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MEC-101

(Subject Code and Roll No. to be filled in your Answer book)

Roll No:

M.TECH: Electronics and Communication Engg.

I SEM THEORY EXAMINATION 2012-13

ADVANCED SEMICONDUCTOR DEVICES

Time: 3Hours

Total Marks: 100

Notes :(1) Attempt all questions.

(2) All question carry equal marks.

(3) Assume the missing data if any.

1. Attempt any two of the following:

(a) Sketch the covalent bonding of Si atoms in an intrinsic Si crystal. Illustrate with sketches the formation of bonding in presence of donor and accepter atoms. Sketch the energy band diagram, indicating the position of donor, acceptor and Fermi level at 0K and 300K.

(b) What is the physical significance of diffusion length? Show that diffusion length is the average distance that a carrier diffuses before recombination.

(c) In intrinsic Si, the Fermi level lies near the middle of the band gap. How does the Fermi level move when it is doped with (i) phosphorus and (ii) boron atoms? Can the Fermi level be pushed up into the conduction band? If yes, explain how. If not explain why.

2. Attempt any two of the following:

(a) What is the contact potential? Explain, derive an expression for it assuming step junction at equilibrium condition. For a Si p-n junction with Na $=2\times10^{19}$ cm^{-3} and $N_d=8\times10^{15}cm^{-3}$ .Calculate the junction capacitance at zero bias and a reverse bias of 4v. (T=300K) and $n_i = 1.5\times10^{10}cm^{-3}$.

(b) A Si bar 0.1cm long has a cross-sectional area of $0.01cm^2$.

(i)What measurements would you use to find out the majority carrier type and concentration?

(ii)If the measurement in (i) show the n type an electron concentration of $10^{17}/cm^3$, and you measure the resistance to be 1ohm. What is the electron mobility?

(c) Define carrier mobility. Draw a graph showing the variation of carrier mobility in a semiconductor with increasing temperature.

3. Attempt any two of the following:

(a) A 0.46 μm thick sample of GaAs is illuminated with monochromatic light of energy 2ev. The absorption coefficient α is $5\times10^4cm^{-1}$. The power incident on the sample is 10mW.

(i) Find the total energy absorbed by the sample per second (J/s).

(ii) Find the rate of excess thermal energy given up by the electron to the lattice before recombination (J/s).

(iii) Find the number of photons per second given off from recombination events, assuming perfect quantum efficiency.

(b) An intrinsic Si sample is doped with donors from one side such that $N_d = N_o \exp(-ax)$.

(i) Find an expression for the built- in electric field at equilibrium over the range for which ($N_d >> n_i$).

(ii) Evaluate the field when $a=1\mu m^{-1}$.

(iii) Sketch a band diagram and indicates the direction of electric field.

(c) A bipolar transistor has two junction either one of which may be forward or reverse biased. Therefore, we have four mode of operations: Active, Cutoff, Saturation, and inverse active. With the help of Ebers –moll equations, model the transistor circuit with a single set of equations describing these four regions.

4. Attempt any **two** of the following:

(a) Indicate with proper justification whether the β-value of a BJT increases or decreases with increases in the following parameters:

(i) Base width.

(ii) Minority carrier life time in the base region.

(iii) Temperature.

(b) What parameters determine the threshold voltage V_T of a MOS device? How can V_T be controlled? What phenomena become important in short channel devices and how are the device characteristic affects.

(c) Explain the construction and working principle of HEMT. What are its advantages over MESFET?

5. Attempt any **two** of the following:

(a)

(i) Why a solar cell must operate in the fourth quadrant of the p-n junction I-V characteristics.

(ii) If one makes an LED in a semiconductor with a band gap of 2.5eV, what wavelength of light will it emit? Can you use it to efficiently detect photons of wavelength 1900nm and100nm?

(b) What does it meant by negative conductance device? Describe transferred-electron mechanism in Gunn diode.

(c)

(i) A GaAs Gunn diode is 5μm long and operates in the stable domain mode. What is the minimum electron concentration n_o? What is the time between current pulses?

(ii) "An n-type semiconductor has more number of electrons than holes; hence it has a net negative charge". Justify or nullify the above statement.