SUBJECT: BASIC ELECTRONICS

Diffusion Current Equation In Semiconductor Diode

Elementrix Classes

Diffusion Current Equation in Semiconductor Diode :

$$I_{diffusion} = A \times \left(qDp\,\frac{d_p}{d_x} - qDn\,\frac{d_n}{d_x} \right)$$

- The diffusion current density **($J_{diffusion}$)** is a measure of the flow of charge carriers (such as electrons or holes) in a semiconductor material due to concentration gradients.

$$\mathbf{J_{diffusion} = J_e + J_h}$$

$$J_e(diffusion) = -qD_n\frac{d_n}{d_x}$$

where J_e (diffusion) is the diffusion current density due to electrons.

$$J_h\,(diffusion) = qD_p\frac{d_p}{d_x}$$

where J_h (diffusion) is the diffusion current density due to holes.

- **q** is the elementary charge, 1.6 x 10^{-19}. It represents the charge of an electron or hole.

- **D_n and D_p** are the diffusion coefficients, representing how fast electrons and holes move in response to a concentration gradient.

- $\frac{d_n}{d_x}$ and $\frac{d_p}{d_x}$ are the gradients of electron and hole concentrations

  with respect to position. They indicate how the concentration of carriers changes along the length of the semiconductor.

- **A** represents the **cross-sectional area** perpendicular to the direction of carrier flow.It represents the area through which charge carriers can move.

- $\mathbf{I_{diffusion}}$ represents the diffusion current.

Example:

Consider a silicon p-n junction diode with the following parameters:

- Electron diffusion coefficient **(D_n) = 30 cm^2/s**
- Hole diffusion coefficient **(D_p) = 15 cm^2/s**
- Electron concentration gradient at the junction $\frac{d_n}{d_x} = -10^{18} cm^{-5}$
- Hole concentration gradient at the junction $\frac{d_p}{d_x} = 10^{18} cm^{-5}$
- Elementary charge **(q) = 1.602 x 10^{-19} C**
- Cross-sectional area of the junction **(A) = 10^{-4} cm^2 (assumed for calculation)**

Calculations:

- ❑ **Electron Diffusion Current Density** $J_e(diffusion) = -qD_n\frac{d_n}{d_x}$

$J_e(\text{diffusion}) = -\ (1.602 \times 10^{-19}\ \text{C}) \times (30\ \text{cm}^2/\text{s}) \times (-10^{18}\ \text{cm}^{-5})$

$= 4.806\ \text{A/cm}^2$

- ❑ **Hole Diffusion Current Density** $J_h\,(diffusion) = qD_p\frac{d_p}{d_x}$

$J_h(\text{diffusion}) = (1.602 \times 10^{-19}\ \text{C}) \times (15\ \text{cm}^2/\text{s}) \times (10^{18}\ \text{cm}^{-5})$

$= 2.403\ \text{A/cm}^2$

- **Total Diffusion Current Density ($J_{diffusion}$):**

$$J_{diffusion} = J_e + J_h$$

$$= 4.806\ A/cm^2 + 2.403\ A/cm^2$$

$$= 7.209\ A/cm^2$$

- **Diffusion Current $I_{diffusion}$:**

$$I_{diffusion} = J_{diffusion} \times A$$

$$= 7.209\ A/cm^2 \times 10^{-4}\ cm^2$$

$$= 7.209 \times 10^{-4}\ A$$

$$\mathbf{I_{diffusion} = 0.729\ mA}$$

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