Total number of printed pages – 7 **B. Tech**

BSCP 2202

Fourth Semester Examination – 2008

PHYSICS OF SEMICONDUCTOR DEVICES

Full Marks – 70

Time : 3 Hours

*Answer Question No. **1** which is compulsory and any **five** from the rest.*

The figures in the right-hand margin indicate marks.

Assume any data if not given in the question. You may use the physical constants given anywhere in the question paper.

1. Answer the following questions : 2×10

   (a) Calculate the electron and hole concentration in a semiconductor in thermal equilibrium if intrinsic carrier concentration is 1.5×10^{10} cm^{-3} and holes are 36×10^4 times than the electrons per cm^3.

   (b) "Conduction in a p-type semiconductor is due to holes in the conduction band." State whether the statement is true or false. Justify your answer.

   (c) What is Einstein relation ? Write down the expression and define the terms.

   (d) Explain the process of excess carrier generation and recombination.

   (e) Draw the energy band diagram of a reverse biased p-n junction.

   (f) Differentiate between Zener breakdown and Avalanche breakdown.

   (g) If two p-n junction diodes are connected, such that both p sides are together, will the combined circuit behave as a transistor ? Give reasons for your answer.

   (h) Define Flat-Band voltage in a MOS.

   (i) Draw a CMOS invertor circuit.

   (j) If β of a transistor is 50, calculate α and γ.

2. (a) Derive the expression to determine the position of the Fermi energy level as a function of the doping concentration and temperature. 5

(b) A semiconductor material made of silicon has an acceptor impurity concentration of $N_a = 10^{16}$ per cm^3. Calculate the concentration of donor impurity atoms that must be added so that the semiconductor is n-type and the Fermi energy is 0.13 eV below the conduction band edge.

Assume kT = 0.26 eV. 5

3. (a) What is drift current ? Derive the expression for drift current density. 1+4

(b) A semiconductor sample of Ga As at 300°K has doping concentration $N_a = 0$ and $N_D = 10^{16}$ per cm^3. If the electron and hole mobilities are 8500 and 400 Cm^2 per volt.sec respectively, calculate the drift current density under complete ionisation. 5

4. (a) Why is the general ambipolar transport equation nonlinear ? 4

(b) A semiconductor has the following :

$n_o = 10^{15}\ cm^{-3}$

$n_i = 10^{10}\ cm^{-3}$

Excess carrier lifetime is 10^{-6} s.

Determine the electron-hole recombination rate if the excess-hole concentration is $5 \times 10^{13}\ cm^{-3}$. 6

5. (a) Calculate the built-in potential barrier in a p-n junction given that 3

Semiconductor	=	Silicon
Temperature	=	27°C
N_a	=	$1.5 \times 10^{18}\ cm^{-3}$
N_d	=	$1 \times 10^{15}\ cm^{-3}$
Thermal voltage	=	0.26 eV
n_i	=	$1.5 \times 10^{10}\ cm^{-3}$

(b) Show that the total space charge width increases as a reverse bias voltage is applied. 5

(c) Determine the total width for Q5(a) if relative permittivity of the semiconductor is 11.7 and voltage applied is 5V. Assume permittivity in free space to be 8.85×10^{-14} F/cm. 2

6. (a) Calculate the ideal reverse saturation current density in a silicon p-n junction of 300°K temperature, where, 3

$N_a = N_d = 10^{16}\ cm^{-3}$

$n_i = 1.5 \times 10^{10}\ cm^{-3}$

$D_n = 25\ cm^2/s$

$D_p = 10\ cm^2/s$

$\tau_{po} = \tau_{no} = 5 \times 10^{-7}\ s$

$\epsilon_r = 11.7$

(b) Describe with illustrations how amplification takes place in a bipolar junction transister. 5

(c) Draw the bipolar transistor common-emitter V-I characteristics. Indicate saturation, cut off an active region. Mention significance of load line. 2

7. (a) Is MOS a voltage controlled or current controlled device ? Give reasons. 3

(b) Draw the energy band diagrams of MOS capacity with p-type substrate when a negative gate bias and a moderate positive gate bias is applied. Repeat for n-type substrate when positive gate bias and a moderate negative gate bias is applied. 5

(c) Calculate the oxide capacitance for MOS where thickness $t_{ox} = 500\ \mathring{A}$ and relative permittivity is 3.9. 2

8. Write short notes on : 2.5 × 4

(a) CMOS technology

(b) Hybrid – pi Model

(c) Frequency limitations in MOS

(d) Diffusion current.

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