FUNDAMENTALS OF NANOELECTRONICS

Basic Concepts

The New Perspective

2. Energy Band Model

3. What and Where is the Voltage?

4. Heat & Electricity: Second Law & Information

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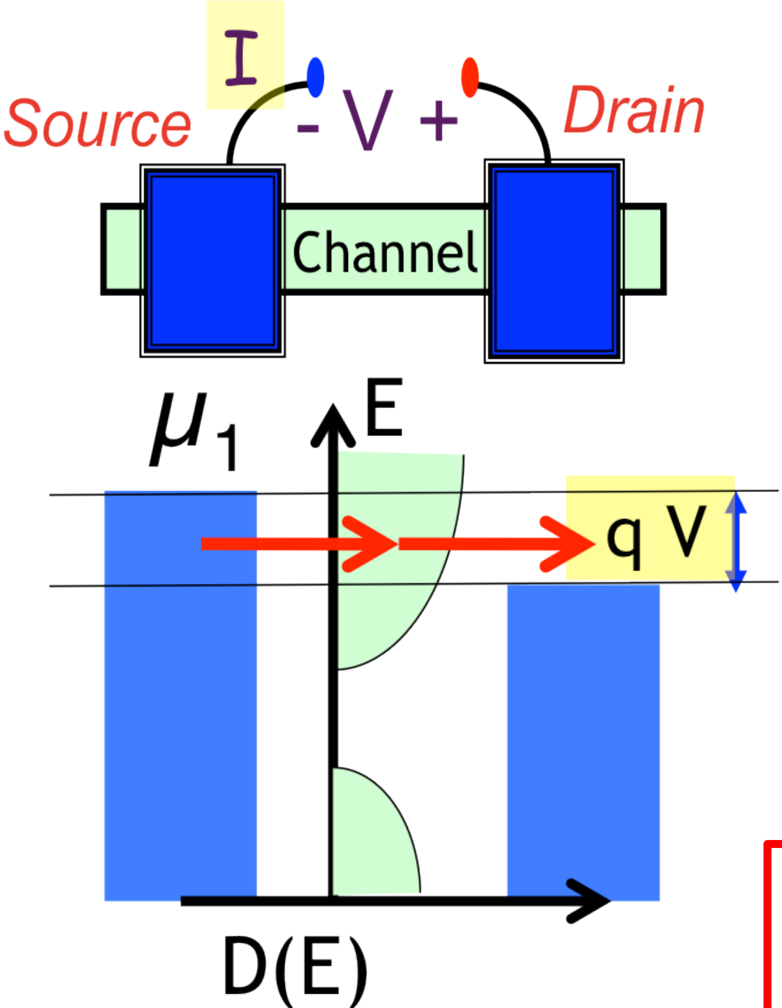
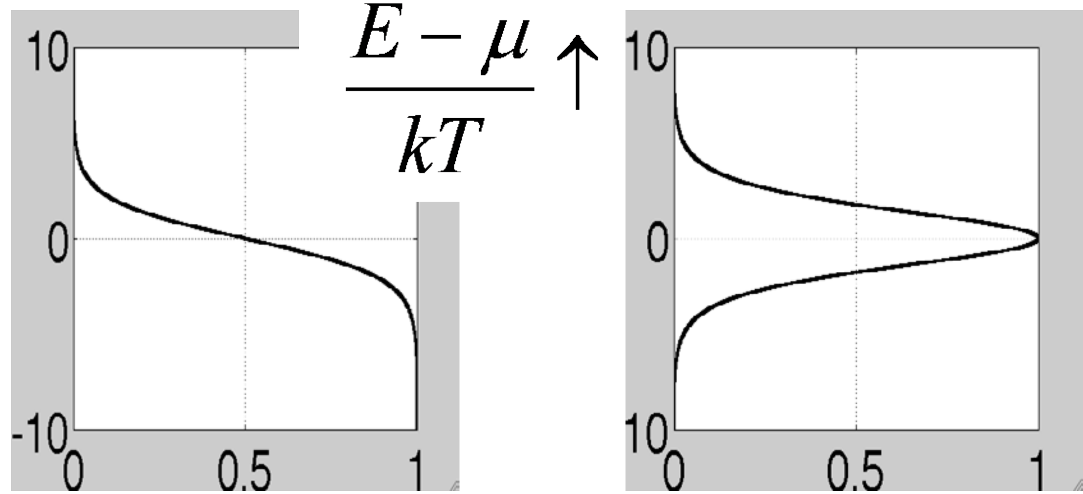
1.4a Conductance Formula





$$\frac{E-\mu}{kT} \uparrow$$

$$f_0(E) \quad \rightarrow \quad 4\,kT\left(-\frac{\partial f_0}{\partial E}\right)$$

$$\boxed{I/V \; = \int_{-\infty}^{+\infty} dE\left(-\frac{\partial f_0}{\partial E}\right) G(E)}$$

$$I = \frac{1}{q}\int_{-\infty}^{+\infty} dE\, G(E)\,\big(\, f_1(E) - f_2(E)\,\big)$$

$$\boxed{G(E) \equiv \frac{q^2\, D(E)}{2\, t(E)}}$$

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1.4b Conductance Formula

Fermi function

$$f(E) = \frac{1}{1+e^{(E-\mu)/kT}} = \frac{1}{1+e^{x}}$$

$$x \equiv \frac{E-\mu}{kT}$$

$$\frac{\partial f}{\partial \mu} = \frac{df}{dx}\frac{\partial x}{\partial \mu} \qquad -\frac{1}{kT}$$

$$\frac{\partial f}{\partial E} = \frac{df}{dx}\frac{\partial x}{\partial E} \qquad +\frac{1}{kT}$$

$$f_1(E) - f_2(E) = f(E,\mu_1) - f(E,\mu_2)$$

$$\approx \left(\frac{\partial f}{\partial \mu}\right)_{\mu=\mu_0} (\mu_1 - \mu_2) = \left(-\frac{\partial f}{\partial E}\right)_{\mu=\mu_0} (\mu_1 - \mu_2)$$

$$\boxed{G(E) \equiv \frac{q^2\, D(E)}{2\, t(E)}}$$

$$I = \frac{1}{q}\int_{-\infty}^{+\infty} dE\, G(E)\, \left(f_1(E) - f_2(E) \right)$$

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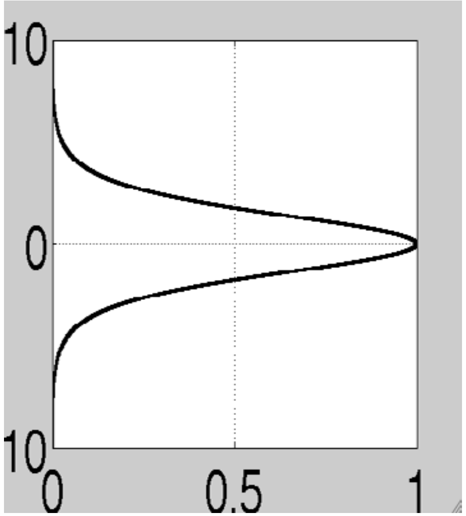
1.4c Conductance Formula

$$I = \frac{1}{q}\int_{-\infty}^{+\infty} dE\, G(E)\,\big(f_1(E) - f_2(E) \big)$$

$$\approx \frac{1}{q}\int_{-\infty}^{+\infty} dE\, G(E)\left(-\frac{\partial f_0}{\partial E} \right) qV$$

$$\frac{E-\mu}{kT} \uparrow$$



$$4kT\left(-\frac{\partial f_0}{\partial E} \right)$$

$$\boxed{I/V = \int_{-\infty}^{+\infty} dE\left(-\frac{\partial f_0}{\partial E} \right) G(E)}$$

$$f_1(E) - f_2(E) \approx \left(-\frac{\partial f}{\partial E} \right)_{\mu=\mu_0} \underbrace{(\mu_1 - \mu_2)}_{qV}$$

$$\int_{-\infty}^{+\infty} dE\left(-\frac{\partial f_0}{\partial E} \right) = f_0(-\infty) - f_0(+\infty) = 1$$

$$\boxed{G(E) \equiv \frac{q^2\, D(E)}{2\, t(E)}}$$

qV

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$$I/V = \int_{-\infty}^{+\infty} dE \left(-\frac{\partial f_0}{\partial E}\right) G(E)$$

$$G(E) = \frac{q^2 D}{2t}$$

$$G_B = q^2 \frac{D\overline{v}}{2L}$$

Ballistic

Coming up next ..