Semiconductors
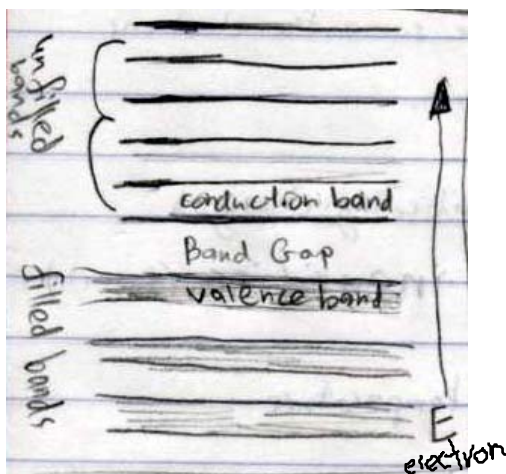
- Sold materials are classified in terms of electric conductivity.

  1. Insulators: do not conduct – no free electrons.   e.g. Plastic, Wood.

  2. Conductors: conduct with little resistance – abundancy of free electrons. e.g. Metals.

  3. Semiconductors: conduct but with large resistance – have some free electrons.   e.g. Silicon.

- Resistivity can be significally changed by adding certain impurities (Also called Dopants).

- Resistivity depends on temperature.

Energy Bands

When a solid is formed, energy levels in the atoms interact and form energy bands.
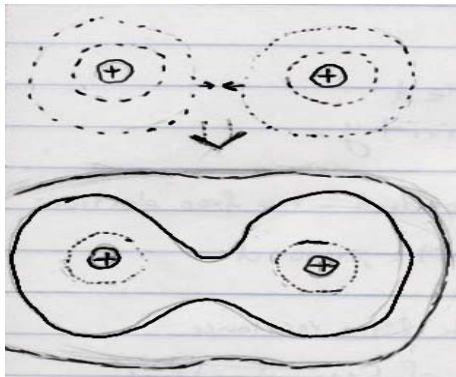

Energy Levels Splitting to form Bands

- the most important bands are:

  1. the valence band:
     - This is the outermost band filled with electrons. This is also the band where electrons that are involved in chemical bound exist

  2. the conduction band:
     - this is the band next to the valence band where free electrons would be if they exist. It is the lowest of the unfilled bands

- there is an energy gap between these two bands which determine whether the solid is   (conductor / insulator / semiconductor)

- *Insulators* have large energy Gap (E.G>2 e.v)

- *Semiconductors* have smaller energy Gap (0<E.G<2 e.v)

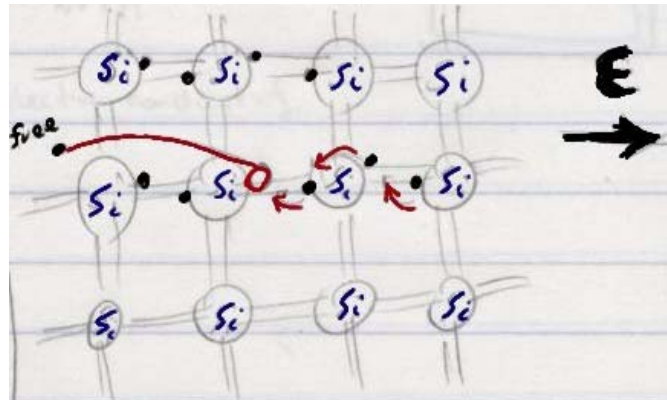- *Conductors* have the valence & conduction bands overlapped (E.G < 0 e.v)

The Energy Bands
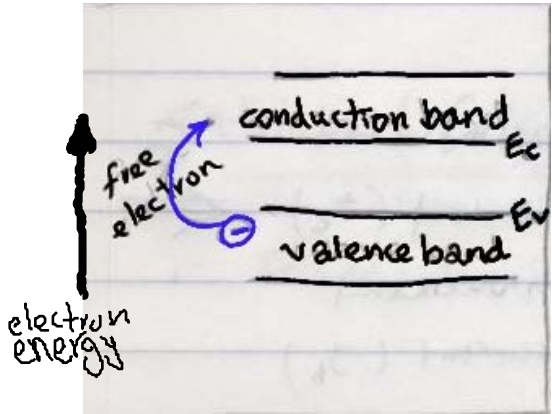
- The highest energy level of the valence band is called Ev.

- The lowest energy level of the conduction band is called Ec.

- E_G = Ec - Ev

- Energy Gap is a unique characteristic of a material, However, it can be slightly modified by applying physical pressure.

- An electron can become free by acquiring an energy (thermal / photons) = E_G

  - It jumps from valence band to conduction band leaving a hole in the valence band.
  - This hols is positively charged & it is free to move within the valence band.
  - In Semiconductors, currents are transported via:
    1. electrons (-ve charges)
    2. holes   (+ve charges)
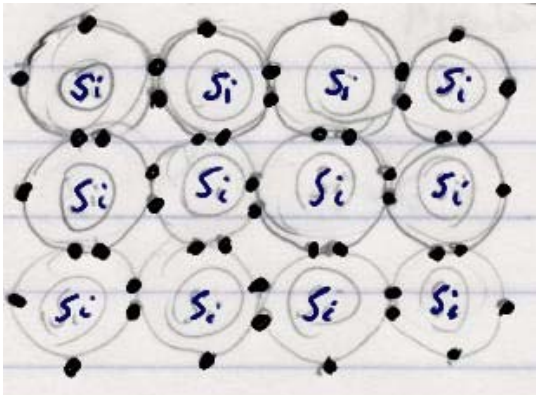
Crystal structure, showing valence electrons associated with each bond

movement of a hole

Electron movement

Electron current (J_e)

Hole movement

Hole current (J_h)

Total Current = J_e + J_h

J total = J_e + J_h