Junction Diode

Lecture - 15

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B.Sc (Electronics)
TDC PART - I
Paper – 1 (Group – B)
Unit – 5
by:

Dr. Niraj Kumar

Assistant Professor (Guest Faculty)

Department of Electronics

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

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➢ Zero Applied Biased P-N Junction Diode (PART – 3)

⇨ Here in this **Lecture** we will examine the properties of the Step Junction in Thermal Equilibrium, where no currents exist and no External Excitation is applied. We will also determine here,

(1) Built-in Potential Barrier through the Depletion Layer or Space Charge Region,

(2) Electric Field and

(3) Space Charge Width

➢ (3) Space Charge Width

⇨ The **Space Charge Region** extends into the **N –Type region and P – Type region** from the **Metallurgical Junction**. **This distance is known as the Space Charge Width.**

$$x_p = \frac{N_D\, x_n}{N_A} \quad \text{...} \quad \textbf{(122)}$$

⇨ Now **substituting value** of above **Equation (122)** in **Equation (121)** of **Lecture – 14** and solving for x_n, then we get,

$$\therefore\ V_{bi} = \phi\,(x = x_n) = \frac{e}{2\epsilon}\left(N_D\, x_n^2 + N_A\, x_p^2\right) \quad \text{....................} \quad \textbf{(121)}$$

$$x_n = \sqrt{\frac{2\epsilon\, V_{bi}}{e}\, \frac{N_A}{N_D}\left[\frac{1}{N_A + N_D}\right]} \quad \text{..} \quad \textbf{(123)}$$

⇨ The above **Equation (123)** provides the **Space Charge Width**, or the **Width of the Depletion Region** x_n extending into N –Type region when the **No Voltage** is applied between the P – Type region and N – Type region.

⇨ **Similarly,**

⇨ The **Space Charge Region** extends into the **N –Type region and P – Type region** from the **Metallurgical Junction**. This **distance is known as the Space Charge Width,**

$$x_p = \frac{N_A\, x_P}{N_D} \quad \text{...} \quad \textbf{(124)}$$

⇨ Now **substituting value** of above **Equation (124)** in **Equation (121)** of **Lecture – 14** and solving for x_P, then we get,

$$\therefore\ V_{bi} = \emptyset\,(x = x_n) = \frac{e}{2\epsilon}\left(N_D\, x_n^2 + N_A\, x_p^2\right) \quad \text{.................... (121)}$$

$$x_P = \sqrt{\frac{2\epsilon\, V_{bi}}{e}\ \frac{N_D}{N_A}\left[\frac{1}{N_A + N_D}\right]} \quad \text{.. (125)}$$

⇨ The above **Equation (125)** provides the **Space Charge Width**, or the **Width of the Depletion Region** x_p extending into P –Type region when the **No Voltage** is applied between the P – Type region and N – Type region.

⇨ Hence **Total Depletion or Space Charge Width**,

$$W = x_n + x_p \quad \text{... (126)}$$

⇨ Now putting the value of x_n from above **Equation (123)** and value of x_p from above **Equation (125)** into the above **Equation (126)**, then we get,

$$W = x_n + x_p$$

$$W = \sqrt{\frac{2\epsilon\, V_{bi}}{e}\ \frac{N_A}{N_D}\left[\frac{1}{N_A + N_D}\right]} + \sqrt{\frac{2\epsilon\, V_{bi}}{e}\ \frac{N_D}{N_A}\left[\frac{1}{N_A + N_D}\right]} \quad \text{............... (127)}$$

$$W = \left(\frac{2\epsilon\, V_{bi}}{e}\ \frac{N_A}{N_D}\left[\frac{1}{N_A + N_D}\right]\right)^{\frac{1}{2}} + \left(\frac{2\epsilon\, V_{bi}}{e}\ \frac{N_D}{N_A}\left[\frac{1}{N_A + N_D}\right]\right)^{\frac{1}{2}} \quad \text{........... (128)}$$

$$W = \left(\frac{2\epsilon\, V_{bi}}{e}\ \frac{N_A}{N_D}\ \frac{1}{N_A + N_D}\right)^{\frac{1}{2}} + \left(\frac{2\epsilon\, V_{bi}}{e}\ \frac{N_D}{N_A}\ \frac{1}{N_A + N_D}\right)^{\frac{1}{2}} \quad \text{............. (129)}$$

$$W = \left[\frac{2\in V_{bi}}{e}\cdot\frac{N_A + N_D}{N_A . N_D}\right]^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (130)$$

- The **Built-in Potential Barrier** can be determined from **Equation (96)** of **Lecture – 13** and **Electric Field** in **P – Type region and N – Type region** can be determined from **Equation (103)** and **Equation (107)** of **Lecture - 14** then in last **Total Space Charge Region Width** can be determined from above **Equation (130).**

- In the next **Lecture - 16,** we will discuss the detailed of the **Reverse Biased P-N Junction Diode.**

to be continued ....

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