Reg. No: 24BEC0336

E/E/TY

Final Assessment Test – April 2025

VIT
Vellore Institute of Technology

Course: BECE201L - Electronic Materials and Devices

Class NBR(s): 0749 / 0755 /0758 / 0761 / 0762 Slot: E2+TE2

Time: Three Hours Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

General Instructions :

1. Non Programmable calculator is permitted.
2. Constants for Silicon at RT (300 K): $n_i = 1.5\times10^{10}$ cm^{-3}, Eg =1.1eV, Relative permittivity of Si $\varepsilon_r = 11.8$, kT=0.026 eV, Boltzman's constant k= 8.66×10^{-5} eV/K, $\varepsilon_0=8.854\times10^{-12}$ F/m, q=1.6×10^{-19} C, Planck's constant h = 4.136×10^{-15} eV.s, Normalized effective mass for Si $m_n/m_o=0.26$, $m_p/m_o=0.39$, m0 = 9.1×10^{-31} kg, Relative permittivity of SiO_2 $\varepsilon_r = 3.9$

Answer ALL Questions
(10 X 10 = 100 Marks)

1. The resistivity of aluminium at 25 °C has been measured to be $2.72\times10^{-8}\ \Omega$ m. The thermal coefficient of resistivity of aluminium at 0 °C is 4.29×10^{-3} K^{-1}. Aluminium has a valency of 3 and density of 2.70 g cm^{-3} and an atomic mass of 27 g mol^{-1}. Estimate the mean free time between collisions for the conduction electrons in aluminium at 25 °C and hence estimate their drift mobility.

2. Silicon at T = 300 K contains acceptor atoms at a concentration of $N_a = 5\times10^{15}$ cm^{-3}. (a) Calculate the electron and hole concentration and draw the band diagram. (b) Donor atoms are added forming an n-type compensated semiconductor such that the Fermi level is 0.215 eV below the conduction band edge. What concentration of donor atoms are added? The effective density of states in the conduction band is given to be 2.8×10^{19} cm^{-3}.

3. The Fermi level in n-type silicon at T = 300 K is 245 meV below the conduction band and 200 meV below the donor level. Determine the probability of finding an electron (a) in the donor level and (b) in a state in the conduction band kT above the conduction band edge.

4. In a particular semiconductor material, $\mu_n = 1000$ cm^2/V-s, $\mu_p = 600$ cm^2/V-s, and $N_C = N_V = 10^{19}$ cm^{-3}. These parameters are independent of temperature. The measured conductivity of the intrinsic material is 10^{-6} /Ω cm at T = 300 K. Find the conductivity at T = 500 K. Assume N_C, N_V, μ_n, μ_p remain same at 500 K.

5.a) An abrupt silicon pn junction at zero bias has dopant concentrations of $N_a = 10^{17}$ cm^{-3} and $N_d = 5\times10^{15}$ cm^{-3} at T = 300 K. (i) Sketch the equilibrium energy band diagram for the junction (ii) Determine built-in barrier potential and (c) peak electric field for this junction.

OR

5.b) An $n^{+}p$ silicon diode at T = 300 K has the following parameters: $N_d = 10^{18}\ cm^{-3}$, $N_a = 10^{16}\ cm^{-3}$, $D_n = 25\ cm^2/s$, $D_p = 10\ cm^2/s$, $\tau_{n0} = \tau_{p0} = 1\mu s$ and Area (A) = $10^{-4}\ cm^2$. Determine the diode current for (i) a forward bias voltage of 0.5 V and (ii) a reverse biased voltage of 0.5 V.

6. Draw energy band diagram and identify the nature of contacts of an n-type semiconductor and a metal for which the metal work function is smaller than the semiconductor. Draw also the energy diagram for forward and reverse bias condition for such contacts.

7. A BJT is biased at I_C = 2 mA and V_{CE} = 5 V. Given parameter are β_F=150, t_F=7 ps and T = 300 K. Find

(a) Emitter current (I_E)

(b) Common-base current gain (α)

(c) Transconductance (g_m)

(d) Diffusion resistance (r_π),

(e) Diffusion capacitance (C_π)

8. Consider a p-channel MOSFET with the following parameters: $\mu_p C_{ox} = 0.12\ mA/V^2$ and $W/L = 20$. The drain current is 100 μA with applied voltages of $V_{SG} = 0$ and $V_{SD} = 1.0$ V. (*a*) Determine the threshold voltage V_T value. (*b*) Determine the drain current I_D for $V_{SG} = 0.4$ V, and $V_{SD} = 1.5$ V.

9. a) An Al-gate p-channel MOS transistor is made on an n-type Si substrate with $N_d = 5 \times 10^{17}\ cm^{-3}$. The SiO_2 thickness is 10 nm in the gate region and the work function difference is ϕ_{ms} = -0.15V, and the effective interface charge Q_i is $5 \times 10^{10}\ qC/cm^2$. Find maximum depletion width (W_{max}), Flat band voltage (V_{FB}), and threshold voltage (V_T).

OR

9. b) An n^+ polysilicon gate–silicon dioxide–silicon MOS capacitor has an oxide thickness of t_{ox} = 18 nm and a doping of $N_a = 10^{15}\ cm^{-3}$. The oxide charge density is $Q_i = 6 \times 10^{10}\ qC/cm^2$. Assume the work function of polysilicon gate as 4.03 eV and work function of Si= 5 eV. Calculate the (a) flat-band voltage (V_{FB}) and (b) threshold voltage (V_T)

10. Discuss the role of emerging carbon-based materials :

(a) graphene and (b) carbon nanotubes in the field of transistor applications.

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