

類組：電機類 科目：固態電子元件(300G)

※請在答案卷內作答

1. For the material of Figure 1, there are two different effective masses (heavy / light) for electrons. Which effective mass will be the one displayed by most electrons in the conduction band? Explain why? (10%)

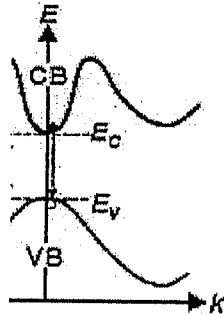


Figure 1

2. For a medium doped semiconductor with saturation velocity, $v_{sat}=10^7$ cm/sec, and critical field (when drift velocity reaches v_{sat}) equals 10^4 V/cm,
 (a) Find its low-field mobility and sketch the plot of drift velocity vs. electric field. (10%)
 (b) Plot qualitatively its mobility as a function of temperature and explain why it increase or decrease with temperature. (10%)
3. Consider one side P+/N junction where N_D is 10^{17} cm⁻³, this junction has the built-in voltage, $V_{bi} = 1$ V and the depletion width is 2 μ m for $V_A=-2$ V external reverse bias. Please answer the problems as below, (15%)
 (a) No external bias, what is the maximum electric field (V/cm)? (5%)
 (b) For $V_A=-5$ V reverse bias, what is the depletion width (μ m)? (5%)
 (c) Assume junction breakdown field is 1 MV/cm, what is the maximum reverse voltage (V) drop? (5%)
4. For a PN junction at forward operation, the total forward current is contributed by diffusion current J_{diff} and generation/recombination current J_{GR} , where $J_{GR0} = 1000 \times J_{0(diff)}$, please answer the problem below, (10%)
 (a) For external bias V_A , write down the total forward current equation. (5%)
 (b) Plot I/V curve of the forward current, where V_A is as X-axis and J is as Y-axis. (5%)
5. Draw the energy band diagram (E_c , E_v , E_i , E_F , the depletion region) for a PNP transistor in Figure 2 at following conditions, (10%)
 (a) Active mode (5%)
 (b) Base Push-out effect (5%)

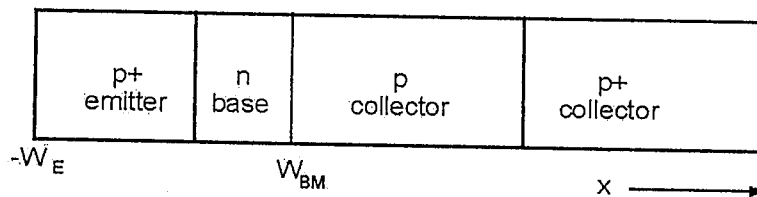


Figure 2

參考用

注意：背面有試題

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6. MOS capacitor (20%)

Assumed that there is an $n^+ - poly - Si / SiO_2 / n - Si$ metal-oxide-semiconductor (MOS) capacitor; it is given that the thickness of SiO_2 is t_{ox} , the doping level of the $n - Si$ is N_D and the total area of the MOS capacitor is

A. Assumed furthermore that the work function of the $n^+ - Poly - Si$ equals χ_{Si} , which is the electron affinity of Si .

- Please plot the band diagrams of the MOS capacitor when the MOS capacitor is biased at equilibrium, depletion, threshold, flatband and accumulation, respectively. (10%)
- Supposed that there is no charge in the oxide and at the SiO_2 / Si interface and that the SiO_2 is perfect insulator. Without derivation, please write down the threshold voltage V_{th} of this MOS capacitor. Other than those given above, please define the symbols you used. (5%)
- Describe how the fixed charges, interface traps, mobile ions in the MOS capacitor affect the V_{th} of this MOS capacitor. (5%)

7. MOSFET (15%)

- Please explain how enhancement-mode and depletion-mode MOSFETs are defined and their relationship to the threshold voltage in the case of an n-channel MOSFET. (5%)
- Please explain the sub-threshold slope of an n-channel MOSFET and how it affects the threshold voltage V_{th} . (5%)
- Please explain drain-induced barrier lowering in a short-channel n-channel MOSFET.? (5%)

注意：背面有試題

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