ECE 659 Quantum Transport: Atom to Transistor

Lecture 1: Introduction

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Spring 2009

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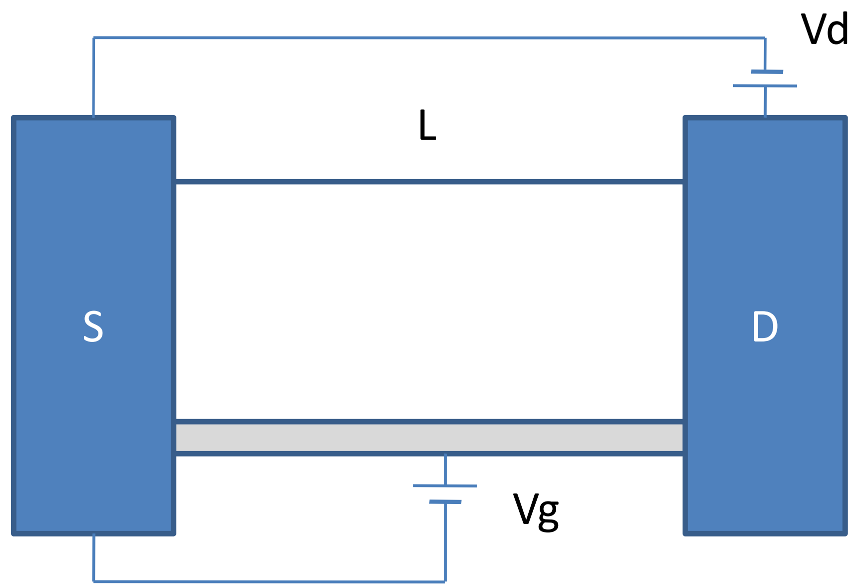
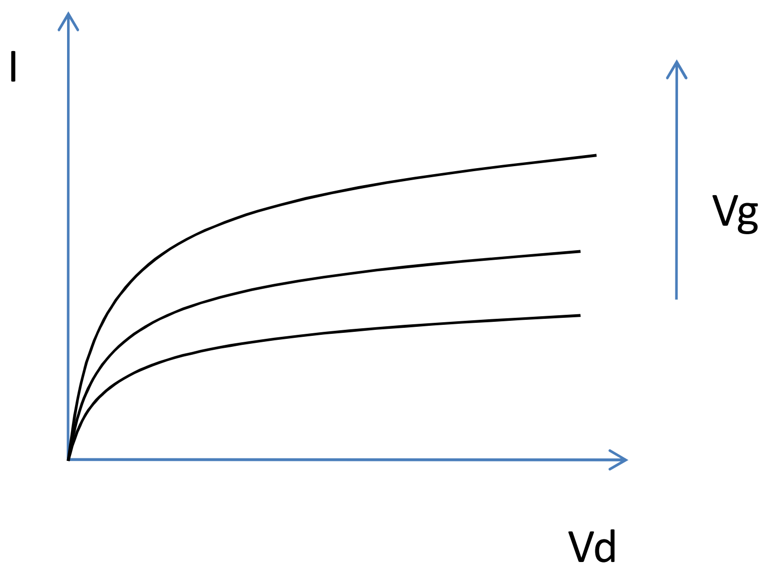
- Field Effect Transistor is the most common device today
- Modern day processors have a billion each
- It is a resistor whose resistance can be controlled
- The third terminal, gate (Vg), controls the resistance
- Vd drives the current through the device



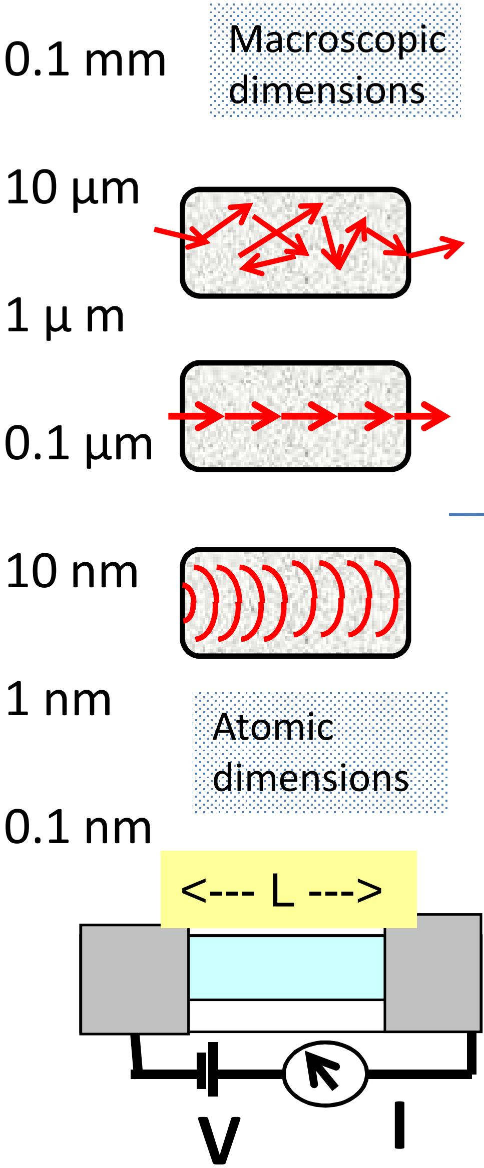


Typically Vd varies from 0.5V to 1V,
R varies from 10k to 100M*

Other interesting device:

- Energy Conversion devices
- Sensors

*The online lecture shows the variation as 10k to 1M, these notes present the correct value



Ohm's Law

$$R = \frac{\rho L}{A}$$

$$G = \frac{\sigma A}{L}$$

Does it makes sense to talk about resistance of very small conductor?
Yes. It does.

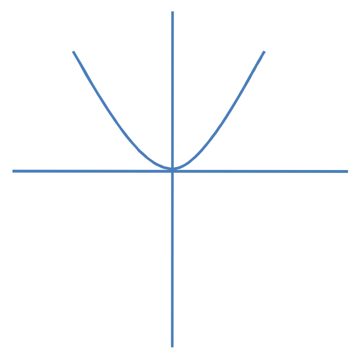
Present commercial technology

Top down approach: $$\sigma = qn\frac{q\tau}{m}$$

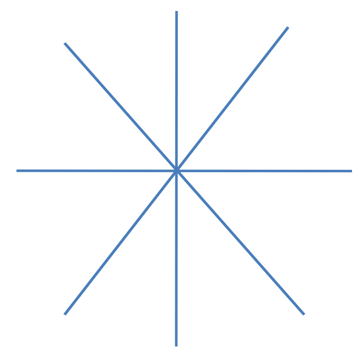
Mean free time

Electron density

Effective mass



$$\frac{1}{m} = \frac{1}{\hbar^2}\frac{d^2E}{dk^2}$$



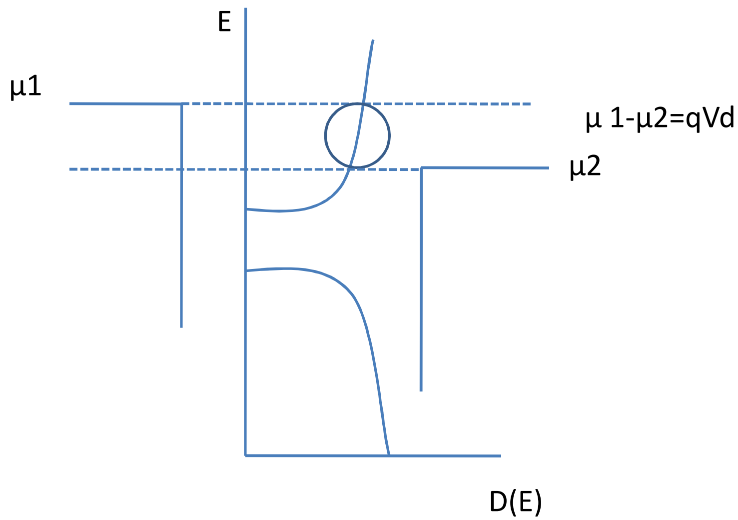
$m = \infty$

Quantum of Conductance

$$G = \frac{q^2}{h}(\pi D \gamma)$$

$\frac{q^2}{h} \rightarrow \frac{1}{25k\Omega}$

D -> density of states



$$\frac{\gamma}{h} =$$ Rate at which electrons can come out and go into channel

$$D \sim AL$$

$$\gamma \sim \frac{1}{L} \rightarrow \text{Ballistic transport}$$

$$\gamma \sim \frac{1}{L^2} \rightarrow \text{Diffusive transport}$$