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Registration No :

Total Number of Pages : 02 **B.Tech**
PET3I001

3rd Semester Back Examination 2019-20
SEMICONDUCTOR DEVICES
BRANCH : ECE, ETC
Max Marks : 100
Time : 3 Hours
Q.CODE : HB687

Answer Question No.1 (Part-1) which is compulsory, any EIGHT from Part-II and any TWO from Part-III.
The figures in the right hand margin indicate marks.

Part-I

Q1 Only Short Answer Type Questions (Answer All-10) (2 x 10)

- **a)** Define Thermal Equilibrium?
- **b)** What is the relationship between equivalent mobility and individual mobility of carriers inside a crystal?
- **c)** Draw the capacitance voltage characteristics of Diode and mention the X and Y intercept.
- **d)** What do you mean by base-width modulation?
- **e)** Determine the total number of energy states in GaAs between E_C to $E_C + K_B T$ at T = 300K, where K_B is Boltzmann's constant, (Given that electron effective mass of GaAs, $m_n^* = 0.067 m_0$ and Planck's constant, $h = 6.6 \times 10^{-34} Js$.)
- **f)** Distinguish between PN-junction diode and Schottky barrier diode.
- **g)** What do you mean by specific contact resistance?
- **h)** What is difference between ohmic contact and rectifying junction?
- **i)** What is the value of surface potential under flat band condition?
- **j)** What is latch-up in CMOS circuits?

Part-II

Q2 Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve) (6 x 8)

- **a)** Derive the expression for total current due to both drift and diffusion.
- **b)** Derive the expression for induced electric field for a non-uniformly doped n – type semiconductor and the Einstein's relation between diffusion co-efficient and mobility.
- **c)** Calculate the ideal diode current equation from minority carrier distribution.
- **d)** Derive the expression for junction capacitance in case of pn junction.
- **e)** Calculate the total space charge width of depletion region of a pn junction.
- **f)** Write the difference between Punch through and Avalanche breakdown.
- **g)** Discuss briefly about Base width Modulation.
- **h)** Write in details about Ohmic contact for n-type and p-type semiconductor.
- **i)** Calculate the theoretical barrier height, built-in potential barrier and maximum electric field in a metal-semiconductor diode between tungsten and n-type silicon doped to $N_d = 10^{16} cm^{-3}$ at $T = 300K$ for zero applied bias if work function of metal is $\emptyset_m = 4.55\,V$ and electron affinity of the semiconductor is $\chi = 4.01V$. Given $n_i = 1.5 \times 10^{10} cm^{-3}$, $\epsilon_s = 11.7\epsilon_0$ with $\epsilon_0 = 8.85 \times 10^{-14} C^2 N^{-1} cm^{-2}$.
- **j)** Write short notes on Complete ionization and freeze-out.
- **k)** Define the Flat-band condition. Derive the expression for Flat-band voltage of a MOS Capacitor.
- **l)** Discuss aboutC-V Characteristics of MOS capacitor.

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four)

Q3 a) Derive the expression for thermal equilibrium hole concentration in an intrinsic semiconductor from Density of states and Fermi Dirac probability function. Calculate the electron and hole concentration in a semiconductor in thermal equilibrium, if $n_i = 1.5 \times 10^{10} cm^{-3}$ and holes are 10^4 times than the electrons per cm^3. **(8)**

b) Derive an expression for electric field and potential in the space charge region of a uniformly doped pn-junction. Where does the maximum electric field occur in space charge region? **(8)**

Q4 a) Derive the expression for excess minority carrier electron concentration in the emitter region for the forward active mode of an npn BJT. **(6)**

b) Using Ebers-Moll model of a bipolar transistor, derive the expressions for emitter and collector currents with necessary equivalent circuit diagram. **(6)**

c) The electron concentration in silicon is given by $n(x) = 10^{15} e^{-\left(\frac{x}{L_n}\right)} (x \geq 0)$ where $L_n = 10^{-4} cm$. The electron diffusion coefficient is $D_n = 25\ cm^2/s$. Determine the electron diffusion current density at (i) $x = 10^{-4} cm$, (ii) $x = 0$ and (iii) $x \to \infty$. **(4)**

Q5 a) Derive and Prove that the depletion layer capacitance of a one sided junction is a function of the doping concentration in the low doped region. **(8)**

b) Derive quasi equilibrium boundary condition for excess minority carrier concentration.Calculate minority carrier distribution in Base region and collector current. **(8)**

Q6 a) Derive an expression for the diode current in an ideal Schottky barrier diode and describe its I-V characteristics. **(6)**

b) What is threshold inversion in a MOS capacitor? Derive the expression for threshold voltage of a MOS capacitor with p – type semiconductor substrate. **(6)**

c) An MOS device has the parameters; aluminum gate, p-type substrate with $N_a = 3 \times 10^{16} cm^{-3}$, $t_{ox} = 250 A^0$ and $Q'_{ss} = 10^{11} e\ Coulomb\ .\ cm^{-2}$ and $\emptyset_{ms} = -0.981$. Determine the threshold voltage at T = 300 K if, $n_i = 1.5 \times 10^{10} cm^{-3}$, $\epsilon_s = 11.7\epsilon_0$ and $\epsilon_{ox} = 3.9\epsilon_0$; $\epsilon_0 = 8.85 \times 10^{-14} C^2 N^{-1} cm^{-2}$. **(4)**