VẬT LIỆU

KIM LOẠI – BÁN DẪN – ĐIỆN MÔI

NỘI DUNG

Chương 1: Phân biệt vật liệu Kim loại – Bán dẫn – Điện môi

1. Cấu trúc vùng năng lượng
2. Điện trở - Nhiệt độ

Chương 2: Vật liệu kim loại

1. Cấu trúc
2. Tính chất
3. Ứng dụng
4. Bài tập

Chương 3: Vật liệu bán dẫn

1. Cấu trúc
2. Tính chất
3. Ứng dụng
4. Bài tập

Chương 4: Vật liệu điện môi

1. Cấu trúc
2. Tính chất
3. Ứng dụng
4. Bài tập

Tài liệu

1. Understanding Solid

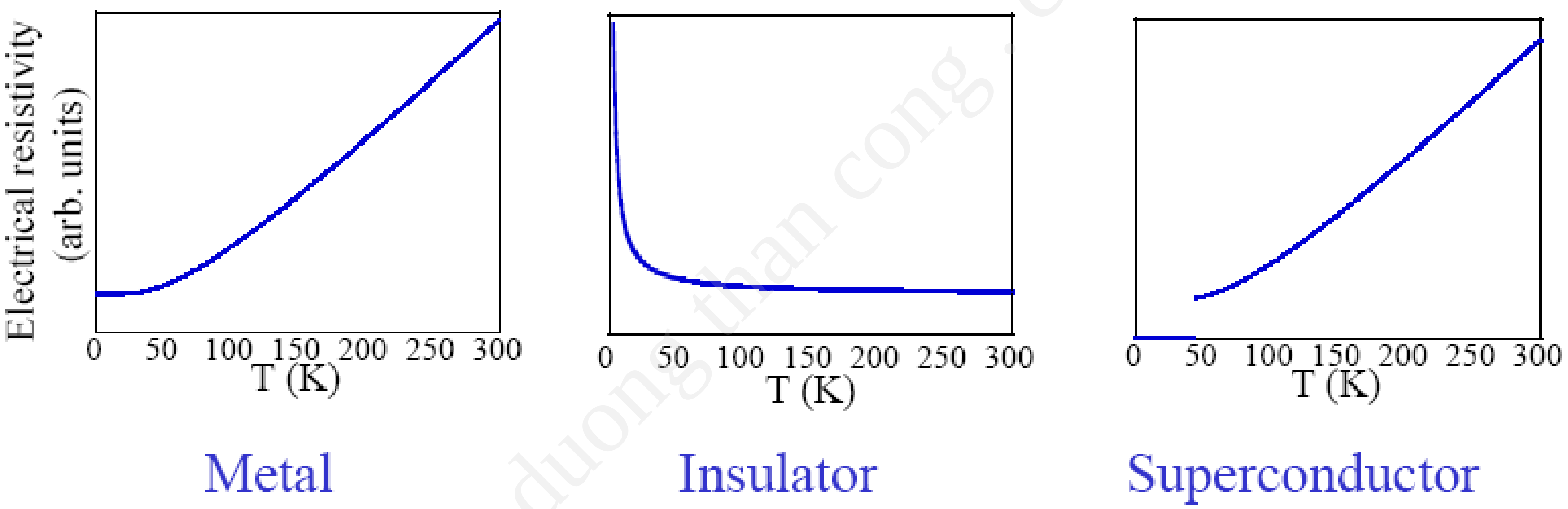
2. Electronic materials

3. Cơ sở vật lý chất rắn

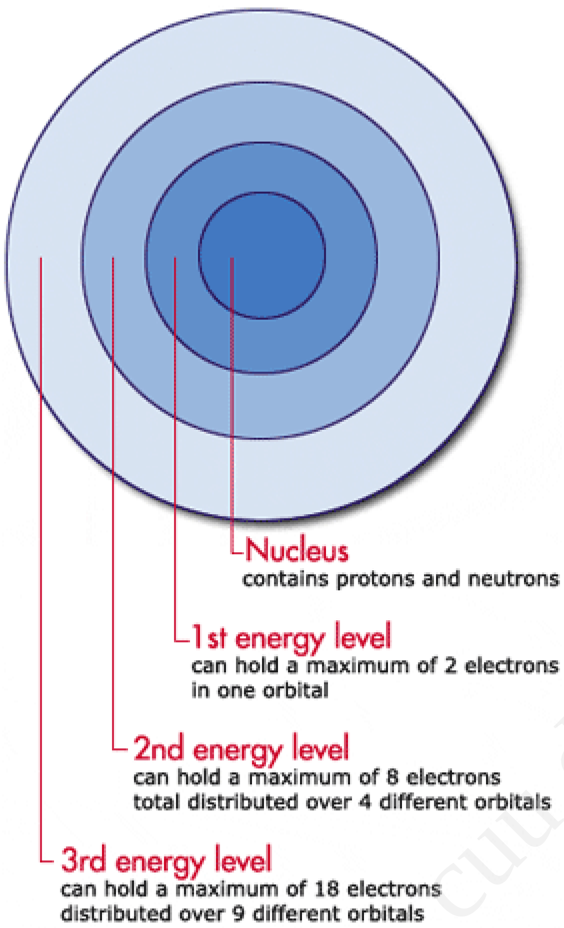
Chương 1: Phân biệt vật liệu Kim loại – Bán dẫn – Điện môi

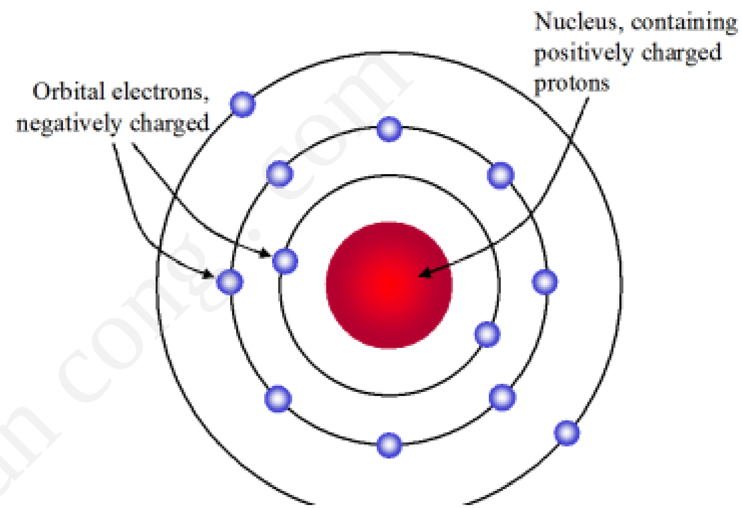
1. Điện trở - Nhiệt độ
2. Cấu trúc vùng năng lượng

1. Điện trở - Nhiệt độ



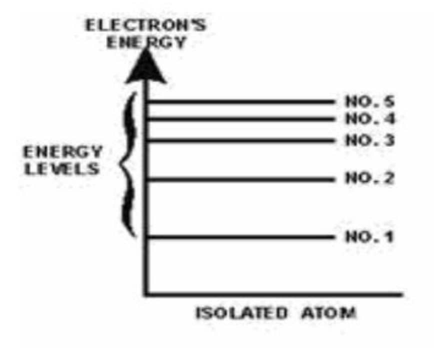
2. Cấu trúc vùng năng lượng





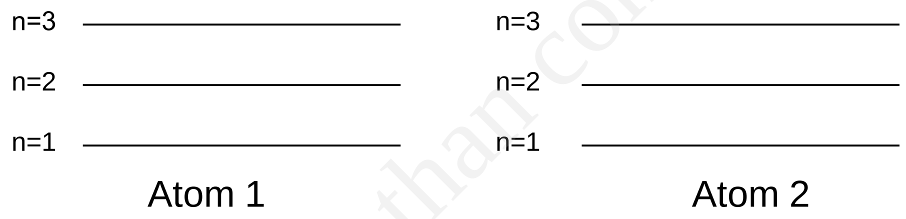
ENERGY BANDS IN SOLIDS

There are discrete energy levels in the case of an isolated atom.

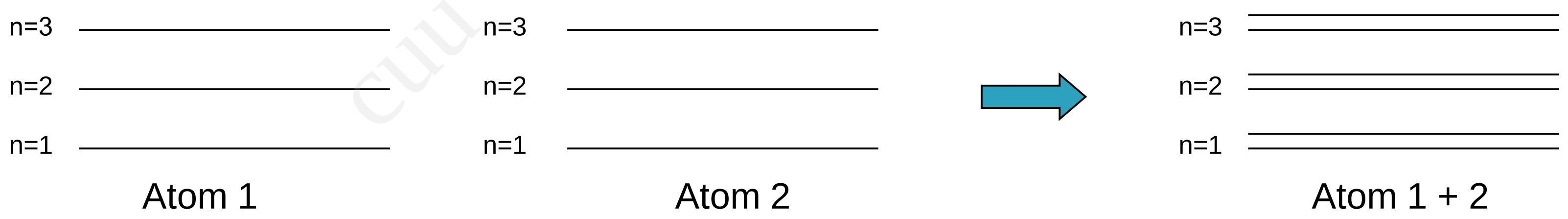


Band theory of a solid

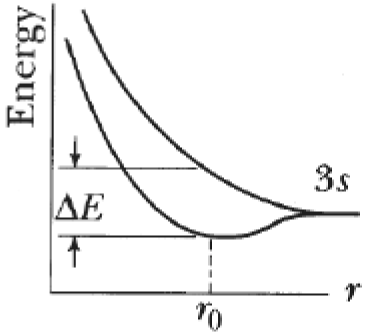
- A solid is formed by bringing together isolated single atoms.
- Consider the combination of two atoms. If the atoms are far apart there is no interaction between them and the energy levels are the same for each atom. The numbers of levels at a particular energy is simply doubled



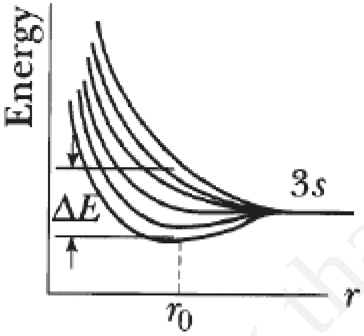
- If the atoms are close together the electron wave functions will overlap and the energy levels are shifted with respect to each other.



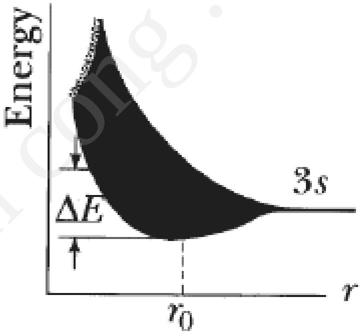
Band theory of a solid



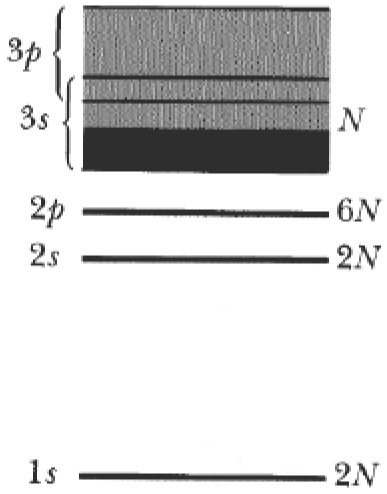
Splitting of the 3s level when 2 Na atoms are brought together



Splitting of the 3s level when 6 Na atoms are brought together

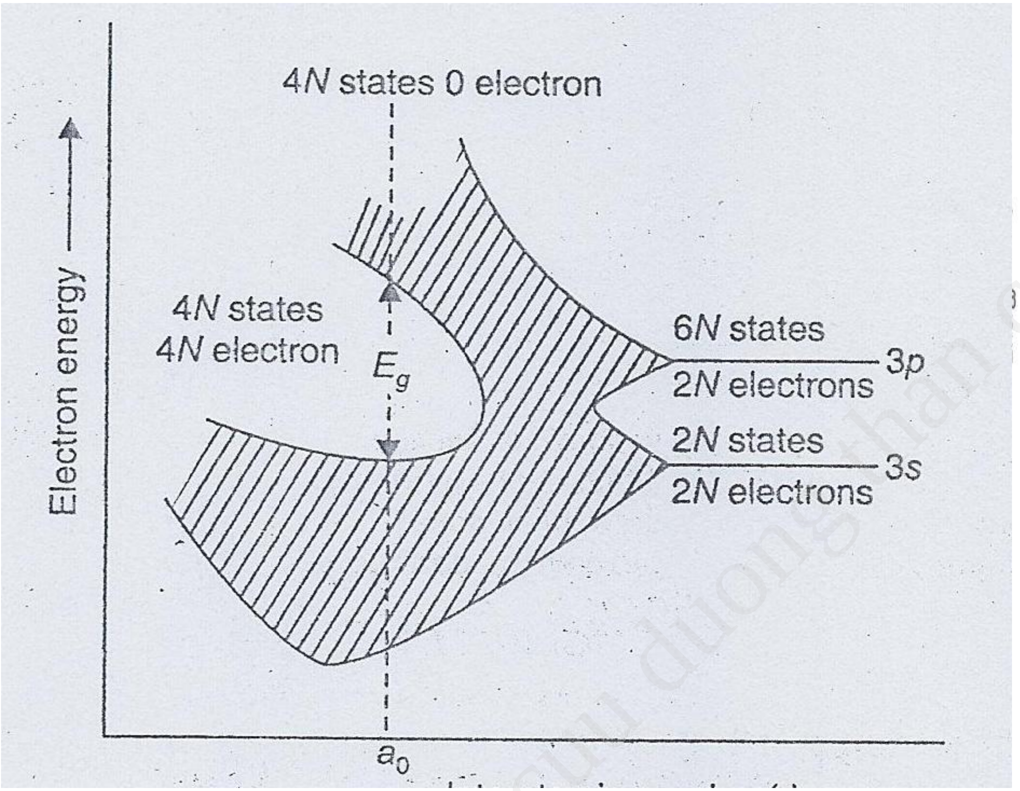


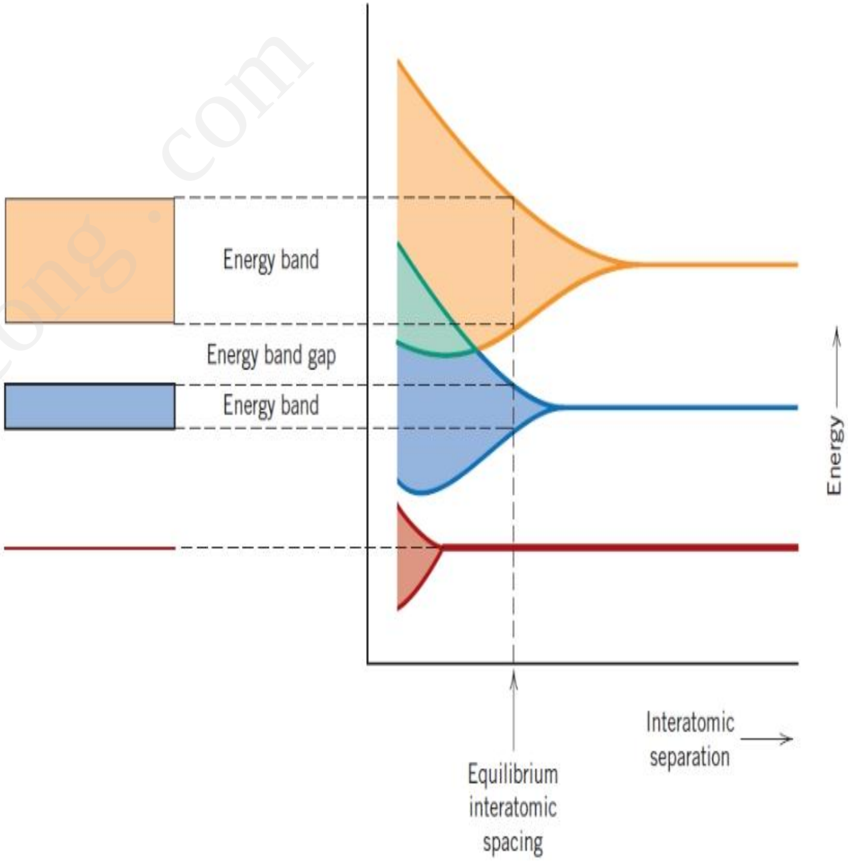
Formation of a 3s energy band when Na atoms form a crystalline solid



Energy bands in sodium

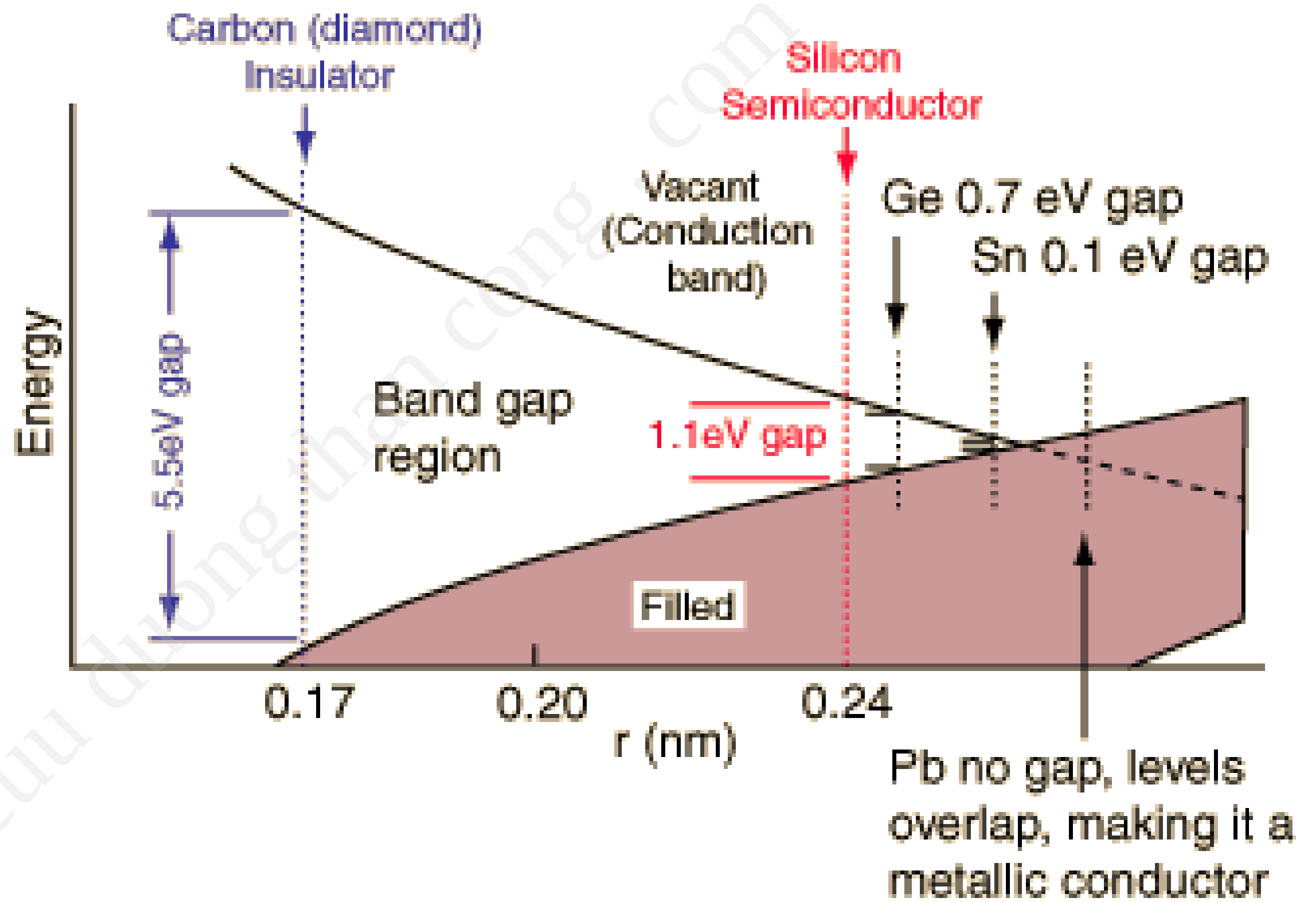
Band theory of solids takes into account the interaction between the electrons and the lattice ions.

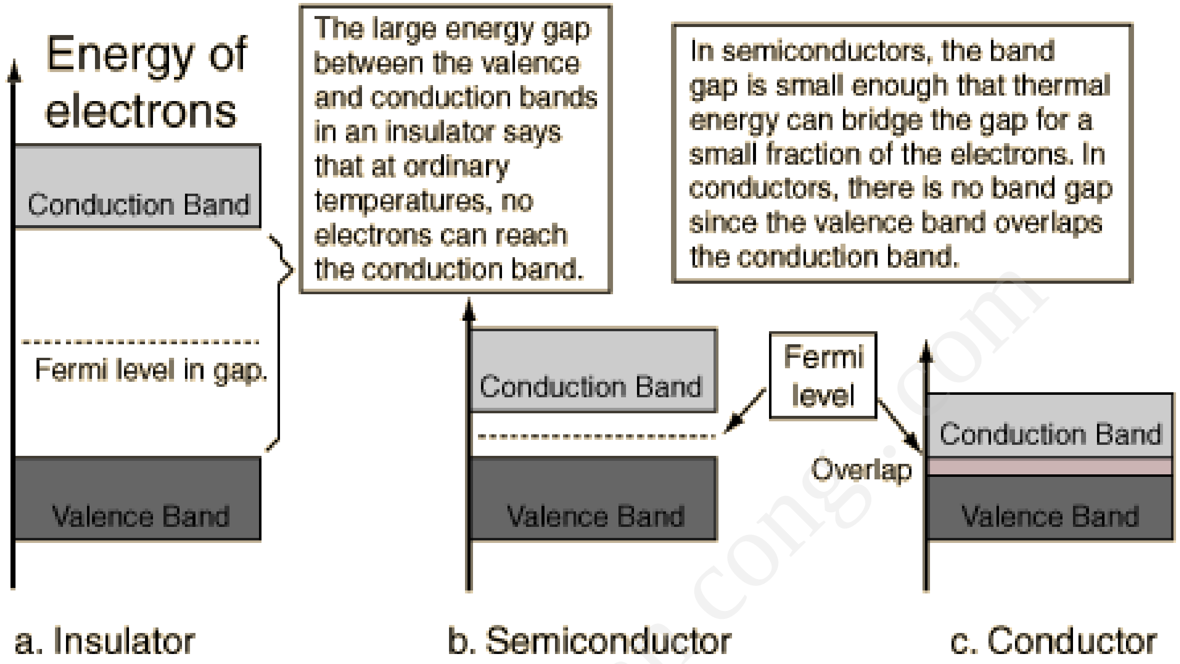

4N states 0 electron
Electron energy
4N states
4N electron
E_g
6N states
2N electrons
3p
2N states
3s
2N electrons
a_0


Energy band
Energy band gap
Energy band
Energy
Interatomic separation
Equilibrium interatomic spacing

Periodic table environment of semiconductors

B	C_2 $2p^2$	N
Al	Si $3p^2$	P
Ga	Ge $4p^2$	As
In	Sn $5p^2$	Sb
Tl	Pb $6p^2$	Bi



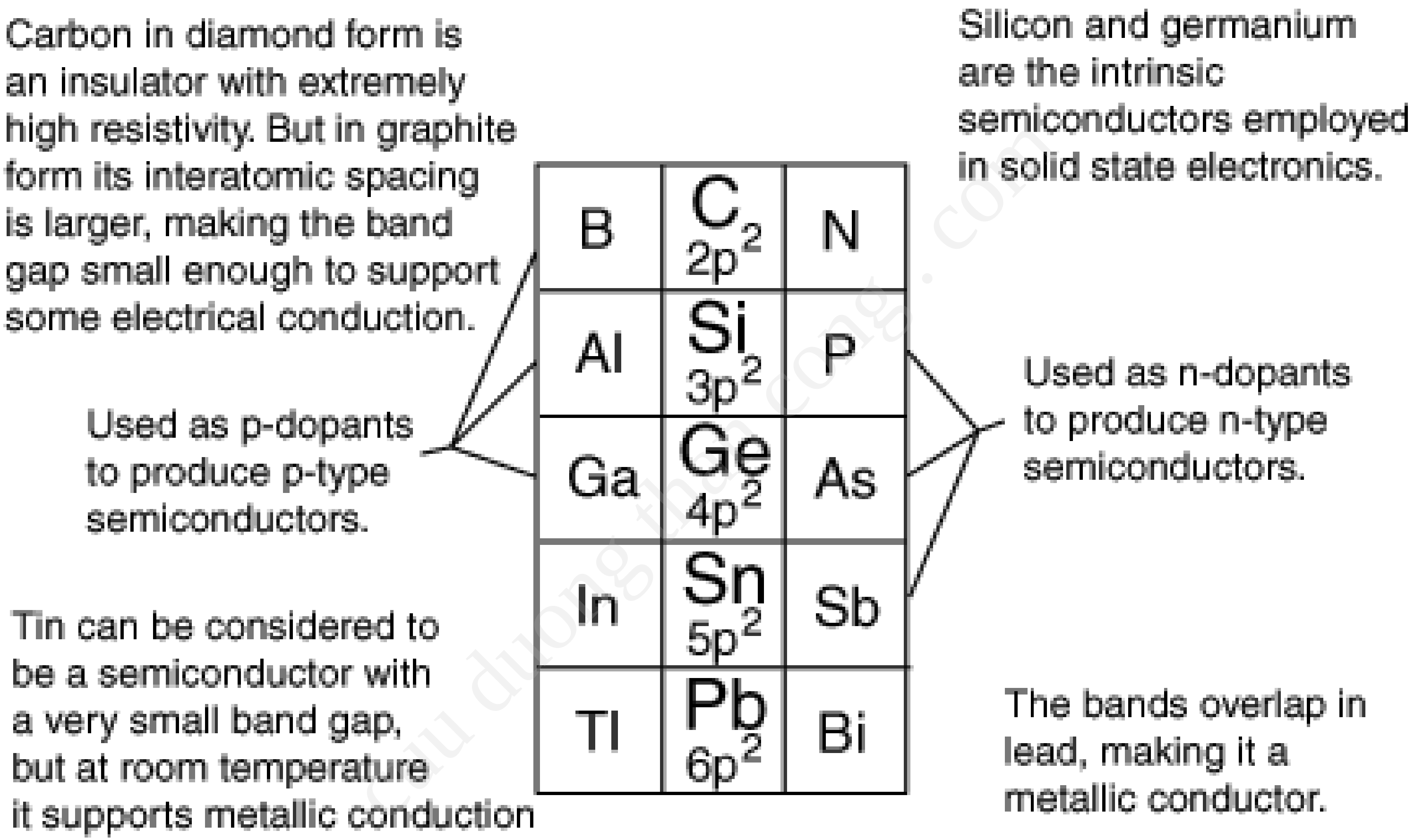


Insulators are characterized by Fermi level lying in between valence and conduction band. Valence band is therefore full and its electrons can't contribute to current. Conduction band is therefore empty and there are no electrons which can contribute to current at all.

Does this mean that an insulators can't conduct current at all? Well, no. It means that if you want to see current flow in insulator, you must transfer huge energy to electrons in order to transit them from valence band into conduction band.

Semi conductors have the same band structure as insulators, with Fermi level lying inside the band gap. The only difference is that the band gap of semiconductors is relatively small, which allows for low energy transitions of electrons from the valence band into the conduction bands. The energy for this transition may be gained from electrostatic energy, optical energy, heat energy etc...

Conductors are characterized by overlapping valence and conduction bands (otherwise stated: Fermi level lies inside conduction band of conductors, and this band is partially filled with electrons). Valence electrons can freely transit to higher energy states in the conduction band, therefore applied voltage will cause their drift - electrical current.


Carbon in diamond form is an insulator with extremely high resistivity. But in graphite form its interatomic spacing is larger, making the band gap small enough to support some electrical conduction.
Silicon and germanium are the intrinsic semiconductors employed in solid state electronics.
B
C
$2p^2$
N
Al
Si
$3p^2$
P
Ga
Ge
$4p^2$
As
In
Sn
$5p^2$
Sb
Tl
Pb
$6p^2$
Bi
Used as p-dopants to produce p-type semiconductors.
Used as n-dopants to produce n-type semiconductors.
Tin can be considered to be a semiconductor with a very small band gap, but at room temperature it supports metallic conduction
The bands overlap in lead, making it a metallic conductor.

Systems with even numbers of electrons per primitive cell (even valency atoms if all the atoms in the primitive cell are the same) carry no current and are INSULATORS or SEMICONDUCTORS.

Systems with odd numbers of electrons per primitive cell have a half-filled upper band and are metals (as in the free electron model where band-gaps are ignored).

Example 1 : C (diamond), Si and Ge are from group 4 with even valency. They have diamond structures (2 atoms per primitive cell) and thus 8 electrons per primitive cell. They form an insulator (diamond), and two semiconductors (Si, Ge).

Example 2 : Alkali metals Na, K have one electron per primitive cell and are metals.

Example 3 : Compound semiconductor GaAs has 1 Ga atom (group 3) and 1 As atom (group 5) per primitive cell (zinc blende structure) and hence 8 electrons per cell and is a semiconductor.