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Vaishali mam
13:15

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MODULE-II SEMICONDUCTING MATERIAL

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PHYSICS
Group-II

Topic outline

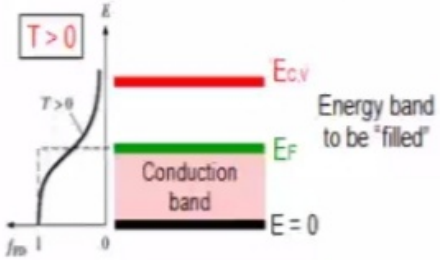
- Introduction to solid state material (3-4)
- To reach for Semiconductor- Looking into periodic table (5)
- Basics and types of Semi-conducting materials (6 and 8)
- Intrinsic SEMICONDUCTOR (7)
- Fermi-Dirac Distribution function and FERMI ENERGY LEVEL (9)
  - FERMI ENERGY LEVEL @ T=0 K and @ T> 0 K
- Conductivity of Intrinsic semiconductor –A general expression (10)
- Need of Extrinsic SEMICONDUCTOR –An Overview (11-12)
- Types of Extrinsic SEMICONDUCTOR (13)
  - Distinguish between N- type and P- type Semiconductors
- Energy band diagram of doped Semiconductor
  - N- type (14)
  - P- type (15)

Note: Refer the PDFs (total 5) for comprehensive derivations as mentioned in slide no.16

Zoom in to Microscopic view

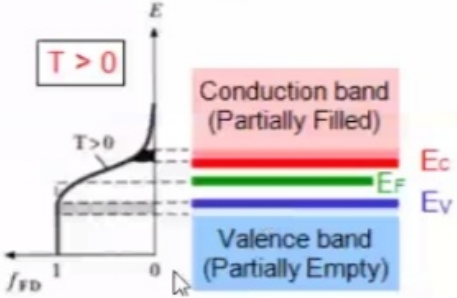
Metals:

- Highest occupied energy bands are partially filled with electrons, while above the Fermi energy level(E_F) all bands are empty.
- With a very small amount of energy lead the electrons go to the conduction band, leading to high conductivity.
- At T>0 electrons thermally excited and cross the barrier of E_F.



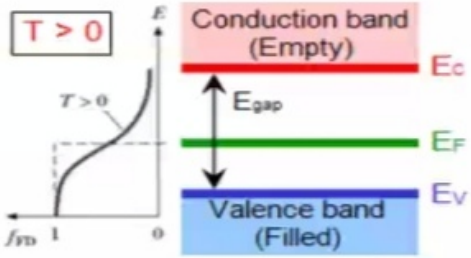
Semiconductors:

- At T=0, conduction band is empty and valence is completely filled, hence zero conductivity. Eg is < 4eV
- (Si: 1.17, Ge=0.74, GaAs= 1.52eV at T=0).
- At higher temperature electron thermal excitation does happen and hence the conductivity lies between metal and insulator.

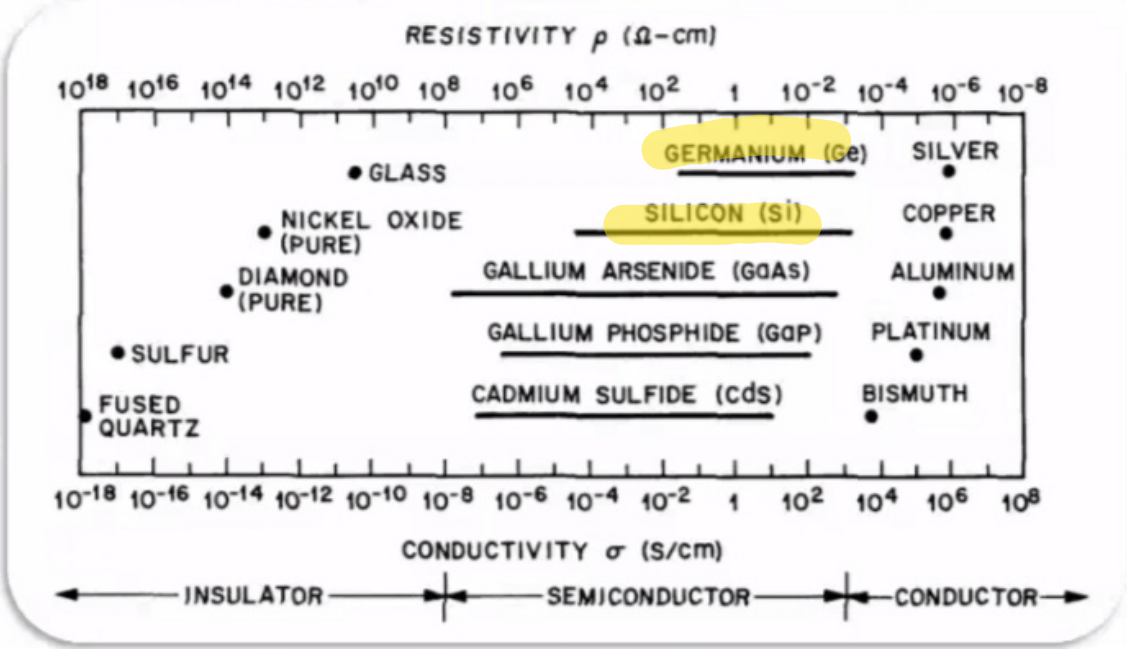


Insulators:

- At T=0, conduction band is completely empty and valence band is filled, leading to zero conductivity.
- Very big energy gap (E_g>4,5 eV) between conduction (EC) and Valance (EV) bands, where E_F is in the middle.
- No thermal excitation and hence even higher temperature, conduction are zero.



Classification of Solid-state material



Insulator	Semiconductor	Metal
Teflon, Quartz, SiO_2 etc.,	Silicon, Germanium, etc.,	Silver, platinum, copper, gold, etc.,
10^{-7}- 10^{-25} $(\Omega\text{-m})^{-1}$	10^{-8} to 10^{3} $(\Omega\text{-m})^{-1}$	Conductivity : 10^{6} to 1 $(\Omega\text{-m})^{-1}$
	Completely filled at low temperatures. Upper band conduction band is empty	Highest occupied energy bands are partially filled with electrons

Raw materials for semiconductor device

Period	Column II	Column III	Column IV	Column V	Column VI
2		B	C	N	
3	Mg	Al	Si	P	S
4	Zn	Ga	Ge	As	Se
5	Cd	In	Sn	Sb	Te
6	Hg		Pb		

	IV-IV	III-V	II-VI	IV-VI	
Elemental	Compound/ Alloys	Compound/ Binary alloys (AlY,GaY,IY)	Compound/ Binary alloys	Compound/ Binary alloys	Ternary Alloys
Si	Sic	AlP	CdS	PbS	AlGaAs
Ge	SiGe	AlAs	CdSe	PbTe	
	SiCGe	AlSb	CdTe		
		GaN	ZnS		
		GaAs	ZnSe		
		GaP	ZnTe		
		GaSb	ZnO		
		InAs			
		InP			
		InSb			

Semi-Conducting Materials

SEMICONDUCTOR

Intrinsic (Pure)

- Low electrical conductivity
- Can't fabricate device

Extrinsic (Doped)

P-type

N-type

A junction/s

Of all solid state devices

Current transport mainly due to

I. Drift mechanism

II. Diffusion mechanism