國立中山大學113學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：半導體概論【電機系碩士班甲組】

－作答注意事項－

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答。
- 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶書籍、紙張（應考證不得做計算紙書寫）、具有通訊、記憶、傳輸或收發等功能之相關電子產品或其他有礙試場安寧、考試公平之各類器材入場。
- 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。
- 試題採雙面列印，考生應注意試題頁數確實作答。
- 違規者依本校招生考試試場規則及違規處理辦法處理。

國立中山大學 113 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：半導體概論【電機系碩士班甲組】　　　　題號：431012

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　共 1 頁第 1 頁

Please note that all calculation answers must include the unit and calculation process.

Dielectric permittivity of Si: $\varepsilon_{Si} = 11.7 \times 8.85 \times 10^{-14}$ F/cm

Dielectric permittivity of SiO_2: $\varepsilon_{SiO2} = 3.9 \times 8.85 \times 10^{-14}$ F/cm

Energy bandgap of Si: $E_g = 1.12$ eV.

Charge $q = 1.6 \times 10^{-19}$ C.

Thermal energy kT = 25.9 meV at T = 300 K

Electron affinity of Si: $q\chi = 4.01$ eV.

Intrinsic concentration of Si at T = 300 K: $n_i = 1.5 \times 10^{10}$ cm^{-3}.

1. (10%) Please explain what a degenerate semiconductor is and the freeze-out effect.
2. (5%) How to achieve ohmic contact for a metal/semiconductor junction? Please provide two methods.
3. (20%) The values of effective density of states function in the conduction band N_c and valence band N_v for a semiconductor at T = 300 K are 3×10^{19} cm^{-3} and 2×10^{19} cm^{-3}, respectively.
   (a) Calculate the intrinsic concentration of the semiconductor at T = 300 K and 400K, respectively. Assume the bandgap energy of the semiconductor is 1 eV and does not vary over this temperature range. (10%)
   (b) Based on the previous question, if this semiconductor is doped with both donor $N_d = 10^{13}$ cm^{-3} and acceptor $N_a = 3 \times 10^{13}$ cm^{-3}. What are the carrier concentrations of electrons and holes at T = 400 K? (10%)
4. (15%) A semiconductor Hall device at T = 300 K has following geometry as shown in Fig. 1: $d = 10^{-2}$ cm, W = 0.1 cm, and L = 1 cm. The following parameters are measured: $I_x = 5$ mA, $V_x = 10$ V, $V_H = -5$ mV, and $B_z = 0.1$ tesla. Determine (a) conductivity type (please explain whether this semiconductor is of n-type or p-type) (5%), (b) majority concentration (5%), and (c) majority carrier mobility. (5%)
5. (30%) Consider a uniformly doped silicon pn junction at T = 300 K. At zero bias, 20 percent of the total space charge region is in the n-region. The built-in potential barrier is $V_{bi} = 0.75$ V.
   (a) Determine dopant concentration and depletion width in p-region and n-region, respectively. (i.e. determine N_a, N_d, x_n, x_p) (20%)
   (b) Determine the maximum electric field (E_{max}) and junction capacitance density C_j. (10%)
6. (20%) A MOS-Capacitor with metal work function 4.6 eV, gate insulator SiO_2 with thickness 15 nm, silicon substrate with boron doped (p-type) to 1×10^{17} cm^{-3} at T= 300 K. Please find out (a) the ideal flat-band voltage V_{FB} (5%), (b) flat-band capacitance density (5%), (c) ideal threshold voltage V_{TH} (5%), and (d) saturated depletion width (5%). The V_{TH} means the MOC-Cap is biased into strong inversion.

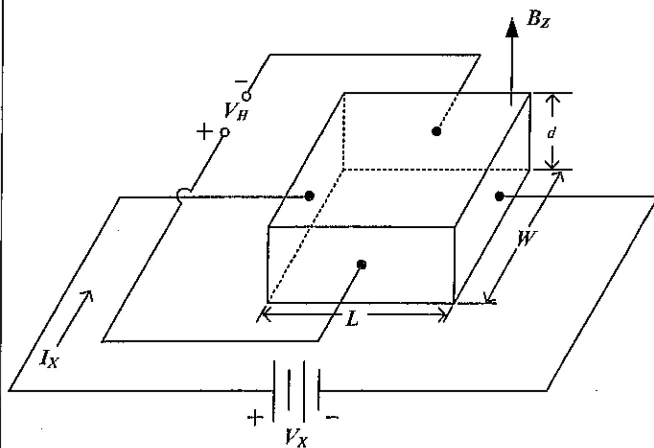

Figure 1