SUBJECT: BASIC ELECTRONICS

Drift Current Equation In Semiconductor Diode

Elementrix Classes

Drift Current Equation in Semiconductor Diode:

$$I_{drift} = A \times E(qp\mu_p - qn\mu_n)$$

- Drift current density(**J_{drift}**) in a semiconductor diode refers to the flow of charge carriers (electrons and holes) in response to an applied electric field within the semiconductor material.

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

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

$$J_e(drift) = -qn\mu_n E$$

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

$$J_h(drift) = qp\mu_p E$$

- **q:** This represents the elementary charge 1.6 x 10^{-19}. It represents the charge of an electron or hole.
- **p:** This is the concentration of holes in the semiconductor diode. Holes are the majority carriers in p-type semiconductors, and p represents the number of holes per unit volume.
- **n:** This is the concentration of electrons in the semiconductor diode. Electrons are the majority carriers in n-type semiconductors, and n represents the number of electrons per unit volume.
- **μ_p:** This is the mobility of holes. It represents how easily holes can move in response to an electric field.

- **μ_n:** This is the mobility of electrons. It represents how easily electrons can move in response to an electric field.

- **E:** This is the electric field within the semiconductor diode. It is typically due to an applied voltage and influences the motion of charge carriers.

- **A:** This is the cross-sectional area of the semiconductor diode. It represents the area through which charge carriers can move.

- **I_{drift}:** This is the total drift current in the semiconductor diode, which is the sum of the drift currents contributed by both electrons and holes.

Example:

Consider a forward-biased p-n junction diode with the following properties:

Material properties:Electron mobility (μ_n) = 1350 cm²/Vs

Hole mobility (μ_p) = 480 cm²/Vs

Forward bias voltage (V_f) = 0.7 V

Depletion region width (W) = 0.5 μm

Electron concentration (n) = 10^{16} cm^{-3}

Hole concentration (p) = 10^{14} cm^{-3}

Cross-sectional area (A) = 10^{-4} cm²

Solution:

- **Calculate the electric field (E):**

$$E = \frac{V}{W} = \frac{0.7V}{0.5\mu m} = 1400\,V/cm$$

- **Calculate the electron drift current density (J_e):**

$J_e = -qn\mu_n E$

$J_e = -(1.602 \times 10^{-19}\ C) \times (10^{16}\ cm^{-3}) \times (1350\ cm^2/Vs) \times (1400\ V/cm)$

$J_e = -32.4456\ A/cm^2$

- **Calculate the hole drift current density (J_h):**

$$\mathbf{J_h = qp\mu_p E}$$

$$J_h = (1.602 \times 10^{-19}\ C) \times (10^{14}\ cm^{-3}) \times (480\ cm^2/Vs) * (1400\ V/cm)$$

$$J_h = 10.7584\ A/cm^2$$

- **Calculate the total drift current density (J_{drift}):**

$$\mathbf{J_{drift} = J_e + J_h} = -32.4456\ A/cm^2 + 10.7584\ A/cm^2 = -21.6872\ A/cm^2$$

- **Calculate the total drift current (I_{drift}):**

$$I_{drift} = J_{drift} \times A = -21.6872 \text{ A/cm}^2 \times 10^{-4} \text{ cm}^2 = -2.16872 \times 10^{-4} \text{ A}$$

NOTE:

The negative drift current (**I_{drift}**) indicates that the net flow of electrons is against the electric field. This is because electrons have a negative charge and move in the opposite direction of the field.

However, in semiconductor analysis, we often use conventional current, which considers the flow of positive charge carriers.

To obtain the conventional current, we negate the negative drift current:

$$I_{conventional} = -I_{drift} = 2.16872 \times 10^{-4}\ A$$

$$\mathbf{I_{drift} = 0.216872\ mA}$$

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