參考用

1.

(a) At 300 K, the lattice constant for Si is 5.431 $\times 10^{-8}$ cm^{-3}. Calculate the number of Si atoms per cubic centimeter and the distance between nearest neighbors in Si. (10 分)

(b) Consider the density of states for a free electron given by $g(E) = c \times \sqrt{E}$ $(\mathrm{eV})^{-1}\mathrm{cm}^{-3}$, where c is a constant and E is the energy in eV. Calculate the density of states per cubic centimeter with energies between 0 and 1 eV. (5 分)

(c) Let $T = 300$ K, $kT = 0.026$ eV. Determine the probability that an energy level kT above the Fermi energy is occupied by an electron. e^1=2.718. (5 分)

2.

(a) If W is the space charge width in a pn junction, and assume $W = \{V_{bi} \times f_1\}^{1/2}$, where f_1 is a function of dopings N_a and N_d. Find the expression for $f_1(N_a, N_d)$. (10 分)

(b) If a $\mathrm{p^+n}$ junction is biased with a reverse-biased voltage V_R. Assume the inverse capacitance squared is given as $(1/C')^2 = f_1(f_2 + V_R)$, where f_1 is a function of N_d, f_2 is a function of V_{bi}, and C' is the capacitance per unit area. Find $f_1(N_d)$ and $f_2(V_{bi})$. (10 分)

3.

(a) Sketch the minority carrier concentrations in a pnp bipolar transistor biased in the forward-active mode. (5 分)

(b) Describe the voltage breakdown mechanisms in a bipolar transistor. (5 分)

(c) Define I_{CBO} and I_{CEO}, and explain why $I_{CEO} > I_{CBO}$. (5 分)

(d) Define the emitter injection efficiency factor γ and base transprt factor α_T in a bipolar transistor. (5 分)

4.

Consider a silicon MOS device at $T = 300$ K for the following parameters: $\mathrm{p^+}$ polysilicon gate, $N_a = 10^{16}$ cm^{-3}, $t_{ox} = 8$ nm, and the fixed charge at $\mathrm{SiO_2}$-Si interface $Q'_{ss} = 10^{10}$ cm^{-2}.

(a) Calculate the metal-semiconductor work function difference ϕ_{ms}, and the maximum space charge width x_{dT}. (10 分)

(b) Calculate the threshold voltage V_{TN}. (10 分)

The following data may be used for calculation: $\ln 10^3 = 2.3 \log 10^3 = 6.9$. $\ln x = 2.3 \log x$. $V_t = kT/q = 0.026$ V. Silicon band gap $E_G = 1.12$ eV. $n_i = 10^{10}$ cm^{-3}. $\epsilon_{Si} = 11.7 \times 8.85 \times 10^{-14}$ F/cm. $\epsilon_{SiO_2} = 3.9 \times 8.85 \times 10^{-14}$ F/cm. $q = 1.6 \times 10^{-19}$ C.

5.

For n-channel MOSFET, $I_D = \beta_n[2(V_{GS} - V_{TN})V_{DS} - V_{DS}^2]$ in the linear region, and $I_D = \beta_n(V_{GS} - V_{TN})^2$ in the saturation region. For p-channel MOSFET, the I_D can be obtained by modifying the above equations. Consider a p-channel MOSFET with $\beta_p = 1$ mA/V^2.

(a) Assume the drain current $I_D = 1$ mA from source to drain, $V_{SG} = 2$ V, $V_{BS} = 0$ V, and $V_{SD} = 1.2$ V. Determine the V_{TP} value. V_{TP} should be negative. (10 分)

(b) Assume $V_{SG} = 2$ V, $V_{BS} = 0$ V, and $V_{SD} = 0.2$ V. Calculate the drain current I_D. (10 分)