FUNDAMENTALS OF NANOELECTRONICS

Basic Concepts

The New Perspective

2. Energy Band Model

3. What and Where

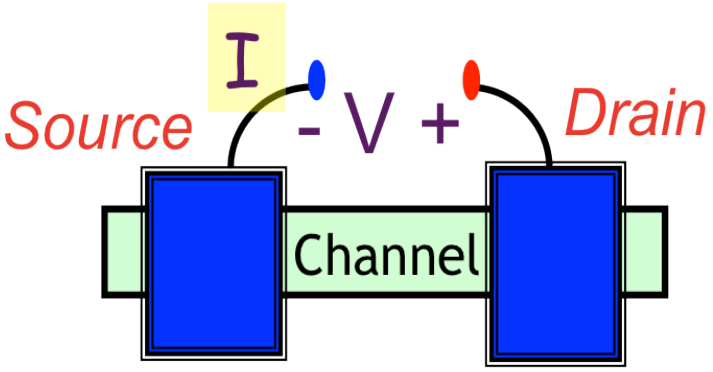
   is the Voltage?

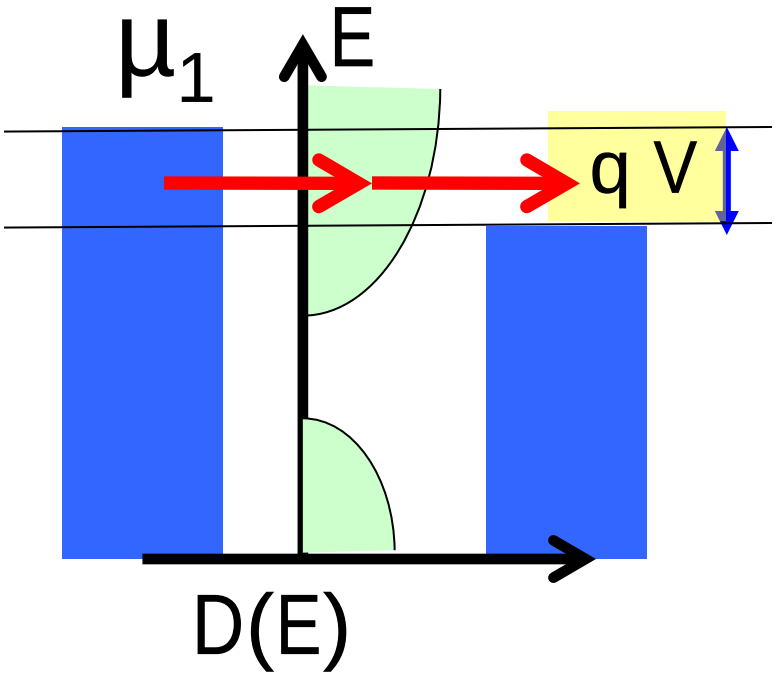
4. Heat & Electricity:

   Second Law & Information

- 1.1. Introduction
- 1.2. Two Key Concepts
- 1.3. Why Electrons Flow
- 1.4. Conductance Formula
- 1.5. Ballistic(B) Conductance
- 1.6. Diffusive(D) Conductance
- 1.7. Connecting B to D
- 1.8. Angular Averaging
- 1.9. Drude Formula
- 1.10. Summing up ..

1.10a Summing up ..





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

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

$$G = \frac{q^2 D}{2t} = \frac{G_B\,\lambda}{L+\lambda} \rightarrow \frac{\sigma A}{L+\lambda}$$

Ballistic

$$\lambda \equiv \frac{2\bar{D}}{\bar{\nu}} \qquad G_B = q^2\frac{D\bar{\nu}}{2L}$$

D: Density of States (DOS)

1.10b Summing up ..

$$\bar{\nu} = \left\langle |\nu_z| \right\rangle = \nu \left\{ 1 \;,\; \frac{2}{\pi} \;,\; \frac{1}{2} \right\}$$

$$1D \quad 2D \quad 3D$$

$$\bar{D} = \left\langle \nu_z^2 \, \tau \right\rangle = \nu^2 \tau \left\{ 1 \;,\; \frac{1}{2} \;,\; \frac{1}{3} \right\}$$

$$\lambda \equiv \frac{2\bar{D}}{\bar{\nu}}$$

$$1D \quad 2D \quad 3D$$

$$= \nu\tau \left\{ 2 \;,\; \frac{\pi}{2} \;,\; \frac{4}{3} \right\}$$

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

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

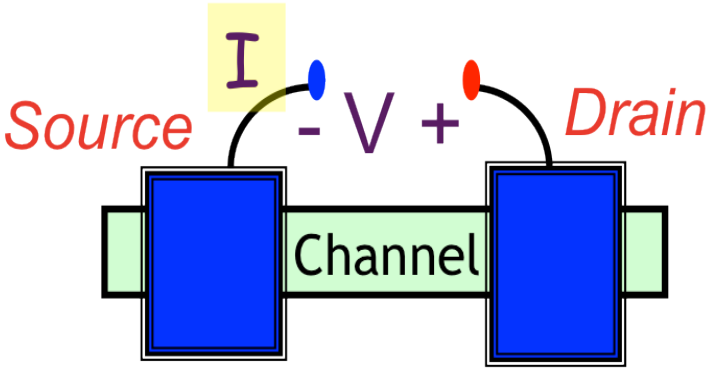
$$G = \frac{q^2 D}{2t} = \frac{G_B \, \lambda}{L + \lambda} = \frac{\sigma A}{L + \lambda}$$

$$G_B = q^2 \frac{D \bar{\nu}}{2L}$$

Ballistic

D: Density of States (DOS)

1.10c Summing up ..



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

Thermodynamics: Entropy driven

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

Mechanics: Force driven

Long Resistors

$$G = \frac{q^2 D}{2t} = \frac{G_B\,\lambda}{L+\lambda} = \frac{\sigma A}{L+\lambda}$$

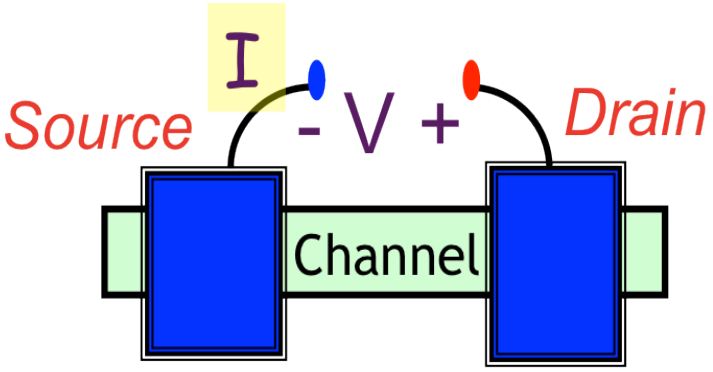
BTE

Newton +  =

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

Ballistic

1.10d Summing up ..

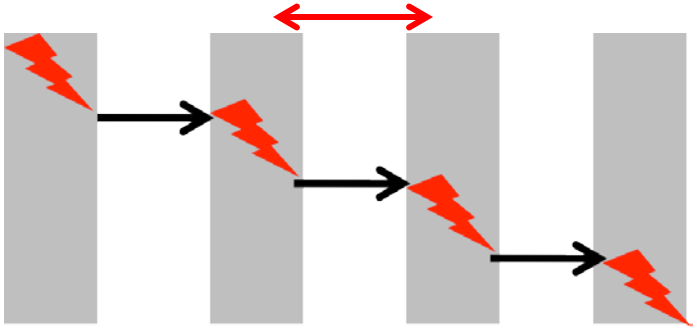


$$I = \frac{1}{q}\int_{-\infty}^{+\infty} dE\, G(E)\,\left(f_1(E) - f_2(E)\right)$$

$qV << kT$

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

$>> kT/q$



$$G = \frac{q^2 D}{2t} = \frac{G_B\,\lambda}{L+\lambda} = \frac{\sigma A}{L+\lambda}$$

$$G_B = q^2\,\frac{D\,\bar{\nu}}{2L}$$

Ballistic

Long Resistors

BTE

Newton +  =

Coming up next ..

Basic Concepts

1. The New Perspective

Energy Band Model

3. What and Where

   is the Voltage?

4. Heat & Electricity:

Second Law & Information

D(E): Density of States (DOS)

$$G = \frac{q^2 D}{2t} = \frac{G_B \lambda}{L+\lambda} = \frac{\sigma A}{L+\lambda}$$

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

Ballistic