$$J = J_{DC} + J_{ac} \qquad Q = Q_{DC} + Q_{ac}$$

$$\frac{dQ}{dt} = 0 + \frac{dQ_{ac}}{dt} = j\omega Q_{ac} \quad [\text{sinusoidal}]$$

$$j\omega Q_{ac} = \cancel{I_{DC}} + i_{ac} - \frac{(\cancel{Q_{DC}} + Q_{AC})}{\tau_p}$$

$$j\omega Q_{ac} = j_{ac} - \frac{Q_{AC}}{\tau_p}$$

$$j_{ac} = \frac{Q_{ac}}{\tau_p / (1 + j\omega\tau_p)}$$

$$J_{DC} = \frac{Q_{DC}}{\tau_p}$$

Subtracting DC+AC & DC to get AC charge

$$\rho_{ac} = q\frac{n_i^2}{N_D} e^{qV_{DC}/kT} \left(e^{qV_{AC}/kT} - 1\right) \cdot e^{-x/L_p}$$

$$Q_{ac} = \int \rho_{ac} = q\frac{n_i^2}{N_D} e^{qV_{DC}/kT} \left(e^{qV_{AC}/kT} - 1\right) L_p$$

$$Q_{ac} = \frac{q n_i^2 L_p}{N_D} e^{qV_{DC}/kT} \left[q\frac{V_A}{kT}\right] \quad \left[\text{assumption small signal analysis}\right]$$

per area

$$Q_{ac} = \frac{q n_i^2 L_{p\,DC}}{N_D (1 + j\omega\tau)^{1/2}} e^{qV_{DC}/kT} \cdot \left[\frac{qV_A}{kT}\right]$$

$$j_{ac} = \frac{Q_{ac}(1 + j\omega\tau)}{\tau} = \frac{q n_i^2 L_{p\,DC}\, e^{qV_{DC}/kT}}{N_D\, kT\, \tau} qV_A (1 + j\omega\tau)^{1/2}$$

$$= J_{DC} (1 + j\omega\tau)^{1/2} \frac{qV_A}{kT}$$

$$\boxed{\frac{j_{ac}}{V_{ac}} = q\frac{J_{DC}}{kT}(1 + j\omega\tau)^{1/2}} = \text{admittance}$$

$$Y = G_0 (1 + j\omega\tau)^{1/2}$$ ⇒ split into real & imag part

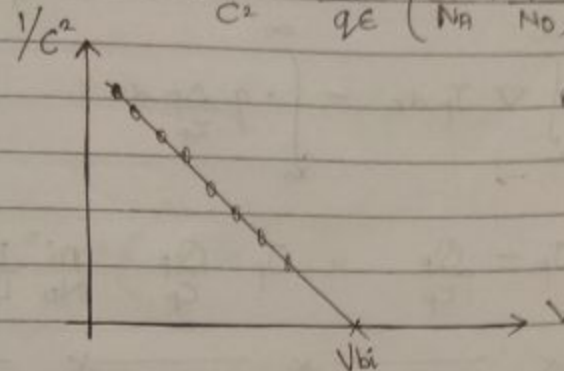
$G_0$ → DC conductance

imag part is C.

hence $\frac{C}{A} = \frac{\epsilon}{W}$ capacitance / unit area is used. = C

$$C = \frac{\epsilon}{\left[\frac{2\epsilon}{q}\left(\frac{1}{N_A}+\frac{1}{N_D}\right)^{\circ}(V_{bi}-V)\right]^{1/2}}$$

$$\frac{1}{C^2} = \frac{2}{q\epsilon}\left(\frac{1}{N_A}+\frac{1}{N_D}\right)(V_{bi}-V)$$




now if diode is $p^+$-n

$\frac{1}{C^2} \propto \frac{1}{N_D}$

hence slope gives $N_D$.

~~bo~~

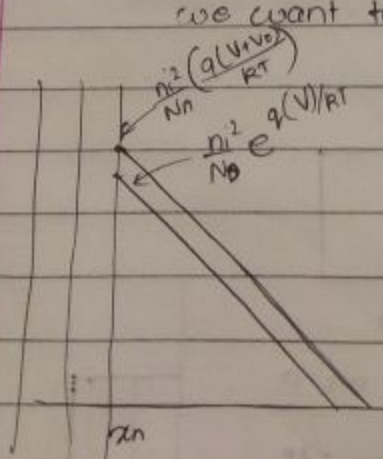
In forward Bias

$$I = I_0\left(e^{qV/kT}-1\right)$$

$$\frac{dI}{dV} = \frac{I_0\left(e^{qV/kT}\right)}{kT/q} = \frac{I_{DC}}{kT/q} = \text{conductance}$$

even though on $V_A > 0$ $W\downarrow$ $C_J = \frac{\epsilon}{W}$ still will exist.

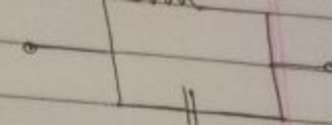
we want to find $Y = \frac{i_{ac}}{v_{ac}}$




the point at the depletion region changes instanteously but rest of the line changes back to original completely depending on recomb. which gives measure of Capacitance.

$$\frac{dQ}{dt} = J - \frac{Q}{\tau_p}$$

$$q\int_{x_n} \ldots = \frac{n_i^2}{N_D} L_p \left(e^{\ldots} - 1\right)$$

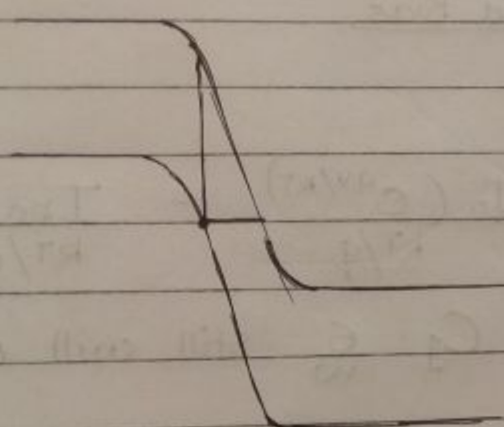


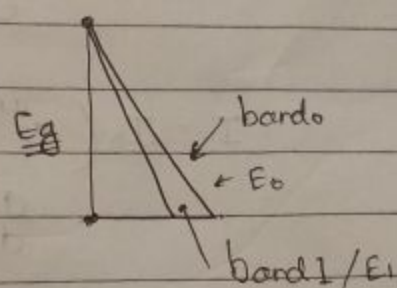
$$q\int_{x_n}^{\infty} \frac{\partial \Delta p}{\partial t}\,dx = \int_{x_n}^{\infty} \nabla \cdot J_p\,dx - \int_{x_n}^{\infty} -q\frac{\Delta p}{\tau_p}\,dx$$

$$0 = \frac{dQ_p}{dt} = J_p - \frac{Q_p}{\tau_p} \Rightarrow J_p = \frac{Q_p}{\tau_p} = \frac{n_i^2}{N_D}\frac{D_p}{L_p}\left(e^{qV/kT} - 1\right)$$

— x — x — x — x —

~~Tut — 3~~ Lec

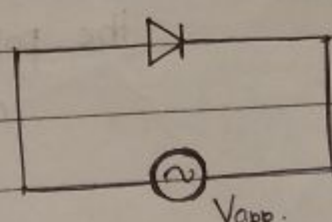





$E_1 > E_0$

hence probability to tunnel increases as E↑.

AC response :-




Vapp = Vdc + Vac

-2V    +10mV

-10mV

at $\omega t = 0$, $V_A = V_{DC} = -2V$

so $-x_p$ & $x_n$ increase

at $\omega t = \frac{\pi}{2}$   $V_A = -2V + 10mV$

so $-x_p$ & $x_n$ reduces a little