BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI, RAJASTHAN
FIRST SEMESTER (2023-24)
ELECTRONIC DEVICES (EEE F214/INSTR F214/ECE F214)

Date: 12-10-2023, Thursday
Time: 90 min **Mid-Semester Test OPEN BOOK MM 100**

Instructions: ***Use the value of constants mentioned in the particular question. Give your answers with proper sign and units.***

1. The equilibrium and steady-state conditions before and after illumination of the semiconductor at room temperature are characterized by the energy band diagram shown in the figure-1. Assume that the semiconductor has intrinsic carrier concentration of 10^{10} cm^{-3} and electron and hole mobility as 1354 cm^2/V-sec and 458 cm^2/V-sec respectively. Determine:
   (i) Electron and hole equilibrium carrier concentrations
   (ii) Electron and hole under steady-state conditions
   (iii) Donor doping.
   (iv) Do we have "*low-level injections*" when the semiconductor is illuminated? Justify by proper calculation.
   (v) What is the resistivity of the semi-conductor before and after illumination?

[25 Marks]

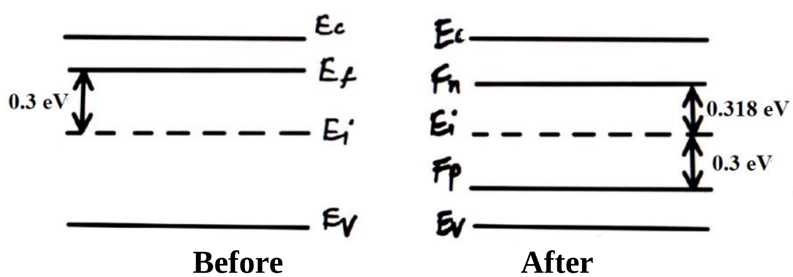

Figure: 1

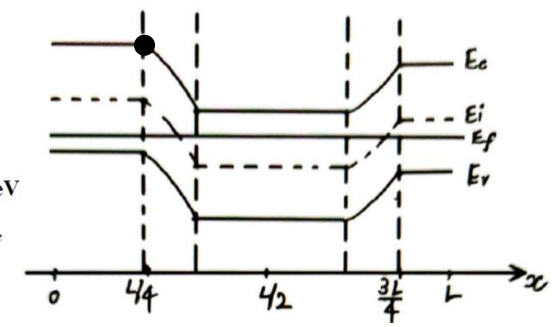

Figure: 2

2. The energy band diagrams shown in figure 2 characterize a Si sample maintained at 300 K.
   (i) Sketch the electrostatic potential (V) inside the semiconductor as a function of *x*.
   (ii) Sketch the electric field (E) inside the semiconductor as a function of *x*.
   (iii) The carrier shown in the diagram moves back and forth between $x = 0$ and $x = L$ without changing its total energy. Sketch the K.E and P.E of the carrier as a function of position inside the semiconductor. Assume E_F as reference level.
   (iv) Roughly sketch of *n* and *p* inside the semiconductor as a function of *x*. (Show n_i as reference)
   (v) Do the equilibrium condition prevails? How to you know?

[25 Marks]

3. While performing a well-established experiment in semiconductors, mobility of minority carriers was determined to be 1800 cm^2/V-sec. In that experiment, the pulse of light was injected at a point on an n-type bar and this pulse arrives at another point after 0.30 ms. The distance between these

points is 1.0 cm. The pulse was recorded in an oscilloscope screen and found to be 120 µs wide. The voltage applied to the set-up is 3V. Calculate:

(i) The length of the sample used in the experiment.

(ii) The parameter that decide the ease with which minority carrier moves due to diffusion.

(iii) The temperature at which experiment was performed. Assume that equilibrium condition holds good.

(iv) Name the experiment. **[20 Marks]**

4. Consider a silicon pn junction with the doping profile shown in figure-3.

(i) Determine the built-in voltage at pn junction.

(ii) Calculate the applied reverse-biased voltage required so that the space charge region extends entirely through the p region.

(iii) Determine the space charge width into the n^+ region with the reverse-biased voltage calculated in part (ii).

(iv) Calculate the peak electric field for this applied voltage.

[Assume: T = 300 K and $n_i = 10^{10}$ cm^{-3}] **[15 marks]**

5. (i) Draw the equilibrium energy band diagram for the "*isotype junction*" (in figure-3) and calculate for the built-in voltage that exists across the isotype junction under equilibrium conditions.

(ii) **(a)** Explain why built-in voltage of a pn junction is high for high band gap semiconductors? Credit will be given if explanation is supported by proper equation.

(b) Explain how doping concentration of a one-sided pn junction should vary to get desired value of the avalanche breakdown voltage. How this create problem with the series resistance of the diode? Credit will be given if explanation is supported by proper equation.

[15 Marks]

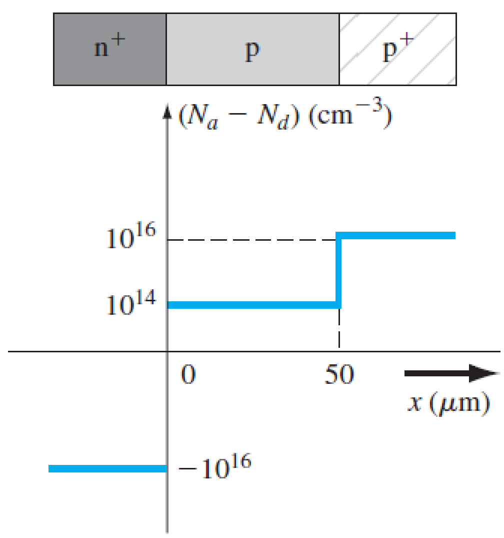

Figure: 3

*********Best of Luck************