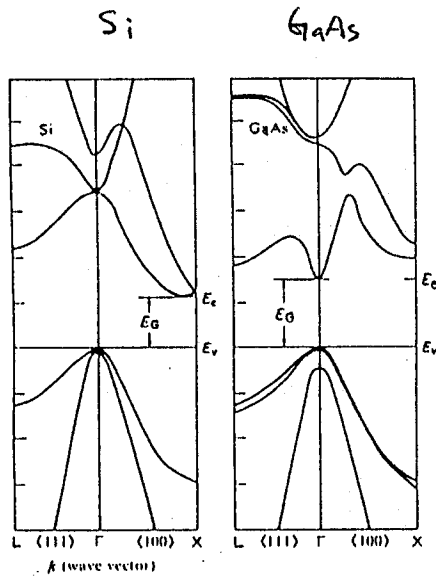


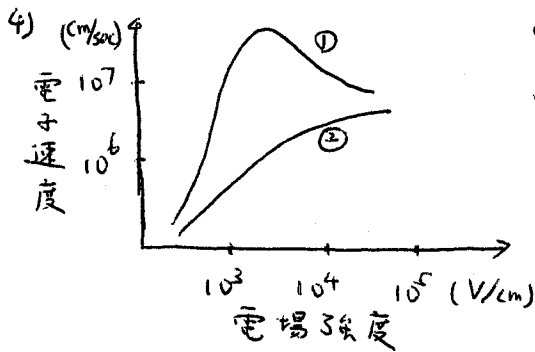
所別：電機工程學系碩士班 乙組 科目：半導體元件

I-1  
(25%)



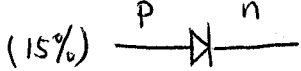
左圖為 Si 及 GaAs 兩種不同半導體之 E-k 圖，請根據此圖作答以下的問題並說明原因。

- 1) 那種半導體有較小的導帶電子 (conduction-band electron) 有效質量 (effective mass) ?
- 2) 那種半導體有較長的少數載子生命期 (minority carrier life-time) ?
- 3) 那種半導體在相同的雜質 (impurity) 濃度條件下，有若較高的崩潰電壓 (breakdown voltage) ?



此圖中表示了兩半導體 (Si & GaAs) 電子速度與電場強度之座標圖，請說明何者為 GaAs，何者為 Si ?

I-2



- (15%) p-n 接面二極體經常被當作開關 (switch) 來使用，請問 1) 有什麼方法可增加 p-n 接面二極體的 switching speed ? 2) p-n 接面二極體的崩潰 (breakdown) 可區分為 tunneling breakdown 及 avalanche breakdown，請分別說明其崩潰的機制 (mechanism) ? 3) 就你所知是否有任何以 p-n 接面所做的元件，其內部會產生增益 (gain) ?

I-3

(10%)

在 p-型半導體中的載子是電洞 (hole)，請問電洞為真實存在的實體嗎？其所帶的電荷為何為正 "+"？其移動率 (mobility) 為何都較電子為低？

注意：背面有試題

參考用

所別： 電機工程學系碩士班 乙組 科目： 半導體元件

II-1 (10%)

Answer the following questions as concisely as possible.

- For a  $p$ -channel J-FET (a J-FET with  $n^+$ - $p$  gating junctions and a  $p$ -region between the source and drain), does the drain current flow into or out of the drain contact under normal operating conditions? Explain.
- What is the mathematical definition of the drain conductance? of the transconductance?
- What do MESFET, D-MESFET, and E-MESFET stand for?

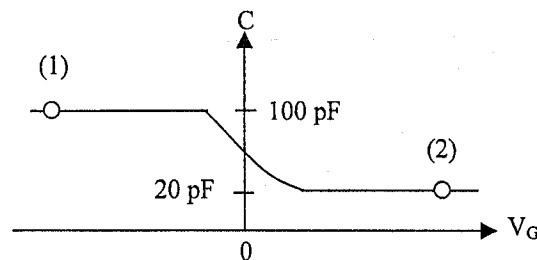
II-2 (15%)

An MOS-C is maintained at  $T = 300$  K, the oxide thickness  $x_o = 0.1 \mu\text{m}$ , and the silicon doping is  $N_A = 10^{15} \text{cm}^{-3}$ .  $\phi_F = kT/q \ln(N_A/n_i)$ .  $kT/q = 0.0259$  V.  $n_i = 10^{10} \text{cm}^{-3}$ .

- Compute the depletion width  $W$  when silicon surface potential  $\phi_S = \phi_F$ .
- Compute the electric field  $E_S$  when  $\phi_S = \phi_F$ , where  $E_S$  is the electric field in the semiconductor at the oxide-semiconductor interface. The silicon permittivity  $\epsilon_{Si} = 11.8 \times 8.85 \times 10^{-14} \text{F/cm}$ .  $q = 1.60 \times 10^{-19} \text{C}$ .
- Compute the gate voltage  $V_G$  when  $\phi_S = \phi_F$ . The oxide permittivity  $\epsilon_{ox} = 3.9 \times 8.85 \times 10^{-14} \text{F/cm}$ .

II-3 (15%)

The C-V characteristic exhibited by an MOS-C (assumed to be ideal) is displayed as follows.



- Is the semiconductor component of the MOS-C doped  $n$ -type or  $p$ -type? Indicate how you arrived at your answer.
- Draw the MOS-C energy band diagram corresponding to point (2) on the C-V characteristic. (Be sure to include the diagrams for all three components of the MOS-C, show the proper band bending in both the oxide and semiconductor, and properly position the Fermi level in the metal and semiconductor.)
- Draw the block charge diagram corresponding to point (1) on the C-V characteristic.
- If the area of the MOS-C is  $3 \times 10^{-3} \text{cm}^2$ , what is the oxide thickness ( $x_o$ )? The oxide permittivity  $\epsilon_{ox} = 3.9 \times 8.85 \times 10^{-14} \text{F/cm}$ .
- Determine the maximum depletion width  $W_T$ . The silicon permittivity  $\epsilon_{Si} = 11.8 \times 8.85 \times 10^{-14} \text{F/cm}$ .

II-4 (10%)

For the  $npn$  transistor biased in the forward active region, the base recombination current is 0.012 mA, the emitter-base junction space-charge recombination current is 0.025 mA, the emitter-base hole-diffusion current is 0.045 mA, the emitter-base electron-diffusion current is 2.1 mA.

- What is the base transport factor?
- What is the emitter efficiency?
- What is the common emitter  $\beta$ .

參考用