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Reg. No. : .....

Name : .....

Third Semester B. Tech. Degree Examination, September 2014
(2008 Scheme)
(Special Supplementary)
08.302 : SOLID STATE DEVICES (TA)

Time : 3 Hours Max. Marks : 100

PART – A

Answer **all** questions briefly. **Each** carries **4** marks.

1. Explain how does the Fermi level position vary with doping in a semiconductor.
2. How are crystal plane and directions designated ?
3. List the assumptions made in the derivation of ideal diode current equation.
4. Define the basic properties of metal-semiconductor junction. Explain the working of a diode, based on this principle.
5. What is meant by carrier life time ? How does it affect the performance of a device ?
6. Sketch the :
   i) space -charge region
   ii) charge density
   iii) electric field and
   iv) barrier voltage for a P^+N junction.
7. Why NPN transistors are preferred over PNP transistors ? Explain.
8. How FET can be used as a variable resistor ? Explain.
9. Explain sub-threshold conduction in MOSFET.
10. Draw and explain CV diagram of a MOS capacitor. **(10×4=40 Marks)**

P.T.O.

PART – B

Answer **any two** full questions from **each** Module. **Each** full question carries **10** marks.

Module – I

11. a) For a GaAs P^+N one-sided abrupt junction with $N_D=8\times10^{14}$/cc , calculate the depletion width at breakdown, if V_{BR} = 500 V. Given ϵ_r =12.4, $\epsilon_0 = 8.85\times10^{-14}$ F/cm^2.

    b) Derive expression for the total current in a semiconductor. Discuss the effect of temperature on total current.

12. a) The resistivity ρ_o of a Germanium sample is measured at 300 K. The sample is then remelted and doped with 4×10^{16} arsenic atoms per cc. The new crystal has a resistivity of 0.1 Ω cm and is n-type. Determine the type and concentration of dopant atoms in the original sample and the value of ρ_o. Assume $\mu_n = 2\mu_p = 3000$ cm^2 / V – S.

    b) Calculate the contact potential of a PN junction diode having $N_A=10^{17}$/cc, $N_D=10^{13}$/cc at 30°C. Given $n_i=1.6\times10^{10}$/cc.

13. a) Derive the expressions for the conductivity of both intrinsic and extrinsic semiconductors.

    b) The mobility of free electrons and holes in Ge are 3800 and 1900 cm^2/V-S. For Si, they are 1300 and 550 cm^2/V-S respectively. Determine the values of intrinsic conductivity of Ge and Si. Take $n_i=2.5\times10^{13}$/cc for Ge and $n_i=1.5\times10^{10}$/cc for S_i at 30°C.

Module – II

14. A Schottky barrier is formed from n-type Si having a doping of 10^{16}/cc and area 10^{-3} cm^2. A Si pn junction has same area and $N_A=10^{19}$, $N_D=10^{16}$, $\tau_p = \tau_n = 1\mu s$.

    a) Calculate the Schottky barrier diode current at 0.4 V and 300 K.

    b) Calculate the equilibrium depletion layer capacitance C_j and storage capacitance C_s at 0.4 V forward bias for Schottky diodes. Electron affinity of Si is 4.15eV, metal work function is 4.9 eV, $B=100A/K^2$ cm^2, D_{pn} =12 cm^2/s, $A=10^{-3}$, $Q=1.6\times10^{-19}$C, $L_{pn} = 3.46\times10^{-3}$ cm, $n_i=1.5\times10^{10}$/cm, $\epsilon=18.854\times10^{-14}$.

15. a) Establishing appropriate relations, explain why BV_{CBO} is larger than BV_{CEO}.

    b) Compute δ, α, β, I_{CBO} and I_{CEO} of a PNP BJT having $I_{EP} = 2mA$, $I_{EN} = 0.02\,mA$, $I_{cp} = 1.98\,mA$ and $I_{cn} = 0.002\,mA$.

16. A symmetrical Silicon P^+nP^+BJT has $A = 10^{-4}\,cm^2$, $W_B = 1\,\mu m$. Its emitter has $N_A = 10^{17}/cc$, $\tau_n = 0.1\mu s$, $\mu_p = 200\,cm^2/V-S$, $\mu_n = 700\,cm^2/V-S$. The base has $N_D = 10^{15}/cc$ $\tau_p = 10\mu s$, $\mu_n = 1300\,cm^2/V\text{-}S$, $\mu_p = 450\,cm^2/V\text{-}S$. Calculate

    a) I_{ES}, I_{CS}

    b) I_B when $V_{EB} = 0.4\,V$ and $V_{CB} = -25\,V$.

Module – III

17. An Aluminium gate p-channel MOS transistor is made on an n-type silicon substrate with $N_D = 6\times10^{16}/cc$. The SiO_2 thickness is 1000 Å in the gate region and the effective interface charge Q_i is $2\times10^{11}qc/cm^2$. Find the maximum width of depletion layer, the flat band voltage and the threshold voltage.

18. An n-channel silicon JFET has $N_A = 10^{19}/cc$, $N_D = 10^{15}/cc$ and $a = 4\,\mu m$. Determine at 300 K.

    a) Pinch-off voltage and

    b) The gate bias required to make the thickness of undepleted channel equal to $1\,\mu m$ with $V_{DS} = 0$.

19. Neatly sketch the constructional diagram and characteristics of IGBT and explain its working. Compare and contrast its performance with BJT.

(3×2×10=60 Marks)