FUNDAMENTALS OF NANOELECTRONICS

Basic Concepts

1. The New Perspective

Energy Band Model →

3. What and Where

   is the Voltage?

4. Heat & Electricity:

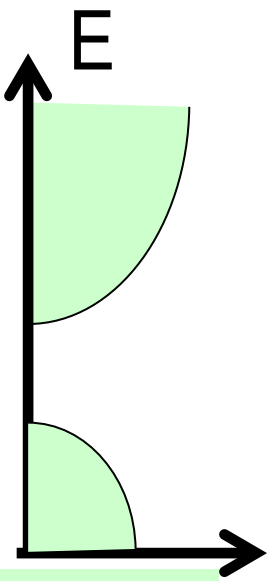
Second Law & Information

- 2.1. Introduction
- 2.2. E(p) or E(k) relation
- 2.3. Counting States
- 2.4. Density of states
- **2.5. Number of modes**
- 2.6. Electron density (n)
- 2.7. Conductivity vs n
- 2.8. Quantum Capacitance
- 2.9. The Nanotransistor
- 2.10. Summing up ..

2.5a Number of modes

$$N(p) = \left(\frac{p}{h}\right)^d \begin{matrix} 1D & 2D & 3D \\ \{ 2L & \pi WL & \frac{4\pi}{3} AL \} \end{matrix}$$

$$E(p)$$



D(E)

M(E)

Ballistic conductance

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

$$M = \frac{hD\nu}{2L}\left\{1 \;,\; \frac{2}{\pi} \;,\; \frac{1}{2}\right\}$$

General Relation valid for all E(p)

$$D\,\nu\,p = N\,d$$

$$N(p) = \left(\frac{p}{h}\right)^d \begin{matrix} 1D & 2D & 3D \\ \{ 2L & \pi WL & \frac{4\pi}{3} AL \} \end{matrix}$$

$$p \times \frac{dN}{dE}\frac{dE}{dp} = \frac{dN}{dp} = d\frac{p^{d-1}}{h^d}\{2L \quad \pi WL \quad \frac{4\pi}{3}AL\} \times p$$

$$D\ \nu\ p \quad = \quad N\ d$$

General Relation valid for all E(p)

2.5c Number of modes

$$N(p) = \left(\frac{p}{h}\right)^d \begin{matrix} 1D & 2D & 3D \\ \{2L & \pi WL & \frac{4\pi}{3}AL\} \end{matrix}$$

$$D\,\nu\,p \;=\; N\,d$$

$$M \;=\; \frac{hD\nu}{2L}\left\{1 \;,\; \frac{2}{\pi} \;,\; \frac{1}{2}\right\}$$

$$= \frac{h}{2L}\frac{N}{p}\,d\left\{1 \;,\; \frac{2}{\pi} \;,\; \frac{1}{2}\right\}$$

$$= \frac{1}{2L}\left(\frac{p}{h}\right)^{d-1}\{2L \;,\; 4WL \;,\; 2\pi AL\}$$

$$M \;=\; \left(\frac{p}{h}\right)^{d-1}\{1 \;,\; 2W \;,\; \pi A\}$$

2.5d Number of modes

$$\begin{array}{cccc} & 1D & 2D & 3D \\ N(p) = \left(\frac{p}{h}\right)^d & \{2L & \pi WL & \frac{4\pi}{3}AL\} \end{array}$$

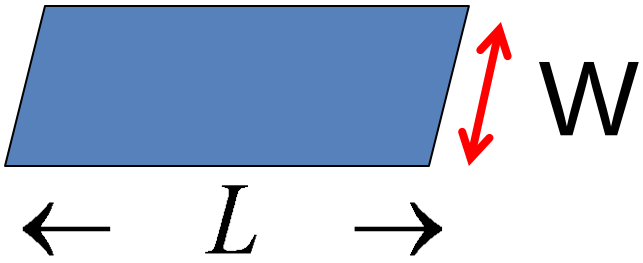
$$\left\{\frac{L}{h/2p} \quad , \quad \frac{\pi}{4}\frac{WL}{(h/2p)^2} \quad , \quad \frac{\pi}{6}\frac{AL}{(h/2p)^3}\right\}$$

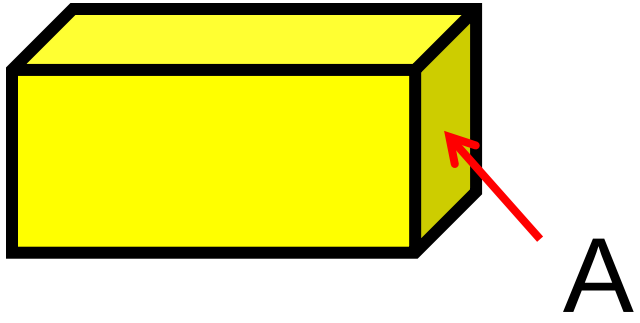
$$\left\{1 \quad , \quad \frac{W}{h/2p} \quad , \quad \frac{\pi}{4}\frac{A}{(h/2p)^2}\right\}$$

$$M = \left(\frac{p}{h}\right)^{d-1} \{1 \quad , \quad 2W \quad , \quad \pi A\}$$

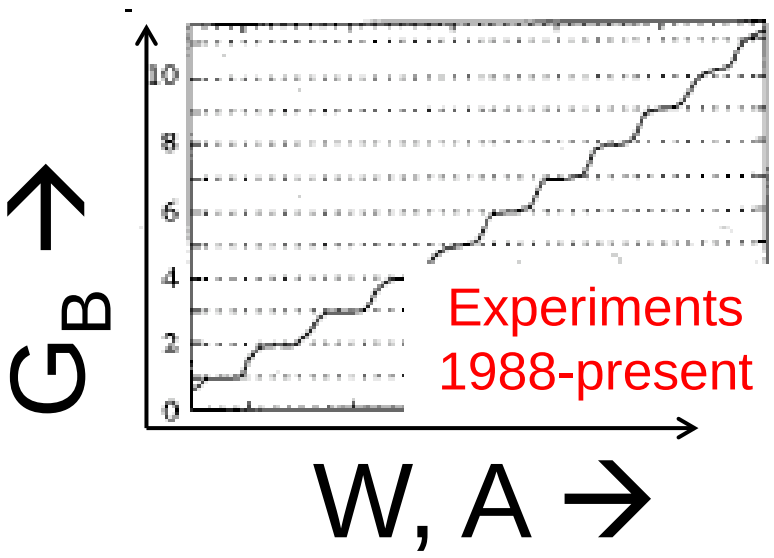
$$D\,\nu\,p = N\,d$$

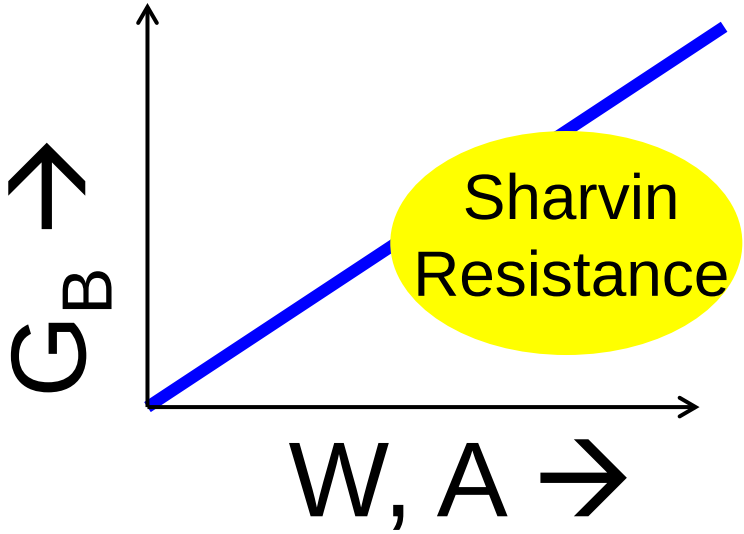
$$M = \frac{hD\nu}{2L}\left\{1 \quad , \quad \frac{2}{\pi} \quad , \quad \frac{1}{2}\right\}$$





2.5e Number of modes





$$\text{Int}\left\{1 \quad , \quad \frac{W}{h/2p} \quad , \quad \frac{\pi}{4}\frac{A}{(h/2p)^2}\right\}$$

$$M = \left(\frac{p}{h}\right)^{d-1}\{1 \quad , \quad 2W \quad , \quad \pi A\}$$

Coming up next ..

$$N(p) = \left(\frac{p}{h}\right)^d \begin{Bmatrix} 1D & 2D & 3D \\ 2L & \pi WL & \frac{4\pi}{3}AL \end{Bmatrix}$$