※請在答案卷內作答

參考用

(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_0p_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%)

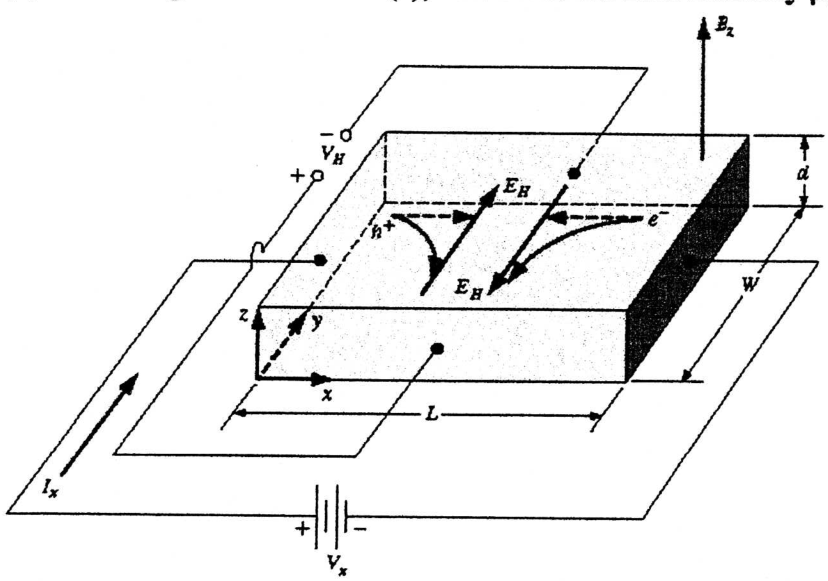

Figure 1　Geometry for measuring the Hall Effect.

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%)

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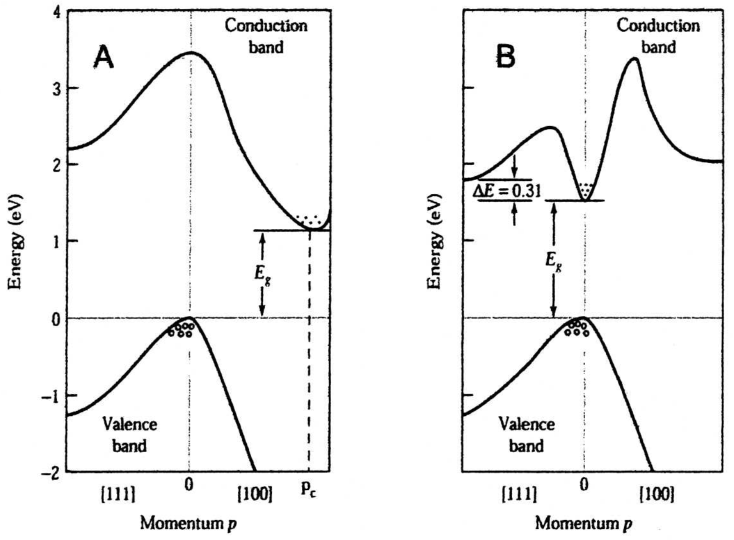

Figure 2

4. **(20%)** An abrupt Si p-n junction has doping concentrations $N_a = 10^{17}$ cm^{-3} on the p side and $N_d = 10^{16}$ 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 (Ec, Ev, Ei, 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 (Ec, Ev, Ei, Fermi level) for cross-section A-A'. (5%)
   (c) Following (b), draw the energy band diagram (Ec, Ev, Ei, Fermi level) with a negative voltage (VGB) on p+ poly gate. (5%)

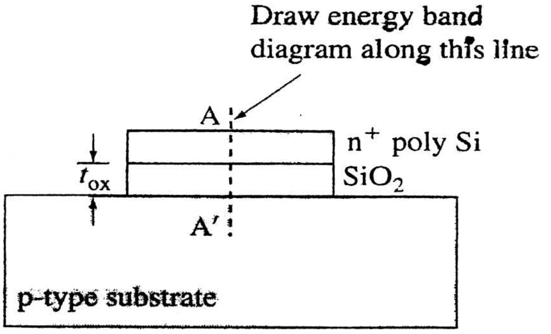

Figure 3

注意:背面有試題

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.

(a) What is the substrate type (n or p)? (3%)

(b) Which region (a, b, c, or d) indicates inversion? (3%)

(c) Draw and compare the C-V curves of another sample with increased the substrate doping level. (4%)

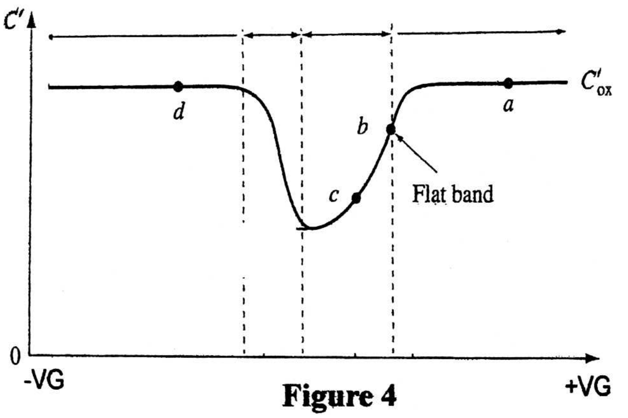

Figure 4

8. **(10%)** Consider the following effects on a MOSFET: (1) Channel Length Modulation (2) Body effect (3) Velocity Saturation,

(a) When its gate dielectric thickness decreases, which effects become more prominent? Explain why? (5%)

(b) When its channel length decreases, which effects become more prominent? Explain why? (5%)