COLLEGE OF ENGINEERING, PUNE

S.Y.B. TECH.

Physics elective: Physics of semiconductor devices

END SEMESTER EXAM Autumn Semester

Date: 19 NOV 2011 Time: 3 Hrs.

Academic Year: 2011-12 Marks: 50

Instructions: 1. All Questions are compulsory.
2. Figures to right hand indicate full marks.
3. Draw neat labeled diagrams wherever necessary.
4. Cell phones are not allowed in the exam hall.

Q1) A) For an intrinsic, n-type and n-type semiconductors sketch the variation of i) Density of states ii) Fermi function and iii) Carrier concentration. **(3)**

B) In an n-type semiconductor bar, there is an increase in electron concentration from left to right and an electric field pointing to the left. Answer the followings with appropriate equations.
i) If we double the electron concentration everywhere, what happens to the diffusion current and the drift current? **(2)**
ii) If we add a constant concentration of electrons everywhere, what happens to the drift and diffusion currents? **(2)**

C) An n-type Si sample with $N_d = 10^{15}$ cm^{-3} is steadily illuminated such that $g_{op} = 10^{21}$ EHP/cm^3-s. If $\tau_n = \tau_p = 1$ µs for this excitation, calculate the separation in the quasi-Fermi levels, $(F_n - F_p)$. Draw a band diagram. n_i=1.5 x10^{10} cm^{-3} **(3)**

OR

C) An intrinsic Si sample is doped with donors from one side such that $N_d = N_0 e^{-ax}$.
(i) Find an expression for built-in electric field at equilibrium over the range for $N_d >> n_i$,
(ii) Evaluate the field when $a = 1(\mu m)^{-1}$. n_i=1.5 x10^{10} cm^{-3} **(3)**

Q2) A) How band gap of the semiconductor materials can be determined using four probe experiment? **(4)**

OR

A) Explain principle, construction and working of UV-Vis absorption spectroscopy **(4)**

B) In a Hall effect experimental set up. a sample of n-type Ge has the donor density of 10^{21} /m^3. Find the Hall voltage developed if the magnetic field used is 0.6 Tesla, given that current density is 500 Amp/m^2 and width of the sample is 5mm. **(4)**

PTO

C) Compare the properties of p-n junction diode and Metal-semiconductor junction diode **(2)**

Q3 A) Derive an expression for the width of depletion region for an abrupt Si p-n junction. Sketch the curves for charge density and electric field distribution within the the transition region.(assume $N_a > N_d$) **(6)**

OR

A) An Abrupt silicon p-n junction has $N_a = 10^{18}$ cm^{-3} on one side and $N_d = 5\times10^{15}$ cm^{-3} on the other side. It has a circular cross section with a diameter of 10μm. Calculate the penetration of space charge region into p and n material (x_{po} & x_{no}), charge density Q, electric field $\xi(x)$. Sketch the curves for charge density and electric field distribution within the transition region. (Given $\varepsilon = 1.04\times10^{12}$F/cm) **(6)**

(B) Derive the expression for contact potential V_o in terms of the donar and acceptor concentrations at equilibrium **(4)**

Q4 A) An abrupt Si p-n junction ($A = 10^{-4}$ cm^2) have following properties at 300 K: $n_i = 1.5\times10^{10}$ cm^{-3}

p side: $N_a = 10^{17}$cm^{-3}, $\tau_n = 0.1\mu s$, $\mu_p = 200$cm^2/V-s, $\mu_n = 700$cm^2/V-s,

n side: $N_d = 10^{17}$cm^{-3}, $\tau_p = 10\mu s$, $\mu_n = 1300$cm^2/V-s, $\mu_p = 450$cm^2/V-s

The junction is forward biased by 0.5V. What is the forward current? What is the current at a reverse bias of -0.5V **(4)**

(B) Write short note on Varactor diode. Also write the expression for the voltage-variable capacitance of the junction. **(3)**

(C) Draw a neat labeled energy band diagram of a p-n junction under forward bias. Write the expression for current flowing through the junction under forward bias. **(3)**

OR

(C) Draw a neat labeled energy band diagram of a p-n junction under reverse bias. Write the expression for current flowing through the junction under reverse bias. **(3)**

Q5 A) Draw neat and labeled energy band diagram for ideal Metal- n type Semiconductor contacts for $\Phi_m > \Phi_s$ and $\Phi_m < \Phi_s$ at thermal equilibrium. **(6)**

B) Explain the working of Metal-Semiconductor(n type) contact under forward and reverse bias. **(4)**

OR

C) Explain the concept of work function and electron affinity of semiconductors and metals. **(4)**