B/E/TY

Reg. No: 24BEC0307

Final Assessment Test – April 2025

VIT
Vellore Institute of Technology

Course: BECE201L - Electronic Materials and Devices
Class NBR(s): 0748 / 0750 / 0752 / 0754 / 0757 / 0759 / 0760
Slot: E1+TE1

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: Constants for Silicon: $n_i = 1.5\times10^{10}$ cm^{-3}, $E_g = 1.1$ eV, Relative permittivity of Si $\varepsilon_r = 11.8$, $kT = 0.026$ eV at 300K, Boltzman's constant $k= 8.66\times10^{-5}$ eV/K, $\varepsilon_0=8.854\times10^{-12}$ F/m, $q=1.6\times10^{-19}$ C, $h = 4.136\times10^{-15}$ eV.s, Normalized effective mass for Si $m_n/m_o = 0.26$, $m_p/m_o = 0.39$, $m_0 = 9.1\times10^{-31}$ kg, Relative permittivity of SiO_2 $\varepsilon_r = 3.9$.

Answer ALL Questions

(10 X 10 = 100 Marks)

1. (a) Estimate the conductivity of copper if the mean free time of the electrons is 1.9×10^{-14} s and the atomic concentration is 8.5×10^{28} m^{-3}. [5]

   (b) With a neat diagram explain the single crystal growth by Czochralski method. [5]

2. The Fermi energy level for a particular material at T = 300 K is 6.25 eV. The electrons in this material follow the Fermi-Dirac distribution function. Obtain the probability of an energy level at 6.50 eV being occupied by an electron (a) at T = 300 K (b) T = 950 K (Assume that E_F is a constant) (c) Determine the temperature at which there is a 1 percent probability that a state 0.30 eV below the Fermi level will be empty of an electron.

3. A silicon sample with arsenic doping of 10^{16} atoms/cm^3 is steadily illuminated such that 10^{21} cm^{-3}s^{-1} electron-hole pairs are generated. If the life time of electrons and holes are 10^{-6} s, calculate separation between quasi-Fermi levels and show the positions of equilibrium and quasi-Fermi levels at 300 K.

4. The resistivity of a Ge sample is measured at 300 K. The sample is then remelted and doped with 4.4×10^{16} arsenic atoms cm^{-3}. The new crystal has resistivity of 0.1 Ω cm and is n-type. Determine the type and concentration of impurity atoms in the original sample and value of resistivity. Assume $\mu_n = 2\mu_p = 3000$ cm^2/Vs.

5.(a) A silicon pn junction in thermal equilibrium at $T = 300$ K is doped such that the intrinsic Fermi level is 0.365 eV below the Fermi energy level in the n region and the intrinsic Fermi level is 0.33 eV above the Fermi energy level in the p region. (a) Sketch the energy band diagram for the pn junction. (b) Compute the impurity doping concentration in each region and built-in barrier potential.

OR

5.(b) Consider a GaAs pn junction with doping concentrations $N_a = 5 \times 10^{16}$ cm^{-3} and $N_d = 10^{16}$ cm^{-3}. The junction cross-sectional area is $A = 10^{-3}$ cm^2 and the applied forward-bias voltage is $V_a = 1.10$ V. Given $D_n = 205$ cm^2/s, $D_p = 9.8$ cm^2/s, $n_i = 1.8 \times 10^6$ cm^{-3}, $\tau_{n0} = 0.05$ μs, $\tau_{p0} = 0.01$ μs. Calculate the total current in the pn junction diode.

6. Sketch the energy band diagram of a p-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. Identify the nature of such contacts.

7. (a) Describe the bipolar junction transistor in common emitter configuration through a diagram. Draw the input and output characteristics. Also, explain different region of operations in the output characteristics. [6]

(b) A transistor has a base current of 100 μA and collector current of 2.5 mA. Calculate the current amplification factors for CB and CE configurations. [4]

8.(a) Consider a MOS capacitor fabricated on a P-type silicon with a doping of $N_a = 10^{18}$ cm^{-3} with an oxide thickness of 2 nm and an N^+ poly-gate. Calculate the flat-band voltage, the maximum depletion region width and the threshold voltage, of this device. Given $n_i = 10^{10}$/cm^3.

OR

8.(b) An n^+ polysilicon-gate n-channel MOS transistor is made on a p-type Si substrate with $N_a = 5 \times 10^{15}$ cm^{-3}. The SiO_2 thickness is 100 Å in the gate region, and the effective interface charge is 4×10^{10} q C/cm^2 (q is the charge of the electron). Assume the work function difference as -0.95 V. Determine the maximum depletion width, flat band voltage and the threshold voltage.

9. Consider an n-channel MOSFET with the following parameters:

$\mu_n C_{ox} = 0.18\ mA/V^2$, $W/L = 8$, and $V_T = 0.4$ V. Obtain the drain current for (*a*) $V_{GS} = 0.8$ V, $V_{DS} = 0.2$ V; (*b*) $V_{GS} = 0.8$ V, $V_{DS} = 1.2$ V; (*c*) $V_{GS} = 0.8$ V, $V_{DS} = 2.5$ V; and (*d*) $V_{GS} = 1.2$ V, $V_{DS} = 2.5$ V.

10. (a) Explain electric polarization in dielectric materials and describe the relationship between polarization and the dielectric constant of a material [5]

(b) Differentiate between traditional capacitors and supercapacitors. [5]

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