and silicon at $V_G = 0$. Sketch the electric field distribution for $V_G = 0$.
(5%) (b) Find the gate voltage ($V_G = V_{G1}$) to realize the flat-band condition (i.e. the electric field is zero at x^+.) Sketch the electric field distribution for $V_G = V_{G1}$.

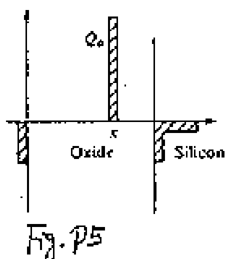


Fig.P5

6. For a p^+ polysilicon gate, the Fermi level is essentially pinned at E_v (i.e. $E_f = E_v$ in p^+ region). The work-function difference for the MOS system is

$$\phi_{ms} = (E_{vac} - E_v) - (E_{vac} - E_{fs})$$

where E_{fs} is the Fermi level of the substrate.
(5%) (a) For an n-type substrate, show

$$\phi_{ms} = E_g - kT\ln\frac{N_c}{N_d}$$

(5%) (b) For a p-type substrate, show

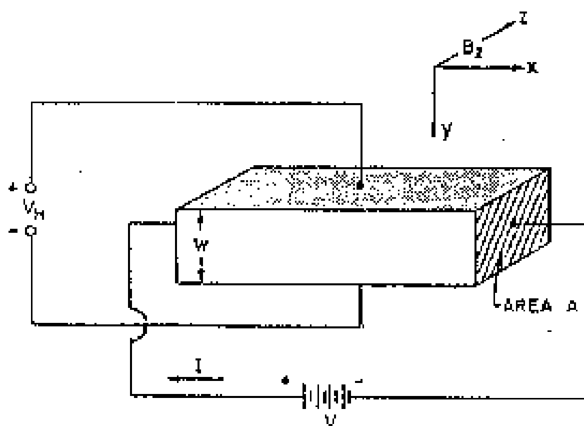
$$\phi_{ms} = kT\ln\frac{N_v}{N_a}$$

參考用

注意：背面有試題

7. Considering a stripe semiconductor laser,
   (a) derive an expression for the wavelength separation $\Delta\lambda$ between the allowed modes in the longitudinal direction of a Fabry-Perot cavity having length L. (15%)
   (b) for a laser operated at a wavelength $\lambda = 0.65\ \mu m$ with the refractive index of active region $\bar{n} = 3.58$, $L = 200\ \mu m$, and $d\bar{n}/d\lambda = 3.5\ \mu m^{-1}$, estimate $\Delta\lambda$. (5%)

8. (a) Given a uniform Si semiconductor sample of resistivity $\rho = 1.12\ \Omega\text{-cm}$. Hall measurement has been made and the following information obtained : $W = 0.1$ cm, $A = 3.2 \times 10^{-3}\ cm^2$, $I = 2.5$ mA and the magnetic field B_z is 60 nT (refer to the shown figure). If a Hall voltage of +20 mV is measured, find Hall coefficient, conductivity type, majority carrier concentration and mobility of the sample. (14%)



   (b) Draw three pratical configurations of sample geometry suitable to Hall measurement. (6%)

參考用