BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

K.K BIRLA GOA CAMPUS

FIRST SEMESTER (2022-23) MID SEM TEST

Physics and Modeling of Microelectronic Devices (MEL G631)

Date: 03-11-2022 **Time : 90 min** **Maximum Marks: 50 (25%)** **Closed Book**

Instructions: **(i) Answer All questions.**

(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) Enclose the final answer in a box.

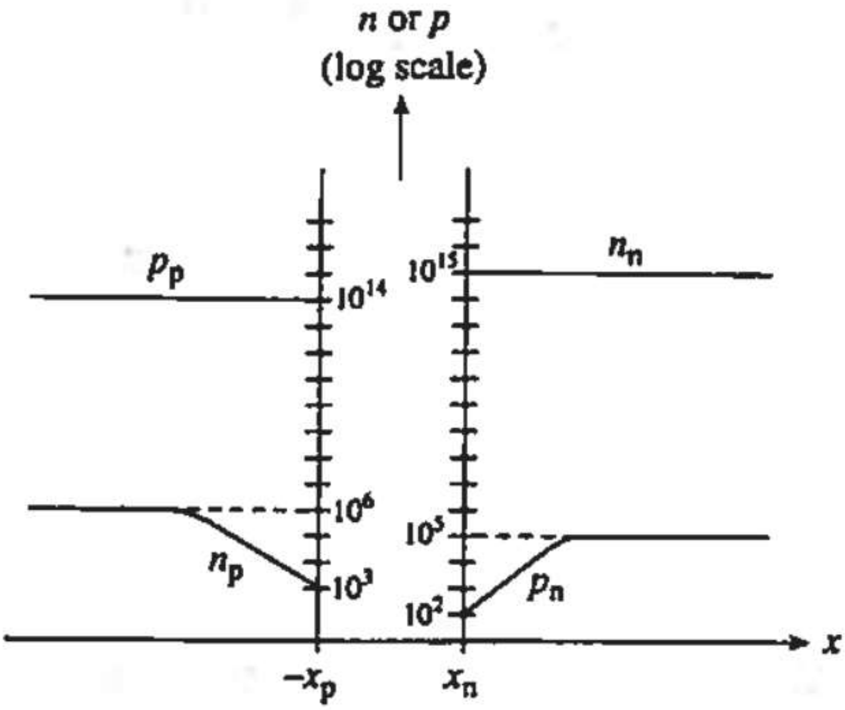
Q1. The fig shows the plot of steady state carrier concentrations inside a pn junction diode maintained at T=300K.

(a) Is the diode forward biased or reverse biased? Explain how you arrived at your answer.

(b) Do low level injection conditions prevail in the quasineutral regions of the diode? Explain how you arrived at your answer.

(c) Determine the applied voltage, Va.

(d) What are p-side and n-side doping concentrations? **[8]**



Q2. A silicon pn junction is to be designed which meets the following specifications at T=300K. At a reverse bias voltage of 1.2V, 10 percent of the total space charge region is to be in the n region and the total junction capacitance is to be 3.2×10^{-12} F with a cross sectional area of 5.5×10^{-4} cm^2. Determine (a) N_a (b) N_d and (c) V_{bi}. **[7]**

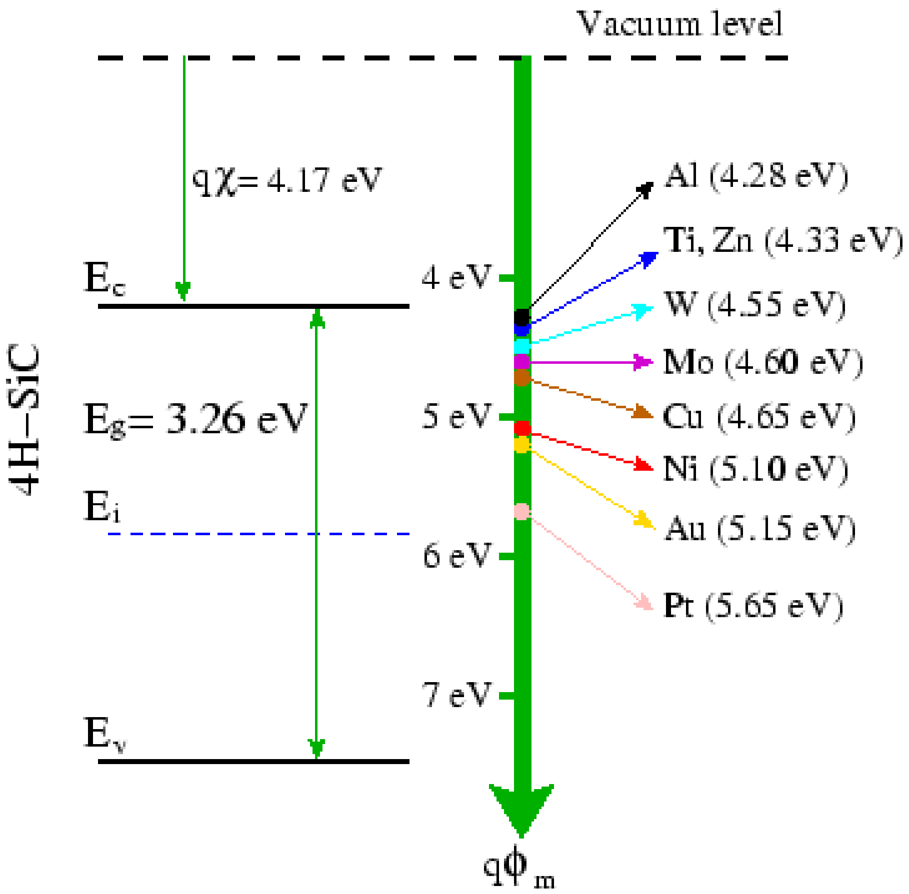
Q3. The electron concentration in a sample of uniformly doped n – type silicon at 300K varies linearly from $10^{17}/cm^3$ $at\ x = 0$ to $6\times10^{16}/cm^3$ $at\ x = 2\mu m$. Assume a situation that electrons are supplied to keep this concentration gradient constant with time. If electronic charge is 1.6×10^{-19} C and the diffusion constant D_n=35 cm^2/s, find the current density in the silicon, if the electric field 10 V/cm is applied across the bar. Assume electron mobility to be 1400 cm^2/V-s. **[7]**

Q4. An n-channel Si JFET is to be constructed with a doping of Nd= 10^{16} cm^{-3}. Assuming room temperature operation, determine the maximum junction-to-junction half-width that can be employed in constructing the JFET. Assume the breakdown voltage of the JFET is 60 V. **[7]**

Q5. A Silicon p-n junction diode with doping concentrations of Na= 10^{16} cm^{-3} and Nd= 10^{15} cm^{-3}. (a) Calculate the reverse voltage required to make the space charge width equal to 2.83×10^{-4} cm. (b) With this reverse bias voltage, calculate the junction capacitance of the pn junction. **[7]**

Q6. Consider a metal-semiconductor contact formed between tungsten (ϕ_m=4.55 eV) and n-type Silicon doped with $N_d = 10^{16}$ cm^{-3} at T=300K. Calculate the theoretical barrier height, built-in potential and maximum electric field. Also draw the energy level diagram. **[7]**

Q7. With respect the diagram shown in Fig, (a) List out the metals which forms Schottky contact with the semiconductor. (b) Which is the best Schottky contact scheme and why? Draw the thermal equilibrium band diagram for this metal scheme. Assume Effective conduction band density of states =$8.9 \times 10^{19}$$cm^{-3}$, Effective valence band density of states= 2.5×10^{19} cm^{-3}, and doping concentration on semiconductor side is $N_d = 1\times^{15}$ cm^{-3}. **[7]**



List of constants:

k= 8.62×10^{-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= 1.6×10^{-19} C	n_i (Si) = 1.5×10^{10} cm^{-3}
μ_p (Si) = 480 cm^2/V-s	N_c(Si)= 2.8×10^{19} cm^{-3}
μ_n (Si) = 1350 cm^2/V-s	E_g(Si) = 1.1 eV
χ(Si)= 4.01 eV	N_V(Si) = 1.04×10^{19} cm^{-3}

ALL THE BEST