FIZ1951-MÜHENDİSLİK İÇİN YARIİLETKEN FİZİĞİ DERSİ FORMÜL KAĞIDI

$$V = IR \qquad J = \frac{I}{A} \qquad R = \rho\frac{l}{A} \qquad \rho = \frac{1}{\sigma} \qquad \boldsymbol{J} = \sigma\boldsymbol{E}$$

$$E = \rho J$$

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

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

$$\rho = \rho_0(1 + \alpha T)$$

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

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

$$\boldsymbol{n_i \cdot p_i = n_i^2 = p_i^2} \qquad \boldsymbol{n_i = p_i = \sqrt{n_i p_i}}$$

$$\boldsymbol{N_{VB}(E) = \frac{1}{2\pi^2\hbar^3}(2m_h^*)^{3/2}(E_V - E)^{1/2}}$$

$$\boldsymbol{N_{CB}(E) = \frac{1}{2\pi^2\hbar^3}(2m_e^*)^{3/2}(E - E_C)^{1/2}}$$

$$\boldsymbol{f_n(E,T) = \frac{1}{1 + e^{\frac{E - E_F}{k_B T}}}}$$

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

$$\boldsymbol{n_i = N_C exp\left(-\frac{E_C - E_F}{k_B T}\right)} \qquad \boldsymbol{N_C = 2\left(\frac{2\pi m_e^* k_B T}{h^2}\right)^{\left(\frac{3}{2}\right)}}$$

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

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$$E_g = E_C - E_V$$

$$n_i = \sqrt{N_C N_V}\, exp\left(-\frac{E_g}{2k_BT}\right)$$

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

$$E_F = E_V + \frac{1}{2}E_g + \frac{k_BT}{2} ln\frac{N_V}{N_C}$$

$$E_F = E_V + \frac{1}{2}E_g + 3\frac{k_BT}{4} ln\frac{m_h^*}{m_e^*}$$

$$n.p = n_i^2$$

$$n = n_i + N_D$$

N_D: : n tipi katkılı yarıiletkende Donör atom konsantrasyonu ($1/m^3$)

$$N_D \gg n_i \longrightarrow n = N_D$$

$$p = \frac{n_i^2}{N_D} \ll N_D$$

$$\sigma \approx N_D e \mu_n$$

$$E_{Hidrojen} = -\frac{m_e e^4}{8\varepsilon_o^2 h^2} = -13.6\ eV$$

$$E_d = E_C - 13.6\frac{m_e^*}{m_o}\left(\frac{\varepsilon_o}{\varepsilon}\right)^2 \quad eV$$

E_b

$$p = p_i + N_A$$

N_A: : p tipi katkılı yarıiletkende Akseptör atom konsantrasyonu ($1/m^3$)

$$N_A \gg n_i \longrightarrow p = N_A$$

$$n = \frac{n_i^2}{N_A} \ll N_A$$

$$\sigma \approx N_A e \mu_p$$

$$E_{Hidrojen} = -\frac{m_e e^4}{8\varepsilon_o^2 h^2} = -13.6\ eV$$

$$E_a = E_V + 13.6\frac{m_e^*}{m_o}\left(\frac{\varepsilon_o}{\varepsilon}\right)^2 \quad eV$$

E_b

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

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

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

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

$$\vec{F} = m\vec{a} = m\frac{d<\vec{v}>}{dt} = \frac{m<\vec{v}>}{\tau_c}$$

$$I_{ort} = \frac{\Delta q}{\Delta t} \rightarrow \frac{C}{s}$$

$$I_{ani} = \frac{dq}{dt} \rightarrow A$$

$$\mu = \frac{\Delta |\vec{v}|}{|\vec{E}|} = \frac{q\tau_c}{m}$$

$$\vec{J} \equiv \frac{\vec{I}}{A} = nq\vec{v_s}$$

$$\Rightarrow \vec{\vartheta} = \frac{-e\vec{E}\tau}{m_e^*} \quad sürüklenme\ hızı$$

$$\vec{E} = \frac{V}{l}$$

$$\mu = \frac{\vec{\vartheta}}{\vec{E}} = \frac{-e\tau}{m_e^*}$$

$$\mu_n = \frac{e\tau}{m_e^*}$$

$$\mu_p = \frac{e\tau}{m_p^*}$$

$$\sigma = \frac{ne^2\tau}{m_e^*}$$

$$J_n = \sigma_n E = nq\mu_n E = nqv_s$$

Elektronlar için akım yoğunluğu

$$J_p = \sigma_p E = nq\mu_p E = pqv_s$$

Boşluklar için akım yoğunluğu

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

Genel akım yoğunluğu

$$J = \sigma E$$

$$J = e(p\mu_p + n\mu_n)\, E$$

$$\vartheta_{th} = \frac{l}{\tau_C}$$

$$J_n = qD_n\frac{dn}{dx}$$

$$J_p = -qD_p\frac{dp}{dx}$$

$$\frac{kT}{2} = \frac{m^*\vartheta_{th}^{\ 2}}{2}$$

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$$D_n = \frac{kT}{q}\mu_n \Rightarrow = \mu_n \vartheta_t \qquad D_p = \frac{kT}{q}\mu_p \Rightarrow = \mu_p \vartheta_t$$

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

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

$$\frac{\mu_n}{D_n} = \frac{\mu_p}{D_p} = \frac{e}{k_B T}$$

- $F_B = F_E$
- $qv_sB = qE_{Hall}$
- $E_{Hall} = v_sB$, $v_s = \frac{I}{nqA}$, $A = t.W$, $R_{Hall} = \frac{1}{nq}$
- $V_{Hall} = E_{Hall}W = v_sBW = \frac{I}{nqtw}BW = \frac{IB}{nqt}$
- $V_{Hall} = R_{Hall}\frac{IB}{t}$
- Benzer denklemler p tipi yarıiletkenler için de türetilebilir.

$\varepsilon_o = 8.85x10^{-12}\frac{F}{m}$, $\mu_o = 4\pi x10^{-7}\frac{N}{A^2}$, $h = 6.64x10^{-34}J.s$

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