DEPARTMENT OF ELECTRICAL ENGINEEERING
GOVERNMENT POLYTECHNIC KORAPUT

Subject- Electrical Engg. Material

3rd Sem Electrical Engg.

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Conducting Materials

D1 - 05/10/21

Introduction :-

→ The material which through current can pass easily that is know as **conducting material**.

OHM'S LAW (Georg Simon Ohm) (1787-1854)

* At A constant tempreture voltage directly propertional to current.

$V \propto I$ where V = voltage
I = current

$V = IR$

$I = \frac{V}{R}$, $R = \frac{V}{I}$

Resistivity :- electrical resistance of a conductor of unit cross-sectional Area And length.

$R \propto \frac{l}{a}$, where l = legngth of the conductor
a = cross sectional Area of the conductor

IMP POINT If the Area is Increase then the Resistivity is decrease.

$R = \rho \frac{l}{a}$ | where, l = length, a = area, ρ = Resistivity

$= \rho = R\frac{a}{l} \Rightarrow \Omega \frac{cm^2}{cm} = \Omega$ meter (unit)

Factors Affecting the Resistance

1) **Tempreture** (when we Heat the conductor then The resistance is change) $T \propto R$
2) **Alloying** (when we mix Alloying with conductive material then the resistance is change)
3) **Mechanical Stress** (when we give physical effort to conductive material then its change the resistance

$R_t = R_0 (1 + \alpha t)$
where R_t = some tempresure
R_0 = 0° tempresure
α = tempretune coefficient of Resistance

$R_t - R_0 = \alpha R_0 t$

$\Rightarrow R_t = R_0 + \alpha R_0 t$

$\Rightarrow R_t = R_0(1+\alpha t)$

$\Rightarrow R_{t_1} = R_0(1+\alpha t_1)$

$$\Rightarrow \frac{R_{t_1}}{R_t} = \frac{R_0(1+\alpha t_1)+\alpha t - \alpha t}{R_0(1+\alpha t)}$$

$$= \frac{1+\alpha t}{1+\alpha t} + \frac{\alpha(t_1 - t)}{(1+\alpha t)}$$

$$R_{t_1} = \boxed{R_t\left[1 + \frac{\alpha(t_1 - t)}{1+\alpha t}\right]}$$

Numerical Q

A coil of reel is made up cupper wire At a temprature 20°C the resistance of coil is 400Ω then calculet the Resistance of the coil at temprature 80°C.

$\alpha = 0.0038$

Ans- We know the eq.

$$R_{t_1} = R_t\left[1 + \frac{\alpha(t_1 - t)}{1+\alpha t}\right]$$

where $t = 20°$, $R_t = 400\,\Omega$

$t_1 = 80°$, $R_{t_1} = ?$

$\alpha = 0.0038$

$$R_{t_1} = 400\left[1 + \frac{0.0038(80-20)}{1+(0.0038 \times 20)}\right]$$

$$= 400\left[1 + \frac{0.228}{1.076}\right]$$

$= 400 \times 1.211$

$= 484.758$ (Ans)

$\therefore R_{t_1} = 484.758$

According to conducting of material the material is two type
-> Low Resistivity material - Low Resistance (current allow)
-> High Resistivity Material - High Resistance (Not current allow)

Low Resistivity material :- } (Radis colour)

Copper (Cu) (29) atomic number

-> copper is Low Resistivity material.
-> it has higher conductivity.
-> It is malleable and ductile in nature

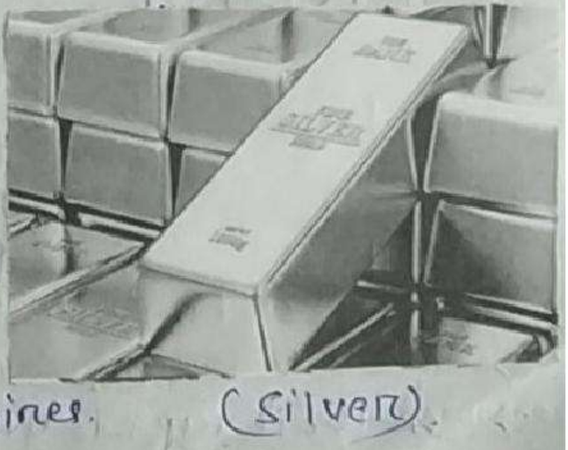
-> melting point 1083°c
-> Boiling point 2595°c
-> Density 8.9 g/cm³

Application

-> making electric wires
-> making cables
-> winding of machines And transformer.
-> Industries, factory etc.

Silver

-> It is an excellent conductor of electricity.
-> It is malleable and ductile in nature
-> It is a soft white



-> melting point 960°c
-> Boiling point 2,212°c
-> atomic number 47
-> It is cheaper than copper

Application

(Silver)

-> use in transmmision line wires.
-> use in transistors.
-> use in ~~straight lig~~ street light pole
-> use in motor wiring.
-> use in electrolyte capacitor.

Gold metal

→ It is a low Resistivity material.
→ It is a good conductor of electricity ~~and heat~~.
→ It is a soft and ductile, ~~metal~~ malleable in ~~nat~~
→ ~~It is~~ nature
→ It has high melting and boil

→ It has high density.
→ It is most expenssive.

Application

→ use in jewellery
→ use in diffrent typ of prizes like olympic, oscar
→ use in electronic device
→ use in temples.

Aluminium melting - 660°C, Boil - 2700°C

→ It is Low Resitivity material
→ It is good conductor of electricity. ~~and heat~~
→ It has low density
→ It is malleable metal and ductile in nature
→ It has high melting and boiling
→ It is cheap to buy.

Application

→ use transmmision lines
→ Air caraft componet
→ space craft componet
→ use in Indurstries and factories.

Aluminium

→ this type of uses etc.

2 mark ACSR - Aluminimum conductor steel reinforced
It is made up of aluminium conductor with steel reinforced.
ACSR use for trasnmision line.

Steel melting- 1400°c , Boil 1500°c

- It is a ~~high~~ low Resistivity material
- It is a good conductor of electricity
- It is contains Iron with small percent of carbone.
- It has low weight
- It is a cheap metal, → good corrosion to Resistance
- It has high melting and boiling point.

Application

- Electrical Equipment
- Metal products
- Mechanical Equiment
- Buildings, factory etc
- Domestic Appliances.

[Steel]

High Resistivity material

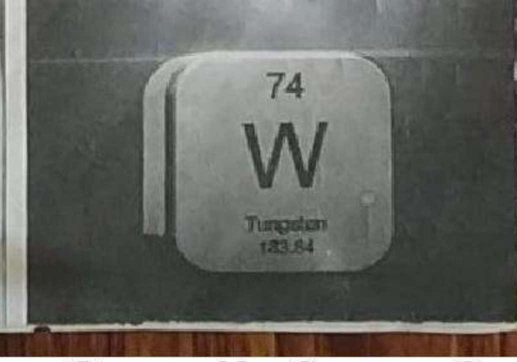
- High Resistivity material is nothing but a ~~High R.~~ High Resistance material.
- It ~~has~~ is not a good conductor of electricity.
- Example:- Tungsten, carbon, mercury

Tungsten melt - 3,410°, Boil - 5,660°

- It is a high Resistivity material
- It is not a good conductor of electricity
- It has high melting and boiling point.
- It has high density
- It ~~has~~ is malleable and ductile.

Application

- use in electrods
- heating element.
- field emitters
- electical equment.



Carbon melting - 3,550°c , Boiling - 4,800°c

→ It is high Resistivity material
→ It is Bad conductor of eletricity
→ It has high melting and boiling point.
→ It has high density
→ It is Malleable and duc

Application

→ use in jewellery
→ use in industries
→ use in make inks and points
→ Diamon and graphite made by help of carbon.

Mercury (melting = -38.9°c , Boiling = 356°c)

→ It is a high resistivity material.
→ It is a bad conductor of electricity.
→ It has high density
→ It has low melting and boiling point
→ It is a highly toxic element.

Application

→ thermometers
→ barometers
→ diffucion pumps
→ Florescent lamps
→

MERCURY

Stranded conductor

→ It is nothing but a composed of steel, copper, aluminumum wires. use in Home wairings.

Bundle conductor

→ It is nothing but a combination of two or more sub conductors.

→ use in transmmision line.

Super conducting materials Long Question

→ it is nothing but a type of conductor which have zero Resistivity (not complete zero). Which through current can flow fluently without lossing energy. This type of conductor is know as super conductor.

→ Example of super conductor - Aluminium, mercury, Titanium

Application super conducting materials

→ used in Generators
→ used in electric motore
→ used in power transmission
→ used in transportation
→ used in Medical
→ used in computing
→ used in Memory or storage element
→ used in electric Machine

Properties of superconducting material

→ There are almost zero Resistance.
→ Infinite conductivity.
→ critical magnetic field.
→ critical current.

platinum

→ It is high resitivity material.
→ It is good conductor of electricity.
→ It is malleable and ductile in nature.
→ melting point 1,768°C
→ Boiling point 3,825°C
→ expensive in price

Application :-

-> used in jewellary.
-> used in car, truck for desine.
-> used in chemical indurstries.
-> etc use of platinum.

Platinum

Q. Explain the effect of temperatuire coff alloying, Mechanical stress or factor on resistivity of conducting materal.

Ans - Generally there are three type of factor which is ① Tempreture ② Alloying ③ Mechanical stress.

-> Tempretune :-

Effect of tempreture on resistivity.

-> Resisitivity related to resistance of the conductor. So the resistance is related with resistivity.

-> If we Increace the tempreture then resistance also Increace so resistance propertional tempreture. $T \propto R$.

-> If we increase tempreture then in the resistance is change which give effect to resistivity.

Alloying

Effect of Alloying on resistivity

-> By adding some Impuritie in small percent the resistivity will be Increase.

-> for example when coppor alloyed with zinc, resistivity Increase and conductivity decrease.

Mechanical stress

Effect of Mechanical stress on resistivity

-> when we give any physical error to the material the its Mechanical stress in Increase and the resistivity in decrease.

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2nd chapter

Semiconducting Materials

→ **Semiconductor**

It is nothing but a typ of ~~conductor~~ electrical componet. which is works both conductor and Insulater.

Ex - silicon, Germanium, carbon

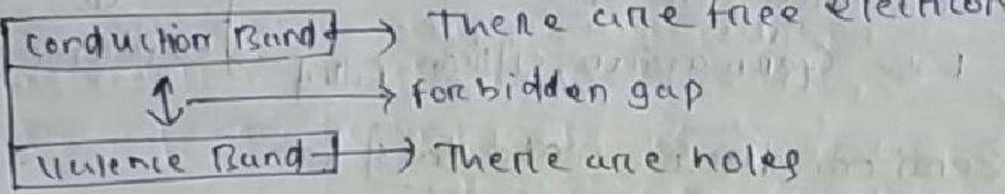
Defination →

→ Semiconductor are materials which ~~have~~ conductivity lie between conductor and insulater.

Electron Band Theory

Solid —
- Valence Band
- conduction Band
- forbidden gap

Energy Band



Classification of solids according to energy band (D)

→ ① conductor → ② Insulater → ③ Semi conducter

conductor

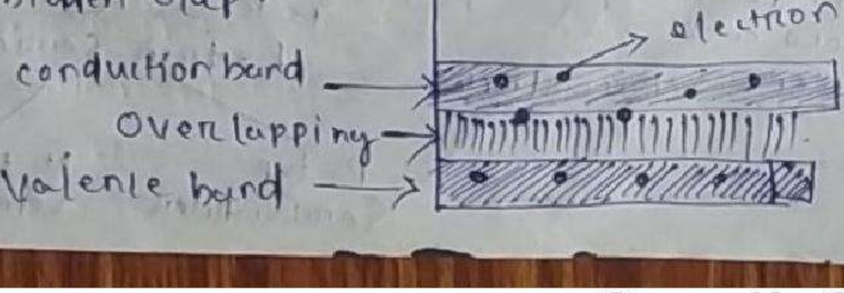
→ conductor is the substance which allow the flow of electricity through itself.

→ It's because that there are large number of electrons available in conductor.

→ The valence band and conduction Band overlape to each other.

→ Ex - all metals

→ less forbidden Gap.

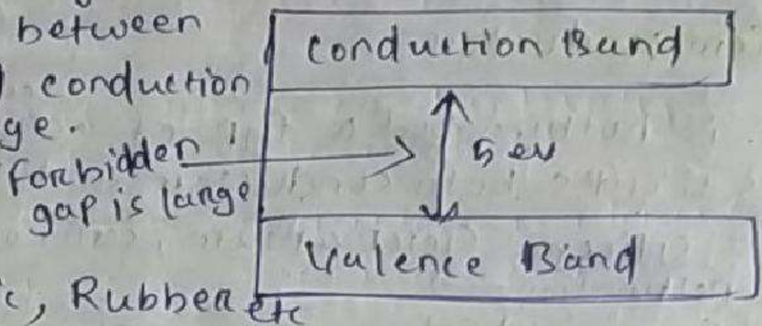


Insulater

→ Insulater is the substance which do not allow the flow of eletricity is called Insulater.

→ The energy gap between Valence Band and conduction band is very large.

→ forbidden gap is around 5ev.



→ ex- wood, plastic, Rubber etc

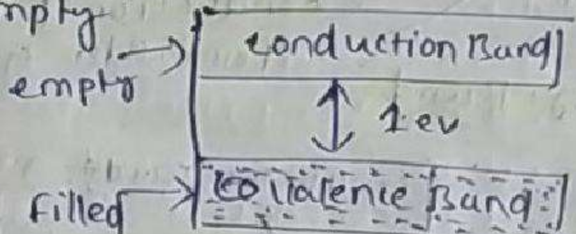
Semi conducter

↳ semiconduter is a substance whose conductivity lie between conductor and insulater.

→ The Valence Band is almost filled but the conduction Band is empty

→ The forbidden Gap is very small.

→ Ex. Germanium, sillicon



Semi conductor materials :-

It is a semiconductor material whose conductivity lies between conductor and Insulator.

Basically semiconductor Devided in ~~two~~ 2 type

Semi condter

- ↓ Instrinsic semiconductor
  - ↓ pure form of Semiconductor is know as Instrinsic semiconducter
- ↓ Extrinsic semiconductor
  - ↓ Impure form of Semiconductor is know as Extrin semiconductor
    - P-typ Semiconduter
    - N-typ semiconductor

Instrinsic Semicondutor

- Pure form of semiconductor is know as Intrinsic semiconductor.
- The electrical conductivity of Instrinsic semiconductor depends upon the tempreture.
- The electrical conductivity is very low.
- There are no typs of Instrinsic semiconduter
- The no of holes in valence is equal to no of free electron in conduction Band.
- ex - Sillicon, Germanium

Extrinsic Semiconductor

- Impure form semiconductor is know as Extrinsic semiconductor.
- The electrical conductivity depends upon the tempreture as well as the amount of dopped impurity.
- The electrical conductivity is significantly high.
- There are two typs of Extrinsic semiconductor. ① P-typ ② N-typ.
- The no of e free electron in conduction Band is equal to no of holes in valence band.
- ex - 'p' dopped with 'si'
  'P' dopped with Al

P-typ Semiconductor

- Holes are majority carries
- electron are minority carries
- This is also know as ~~tetravo~~ Trivelent semiconductor.
- It has larger hole concentration and less electron concentration
- They have ability to accept electron.
- They are rich in holes
- ex - Al dopped with si.

N-typ Semiconductor

- electron are majority carries
- Holes are minority carries.
- This is also know as pentavalent semiconductor.
- It has larger electron concentration and less hole concentration.
- The have ability to donate eletron.
- They are rich in electrons.
- ex - P dopped with si.

P-type Semiconductor

N-typ semicondutor

~~Super~~ Semi conductor material :-

-> This is a material whose conductivity lie between conductor and Insulater. that is know as ~~super~~ semi conductor material.

~~Ex- Aluminiume, mercury, niobium etc.~~

Ex- sillicon, Germanium etc.

Application of semiconductor material :-

Property of Sillicon

-> It is a semiconducting material
-> It is blue-gray color.
-> Density = $2.32 g/cm^3$
-> melting point 1687K.
-> Boiling point 3538K.
-> It is cheaper in price.

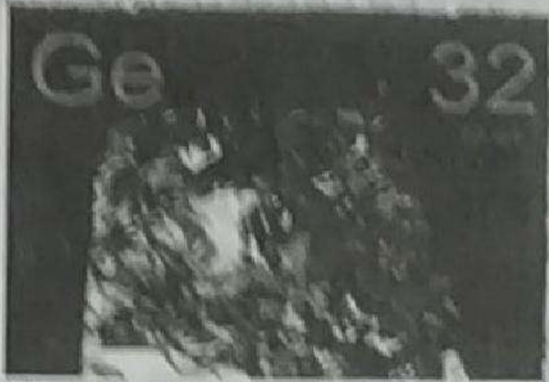
Sillicon

Application of Si

-> mostly used to make alloys.
-> To make dynamo, transformer plates
-> To make transitors.
-> used in computer chips.
-> used in solar cell.
-> etc

Property of Germanium

-> It is a semiconducting material.
-> It is expensive in price
-> Density - 5.32 g/cm³
-> melting point 938° c.
-> Boiling point 2820° c.
-> colour -> grey-white.



Germanium

Application of Germanium

-> used in fiber optic systems
-> used in Rectifier for manufacture.
-> used in transistors
-> used in integrated circuit.
-> used in wide-angle camera lenses for manufacture.

Rectifier

-> It is noting but a electronic device which convert AC into pulsating DC.
-> Generally Rectifier devided in to two typ
① Full wave rectifier ② Half wave rectifier
-> Full wave rectifier is defined as a rectifier convert the complete cycle of AC in to pulsating DC.
-> Half wave rectifier is defined as a rectifier that convert one half cycle of AC in to pulsating DC.
-> The full wave rectifier devided in to two typ ① center tapped rectifier
② Bridge rectifier

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Photoconductive cell

-> photoconductive cell are light sensitive resistor in which resistance decreases with an increase in light intensity when illuminated.
-> These devices combination of thin single crystal film of compound semiconductor substra

photovoltaic cell

-> This is also know as solar cell.
-> The photovoltaic cell is used for converting Sunlight into electricity.
-> The photovoltaic cell is consist of one or two layer of semiconducting material, usally sillicon.

Varistor

-> Varistor is a 2 terminal semiconductor device that protect the electrical and electronic devices from over voltage transient

Transistors

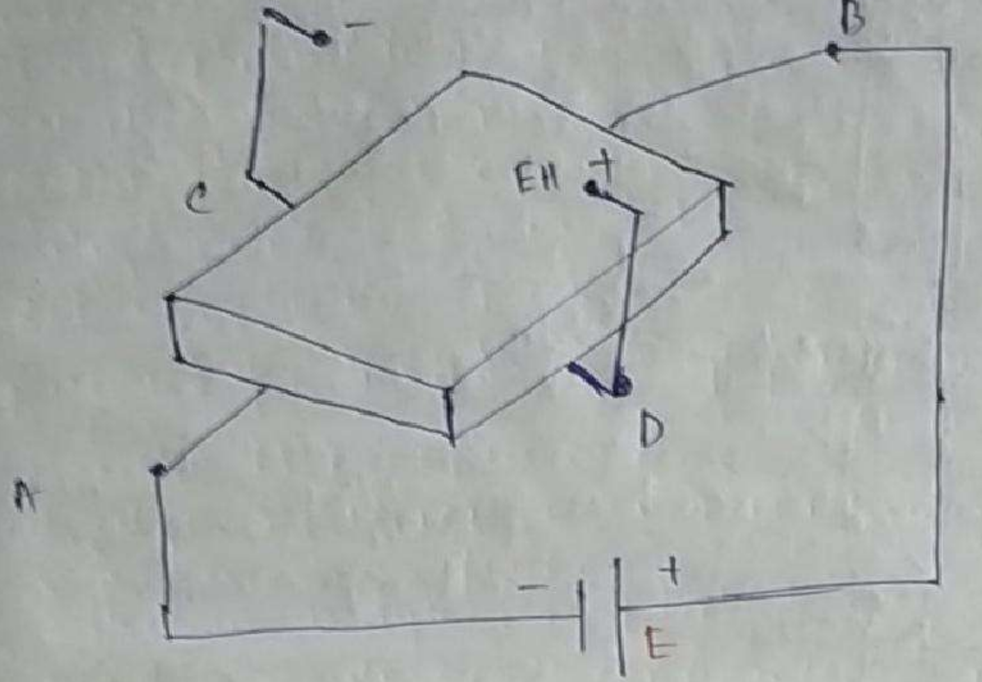
-> Transistors is semiconductor device that use for switch electrical singnal.
-> There are two type of transistors
① PNP transitor
② NPN transitor

Hall effect generator

smark (Internal)

Application- Hall effect generator use for measure magnetic field.

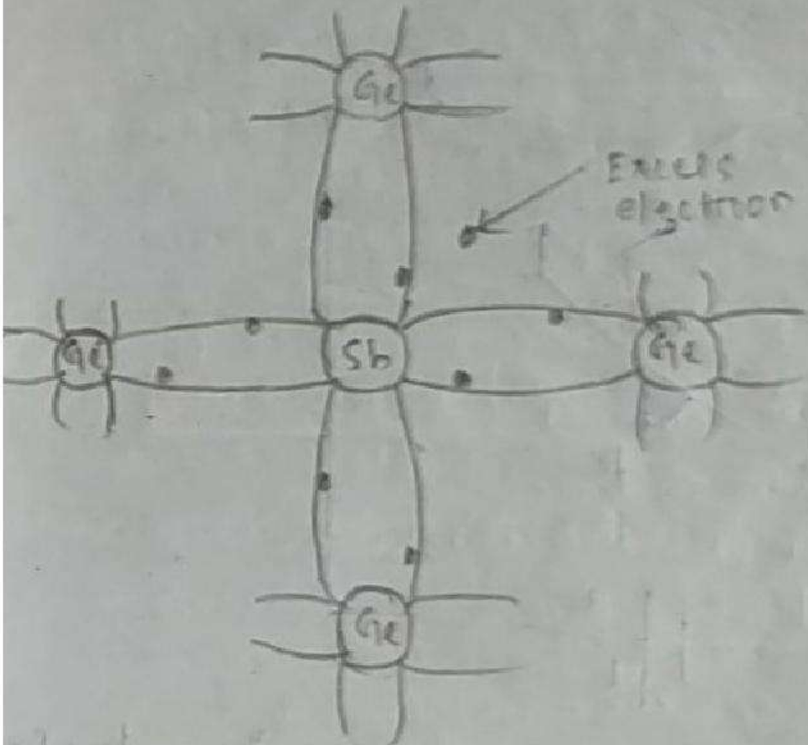
Hall effect Generator



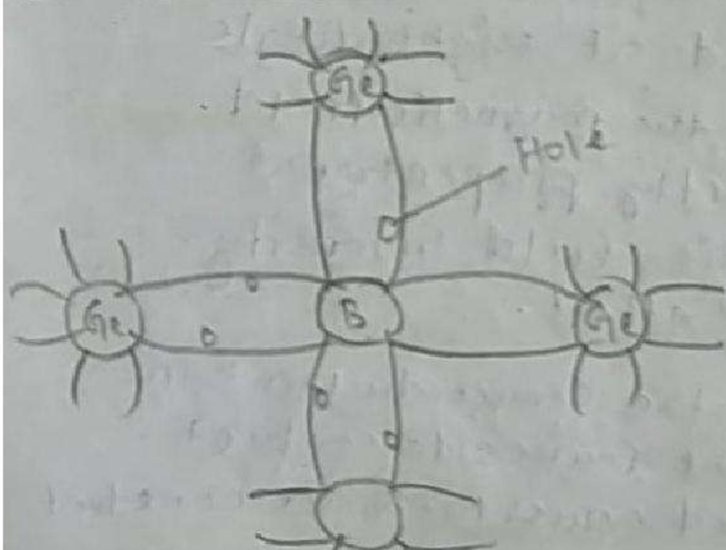
When current flow through semiconductor bar placed ~~on~~ in a magnetic field, a voltage ~~dq~~ developed at right Angle to both current and the magnetic field. The voltage is directly propertional current and magnetic field intensity. that is know as Hall effect.

Let consider the semiconducter bar shown in figure which has foure side contact. if a voltag 'E' is applied across to opocite conetact o'A' and 'B' then a curren will flow. ~~The~~ if the bar is perpendicular to the magnetic field B, then an electric potential E_H will Generate between towo other o contact 'C' and 'D' that is the mesure of magnetic field ~~laten~~ Streagth and it can easily measure by Volt meter.

N- type Semiconductor



P- typ Semiconductor



Insulating Materials

Intorduction :-

The material which through current can not pass that is know as Insulating material.

Ex- Wood, plastic, Rock

General properties of Insulating materials :-

Propeties

- → Electrical properties
- → Visual properlies
- → Mechanical properties
- → Thermal properties
- → chemical properties

Electrical properties

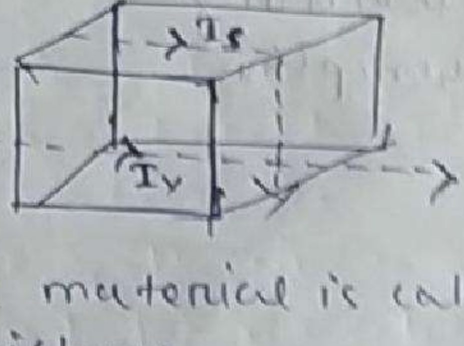
1) Insulation Resistivity

The Resistance ~~offered~~ to (oppose or offered) the flow of current through the material is called Insulation ~~material~~. Resistance.

There two type of Insulation Resistance

1. Volume Insulation Resistance and Resisvity
2. Surface Insulation Resistance and Resistivity

Volume Insulation Resistance



The Resistance to offered the flow of current ~~through~~ I_v which flow through the material is called Volume Insulation Resistance.

Surface Insulation Resistance

The Resistance offered ~~flow~~ current I_s which is flow through the material is called Surface Insulation Resistance.

(7) Dieelectric strength (Break Down voltage)

(8) Dia electric constant

property (Electrical)

- It should have low dieletric loss.
- It should have high value of dieleetric strength
- It should have low permittivity
- It should have lower power factor for measurement of any power loss.
- It Increases will rise in tempreture power factor.

Mechanical ~~Peap~~ property of Insulating Material

- High Impact strength
- Toughness
- High Tensile strength
- Less Elongated
- Hardness
- Flexibility
- Absorption

Thermal propperoroperty of Insulating material

→ Thermal conductivity.
The best thermal Insulator have the lowest thermal conductivity this is the property of a material that measure how well it can conduct heat through its mass---

→ Heat resistance ---

→ Air permeability ---

→ Thermo-Insulating material---

physical property of Insulating material

→ Tempreture Limits --

→ Electrical conductivity ---

→ Dielectrical strength---

→ Density — —

→ Fire Resistance---

→ Vapore permeability--

→ Thermal Expansion.---