Phys 570

Lecture #5

Physics & Astronomy Dept.
College of Science
King Saud University

Nasser S. Alzayed

nalzayed@ksu.edu.sa

Chapter 7: Energy Bands

Introduction

- The free electron model of metals gives us good insight into the heat capacity, thermal conductivity, electrical conductivity, magnetic susceptibility, and electrodynamics of metals.
- But the model fails to help us with other large questions:
  - *the distinction between metals, semimetals, semiconductors, and Insulators*
  - *the occurrence of positive values of the Hall coefficient*
  - *the relation of conduction electrons in the metal to the valence electrons of free Atoms*
  - *many transport properties, particularly magnetotransport*

- Hence, we need to modify Fermi Electron Model to be able to answer these puzzles. We will see that little modification is just adequate.

Chapter 7: Energy Bands

Introduction

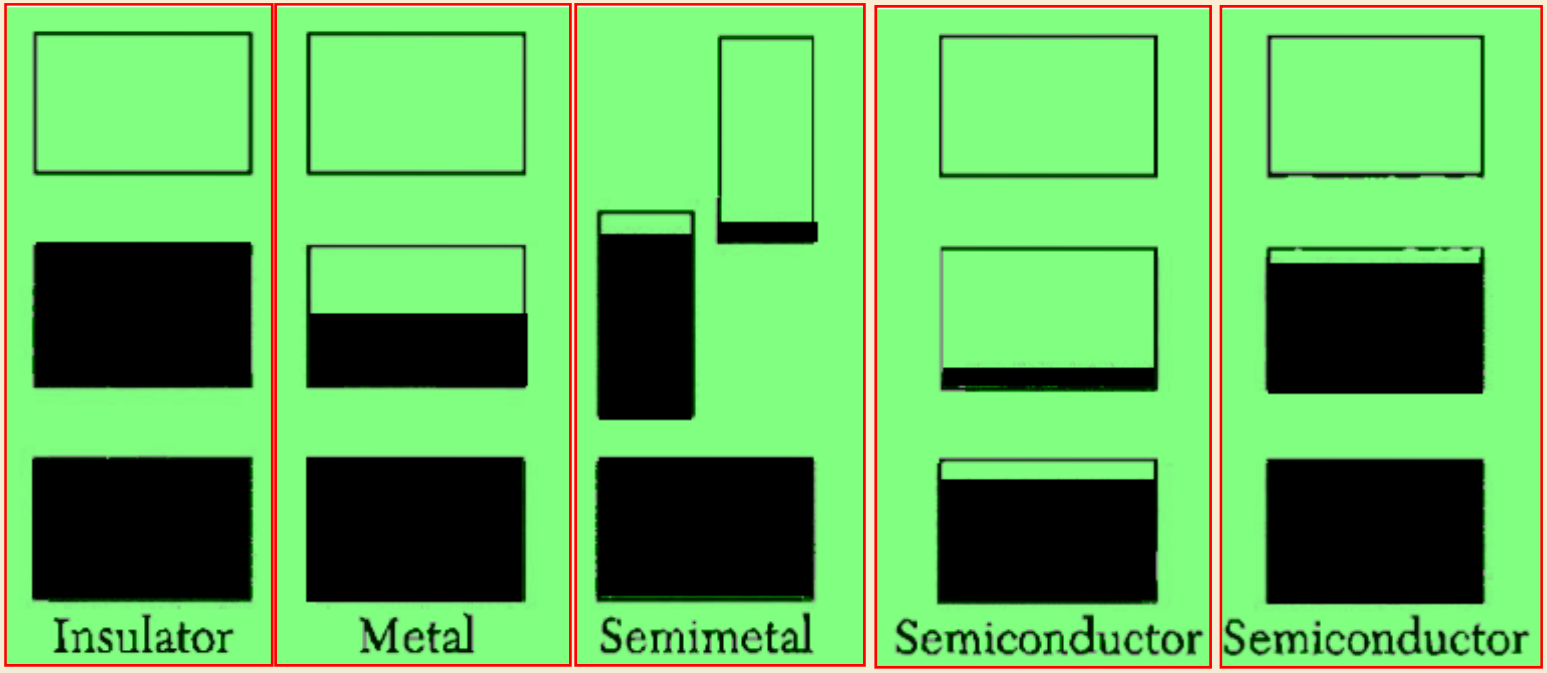
- The difference between a good conductor and a good insulator is striking. The electrical resistivity of a pure metal may be as low as 10^{-10} Ω.cm at 1 K, apart from the possibility of superconductivity.
- The resistivity of a good insulator may be as high as 10^{22} Ω.cm.
- This range of 10^{32} may be the widest of any common physical property of solids.

- Every solid contains electrons. The important question for electrical conductivity is how the electrons respond to an applied electric field.
- electrons in crystals are arranged in energy bands.
- Bands are separated by band gaps (Forbidden Regions)
- Source of bands come from the interaction of the conduction electron waves with the ion cores of the crystal

Chapter 7: Energy Bands

Introduction

- ❑ Insulator: if the allowed energy bands are either filled or empty, for then no electrons can move in an electric field.
- ❑ Metal if one or more bands are partly filled.
- ❑ Semiconductor or a semimetal if one or two bands are slightly filled or slightly empty.



Chapter 7: Energy Bands

Introduction

- To modify the Free Electron Model; we will assume that electron is not totally free. It has to respect the periodicity of the crystal.
- This will directly lead to the important result: band gap.
- Also; we introduce the concept of effective mass of electron m^* *which may be larger or* smaller than the free electron mass, or may even be negative.
- Negative and Positive effective mass can directly explain for +tive Hall coefficient.