FUNDAMENTALS OF NANOELECTRONICS

Basic Concepts

The New Perspective

2. Energy Band Model

3. What and Where

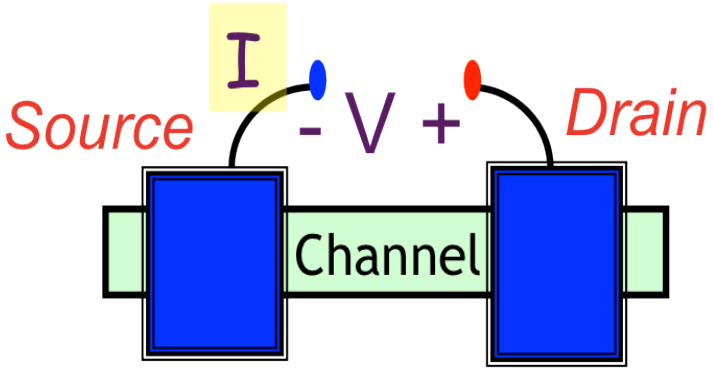
   is the Voltage?

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 ..

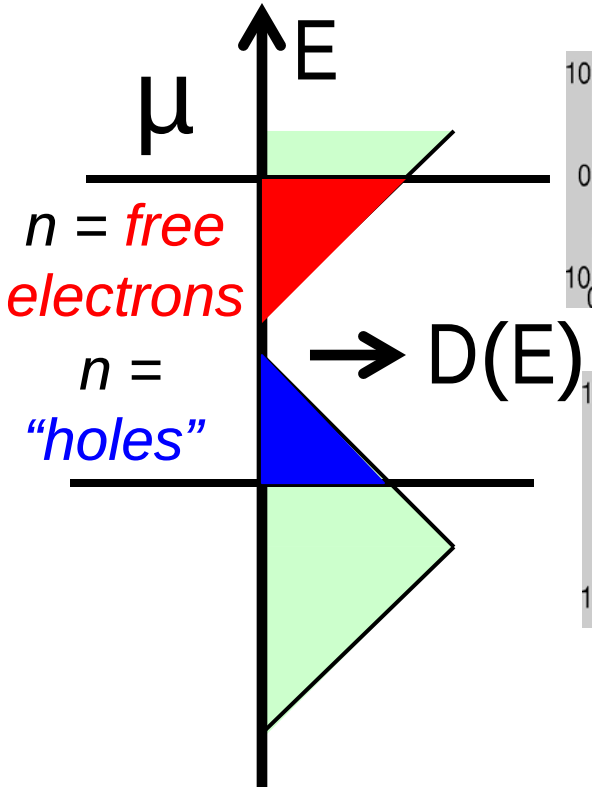
1.9a Drude Formula

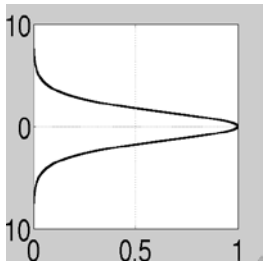


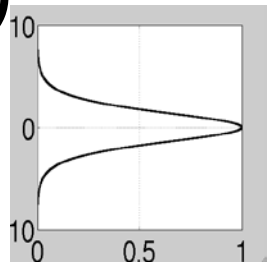
$$I/V = \int_{-\infty}^{+\infty} dE \left(-\frac{\partial f_0}{\partial E}\right) G(E)$$

$$\frac{q^2 D}{2t}$$

$$\sigma = q^2 \frac{D}{AL} \bar{D}$$



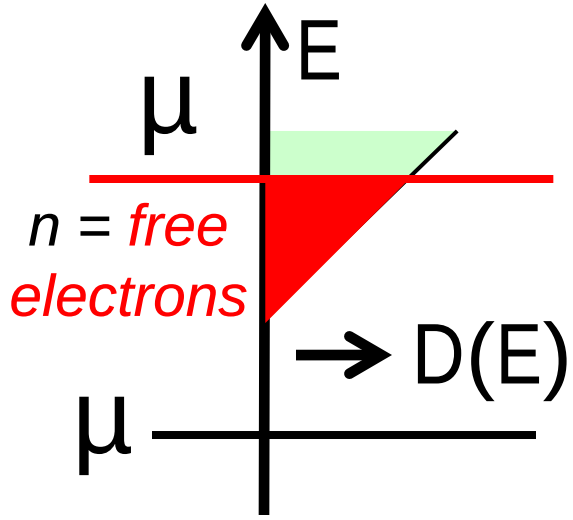


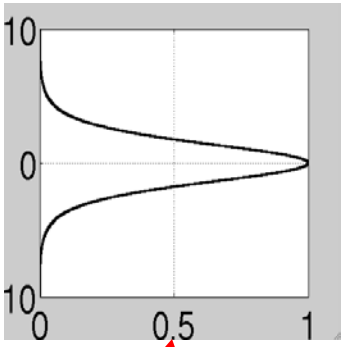


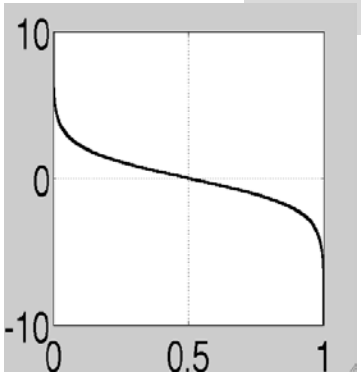
" Filled bands do not conduct "

n: "free" electrons $\sigma = \frac{q^2 n \tau}{m}$ *Drude formula*

1.9b Drude Formula







Degenerate Conductors

Non-degenerate Conductors

$$\sigma = \int_{-\infty}^{+\infty} dE \left(-\frac{\partial f_0}{\partial E}\right) q^2 \frac{D(E)}{AL} \bar{D}$$

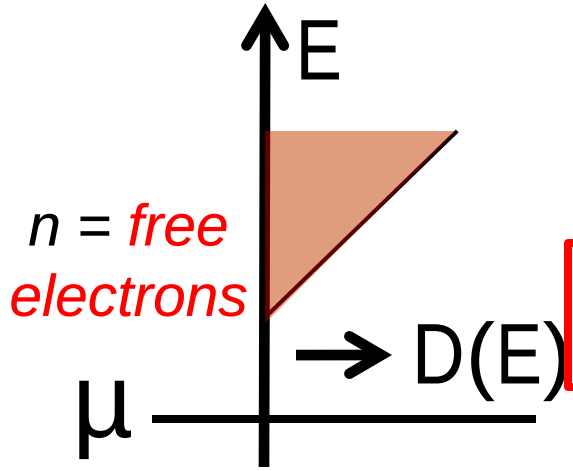
What we obtained

$$\int_{-\infty}^{+\infty} dE\, f_0(E) \frac{D(E)}{AL} \frac{q^2 \tau}{m}$$

$$\sigma = \frac{q^2 n \tau}{m}$$

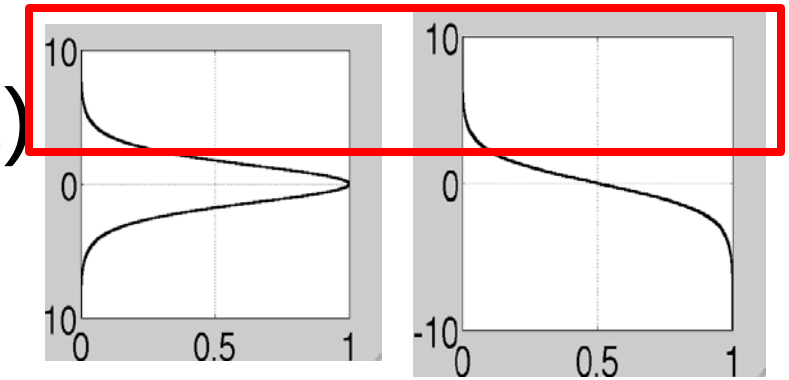
Drude formula

1.9c Drude Formula



$$-\frac{\partial f_0(E)}{\partial E} \approx \frac{f_0}{kT}$$

$$f_0(E) = \frac{1}{1+e^{(E-\mu)/kT}} \approx e^{-(E-\mu)/kT}$$



Non-degenerate Approximation

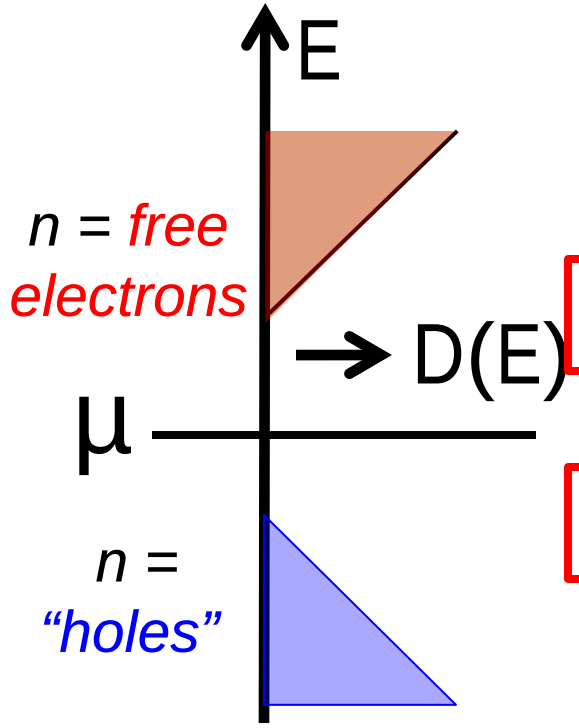
$$q \times \frac{\bar{D}}{kT} \qquad mobility \rightarrow q \times \frac{\tau}{m}$$

$$\sigma = \int_{-\infty}^{+\infty} dE \left(-\frac{\partial f_0}{\partial E}\right) q^2 \frac{D(E)}{AL} \boxed{\bar{D}}$$

$$\int_{-\infty}^{+\infty} dE\, f_0(E) \frac{D(E)}{AL} q^2 \boxed{\frac{\tau}{m}}$$

What we obtained *Drude formula*

1.9d Drude Formula



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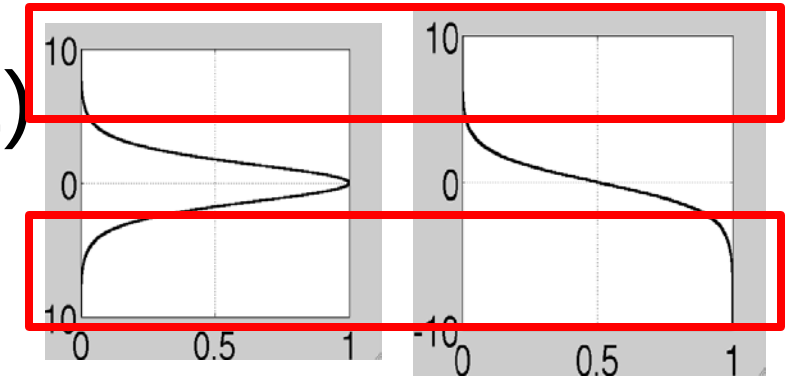

$$\approx e^{-(E-\mu)/kT}$$

Non-degenerate Approximation

$$-\frac{\partial f_0(E)}{\partial E} \approx \frac{1-f_0}{kT}$$

$$1-f_0(E) \approx e^{(E-\mu)/kT}$$

$$\sigma = \int_{-\infty}^{+\infty} dE \left(-\frac{\partial f_0}{\partial E}\right) q^2 \frac{D(E)}{AL} \bar{D}$$

What we obtained

$$\sigma = \frac{q^2 n \tau}{m}$$

Drude formula

Coming up next ..

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1.2. Two Key Concepts

1.3. Why Electrons Flow

1.4. Conductance Formula

1.5. Ballistic(B) Conductance

1.6. Diffusive(D) Conductance

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