FIZ1951-MÜHENDİSLİK İÇİN YARIİLETKEN FİZİĞİ DERSİ FORMÜL KAĞIDI

$V = IR \qquad J = \frac{I}{A} \qquad R = \rho\frac{l}{A} \qquad \rho = \frac{1}{\sigma} \qquad \boldsymbol{J} = \sigma\boldsymbol{E} \quad \boldsymbol{E} = \rho\boldsymbol{J} \qquad \vec{J} = \frac{\vec{I}}{A} = nq\vec{v}_s$

$\rho = \frac{1}{ne\mu} \qquad \sigma = ne\mu$

$l = \vartheta_{ort}\tau_c \qquad \mu_e = \frac{q\tau_c}{m^*} \qquad \boldsymbol{\vartheta_d} = \mu_e\boldsymbol{E} \qquad \boldsymbol{F} = -e\boldsymbol{E}$

$n = CT^{3/2}e^{-E_g/2kT} \qquad C = \frac{2^{5/2}(m\pi k)^{3/2}}{h^3}$

$\sigma_n = ne\mu_n$
$\sigma_p = pe\mu_p \qquad \sigma = \sigma_n + \sigma_p \qquad \sigma = e(p\mu_p + n\mu_n)$

$n_i . p_i = n_i^2 = p_i^2 \qquad n_i = p_i = \sqrt{n_i p_i} \qquad N_{VB}(\mathrm{E}) = \frac{1}{2\pi^2\hbar^3}(2m_h^*)^{3/2}(E_V - E)^{1/2}$

$N_{CB}(\mathrm{E}) = \frac{1}{2\pi^2\hbar^3}(2m_e^*)^{3/2}(E - E_C)^{1/2} \qquad f_n(E,T) = \frac{1}{1 + e^{\frac{E-E_F}{k_BT}}}$

$f_p(E,T) = 1 - f_n(E,T) \Rightarrow f_p(E,T) = \frac{1}{1 + e^{\frac{E_F - E}{k_BT}}}$

$n.p = n_i^2 \qquad n_i = N_C exp\left(-\frac{E_C - E_F}{k_BT}\right) \qquad N_C = 2\left(\frac{2\pi m_e^* k_BT}{h^2}\right)^{\left(\frac{3}{2}\right)}$

$p_i = N_V exp\left(-\frac{E_F - E_V}{k_BT}\right) \qquad N_V = 2\left(\frac{2\pi m_h^* k_BT}{h^2}\right)^{\left(\frac{3}{2}\right)}$

$E_g = E_C - E_V \qquad n_i = \sqrt{N_C N_V}\, exp\left(-\frac{E_g}{2k_BT}\right) \qquad E_F = E_V + \frac{1}{2}E_g + \frac{k_BT}{2} ln\frac{N_V}{N_C}$

$n_i = p_i = 2\left(\frac{2\pi k_B\sqrt{m_e^* m_h^*}}{h^2}\right)^{3/2} T^{3/2} exp\left(-\frac{E_g}{2k_BT}\right) \qquad E_F = E_V + \frac{1}{2}E_g + 3\frac{k_BT}{4} ln\frac{m_h^*}{m_e^*}$

$p = p_i + N_A$

N_A: : p tipi katkılı yarıiletkende Akseptör atom konsantrasyonu (1/m³)

$N_A \gg n_i \longrightarrow p = N_A$

$n = \frac{n_i^2}{N_A} \ll N_A \qquad \sigma \approx N_A e\mu_p$

$n = n_i + N_D$

N_D: : n tipi katkılı yarıiletkende Donör atom konsantrasyonu (1/m³)

$N_D \gg n_i \longrightarrow n = N_D$

$p = \frac{n_i^2}{N_D} \ll N_D \qquad \sigma \approx N_D e\mu_n$

$n = N_C exp\left(-\frac{E_C - E_F}{k_BT}\right)$

$E_F = E_C + k_BT\, ln\left(\frac{n}{N_C}\right)$

$n = \frac{(N_D - N_A)}{2} + \sqrt{\left(\frac{N_D - N_A}{2}\right)^2 + n_i^2}$

$p = N_V exp\left(-\frac{E_F - E_V}{k_BT}\right)$

$E_F = E_V - k_BT\, ln\left(\frac{p}{N_V}\right)$

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$\vec{E} = \frac{V}{l}$ $\mu_p = \frac{e\tau}{m_p^*}$ $\mu_n = \frac{e\tau}{m_e^*}$

$J_p = б_p E = nq\mu_p E = pqv_s$
Boşluklar için akım yoğunluğu

$J_n = б_n E = nq\mu_n E = nqv_s$
Elektronlar için akım yoğunluğu

$J = J_n + J_p = q(n\mu_n + p\mu_p)E$
Genel akım yoğunluğu

J=σE
$J = e(p\mu_p + n\mu_n)\, E$

$\vartheta_{th} = \frac{l}{\tau_C}$ $J_n = qD_n \frac{dn}{dx}$

$J_p = -qD_p \frac{dp}{dx}$ $\frac{kT}{2} = \frac{m^* {\vartheta_{th}}^2}{2}$

- $D_n = \mu_n \frac{kT}{q}$
- $D_p = \mu_p \frac{kT}{q}$

$J_n = qn\mu_n E + qD_n \frac{dn}{dx}$ $J_p = qp\mu_p E - qD_p \frac{dp}{dx}$

$J_{toplam} = en\mu_n E + eD_n \frac{dn}{dx} + ep\mu_p E - eD_p \frac{dp}{dx}$

$20{,}10^{-3}.$

- $V_{Hall} = \frac{IB}{nqt}$
- $V_{Hall} = R_{Hall} \frac{IB}{t}$, $R_{Hall} = \frac{1}{nq}$ veya $R_{Hall} = \frac{1}{pq}$
- $L_z = m_l \hbar$

$\vec{\mu} = (-\frac{e}{2m})\vec{L}$ $\vec{\mu_s} = (-\frac{e}{m})\vec{S}$

- $U_m = \vec{\mu}.\vec{H}$

Bohr manyetonu

$U_m = m_l \left(\frac{e\hbar}{2m}\right) H$ $\mu_B = \frac{e\hbar}{2m}$

$U_m = \mu_B H m_l$ $\mu_B = 9.274 \times 10^{-24}$ J/T

- $\vec{M} = \chi \vec{H}$
- $\vec{M} = \frac{\vec{\mu}_{top}}{V}$

$\vec{B} = \mu_0 \vec{H} + \mu_0 \vec{M} = \mu_o (1 + \chi)\vec{H}$

- $\mu = \mu_0 (1 + \chi)$
- $\vec{B} = \mu \vec{H}$

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- $\mu_r = \dfrac{\mu}{\mu_0}$

$\mu_o = 4\pi \times 10^{-7}$ H/m
B→Tesla, 1T = 1N/A.m
1T = 10^4 Gauss (G)

- $\chi = \dfrac{C}{T - T_c}$
- $\chi = \dfrac{C}{T}$

$$n^* = n_r - ik = \sqrt{\mathcal{E}} \ , \quad n_r = \frac{c}{v}$$

$$\alpha = \frac{4\Pi k}{\lambda} \quad , \quad \alpha = A(\mathrm{h}\mathcal{V} - E_g)^{\gamma}$$

$\gamma = \frac{1}{2}$ direk bant aralıklı yarıiletkenlerde kullanılır

$\gamma = \frac{3}{2}$ indirek bant aralıklı yarıiletkenlerde kullanılır

$$R = \frac{(n_r - 1)^2 + k^2}{(n_r + 1)^2 + k^2}$$

$$T = (1 - R^2)e^{(-\alpha l)}$$

- $I = I_0 e^{(-\alpha l)}$

$I_C = I_S(e^{V_{BB}/V_T} - 1)$, $I_C \gg I_S$ şartı ile $I_C = I_S e^{V_{BB}/V_T}$ dir.

$$I_S = \frac{A_E q D_n n_{p0}}{W}, \ n_{p0} = n_i^2 / N_A$$

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$$V_T = \frac{kT}{q}, \; V_T \cong 26 \text{ mV}$$

(oda sıcaklığında)

$$\beta = \frac{I_C}{I_B}, \qquad I_B = \frac{I_C}{\beta}$$

$$I_E = I_C + I_B \qquad \alpha = \frac{\beta}{\beta + 1} \qquad \beta = \frac{\alpha}{1 - \alpha}$$

$V_{R_B} = V_{BB} - V_{BE}$, $\quad V_{R_B} = I_B R_B$

Dolayısıyla $I_B R_B = V_{BB} - V_{BE}$, ise $I_B = \frac{V_{BB} - V_{BE}}{R_B}$ olur.

$V_{CE} = V_{CC} - V_{R_C}$, $\quad V_{R_C} = I_C R_C$

$V_{CE} = V_{CC} - I_C R_C$, burada $I_C = \beta I_B$

$V_{CB} = V_{CE} - V_{BE}$, $V_{BE} \cong 0.7V$ dur, silikon transistör için.

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)^2 \qquad I_D = K\left(V_{GS} - V_{GS(t)}\right)^2$$

$$R = \left(\frac{n_y - n_ç}{n_y + n_ç}\right)^2 \qquad \theta_k = sin^{-1}\left(\frac{n_ç}{n_y}\right) \approx \frac{n_ç}{n_y}$$

$$\lambda = \frac{hc}{E} = \frac{1.24(eV)}{E(eV)}\mu m \text{ veya } \lambda = \frac{hc}{E} = \frac{1240(eV)}{E(eV)} nm \quad , c = \lambda \nu$$

$$P_{max} = V_{OC} I_{SC} FF$$

$$\eta = \frac{V_{OC} I_{SC} FF}{P_{in}} \qquad FF = \frac{I_m V_m}{I_{SC} V_{OC}}$$

$\varepsilon_o = 8.85x10^{-12}\frac{F}{m}$, $\quad \mu_o = 4\pi x10^{-7}\frac{N}{A^2}$, $\quad h = 6.63x10^{-34} J.s$

$q = e = 1.6x10^{-19} C$, $\quad k_B = 1.38x10^{-23} J/K \quad m_o = 9.1x10^{-31}$ kg