ECE 495N

Fundamentals of Nanoelectronics

Fall 2008

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Lecture: 1
Title: What Makes Current Flow?
Date: August 25, 2008

Video Lectures posted at:
https://www.nanohub.org/resources/5346/

Class notes taken by: Panagopoulos Georgios
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What makes current flow?

ECE 495N

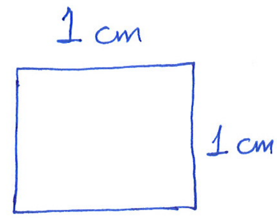
Aug. 25 2008

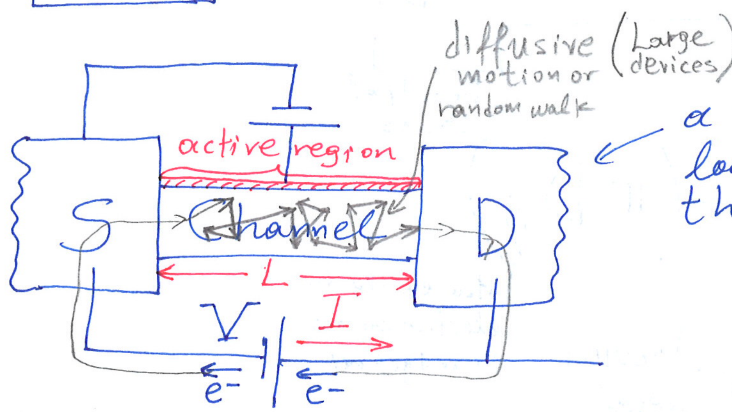
Fundamentals of Nanoelectronics

10 mm } ECE 606
1 mm }

10 μm

1 μm ~ 300-400 atoms





a transistor looks like this

ECE 495N { 1 nm ~ 3-4 atoms
0.1 nm

if we apply a positive voltage then electrons will move as shown in the figure above. The direction of current has opposite direction because the electrons have negative charge.

If now look this voltage V and divide it by the current then we take the resistance $R = \frac{V}{I}$ and taking the inverce this is the conductance $G = \frac{I}{V}$. The transistor is basicaly a resistance whose resistance is controled with the third terminal. The contacts are 10 times the channel length

Top - down   Bottom up

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

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

- σ ← conductivity
- n ← free electron density
- τ ← mean free time
- m ← mass of the electron

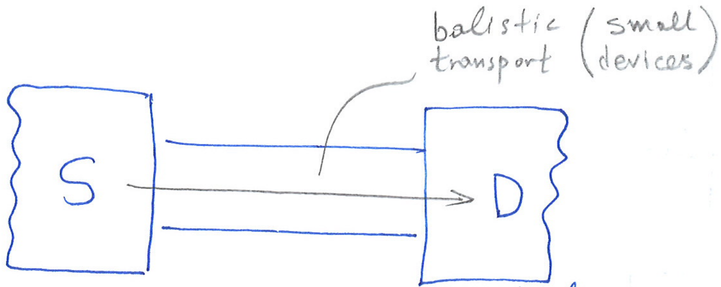
} small devices

$q = 1.6 \times 10^{-19}$ Coul

$m = 9.1 \times 10^{-31}$ Kg (mass of electron in vacuum)

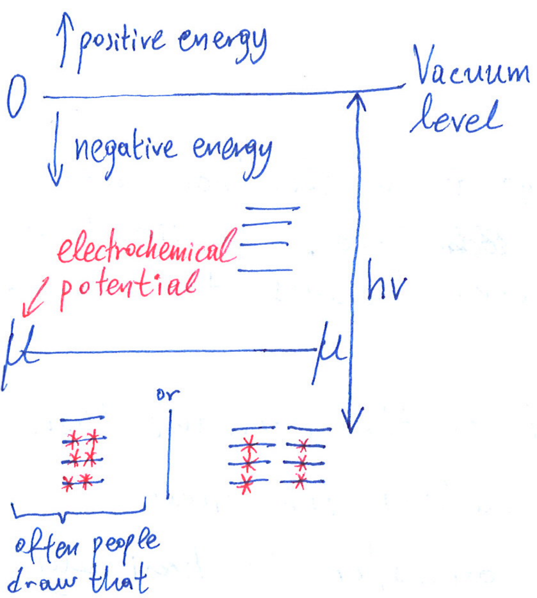
$h = 6.63 \times 10^{-34}$ J-sec

$\hbar = h/2\pi$



$$G = \frac{q^2}{\hbar}\left(\pi D \gamma\right)$$

- D ← Density of states
- γ ← How easily an electron can get in and get out

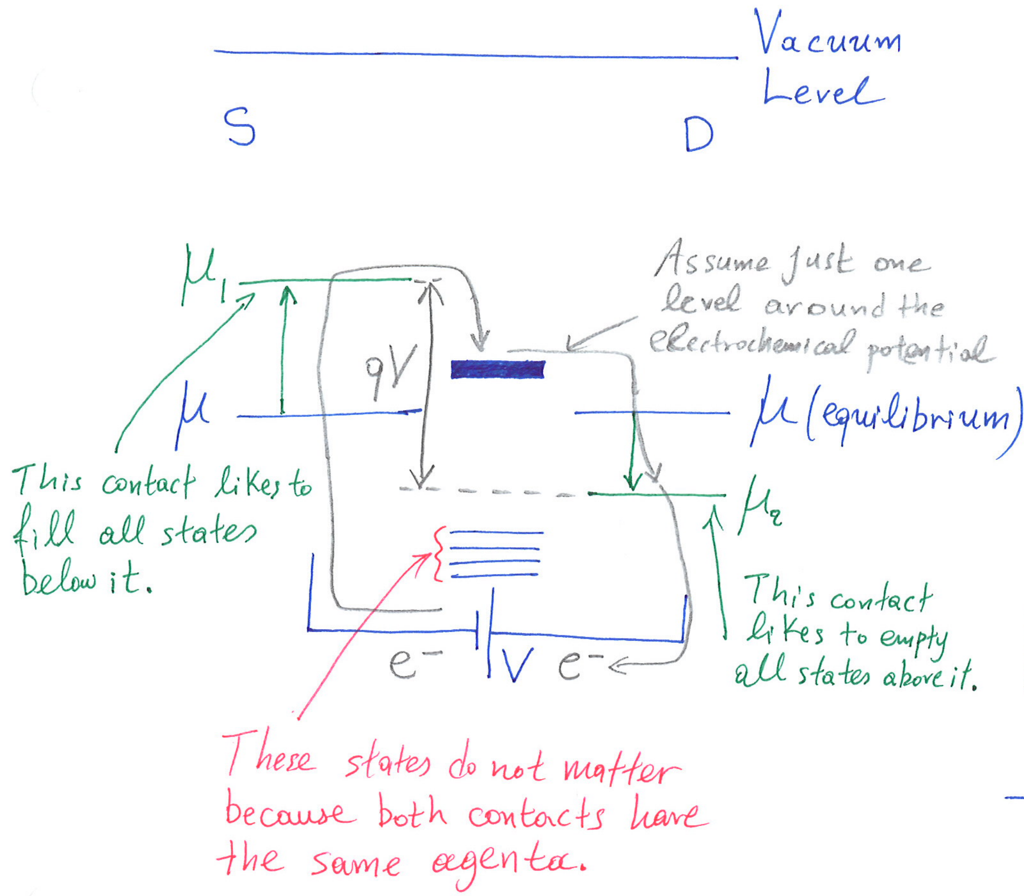


For each material there are energies that the electrons can take. Some of these are filled and some are empty.

All of these levels come in pairs (downspin, upspin)

How we Know experimentaly the existence of these levels. The answer is the photoelectric effect. What energy we need to Kick an electron out.

For visible light $h\nu \sim 2\text{-}4$ eV. For a solid we need ~7-8eV which means that this light is not visible. But photo-emitions does not give information for the empty states. For these energy we have the absorption of light.



There are many other energies but they are away from the electrochemical potential μ.

We have current if there are states between the window of μ_1 and μ_2.

In this case for small voltages there is no current.