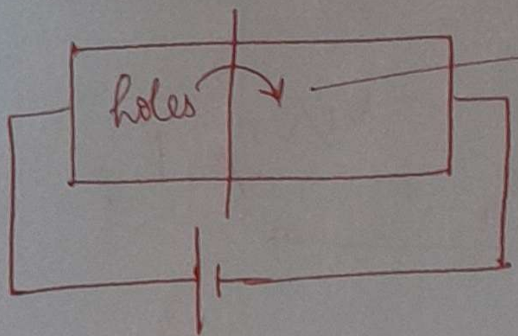
11

Diffusion Capacitance Derivation.

(Storage capacitance)

2

$\infty \longleftarrow 0$



become minority carriers

The excess minority carriers

Assumption

P-side is heavily doped

so, $I \simeq I_p$

$$\boxed{\Delta P(x_n) = P_n\left(e^{V_D/V_T} - 1\right) e^{-x_n/L_p}}$$

$$\int e^{ax}\,dx = \frac{1}{a}e^{ax}$$

For. $V_D = 0.7V$ & $V_T = 26mV$

$$e^{V_D/V_T} - 1 \simeq e^{V_D/V_T}$$

Concentration →

$$\therefore \Delta P(x_n) = P_n e^{V_D/V_T} \cdot e^{-x_n/L_p}$$

Total charge

$$\text{Total charge} = \underline{q P_n} e^{V_D/V_T} \cdot e^{-x_n/L_p}$$

Total charge density

$$\text{Total charge density} = q P_n e^{V_D/V_T} \cdot e^{-x_n/L_p} \cdot (A \cdot dx)$$

$$Q = \int_0^\infty q P_n e^{V_D/V_T} \cdot e^{-x_n/L_p} \cdot A \cdot dx.$$

$$= \frac{q P_n e^{V_D/V_T} A}{\left(-1/L_p\right)} \left[e^{-x_n/L_p}\right]_0^\infty$$

$$[0 - 1]$$

As the applied voltage ↑es, concentration of injected charge carriers ↑es.

→ This rate of change of injected charge with applied forward voltage $\left(\frac{dQ}{dV}\right)$ is defined as diffusion capacitance.

$$Q = \frac{q P_n e^{V_D/V_T} A}{\left(-\frac{1}{L_p}\right)} \left[0 - 1 \right]$$

$$Q = + q \underline{P_n \cdot e^{V_D/V_T}} \cdot A L_p \quad \left[\because P(x_{no}) = P_n e^{V_D/V_T} \right]$$

$$= q P(x_{no}) \cdot A \cdot L_p$$

$$C = \frac{dQ}{dv} = \cancel{\frac{q\, d\, P(x_{no})}{dV}}$$

$$\boxed{C = q A L_p \cdot \frac{d}{dV} \left[P(x_{no}) \right]} \quad \text{--- (1)}$$

<u>Diffusion hole current in the N-side</u>

$$I_p(x_n) = \frac{q}{L_p} D_p A \cdot P(x_{no}) \cdot e^{-x_n/L_p}$$

<u>At $x = 0$</u>

$$I_p = \frac{q}{L_p} D_p A P(x_{no}) = I \quad \left[\because I_p \simeq I \right]$$

$$\boxed{\therefore P(x_{no}) = \frac{I_p L_p}{q D_p A}} \quad \text{--- (2)}$$

Diff ② w.r.t 'V'

$$\boxed{\frac{d[P(x_{no})]}{dV} = \frac{dI}{dV}\,\frac{L_P}{AqD_P}} \quad — ③$$

Subs. ③ in ①,

[Pg 52]

$$\therefore C = \cancel{q}\cancel{A}L_P \cdot \frac{dI}{dV} \cdot \frac{L_P}{\cancel{A}\cancel{q}D_P}$$

e^{ax}

ae^{ax}

$$C = \frac{dQ}{dV} = \frac{dI}{dV} \cdot \frac{L_P^2}{D_P}$$

d

$$I = I_s\left(e^{\frac{V_D}{\eta V_T}} - 1\right)$$

$$\frac{dI}{dV} = \frac{I_s}{\eta V_T} e^{\frac{V_D}{\eta V_T}}$$

$$= \frac{I_s}{\eta V_T}$$

$$\frac{I+I_s}{I_s}$$

I_s

$$\boxed{C_D = g \cdot \tau}$$

where $g = \dfrac{dI}{dV}$

$\tau = \dfrac{L_P^2}{D_P}$

$$= \frac{I_s}{\eta V_T} \cdot e^{\frac{V_D}{\eta V_T}}$$

$$\frac{\cancel{I_s}}{\eta V_T} \times \frac{I+I_s}{\cancel{I_s}}$$

$$\boxed{\therefore C_D = \frac{I}{\eta V_T} \cdot \tau}$$

$$\frac{dI}{dV} = \frac{I + I_s}{\eta V_T} \qquad I \gg I_s$$

$$\frac{dI}{dV} = \frac{I}{\eta V_T} \qquad (I \gg I_s)$$

C_D & frequency

$$I = I_s e^{\frac{V_D}{\eta V_T}} - I_s$$

$$\frac{I + I_s}{I_s}$$

$$I = I_s \left[e^{\frac{V_D}{\eta V_T}} - 1 \right]$$

$$I = I_s e^{\frac{V_D}{\eta V_T}} - I_s$$

$$\frac{I + I_s}{I_s} = e^{\frac{V_D}{\eta V_T}}$$

$$\frac{dI}{dV} = I_s \cdot \frac{1}{\eta V_T} \cdot e^{\frac{V_D}{\eta V_T}}$$

$$= \cancel{I_s} \cdot \frac{1}{\eta V_T} \cdot \frac{I + I_s}{\cancel{I_s}}$$

$$= \frac{I + I_s}{\eta V_T}$$

$\underline{I >> I_s}$ $\quad \simeq \quad \boxed{\frac{I}{\eta V_T} = \frac{dI}{dV}}$