

※請在答案卷內作答

(以下均為問答題)

1. (10%) Silicon semiconductor material in thermal equilibrium

(a) Prove the intrinsic Fermi-level (E_{Fi}) position of Silicon is close to the middle of energy bandgap (E_{midgap}). (5%)

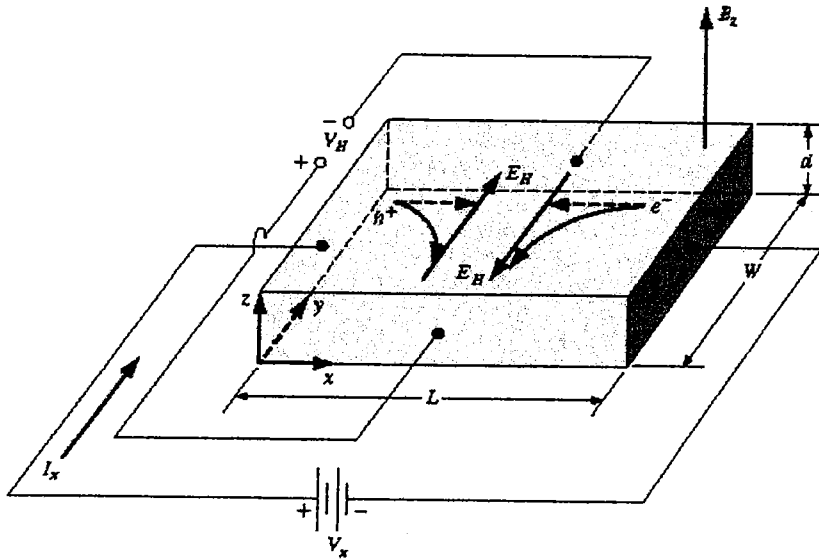
(b) Please derive $n_0 p_0$ product of Si, and give a brief description of the results. (5%)

2. (10%) The Hall Effect

A bulk semiconductor with length= L , width= W , thickness= d , voltage= V_H , voltage= V_x , current= I_x , under magnetic field $(0, 0, B_z)$, is shown in Figure 1.

(a) Determine the hole concentration p in terms of the parameters given above. (5%)

(b) According to the result of (a), determine the hole mobility μ_p . (5%)



參考用

Figure 1 Geometry for measuring the Hall Effect.

3. (15%) According to Figure 2, answer the 3 questions

(a) Define what a direct or indirect bandgap semiconductor is. And explain which category A and B belong to, respectively. (5%)

(b) For light emission diode (LED), semiconductor A or B, which one is suitable for LED application? (5%)

(c) Define the effective mass (m^*). Semiconductor A or B, which one has higher electron effective mass? (5%)

注意:背面有試題

※請在答案卷內作答

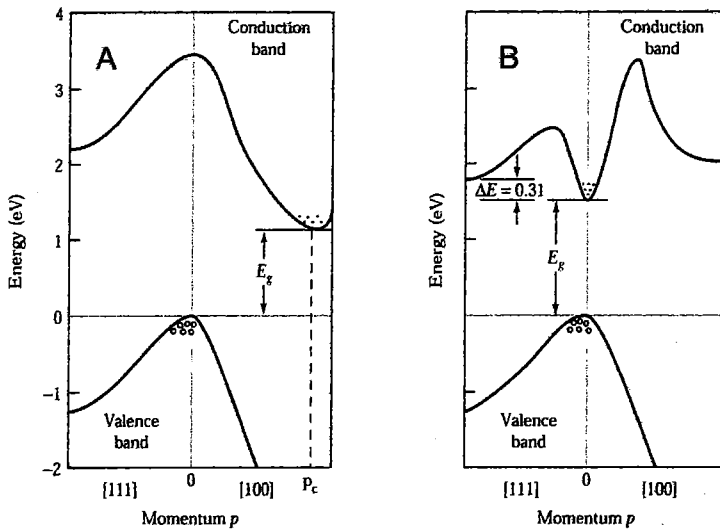


Figure 2

4. (20%) An abrupt Si p-n junction has doping concentrations $N_a = 10^{17} \text{ cm}^{-3}$ on the p side and $N_d = 10^{16} \text{ cm}^{-3}$ on the n side.
 - (a) At 300 K, draw an equilibrium energy band diagram for this p-n junction in which the Fermi level and the built-in potential energy are clearly indicated. Please write the expressions for calculating the positions of the Fermi level and the built-in potential energy. (15%)
 - (b) Is the junction located closer to the p- or n-neutral region? Why? (5%)
5. (10%) For a BJT, if the doping concentration in the base region is increased, which and how the properties of the BJT will be affected? Please list and describe at least two properties. (10%)
6. (15%) Consider a MOS capacitor shown in Figure 3, answer the following questions.
 - (a) Draw the energy band diagram (E_c , E_v , E_i , Fermi level) for cross-section A-A' with zero bias on the gate. (5%)
 - (b) Use p+ poly gate to replace n+ poly gate, draw the energy band diagram (E_c , E_v , E_i , Fermi level) for cross-section A-A'. (5%)
 - (c) Following (b), draw the energy band diagram (E_c , E_v , E_i , Fermi level) with a negative voltage (VGB) on p+ poly gate. (5%)

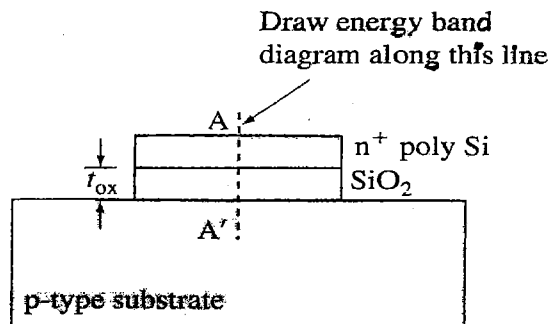
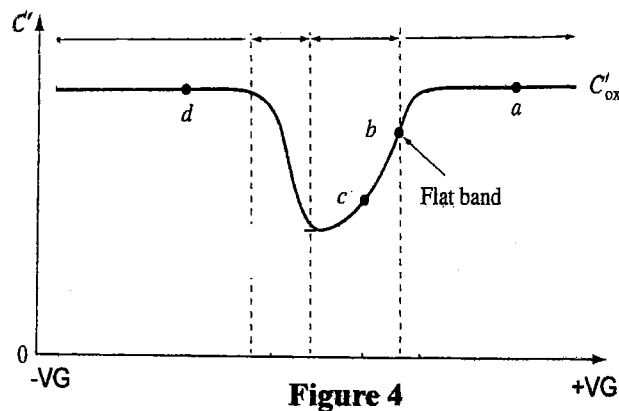


Figure 3

注意:背面有試題

※請在答案卷內作答

7. (10%) For the C-V curve of a MOS capacitor with a p+ poly-Si gate shown in **Figure 4**, answer the following questions.
- What is the substrate type (n or p)? (3%)
 - Which region (a, b, c, or d) indicates inversion? (3%)
 - Draw and compare the C-V curves of another sample with increased the substrate doping level. (4%)



8. (10%) Consider the following effects on a MOSFET: (1) Channel Length Modulation (2) Body effect (3) Velocity Saturation,
- When its gate dielectric thickness decreases, which effects become more prominent? Explain why? (5%)
 - When its channel length decreases, which effects become more prominent? Explain why? (5%)