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)　科目：半導體元件　共 1 頁 第 1 頁

本科考試禁用計算器　　＊請在答案卷（卡）內作答

1.

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

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

2.

(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 $N_d(W) = f_2 \cdot \frac{1}{|d(1/C_j^2)/dV|}$, 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 $C_{ox} = 2 \times 10^{-7}$ F/cm^2, and the work function difference ϕ_{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/cm^2. $V_t = kT/q = 0.026$ 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 $n_i = 10^{10}$ cm^{-3}.

(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/cm^3 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分)

5.

(a) Find the transit time for electrons in an npn prototype transistor with base width of $W_B = 0.15$ μm, and electron diffusion coefficent of $D_n = 20$ cm^2/s. (10分)

(b) Derive the equation for transit time in (a). (10分)