

FIZ1951-MÜHENDİSLİK İÇİN YARIİLETKEN FİZİĞİ DERSİ FORMÜL KAĞIDI

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

$$E = \rho J$$

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

$$l = \vartheta_{ort} \tau_c \quad \mu_e = \frac{q\tau_c}{m^*} \quad \vartheta_d = \mu_e E \quad F = -eE$$

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

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

$$\sigma_n = ne\mu_n$$

$$\sigma_p = pe\mu_p$$

$$\sigma = \sigma_n + \sigma_p$$

$$\sigma = e(p\mu_p + n\mu_n)$$

$$n_i \cdot p_i = n_i^2 = p_i^2 \quad n_i = p_i = \sqrt{n_i p_i}$$

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

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

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

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

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

$$N_C = 2 \left(\frac{2\pi m_e^* k_B T}{h^2} \right)^{\left(\frac{3}{2}\right)}$$

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

$$N_V = 2 \left(\frac{2\pi m_h^* k_B T}{h^2} \right)^{\left(\frac{3}{2}\right)}$$

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$$E_g = E_C - E_V$$

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

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

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

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

$$n \cdot p = n_i^2$$

$$n = n_i + N_D$$

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

$$N_D \gg n_i \rightarrow n = N_D$$

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

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

$$E_{\text{Hidrojen}} = -\frac{m_e e^4}{8\epsilon_0^2 h^2} = -13.6 \text{ eV}$$

$$E_d = E_C - 13.6 \frac{m_e^*}{m_o} \left(\frac{\epsilon_0}{\epsilon} \right)^2 \text{ eV}$$

E_b

$$p = p_i + N_A$$

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

$$N_A \gg n_i \rightarrow p = N_A$$

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

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

$$E_{\text{Hidrojen}} = -\frac{m_e e^4}{8\epsilon_0^2 h^2} = -13.6 \text{ eV}$$

$$E_a = E_V + 13.6 \frac{m_e^*}{m_o} \left(\frac{\epsilon_0}{\epsilon} \right)^2 \text{ eV}$$

E_b

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

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

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

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

$$\vec{F} = m\vec{a} = m \frac{d\langle \vec{v} \rangle}{dt} = \frac{m \langle \vec{v} \rangle}{\tau_c}$$

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

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

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

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

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

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

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

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

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

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

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

Elektronlar için akım yoğunluğu

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

Boşluklar için akım yoğunluğu

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

Genel akım yoğunluğu

$$J = \sigma E$$

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

$$v_{th} = \frac{l}{\tau_c}$$

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

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

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

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

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

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

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

$$\bullet F_B = F_E$$

$$\bullet qv_s B = qE_{Hall}$$

$$\bullet E_{Hall} = v_s B, \quad v_s = \frac{I}{nqA}, \quad A = t \cdot W, \quad R_{Hall} = \frac{1}{nq}$$

$$\bullet V_{Hall} = E_{Hall} W = v_s B W = \frac{I}{nqtW} B W = \frac{IB}{nqt}$$

$$\bullet V_{Hall} = R_{Hall} \frac{IB}{t}$$

• Benzer denklemler p tipi yarıiletkenler için de türetilir.

$$\varepsilon_o = 8.85 \times 10^{-12} \frac{F}{m}, \quad \mu_o = 4\pi \times 10^{-7} \frac{N}{A^2}, \quad h = 6.64 \times 10^{-34} J.s$$

$$q = e = 1.6 \times 10^{-19} C, \quad k_B = 1.38 \times 10^{-23} J/K \quad m_o = 9.1 \times 10^{-31} kg$$