

國立中央大學103學年度碩士班考試入學試題卷

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

*請在試卷答案卷(卡)內作答

1.

The lattice constant for Si is 5.43 Å.

- (a) Find the number of atoms in Si in the (111) plane. (5分)
 (b) Find the number of atoms in Si per cubic centimeter. (5分)

2.

Consider an n-type semiconductor at $T = 300$ K with carrier concentration of $n_o = 10^{16} \text{ cm}^{-3}$, $n_i = 10^{10} \text{ cm}^{-3}$, and $p_o = 10^4 \text{ cm}^{-3}$. In nonequilibrium, assume that the excess carrier concentrations are $\delta n = \delta p = 10^{13} \text{ cm}^{-3}$. Calculate the quasi-Fermi energy levels. $kT = 0.026$ eV. $\ln(10) = 2.3$. (10分)

3.

Consider a pn junction with doping concentration of N_a in the p-side and N_d in the n-side.

(a) Assume $W = x_p + x_n$, where W is the total depletion width, x_p is the p-side depletion width, and x_n is the n-side depletion width. If x_p is given by $x_p = W/(1+f_1)$ and $x_n = W/(1+f_2)$, find f_1 and f_2 as functions of N_a and N_d . (10分)

(b) Assume $V_{bi} = V_{bip} + V_{bin}$, where V_{bi} is the total built-in voltage, V_{bip} is the p-side built-in voltage, and V_{bin} is the n-side built-in voltage. If V_{bip} is given by $V_{bip} = V_{bi}/(1+f_3)$ and $V_{bin} = V_{bi}/(1+f_4)$, find f_3 and f_4 as functions of N_a and N_d . (10分)

4.

Consider a MOS capacitor with doping concentration of N_a in the p-type substrate. The fixed oxide charge Q'_{ss} (C/cm^2) is located at $x = t_{ox}/2$, where t_{ox} is the oxide-layer thickness. Assume the threshold voltage V_{TN} is given by

$$V_{TN} = \frac{f_1}{C_{ox}} + f_2 \cdot Q'_{ss} + \phi_{ms} + 2\phi_{fp}$$

(a) Find f_1 as a function of N_a , f_2 as a function of t_{ox} , and ϕ_{fp} as a function of N_a . Note that C_{ox} is in F/cm^2 . (12分)

(b) If the p-type substrate with N_a is changed to the n-type substrate with N_d , modify the V_{TN} to obtain the V_{TP} for the n-type substrate. (8分)

5.

Consider a MOS capacitor with doping concentration of N_a in the p-type substrate.

(a) Sketch and explain the $C - V$ characteristics of the MOS capacitor under high-frequency and low-frequency conditions. (10分)

(b) If a minimum capacitance C'_{min} is given by $C'_{min} = \epsilon_{ox}/(t_{ox} + (\frac{\epsilon_{ox}}{\epsilon_s}) \cdot f_1)$, find the f_1 as a function of N_a . (10分)

6.

Consider an npn BJT with a base width of x_B . The excess electron concentration is defined as $\delta n_B(x) = n_B(x) - n_{B0}$. The BJT is biased in active region with $V_{BE} > 0$ and $V_{BC} < 0$. Assume the $\delta n_B(x)$ is given by

$$\delta n_B(x) = \frac{\delta n_B(0) \cdot f_1 + \delta n_B(x_B) \cdot f_2}{\sinh(x_B/L_B)}$$

(a) Find $\delta n_B(0)$, $\delta n_B(x_B)$, f_1 , and f_2 . (12分)

(b) Simplify $\delta n_B(x)$ if $x \ll L_B$. (8分)

參考用