Course 18

Schottky junction

$$x_d(V) = \sqrt{\frac{2\varepsilon(\phi_{bi} - V)}{q N_D}}$$

. Energy barrier decreases under forward bias.

∴ # electrons increases <u>exponentially</u> with V.

∴ thinking in terms of electron population explains the rectifying behaviour

* V = 0 drift = diffusion
* electron thermalize in metal
* Bottleneck : reaching the interface

⇒ for high μ ⇒ electrons reach the interface quite easily. <u>thermionic emission</u>

<u>emission</u> ⇒ focus at the tip of the energy band

<u>Thermionic - emission theory :</u>

$$J_t \simeq J_e(0^+) = J_{e,SM}(0^+) - J_{e,MS}(0^+)$$

$$J_{e,SM}(0^+) \simeq -q \cdot n(0^+) \cdot v_e(0^+)$$

in TE $n(0^+) = N_D \exp \frac{-q(\phi_{bi}-V)}{kT}$ but this is <u>not</u> valid!

since electron concentration is different than in equilibrium.

↳ not enough collisions with the lattice → not in equilibrium

at $x = l_{ce}$ only half of the electrons have the v_e pointing to the interface

$$n(0^+) = \frac{n(l_{ce})}{2} \cdot \exp \frac{q[\phi(0^+) - \phi(l_{ce})]}{kT} \quad [1]$$

$$\begin{cases} n(l_{ce}) \simeq N_D \exp \frac{+q\phi(l_{ce})}{kT} \\ \phi(0^+) = -(\phi_{bi} - V) \end{cases}$$

Using [1] ⇒ $n(0^+) = \frac{N_D}{2} \cancel{\exp\left(\frac{q\phi(l_{ce})}{kT}\right)} \cdot \exp\left[-\frac{q(\phi_{bi}-V)}{kT}\right] \cdot \cancel{\exp\left(-\frac{q\phi(l_{ce})}{kT}\right)}$

$$\therefore n(0^+) = \underbrace{\frac{N_D}{2} \exp \frac{-q(\phi_{bi}-V)}{kT}}_{\text{only half of the } n(0^+) \text{ in T.E}} = \frac{N_C}{2} \cdot \exp \frac{-q(\varphi_{bn} - V)}{kT}$$

$$* \quad N_D \cdot \exp\left(-\frac{\phi_{bi}}{kT}\right) = N_C \cdot \exp\left(\frac{-q\varphi_{bn}}{kT}\right)$$

Second : v_{th}

taking into account statistics :

$$v_e(0^+) = -\frac{v_{the}}{2} = -\sqrt{\frac{2kT}{\pi m_{ce}^*}}$$

$$\therefore \; J_{e,SM} = \underbrace{q \cdot N_c \cdot \sqrt{\frac{kT}{2\pi m_{ce}^*}}}_{A^* \cdot T^2} \exp\frac{-q\varphi_{bn}}{kT} \cdot \exp\left(\frac{qV}{kT}\right)$$

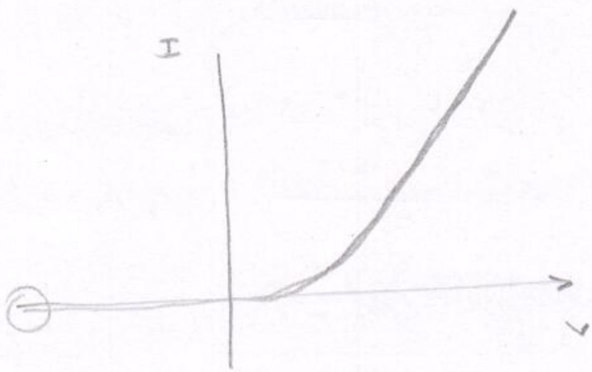
$$A^* = \frac{4\pi q k^2 m_0}{h^3}\sqrt{\frac{(m_{di}/m_0)^3}{(m_{ce}/m_0)}}$$ Richardson's constant

and

$J_{e,MS} = ?$ $\Rightarrow$ $J_t = 0$ when $V = 0$

$$\therefore \; J_{e,MS} = A^* T^2 \exp\left(-\frac{q\varphi_{bn}}{kT}\right)$$

$$\therefore \; \boxed{J_t = A^* \cdot T^2 \exp\frac{-q\varphi_{bn}}{kT}\left(\exp\frac{qV}{kT} - 1\right)}$$



$$I_s = A_J \cdot A^* T^2 \exp\left(-\frac{q\varphi_{bn}}{kT}\right)$$

Ohmic contacts

$$x_d = \sqrt{\frac{2 \cdot \varepsilon \, (\phi_{bi} - V)}{q N_D}}$$

1) $N_D \uparrow \Rightarrow x_d \downarrow$

2) $q\phi_{bn} = q\phi_{bi} + \underbrace{q\phi_{n}}_{(E_c - E_F)} \Rightarrow \downarrow \phi_{bn} \Rightarrow \downarrow \phi_{bi} \Rightarrow x_d \downarrow$

$$J \simeq A^* T^2 \underbrace{\exp\left(-\frac{q\varphi_{bn}}{KT}\right)}_{\simeq 1} \cdot \underbrace{\exp\left(\frac{qV}{KT}\right)}_{\frac{qV}{KT}} \underset{\text{small } V}{\simeq} \frac{V}{\rho_c}$$