Abhinav kumar choudhary
21SCSE1011615, Sec-24
Date __/__/__

Semiconductor

1) In a p-n junction. explain

(i) Minority charge carrier :-

The charge carriers that are present in small quantity are called minority charge carriers. They carry very small amount of electric current in the semiconductor.

(ii) Majorities charge carriers :-

The charge carrier that are present in large quantity are called majority charge carrier. They carry most of the electric charge or current in the semiconductor. It is responsible for electric current flow in semiconductor.

2) Calculate energy band gap of semiconducting material if it emits light of wavelength 414nm.

$\lambda = 414nm$

Energy gap $= E = \frac{hc}{\lambda}$

$$E = \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{414 \times 10^{-9} \times 1.6 \times 10^{-19}} = \frac{19.86 \times 10^{17}}{414 \times 1.6 \times 10^{-19}}$$

$E = 3 \times 10^{2}$ eV

$= 300$ eV

3) Interpret the zener breakdown in pn junction diode.

Zener breakdown occurs due to high electric field. Energetic charges collide with atoms and produce the electron hole pairs. The reverse current start flowing in the junction because of this. It occurs in depletion region.

VISTA

Date __/__/__

4) Define built-in-potential (potential barrier) and indicate the direction of internal electric field developed due to potential barrier in a zero biased p-n junction diode.

Ans→ The potential barrier will always exists even if the device is not connect to power source. The significance of this built-in-potential across the junction is that it opposes both the flow of holes and electrons across the junction. The direction of electric field is from the positive charges to the negative charges.

5) Define current density & mobility of charge carriers for a semiconductors. Hall coefficient of a semiconductor is $3.22 \times 10^{-4}\ m^3/c$ and its resistivity is 9×10^{-3} ohm-metre. Calculate the mobility in the semiconductor.

Ans→ Current density is defined as the electric current carried by conductor per-unit crosssectional area of the conducting medium.

$$J = \frac{I}{A}$$

mobility of electron is defined as average drift velocity acquired by the electrons per unit electric field.

$$\mu = \frac{V}{E}$$

Numerical:-

Given $R_H = 3.22 \times 10^{-4}\ m^3/c$

carrier concentration $= n$

$$R_H = \frac{1}{\rho e} = \frac{1}{3.22 \times 10^{-4} \times 1.6 \times 10^{-19}}$$

$$R_H = 0.194 \times 10^{23}\ m^{-3}$$

Abhinav Kumar Choudhary
21SCSE1011615
Semiconductors

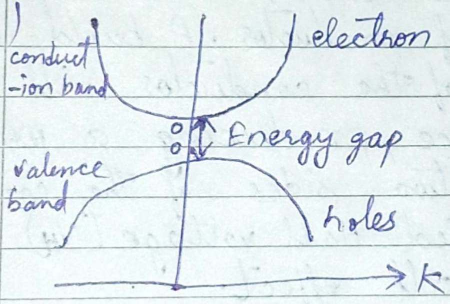
Date 11/06/2022

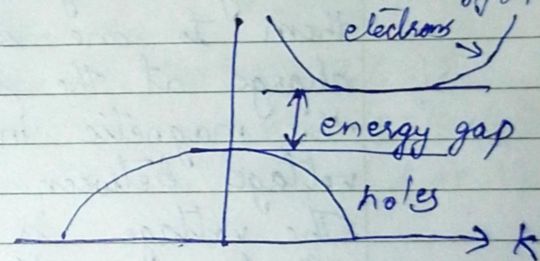
6) Distinguish b/w direct and indirect band gap semiconductors using band diagram along one example each.

Ans→

	Direct band gap	Indirect band gap
(i)	minimum of valence band and minimum of conduction band occur at same momentum value.	maximum of valence band and minimum of conducton band occur at two different momentum values.
(ii)	Electron making a transition from valence band to conduction band need not to und-ergo any change in its momentum	In order to make a transition from max^m point in valence band to minimum point in conduction band the e requires energy for the charge in ~~minimum~~ momentum in addition to energy gap.

(iii)





8) Interpret the recombination & generation of electron-hole pairs in a semiconductor. Find the wavelength correspondi-ng to the band gap of GaAs (1.42 eV) respectively.

Ans→ The electron hole pair is the fundamental unit of generation & recombination in inorganic semiconductor, correspo-nding to an electron transmissing b/w the valence band & conduction band. Where generation of e^- is Transition from the valence band to the conduction band & recombination body the reverse of Transition.

Date ___/___/___

Numericals :-

Given; $E_g = 1.42\,eV = 1.42 \times 1.6 \times 10^{-19} V$

$$E_g = \frac{hc}{\lambda} = \frac{6.65 \times 10^{-34} \times 3 \times 10^{8}}{1.42 \times 1.6 \times 10^{-19}}$$

$$= 8.75 \times 10^{-7}\, m$$

9) Explain the Hall effect phenomenon in a semi-conductor & derive the expression for Hall coefficient. The carrier concentration in n-type semiconductor is $10^{19}/m^3$, determine the value of Hall coefficient.

Ans ⇒ If a current carrying conductor is placed in magnetic field ⊥r to the direction of current, the magnetic field exerts a transverse force on the moving charge carriers which tends to push them to one side of conductor. A build-up of charge at the sides of the conductor will balance this magnetic influence, producing a measurable voltage between the two sides of the conductor. The voltage is called Hall voltage (V_H) and effect is called Hall effect.

Derivation :-

$$F_H = F_M \Rightarrow F_H = eE_H$$

Now at eq^b the magnitude of Hall co-efficient force & Lorentz force will be equal.

i.e $eE_H = eV_d B \Rightarrow E_H = V_d B$ —— (i)

current density

$$J = -neV_d \quad \text{—— (ii)}$$

divide eq^n (i) & (ii)

$$\frac{E_H}{J} = \frac{V_d B}{-neV_d}$$

$$\frac{E_H}{J} = \frac{-B}{ne} \Rightarrow E_H = R_H B J \qquad \boxed{\because R_H = \frac{-1}{ne}}$$

$$\boxed{R_H = \frac{E_H}{BJ} = \frac{-1}{ne}}$$

VISTA

Date __/__/__

$R_H = +ve$ for e^- & $-ve$ for holes

Numericals :-

$-n = 10^{19}/m^3$

We know that

$$R_H = \frac{-1}{ne}$$

$$R_H = \frac{1}{\cancel{10^{19}} \times 1.6 \times \cancel{10^{-19}}} = \frac{1}{1.6} \ m^2/c$$

$$R_H = 0.625 \ m^2/c$$

10) Show that the in intrinsic semiconductor the conductivity of a material is given by: $\sigma = en(\mu_e + \mu_p)$, where [$\sigma$ = conductivity, n = carrier density, μ_e = mobility of electron & μ_p = mobility of ~~proton~~ hole & e = electronic charge]. The intrinsic carrier density of Ge at 27°C is $2.4 \times 10^{17} m^{-3}$, Calculate its resistivity, if the electron & hole mobility are $0.35 m^2 V^{-1} s^{-1}$ & $0.18 m^2 V^{-1} s^{-1}$.

Ans ⇒ If n_e, n_p represents electrons & holes density & V_e, V_p their different velocities.

$$I_e = n_e e A V_e$$

$$I_h = e n_H A V_H$$

$$\text{Total current} = I_e + I_h = n_e e A V_e + n_H e A V_H$$

$$= e(n_e V_e + n_H V_H)A \quad \text{—(i)}$$

We know that $R = \frac{V}{I} = \rho \frac{l}{A}$

$$\frac{V}{I} = \frac{\rho l}{A} \Rightarrow \rho = \frac{AV}{Il} = \frac{EA}{I} \quad \left[\because E = \frac{V}{l}\right] \text{—(ii)}$$

E = Electrical intensity

$$\sigma = \frac{1}{\rho}$$

$$\sigma = \frac{I}{eA} \quad [\because \text{From (ii)}]$$

$$\sigma = \frac{e(n_e V_e + n_H V_H)A}{EA} \quad [\because \text{from eq (i)}]$$

VISTA

Date __/__/__

$$\sigma = e\left[n_e\left(\frac{v_e}{E}\right) + n_h\left(\frac{v_p}{E}\right)\right]$$

$$= e(n_e\mu_e + n_p\mu_p) \quad \left[\because \mu = \frac{v}{E}, \mu = \text{mobility}\right]$$

For intrinsic semiconductor, $n_e = n_p = n$

$$\sigma = ne(\mu_e + \mu_p) \quad \underline{\text{proved}}$$

Numerical:

$n = 2.4\times10^{17}\,m^{-3}$, $\mu_e = 0.35\,m^2/Vs$, $\mu_p = 0.18\,m^2/Vs$

We know that

$$\sigma = ne(\mu_e + \mu_p)$$

$$\sigma = 2.4\times10^{17}\times1.6\times10^{-19}(0.35+0.18)$$

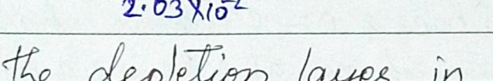
$$\sigma = 3.84\times10^{-2}\times0.53$$

$$\sigma = 2.03\times10^{-12}$$

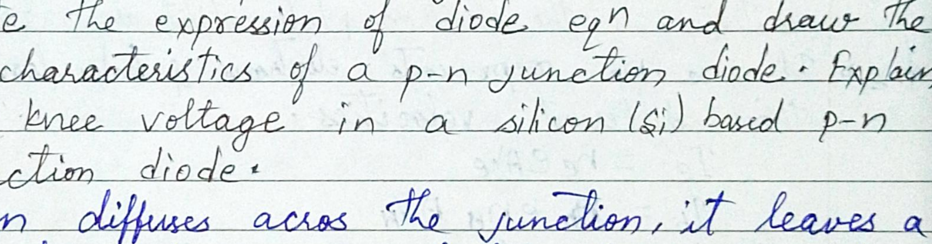
$$\text{Resistivity}(\rho) = \frac{1}{2.03\times10^{-2}} = 49.26\,\Omega m \quad \left[\because \rho = \frac{1}{\sigma}\right]$$

11) Describe the depletion layer in p-n junction diode. Write the expression of diode eqn and draw the V-I characteristics of a p-n junction diode. Explain the knee voltage in a silicon (Si) based p-n junction diode.

Ans ⇒ When diffuses across the junction, it leaves a -ve donor ion & the electron leaves a +ve charge on the n-sides. These oppositely charged layers form a field due to the potential difference b/w the points which forms the depletion region.



depletion layer



Date ___/___/___

12) Differentiate b/w the spontaneous & stimulated ~~non~~ ~~spontaneous~~ emission. Which type of emission produces coherent waves? Also, write two properties of coherent & incoherent waves.

Ans

	Spontaneous	Stimulated
(i)	During Transition of e^- from the excited state to ground state produces a radiation that is called spontaneous emission	stimulated emission of radiation is the process whereby photons are called used to generate their OHW photons.
(ii)	This phenomenon is found in LED's flourescent tube.	This is the key process of laser beam.
(iii)	There is no population insertion of electrons in LED's	This is the key process whereby photons are used to generate others.
(iv)	No external stimulation required.	This stimulated emission is caused by external stimulation

Abhinav kumar choudhary
21SCSE1011615
Sec - 24.

VISTA