0

B.Tech
BSCP 2202

Special Examinations, 2012
PHYSICS OF SEMI CONDUCTOR DEVICES *(Old Course)*
Full Marks: 70
Time: 3 Hours

Answer six questions including question No.1 which is compulsory
Figures in the right hand margin indicate marks

Q1. Answer the followings (2x10=20)

a) What are direct band gap semiconductors? Give one example.
b) For a piece of GaAs semiconductor (E_g=1.43 eV),determine the minimum frequency of an incident photon that can interact with a valence electron and elevate the electron to the conduction band.
c) Differentiate between rectifying contact and ohmic contact.
d) Differentiate between intrinsic semiconductor and compensated semiconductor.
e) A semiconductor has a mobility of 500cm^2/V at T=300K,calculate the diffusion coefficient.
f) What is Einstein relation?
g) What are the difference between a Schottky barrier diode and p-n junction diode.
h) Draw the C-V characteristics of accumulation and inversion region of a n-type substrate.
i) What do you mean by flat band voltage and flat band condition?
j) What is base width modulation?

Q2.

a) Define Fermi energy and Fermi Dirac distribution function. Schematically show the variation of Fermi-Dirac distribution function with temperature and doping concentration. 5
b) Assume the Fermi energy level is 0.35 eV above the valence band energy. Determine the probability of a state being empty of an electron E_v. 2
c) What is electron effective mass ? Write the expression for it. What does a negative electron effective mass imply? 3

Q3.

a) Derive the expression for thermal –equilibrium electron concentration in the conduction band using effective density of states function ,Fermi energy and other terms. 6
b) Determine the thermal equilibrium electron and hole concentrations for an n-type silicon semiconductor at T=300 K in which N_d= 10^{16}cm^{-3} and N_a= 0.The intrinsic carrier concentration is assumed to be n_i=1.5x 10^{10} cm^{-3}. 4

Q4.

a) Derive ambipolar transport equation .Why is the general ambipolar transport equation nonlinear? 5

b) For a sample of silicon at T=300K doped at an impurity concentration of $N_d = 10^{15}\text{cm}^{-3}$ and $N_a = 10^{14}\text{cm}^{-3}$. Calculate the drift current density if the applied electric field is E=35 V/cm. 5
(Given for silicon ,μ_n=1350 cm^2/V.s ; μ_p=480 cm^2/V.s)

Q5.

a) Derive the expression of the built-in-potential barrier voltage . 3

b) Why does the space charge width of a pn junction increase with reverse bias voltage ? 3

c) A silicon p-n junction at T=300K has doping concentration of $N_d = 3.5\text{x } 10^{16}\text{cm}^{-3}$ and $N_a = 8.2\text{x}10^{15}\text{cm}^{-3}$, and has a cross-sectional area of A= 5 x 10^{-5} cm^2.Determine the junction capacitance at V_R= 4 V. 4

Q6.

a) Derive ideal diode equation . 5

b) Describe the breakdown mechanisms in a p-n junction. 5

Q7.

a) Explain the important parameters used in the Ebers-Moll equivalent circuit of BJT, with neat equivalent circuit diagram. 3

b) Draw the excess minority carrier concentration profile in all the three regions of an n-p-n transistor for the following 3

   i. Forward active region
   ii. Reverse active region
   iii. Saturation region
   iv. Cut-off region.

c) The emitter and base of a silicon n-p-n bipolar transistor are uniformly doped at impurity concentrations of 10^{18} cm^{-3} and 10^{16}cm^{-3}. A forward biased base-emitter voltage V_{BE}= 0.640 V is applied. The neutral base width is x_B= 3μm and minority carrier diffusion length in the base is L_B=12 μm Calculate the excess minority carrier concentration in the base at x= $x_B/2$. 4

Q8.

a) Explain the CMOS technology. 4

b) Draw and explain the V-I characteristics of p-channel depletion mode MOSFET. 3

c) Derive the expression for the threshold voltage in a MOS device. 3