八十六學年度 電子所乙電組系（所） 丙 組碩士班研究生入學考試

科目 固態電子元件 科號 3205 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. short questions.

(A) Write down **the order of magnitude** and the **unit** of the intrinsic carrier concentration and electron mobility of Si at room temperature (4%)

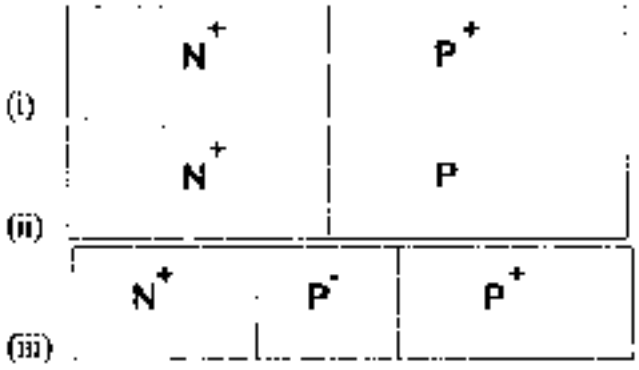
(B) Write down the Einstein relationship. (2%)

(C) Explain how the quasi-Fermi levels are defined and their relationship to current densities (4%)

2. Discuss the **origin** of the capacitance of a P/N junction under (a) reverse bias and (b) forward bias You don't have to derive the detailed mathematical expressions, only the **physical origin** and their **dependence on applied bias** are important You may just draw diagrams to show the charge distribution profile and describe briefly. (15%)

3. In the following structures of P/N junctions,

(A) please plot the electric field distributions as the voltage V_{app} is applied to the P/N junctions. (15%)



(B) In the above three cases, which case has the largest electric field and which case has the smallest electric field? (5%)

(C) In the above three cases, which structure could have 2 maximum fields? (5%)

4.

(A) Write down the expression of the threshold voltage V_{th} for an ideal MOS structure with n-type substrate and explain the meaning of each term. (5%)

(B) In practice, there is a flat-band voltage shift V_{FB} for experimentally measured V_{th} as compared to the ideal theoretical expression given in (A). Write down the expression of the flat-band voltage V_{FB} in term of work function difference ϕ_{MS} and fixed interface charge density Q_f. (5%)

(C) Explain how these two factor ϕ_{MS} and Q_f can be determined from the measurement of V_{FB} of MOS capacitors with different oxide thickness. (5%)

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5. For a long-channel MOSFET,

(A) write down the $I_D - V_D$ relationship in the square-law theory. (5%)

(B) define the saturation voltage V_{Dsat} beyond which the drain current saturates and find the drain saturation current I_{Dsat}. (5%)

(C) There are parasitic resistance R_s and R_D which exist between the source/drain terminal and the channel. Find out the $I_D - V_G$ relationship in the square-law theory under the influence of R_s and R_D. (5%)

6. (20%)

(A) Draw the energy band diagram for a metal to n-type semiconductor junction. Assume that the work function of the metal is larger than that of the semiconductor, that is, $q\phi_m > q\phi_s$, where $q\phi_m$ and $q\phi_s$ are the work function of the metal and the semiconductor, respectively. Denote the electron affinity of the semiconductor as $q\chi$. Find out the Schottky barrier height and the contact potential.

(B) Draw the energy band diagram for a metal to p-type semiconductor junctions. Assume in this case $q\phi_m < q\phi_s$. Denote the electron affinity of the semiconductor as $q\chi$. Find out the Schottky barrier height and the contact potential.

(C) Draw the energy band diagram for case (a), but with $q\phi_m < q\phi_s$. What is the electrical behavior of this junction?

(D) Draw the energy band diagram for case (b), but with $q\phi_m > q\phi_s$. What is the electrical behavior of this junction?