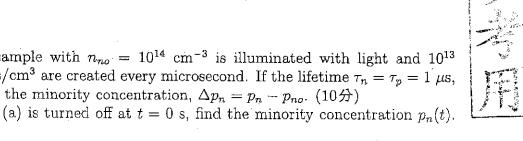
國立中央大學104學年度碩士班考試入學試題

所別:電機工程學系碩士班 固態組(一般生) 本科考試禁用計算器

> (a) A n-type Si sample with $n_{no}=10^{14}~{\rm cm}^{-3}$ is illuminated with light and 10^{13} electron-hole pairs/cm³ are created every microsecond. If the lifetime $\tau_n = \tau_p = 1 \mu s$, find the change in the minority concentration, $\Delta p_n = p_n - p_{no}$. (10%)

> (b) If the light in (a) is turned off at t = 0 s, find the minority concentration $p_n(t)$. (10分)



(a) Consider a Si one-sided abrupt p^+ -n junction with a constant doping N_d . If the junction capacitance C_j is given by $\frac{1}{C_j^2} = f_1 \cdot \frac{V_{bi} - V}{q\epsilon_s}$, find f_1 which is a function of the doping concentration N_d . Note that V_{bi} is the built-in voltage, V is the bias voltage, and ϵ_s is the silicon permittivity. (10分)

(b) If we consider the case in (a) with N_d is not a constant, but $N_d = N_d(x)$, which is position-dependent. Assume $N_d(W) = f_2 \cdot \frac{1}{|d(1/C_i^2)/dV|}$, where W is the depletion width. Find f_2 which is a function of the Si permittivity ϵ_s . (10分)

- 3. Consider a MOS capacitor with p-type semiconductor substrate, $N_a = 10^{15}$ cm⁻³. The oxide capacitance is $C_{ox} = 2 \times 10^{-7} \text{ F/cm}^2$, and the work function difference $\phi_{ms} = -0.88$ V. Assume that a fixed charge Q_f' is located at the oxide-semiconductor interface. $Q_f' = 8 \times 10^{-9}$ C/cm². $V_t = kT/q = 0.026$ V. $\ln 10 = 2.3$. $q = 1.6 \times 10^{-19}$ C. For silicon, $\epsilon_s = 11.7 \times 8.85 \times 10^{-14}$ F/cm $= 103.5 \times 10^{-14}$ F/cm, and $n_i = 10^{10}$
- (a) Calculate the flat-band voltage. (10分)
- (b) Calculate the maximum space charge width x_{dT} , and the threshold voltage V_{T} . (10分)
- 4. Assume the shift in the flat-band voltage due to a fixed charge distribution $\rho(x)$ in the oxide is given by $\Delta V_{FB} = -\frac{f_1}{C_{ox}}$. If $\rho(x) = \rho_0$ C/cm³ and ρ_0 is a constant, find the function f_1 which is a function of the charge distribution ρ_0 and the oxide thickness t_{ox} . Note that $C_{ox} = \frac{\epsilon_{ox}}{t_{ox}}$, and ϵ_{ox} is the oxide permittivity. (20 \Re)
- (a) Find the transit time for electrons in an npn prototype transistor with base width of $W_B = 0.15 \ \mu\text{m}$, and electron diffusion coefficient of $D_n = 20 \ \text{cm}^2/\text{s}$. (10%)
- (b) Derive the equation for transit time in (a). $(10 \, \%)$