Fermi Levels

Last updated 2/9/19

Fermi Levels

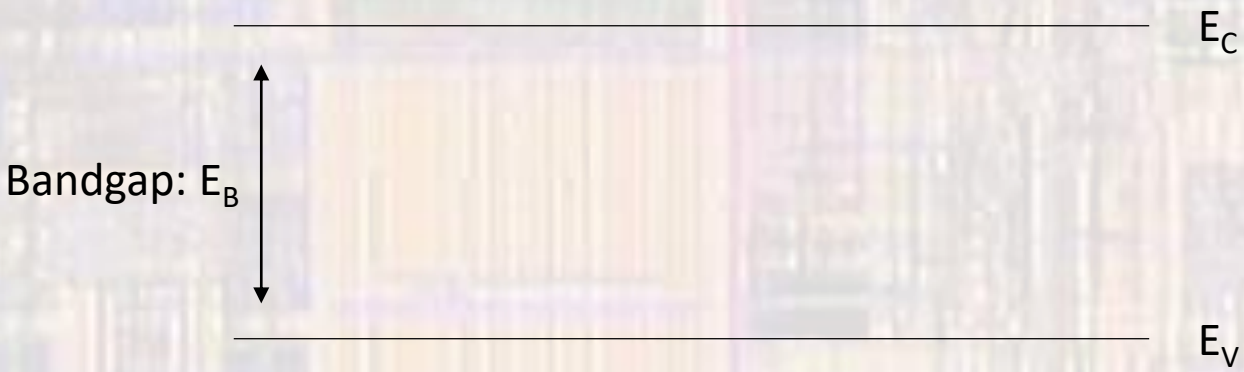
- Electrons and Holes
  - Charge
    - Electron (n) -1.6×10^{-19} Coulomb
    - Hole (p) $+1.6 \times 10^{-19}$ Coulomb
  - Effective mass
    - Mass of a free electron
      - $m_0 = 9.109 \times 10^{-31}$ kilograms
    - Effective mass of an electron in a silicon crystal
      - $m_n^* = 1.1 \times m_0$
    - Effective mass of a hole in a silicon crystal
      - $m_p^* = 0.59 \times m_0$

Fermi Levels

- Electrons and Holes
  - Intrinsic carrier concentration – room temp Si
    - $n_i \cong 10^{10}$ / cm^3
  - Electron/Hole concentrations – room temp Si
    - $n = p = n_i \cong 10^{10}$ / cm^3
    - Charge neutral
  - Note – the density of Si atoms in a crystal is $5x10^{22}$ /cm^3
    - 2 carriers for every 5 trillion atoms

Fermi Levels

- Band Diagrams

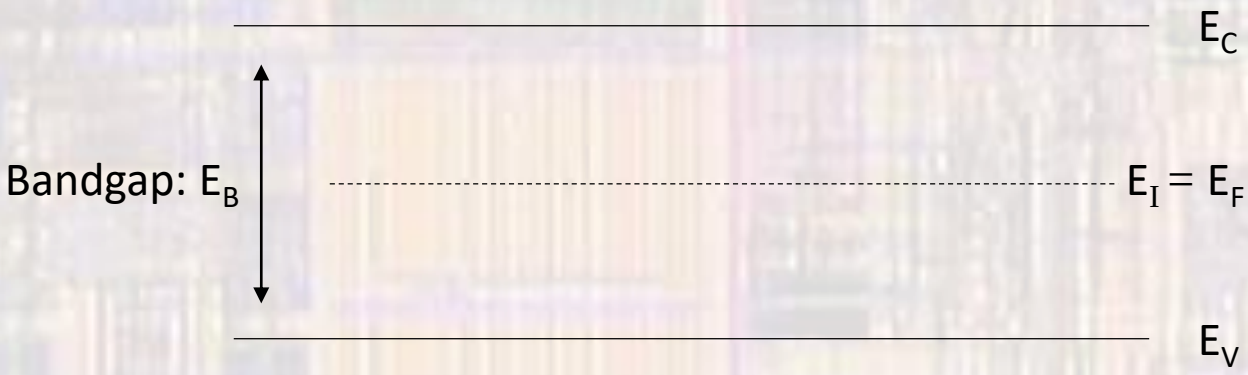


Fermi Levels

- Band Diagrams
  - Fermi Level
    - Indicates the energy level at which half of the possible states are filled with electrons
    - For our purposes the Fermi Level will be used to:
      - Indicate the type of a material
      - Calculate carrier concentrations
      - Analyze semiconductor devices

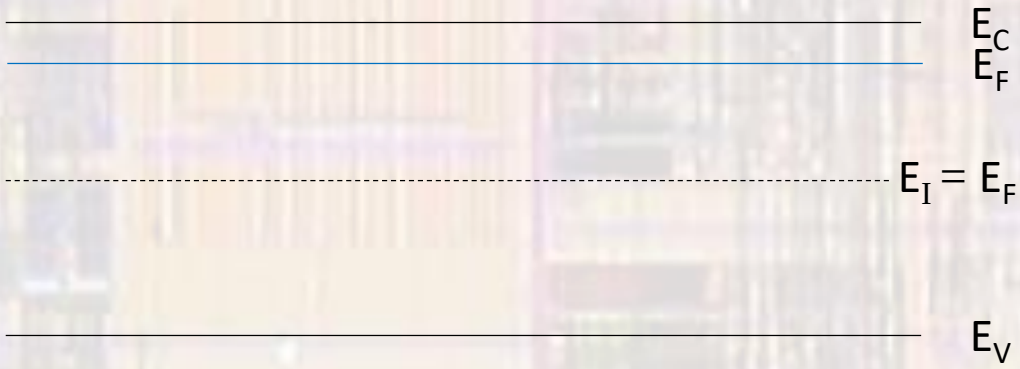
Fermi Levels

- Band Diagrams
  - Fermi Level – Intrinsic
    - $E_I \sim$ mid bandgap



Fermi Levels

- Band Diagrams
  - Fermi Level: n-type doping
    - E_F near E_C
    - Indicates an excess of electrons in the material



Fermi Levels

- Band Diagrams
  - Fermi Level: p-type doping
    - E_F near E_V
    - Indicates an excess of holes in the material