Registration No. : | | | | | | | | | | |

Total number of printed pages – 3

B. Tech

BSCP 1207(New)

Special Examination – 2012

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.

1. Answer the following questions : 2×10

   (a) What is effective mass ? Write mathematical function for it.

   (b) Draw a graph of $f(E)$ versus E and explain its salient features.

   (c) A semiconductor has a mobility of 500 $cm^2/V\text{-}s$ at T = 300K. Calculate the diffusion coefficient.

   (d) Explain about excess carrier generation and recombination of semiconductor material.

   (e) Define and explain the junction capacitance.

   (f) What is base width modulation ?

   (g) Compare a Schottky barrier diode and a pn junction.

   (h) Sketch the energy band diagrams in a MOS capacitor with an n-type substrate in inversion mode.

   (i) Draw and explain the p channel enhancement mode MOSFET.

   (j) Draw the equivalent circuit of Ebers-Moll mode.

2. (a) What is density of states function ? Derive expression for density of states. 5

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(b) Consider a p-type silicon at 300K, doped with boron. Assume that the limit of the Boltzmann approximation occurs when $E_f - E_a = 3kT$. Determine the Fermi-level position and the maximum doping at which the Boltzmann approximation is still valid. 5

3. (a) Derive an expression for the thermal equilibrium concentration of electrons in conduction band in terms of Fermi-Dirac probability function, density of quantum states. 5

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(b) Determine the thermal equilibrium electron and hole concentration in GaAs at T = 300K for the case when the Fermi energy level is 0.30 eV above the valence band energy E_v. 5

4. (a) Draw and explain the C-V characteristics of accumulation region, depletion region and inversion region of a p-type substrate? 4

b) The hole concentration in germanium at T = 300K varies as $p(x) = 10^{15} e^{-\left(\frac{x}{20.7}\right)} cm^{-3}$. Where x is measured in μm. If the hole diffusion coefficient is $D_p = 42\ cm^2/sec$, determine the hole diffusion current density as a function of x. 3

(c) Discuss about the scattering mechanism available in semiconductor material. 3

5. (a) What is built-in-potential barrier ? Derive expression for it. 3

(b) Calculate the built in potential barrier in a silicon pn junction at T = 300K for $N_a = 10^{15} cm^{-3}$, $N_d = 3 \times 10^{16} cm^{-3}$. 3

(b) Consider a pn junction having $N_a = 5 \times 10^{17} cm^{-3}$ and $N_d = 10^{17} cm^{-3}$. The junction has an area of $10^{-4} cm^2$ and reverse bias voltage of $V_R = 5V$. Calculate x_m ; x_p and w(space width charge). 4

6. (a) Draw and explain the V-I characteristics of a pn junction diode. 3

(b) Derive expression for excess carrier electron and hole concentrations in a pn junction. 3

(c) A silicon pn junction at T=300K has the following parameters :

$N_a = 6 \times 10^{16} cm^{-3}$, $N_d = 4 \times 10^{16} cm^3$, $D_n = 25\ cm^2/s$, $D_p = 10\ cm^2/s$, $\tau_{no} = 5 \times 10^{-7} s$ and $\tau_{po} = 1 \times 10^{-7} s$. The cross-sectional area is $A = 10^{-3}\ cm^2$ and the forward bias voltage is $V_a = 0.625$ V. Calculate the total current in the pn junction diode. 4

7. (a) Derive expression for the excess electron concentration in the base region for an npn transistor in the forward active mode. 5

   (b) Discuss the breakdown mechanisms in BJT. 5

8. (a) What do you mean by flat band condition and flat band voltage ? Derive the expression for flat band voltage. 5

   (b) Sketch the cross section of a CMOS structure and explain the CMOS structure. Discuss what is meant by latch–up in a CMOS structure. 5