Electronic Materials

Prepared by: **Dr. Mohamed Abaza**
Email: Mohamed.abaza@aast.edu

Reference: Principles of Electronic Materials and Devices by Safa Kasap

Grading:

10% on the 4th week
20% on the 7th week
10% on the 10th week
20% on the 12th week
40% on the 16th week

Introduction

What is the meaning of electronic material?

Materials used by electronic engineer.

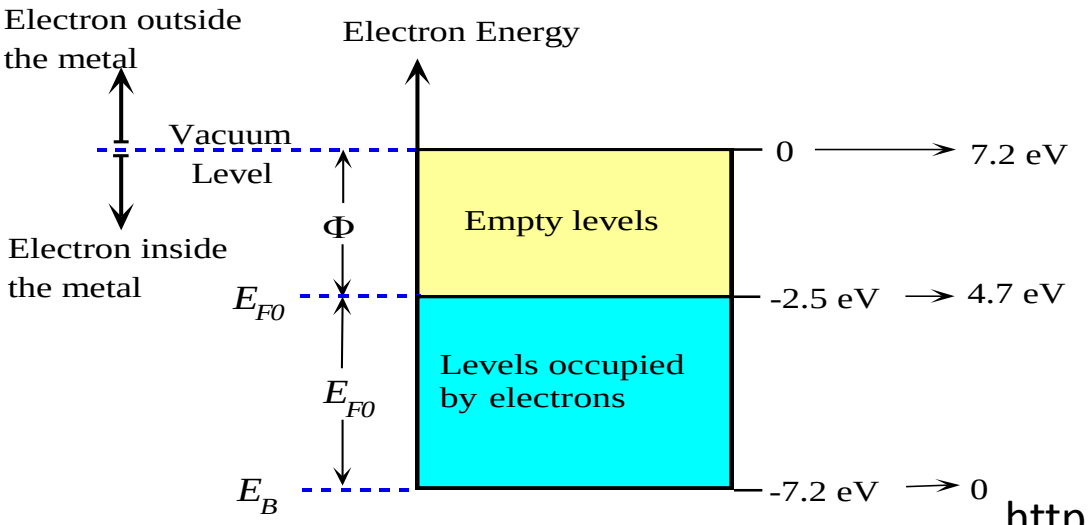
What are the main types of electronic materials?

conductors (metals) – Insulators (dielectric) – semiconductor – magnetic materials – super conductor.

1-Conductor (metal)

Good conduction to electricity (low resistivity).

e.g.: Al, Cu (copper)



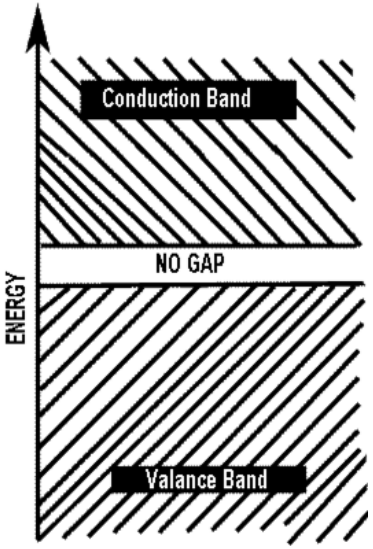


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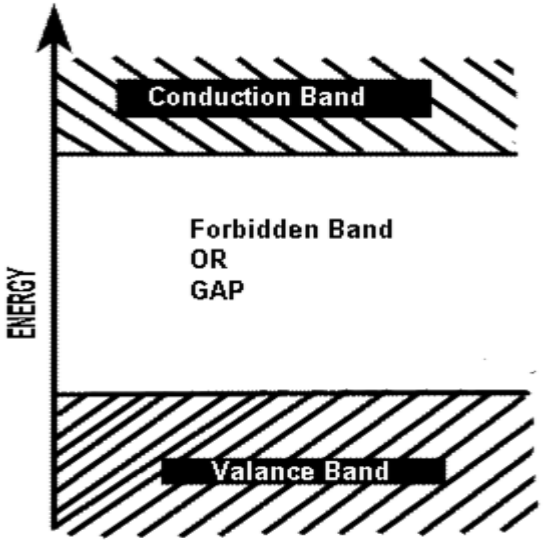
Fig. 4.11: Typical electron energy band diagram for a metal All the valence electrons are in an energy band which they only partially fill. The top of the band is the vacuum level where the electron is free from the solid ($PE = 0$).

From *Principles of Electronic Materials and Devices, Second Edition*, S.O. Kasap (© McGraw-Hill, 2002) http://Materials.Usask.Ca

E_{FO}: Fermi level at zero kelvin & *PE:* potential energy

2-Insulators (Dielectric)

- Bad conductions to electricity (high resistivity) e.g.: wood, mika for capacitors, SiO_2 for MOSFET
- At room temperature, valence band completely filled.
- No holes in conduction band.



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3-Semi conductor

- Range of conductivity or resistivity depend on doping.
- E.g.: Si, Ge, GaAs as diodes, transistors, ICs

Si: Silicon

Ge: Germanium

GaAs: Gallium Arsenic

4-Magnetic materials

- Ferromagnetic (iron)
- Ferrimagnetic
- Parramagnetic

5-Super conductors

- Very high conductors
- Near zero resistivity
- At low temperature resistivity near zero e.g.: Hg (mercury).

What are the main constitutive parameters of electronic materials?

$\in$: Epsilon : permittivity : Farad/m : electric field in the medium

μ : mu : permeability : Henery/m : response of a medium to magnetic

ρ : rho $= \frac{1}{\sigma}$: resistivity Ω.m

n $= \sqrt{\in \mu}$: refraction index

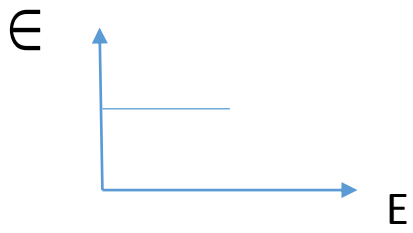
$R = \frac{\rho L}{A}$

How can we classify the materials according to these parameters?

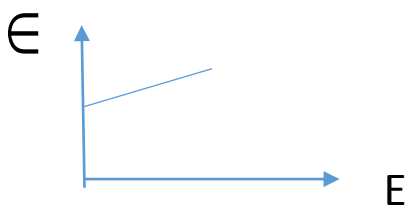
- Linear or non linear material
- Homogenous or non homogenous material
- Dispersive or non dispersive
- Isotropic or non isotropic material

1-Linear or non linear material

- Linear: doesn't change with field.

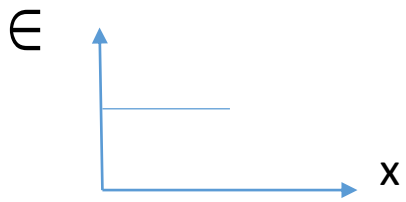


- Non linear: depend on field.



2-Homogenous or non homogenous

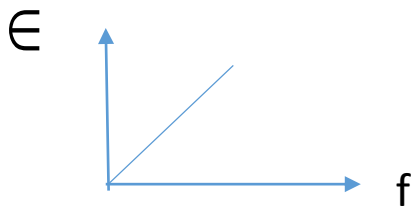
- Homogenous: doesn’t depend on position.



- Non homogenous: depend on position (x, y, z).

3-Dispersive or non dispersive

- Dispersive: parameters depend on frequency.



- Non dispersive: parameters doesn’t depend on frequency.

4-Isotropic or non isotropic

- Isotropic: doesn’t depend on direction.

- Non isotropic: depend on direction.