Atomic Structure and Semiconductor

Lecture - 31

(07/04/2021)

B.Sc (Electronics)
TDC PART - I
Paper – 1 (Group – B)
Chapter – 4
by:

Dr. Niraj Kumar

Assistant Professor (Guest Faculty)

Department of Electronics

L. S. College, BRA Bihar University, Muzaffarpur.

==

➤ Continuity Equation

- Under equilibrium condition, the concentration of carriers (holes and electrons) is constant throughout the semiconductor crystal. On disturbing the equilibrium concentration of carriers, the concentrations of holes and electrons vary with time and approach the equilibrium value exponentially.

- Therefore, in general, the carrier concentration of a semiconductor is a function of both time and distance. The differential equation governing this functional relationship is **called Continuity Equation.**

⇨ Consider the case of an **infinitesimal element** of **volume** of **Area** A and **Length** dx along ***X- axis*** as shown in below **Figure (1).** The variation of concentration along ***Y-*** and ***Z- axes*** is assumed to be **Zero.**

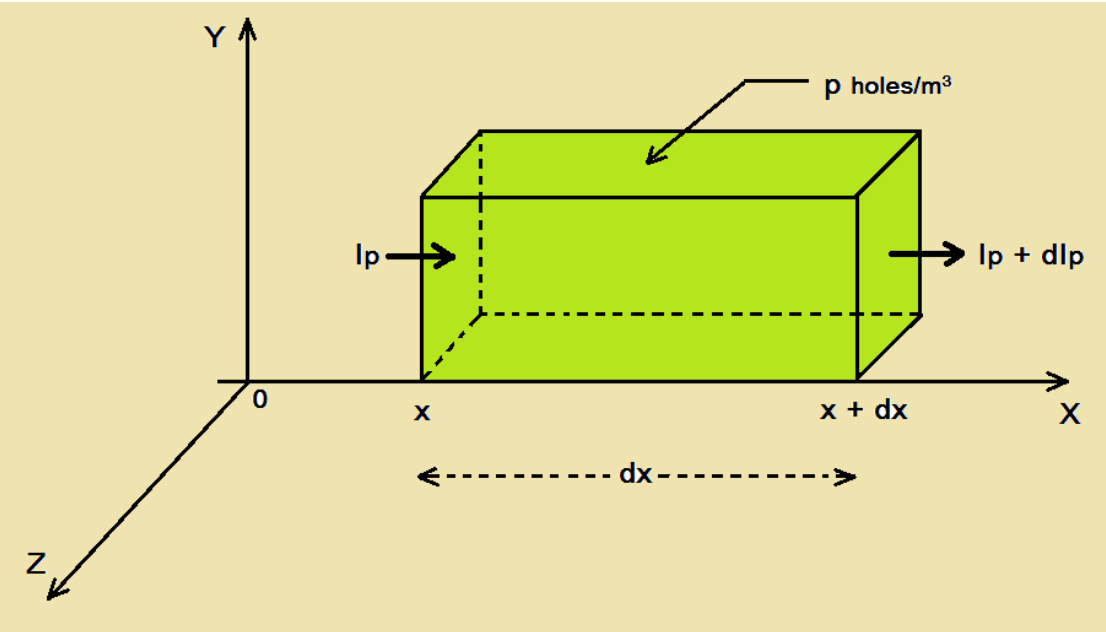

Fig. (1) Shown the case of an infinitesimal element of volume of **Area** A and Length dx along ***X- axis.***

⇨ Let the concentration of holes in the **volume** be p **holes/m3**. The **current** I_p enters the volume and the **current** $(I_p + dI_p)$ leaves the volume. Thus **more current** (i.e., dI_p **coulomb/sec.)** leaves the volume for positive value of dI_p. The following three factors are observed which cause the change in concentration p :-

(1) Concentration of holes **decreases** due to additional current (dI_p)**,**

(2) Concentration of hole **increases** due to thermal generation, and

(3) Concentration of holes **decreases** due to recombination.

⇨ The **decrease** in the number of holes per second within the volume is,

$= \frac{dI_p}{e}$, ... where e is the **magnitude of charge.**

⇨ So the **decrease** in hole concentration (holes per unit volume) per second due to current I_p is given by,

$$\frac{decrease\ in\ charge}{unit\ charge\ \times\ volume} = \frac{dI_p}{e\ .\ (A\,dx)}$$

$$\frac{decrease\ in\ charge}{unit\ charge\ \times\ volume} = \frac{dJ_p}{e\ .\ dx}$$

$$\left(\because\ J_p = \frac{I_P}{A}\right)$$

⇨ The thermal generation **increases** the number of holes at a rate of g **holes** per second. The **increase** of holes per unit time per second due to **thermal generation is given by,**

$g = \frac{p_o}{\tau_p}$, ... where τ_p is life time of holes.

⇨ The **decrease** of holes per unit time per second due to recombination is given by,

Recombination rate = $\frac{p}{\tau_p}$, ... where **p** is concentration of holes.

⇨ As the charge cannot be generated or destroyed, the **increase** in hole concentration per second, **(dp/dt)** must be equal to the algebraic sum of the increase in hole concentration.

⇨ Thus, corresponding equation **for holes** is,

$$\frac{\partial p}{\partial t} = \frac{p_o - p}{\tau_p} - \frac{1}{e}\frac{\partial J_p}{\partial x} \quad \text{...} \quad \textbf{(1)}$$

⇨ Here as both p and J_p are functions of both t and x, the **partial derivative** have been used. **This is known as** **Continuity Equation** for charge or law of conservation of charge.

⇨ The corresponding equation **for electrons** is,

$$\frac{\partial n}{\partial t} = \frac{n_o - n}{\tau_n} + \frac{1}{e}\frac{\partial J_n}{\partial x} \quad \text{...} \quad \textbf{(2)}$$

⇨ Here as both n and J_n are functions of both t and x, the partial derivative have been used. **This is known as Continuity Equation** for charge or law of conservation of charge.

to be continued ....

****