類組：電機類 科目：固態電子元件(300G) 共 3 頁 第 1 頁

※請在答案卷內作答

1. Use $n_i=1\times10^{10}$ cm^{-3} and $2.3kT = 60$ meV for this problem

   (a) The electron concentration n in a piece of silicon at 300 k is 10^5 cm^{-3}. What is the hole concentration p? (5%)

   (b) A silicon sample is doped with impurity concentration $N_D=9\times10^{17}$ cm^{-3} and $N_A=8\times10^{17}$ cm^{-3}. Assume that all the impurities are ionized. Find the electron concentration n and hole concentration p. (5%)

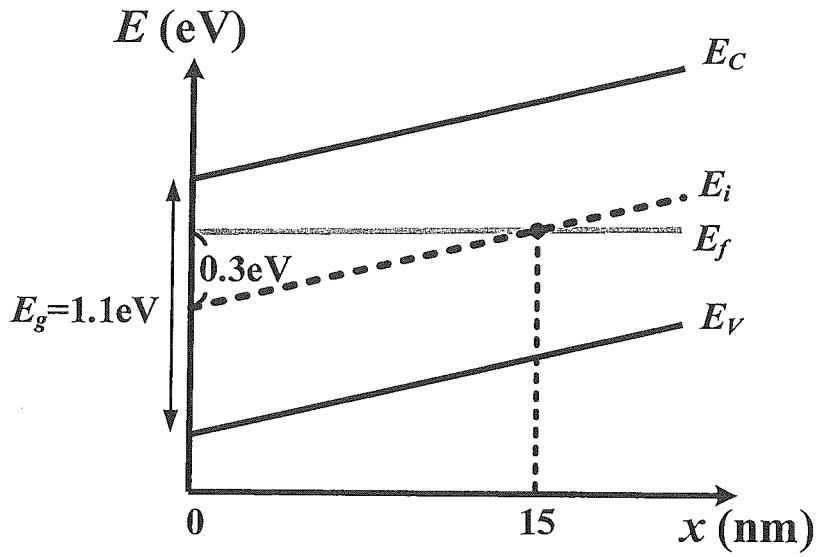
   (c) For a silicon sample at T = 300 K, the Fermi level is located at 0.21 eV above the intrinsic Fermi level. Find the electron concentration n and hole concentration p. (5%)

2. A part of the energy band diagram of a silicon bar under equilibrium conditions is shown below.

   (a) Find the electric field in this region. (5%)

   (b) What is the electron concentration $n(x)$ for this region? (5%)

   (c) What is the drift current density $J(x)$ assume mobility $\mu = 1000$ cm^2/Vs.? (5%)



注意:背面有試題

※請在答案卷內作答

3. Please qualitatively plot the steady-state depletion region widths and the minority carrier concentration profiles in an abrupt p^+n junction under (a) zero bias and (b) reverse bias. Assume that the p-type doping concentration is much larger than that of n-type. (10%)

4.

(a) We deposit a metal with a work function of 4.6 eV on an n-type Si to form an M-S junction. Suppose that the Si has an electron affinity of 4 eV and a doping concentration of 10^{17} cm^{-3}. Please draw the equilibrium band diagram of this M-S junction at room temperature. Please properly indicate important parameters (such as energy, junction position, depletion width, …etc.) on the diagram. (5%)

(b) As a comparison, please draw the equilibrium band diagram of an abrupt Si p^+n junction at room temperature. Suppose that the n-type doping concentration is also 10^{17} cm^{-3} and the p-type doping concentration is 10^{20} cm^{-3}. Please properly indicate important parameters (such as energy difference, junction position, depletion width, …etc.) on the diagram. (5%)

(c) On the same I-V diagram, please qualitatively draw the I-V characteristics of the two junctions described in (a) and (b). (5%)

5. Derive the transconductance formula, $\frac{\partial i_C}{\partial v_{BE}}$, of an NPN BJT biased in the forward-active region.

Please state clearly the parameters used in your expressions. (10%)

注意:背面有試題

類組：電機類 科目：固態電子元件(300G) 共 3 頁 第 3 頁

※請在答案卷內作答

6. MOS capacitor (25%)

Given a MOS-C with area of A, the thickness of SiO_2 is t_{ox}, the doping of the n-Si substrate is N_D and its gate consists of $p+$ doped poly-silicon, while its flat-band voltage is V_{FB}.

(a) Please plot the band diagrams of the MOS-C at depletion, flat-band and accumulation. Include explicitly the Fermi levels, E_c, E_v, E_i in the plots. (9%)

(b) Assumed ideal SiO_2 and SiO_2/Si interface, please derive the thresold voltage V_{th} as a function of (V_{FB}, t_{ox}, N_D). Please explain the symbols used in the derivation and results. (6%)

(c) Please plot the high-frequency and low-frequency C-V curves of this MOS-C. Explain how t_{ox}, V_{th} and N_D can be found based these C-V curves. (10%)

7. MOSFET (10%)

Transfer I_D-V_G characteristic of a MOSFET at 360 K is shown in **figure below**.

(a) What is the subthreshold swing? (4%)

(b) Decrease the temperature to 240 K, please plot is I_D-V_G characteristic against the curve below (compare with the one measured at 360 K), what is the subthreshold swing at 240 K? (6%)