B.Tech III Year 5th Semester

Year(2022)

Branch ECE

Subject : Microelctronics **Class Test : final examination**

Time : 1 Hour **M.M : 90**

Note : Attempt All question each question carry equal marks

1. Answer the following questions (very short Answers).
   (a) What is the hole concentrations in an N-type semiconductor with 10^{15} cm^{-3} of donors? (Assume $n_i=1x10^{10}$ cm^{-3}).
   (b) The forward bias current is associate with what type of carrier activity?
   (c) Explain the base width modulation for BJT.
   (d) What are advantages of scaling?
   (e) Write down the applications of HEMTs.
2. Answer the following questions (short questions Answers).
   (a) If the probability that a state being filled at the conduction band edge (E_c) is precisely equal to the probability equal to the probability that a state is empty at the valence band edge (E_v), where is the Fermi level located What is parallel port device? Give an example.
   (b) Sketch the energy band diagram for an ideal p+ -n step junction diode showing the carrier activity in and near the depletion region when (i) Vi=0 (ii) Vi>0 (iii) Vi<0.
   (c) For BJT , the common base current gain α=-0.98 and the collector base junction reverse bias saturation current I_{co} = 0.64μA. This BJT is connected in the common emitter mode and operated in the active region with a base drive current I_B =20 μA Find the collector current I_C for this mode of operation.
   (d) Explain the working of Tunnel FET with suitable band energy diagram.

3. Part (a) is compulsory and attempt any one of part (b) or part (c).
   (a) Derive an expression for the relation of electric field and the band energy.
   (b) Derive expressions for electron concentrations from conduction band density states and Fermi function.
   (c) In a very long p-type Si bar with cross-sectional area =0.5cm^2 and $N_a=10^{17}$ cm^{-3} we inject holes such that the steady state excess hole concentration is $5x10^{16}$ cm^{-3} at x=0. What is the steady state separation between E_{FP} and E_c at x=100 A? What is the hole current there? How much is the excess stored hole charge? (Assume that μ_P = 500cm^2/V-s and $\tau_p=10^{-10}$ s..
4. Part (a) is compulsory and attempt any one of part (b) or part (c).
   (a) Explain the working I-V characteristics of Tunnel Diode with help of energy band diagram?
   (b) Derive an expression of Diode current (Shockely Equation) for P-N Junction diode.
   (c) A P^+ - N junction has $Na=1x10^{20}$ cm^{-3} and N_d = $1x10^{17}$ cm^{-3}, T=300K
      (i) Calculate the built in potential.
      (ii) Calculate the depletion layer width (W_{ep} =x_n+x_p).
      (iii) Calculate the maximum electric field.
      (iv) Sketch the energy band diagram electric field distribution, electric potential, and the space charge profile.
5. Part (a) is compulsory and attempt any one of part (b) or part (c).

(a) Explain the base width modulation for BJT. Further explain how base width modulation affects the amplification.

(b) Consider a conventional NPN BJT with uniform doping . The base-emitter junction is forword biased and the base-collector junction is reverse biased? (i) Qualitatively sketch the energy band diagram. (ii) Sketch the minority carrier concentrations in the base, emitter and collector regions. (iii) List all the cause contributing to the base and collector currents. You may neglect thermal recombination-generation currents in the depletion regions.

(c) Give a pnp BJT where I_{EP} =1mA, I_{cp}=0.98A and I_{cn}=0.1µA calculate (I) base transport factor(α_T) (II) emitter efficiency(γ) (III) I_E, I_B, I_c (iv) α_{dc} ,β_{dc} (IV) I_{co} and I_{CEO}.

6. Part (a) is compulsory and attempt any one of part (b) or part (c).

(a) Explain the major short channel effects of the short channel MOSFETs.

(b) An n+ -polysilicon-gate n-channel MOS transistor is made on p-type Si substrate with N_a=5x10^{15} cm^{-3}. The SiO_2 thickness (t_{ax}) is 100 A^0 in the gate region, and the effective interface charge Q_1=qx4x10^{10} C/cm^{-3}. Find depletion width (W_m), Flatband voltage C_{min} on the C-V characteristics and also find depletion width(W_m) ,flatband voltage (V_{fb}) and threshold voltage (V_{th}) [Assume n_i=1.5x10^{10} , Dielectric constant of free space ϵ_0 =8.85 x 10^{-14} F/cm, Dielectric constant of Si (ϵ_{si})=11.8x ϵ_0 F/cm, Dielectric constant of SiO_2 (ϵ_{sio2})=3.9 x ϵ_0 F/cm , electron affinity(x) =4.2 V].

(c) Derive an expression for MOSFETs current in liner and saturation region of operations.

7. Part (a) is compulsory and attempt any one of part (b) or part (c).

(a) Explain constant field and constant voltage scaling of MOSFETs.

(b) Explain the working of junctionless Field Effect Transistor with suitable band energy diagram and electron contour.

(c) Why is it necessary for base region in a BJT to be narrow? What is the precise definition of narrow? (b) The given figure is a dimensioned energy band diagram for an ideal MOS capacitor operated at T=300K with VG≠0 . Note that EF =Ei at the Si-SiO2 interface. Calculate (i) ϕF (ii) ϕS (iii) VG (iv) Depletion width(x0) (v) Do the equilibrium condition prevail inside the semiconductor ?