BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
K.K BIRLA GOA CAMPUS
FIRST SEMESTER (2022-23) MID-SEM TEST
Electronic Devices (ECE/EEE/INSTR F214)

Date : 02-11-2022 Time : 90 min Maximum Marks: 90 (30%) Closed Book

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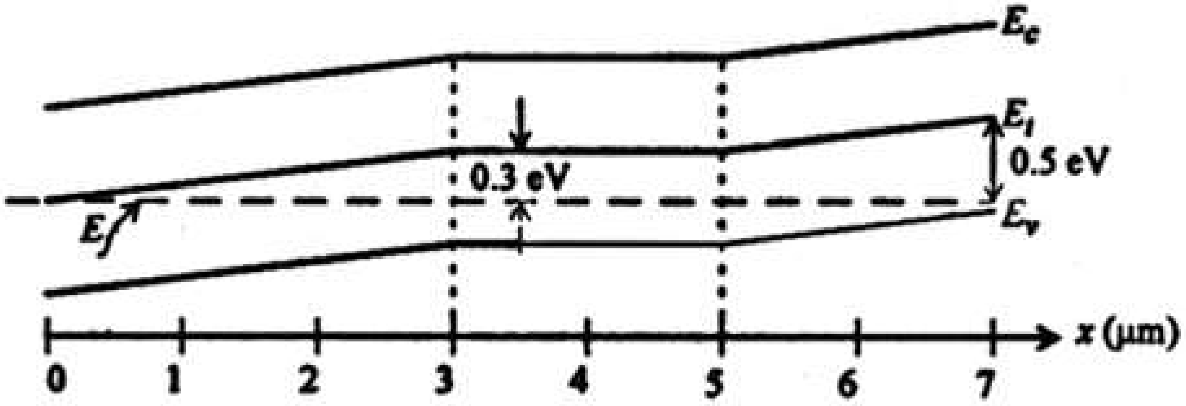
Instructions: **(i) Answer All questions. Assume T=300K unless specified otherwise.**

(ii) Any required data not explicitly given, may be suitably assumed and stated.

(iii) All answers and figures should be written using PEN only.

(iv)Each question should be started from a fresh page. Enclose the final answer in a box.

Q1. The energy band diagram of a silicon sample is shown below.



(a) Sketch the electrostatic potential inside the semiconductor as function of distance (x).

(b) Sketch the electric field as a function of distance (x).

(c) At x=4 μm find the concentration of electrons and holes.

(d) What is the electron drift current density at x = 0 μm. **[12]**

Q2. Consider an N-type semiconductor bar with equilibrium electron density $n_0 = 10^{17}$ cm^{-3} and intrinsic carrier concentration $n_i=10^{10}$ cm^{-3}. When the sample is illuminated with light, it generates 10^{18} electron-hole pairs/cm^3-sec within the sample with $\tau_p=\tau_n= 10^{-6}$ sec:

(a) Is the semiconductor in low-level or high-level injection? Explain why?

(b) Calculate the thermal equilibrium Fermi level with respect to E_i

(c) Determine F_n and F_p with respect to E_i. Also draw the energy level diagram. **[10]**

Q3. A certain semiconductor has $N_C = 10^{19}$ /cm^3, $N_V = 5\times10^{18}$ /cm^3, and E_g = 2 eV. If it is doped with 10^{17}/cm^3 donors, calculate the electron, hole and intrinsic carrier concentration at 900 K. Sketch the simplified band diagram, showing the position of E_F. Assume that the values of N_C, N_V and E_g are independent of temperature. **[12]**

Q4. The total junction capacitance of a one sided silicon pn junction at T=300K is measured at V_R= 60 mV and found to be 1.5 pF. The junction area is 10^{-5} cm^2 and V_{bi}= 0.95 V.

(a) Find the impurity doping concentration of the low-doped side of the junction.

(b) Find the impurity doping concentration of the higher-doped region. **[10]**

Q5. An abrupt silicon pn junction at zero bias has electron and hole concentration on p-side and n-side is 10^{17} cm $^{-3}$ and 5×10^{15} cm^{-3}, respectively at T = 300 K. (a) Calculate the Fermi level on each side of the junction with respect to the intrinsic Fermi level. (b) Sketch the equilibrium energy band diagram for the junction and determine V_{bi}. Determine the peak-electric field for this junction. **[10]**

Q6. An Au-n-Si junction with $N_d = 5 \times 10^{15}$ cm^{-3} has a cross sectional area of A= 5×10^{-4} cm^2 and is maintained at T=300K. Determine (a) barrier height, (b) built-in voltage (c) junction capacitance when V_R= 4V. **[12]**

Q7. Assume that the p$^+$n junction of uniformly doped silicon n-channel JFET at T=300 K has doping concentration of N_a=10^{18} cm^{-3}, N_d= 10^{16} cm^{-3} and the metallurgical thickness a= 0.75 μm. Calculate (i) built-in potential, (ii) pinch-off voltage(V_P) and (iii) What is the effect of built-in potential on pinch-off voltage? **[12]**

Q8. Consider two p-n silicon junctions at T = 300 K reverse biased at V_R = 5 V. The impurity doping concentrations in pn junction- A are N_a = 10^{18}/cm^3 and N_d = 10^{15}/ cm^3 and pn junction-B are N_a = 10^{18}/cm^3 and N_d = 10^{16}/ cm^3. Assuming n_i = 1.5×10^{10} cm^{-3}, calculate the ratio of the following parameters for junction A to junction B:

(a) Depletion Width and (b) Junction Capacitance

(c) In which diode the avalanche mechanism is more significant and why? **[12]**

--------------------------------------**ALL THE BEST**--

List of constants:

$k= 8.62 \times 10^{-5}$ eV/K	At T=300K kT=0.0259 eV
$\varepsilon_o=8.854 \times 10^{-14}$ F/cm	ε (Si) = 11.8 ε_o
$q= 1.6 \times 10^{-19}$ C	n_i (Si) = 1.5×10^{10} /cm^3
μ_p (Si) = 480 cm^2/V-s	μ_n (Si) = 1350 cm^2/V-s
E_g(Si)= 1.1 eV	ε (SiO_2) = 3.9 ε_o
χ(Si)= 4.01 eV	ϕ_m(Au)=4.75 eV
N_C(Si) = 2.8×10^{19} cm^{-3}	N_V(Si) = 1.04×10^{19} cm^{-3}.