LEARNING MATERIAL

OF

ELECTRICAL ENGINEERING MATERIAL (3RD SEM)

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EEM ~~classification~~ classification of materials. Date. 01.11.2021

→ **Electrical Engineering material:-**

Resistance:- oppose the flow.

conductors are those materials that allow the flow of current to them.

Resister:- Those substances that oppose the flow of flow of electric current. Resisters the above phenomena is called resistance.

→ conductors are divided into

① low resistivity materials.

② High resistivity materials.

Resistivity and factors affecting Resistivity:-

Resistivity:-

According to ohm's law.

$V = IR$ where.

(V) V = voltage across the terminals of the conductor.

(A) I = current through the conductor.

(Ω) R = Resistance of the conductor.

→ Resistance of a material is :-

$$R = \frac{\rho l}{a}$$

where R = Resistance of the material in ohm (Ω)

ρ = Resistivity or specific Resistance in (Ω·m)

l = length of the material in meter.

a = area of cross.

Factors affecting resistivity:-

(1) Temperature.
(2) alloying
(3) mechanical stressing.

Effect of temperature on Resistivity:-

→ Resistance of conducting material Increase with temperature.
→ The change in resistance of the material per Ω per degree change in temp. is called temperature co-efficient of resistance.

EEM Date- 06/11/2021

(2) Accoding to the law resistance of a conductor changes with temp.

$$\boxed{R_t = R_0 (1+\alpha t)} \quad \text{--- (1)}$$

where R_t = Resistance of the conductor at $t°C$.
R_0 = resistance of the conductor at $0°C$.
α = temp co-efficient of resistance.
t = temperature.

→ Accoding to the above law resistance of the conductor at any temperature of $t_1°C$ then $R_{t_1} = R_0 (1+\alpha t_1)$ ——— (11)

Dividing R_{t_1} by R_t, we get.

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

Adding & substracting αt in the N^r

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

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

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

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

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

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

It means that the resistence at any temp t_1° can be calculated if the resistance at t° is known. It helps the designer of electrical equipment to determine by calculation of the I^2R loss in the windings of moter transfermer etc.

Effect of alloying on Resistivity Alloying :-

→ Adding some impurities (a small percentage of some other material) to a metal.

→ By alloying resistivity of a metal can be increased.

→ Alloys have high resistivity than the base metal for ex - when cupper is alloyed with zinc it is called Brass (cupper - 60% Zinc - 40%)

Effect of mechanical stressing on Resistivity :-

→ Resistivity of a material changes under the influence of mechanical treatment.

→ The fabrication of the conducter from the ingot to the final stage comprise initially hot working and finally cold - drawing.

→ This hardens the material increase its tensile strength resistivity.

For Ex - over head conductor.

classification on conducting materials:-

① Low Resistivity materials.
② high Resistivity materials.

① Low resistivity material:-

→ Low resistivity materials should caused following properties.

(i) Low value of resistivity.
(ii) Low temperature co-efficient (It means change in resistance with change in temperature. should be low). It is required to variation in voltage drop & power loss with change in temperature)

Voltage drop = IR
power loss = I^2R
heat - lose

(iii) Sufficient mechanical strength:-

The conductor having low resistivity must have sufficient mechanical strength it is required for the conductors used for transmition and distribution. of the electrical power because they are subjected to stresses due to wind and their weight.

(iv) Ductility

It is the property of a material which allows it to be draw out into a wire.

→ conductors are required in different & sizes.

(v) :solderability:-

conductors are required to be jointed The joint should offer minimum contact resistance so minimum contact resistance means the joint is soldered

(vi) Resistance to corrosion :-

The conducting material shouldn't corrod when used in out door atmosphere.

② High Resistivity materials:-

High resistivity materials should causes following properties.

① Low temperature co-efficient:-

High resistivity material are used in electrical measuring instruments for such application, the material should have low temp co-efficient.

(ii) High melting point:-

we expect the material should be able to which stand high temp. for a long time without melting.

(iii) Low tendency for oxidation:-

materials used as high resistance elements in heating appliances should be able to which stand high temp. for a long time with out oxidation. because if an oxide layer formed on the heating element the amount of heat radiation will reduce.

(iv) Ductility:-

These materials are required in different shapes & sizes for ex:- Thick wires are used in ovens; heaters, starters. Thin wires in cases of precision wire would resistors.

(v) High mechanical strength:-

It is used where wire must be thin are required to have high tensile strength.

(*) Low resistivity materials & their application:-

① cupper ② silver ③ Gold ④ Alluminium.
⑤ steel ⑥ stranded conducters ⑦ Bundle conductors
⑧ Brass ⑨ Bronze ⑩ Berilium cuppor alloy.

cupper

properties:-

① Reddish in colour
② non-magnetin metal.
③ High conductivity.
④ Low resistivity.
⑤ coppor is available in hard drawn. cupper and anneled copper.

Anneled cupper:-

→ Anneled cupper means heating it with an oxygen acetylene tourch and rappidly cooling in water.

→ **Anneled cupper:-**

(i) soft.
(ii) Less tensile strength than hardraw cupper.
(iii) It has higher conductivity than hardraw cupper.
(iv) Resistivity of anneled cupper = $1.72 \times 10^{-8}\ \Omega \cdot m$
(v) It is used for insulated conductors in low voltage power cable, winding wires for electrical machines and trams former flexible wires.

Hard draw cupper:-

It is cold worked or formed it because work harded or strain harden.

properties:-

→ It is tensile strength is high.
→ It's conductivity is less than that of anneled cupper.

Limitation:- It is very scarce in India hence used cupper is limited.

Application of cupper.

(1) used as a contact materials for central relese motor strature tap changes etc.

(2) Silver:-

→ Pure silver has high electrical condocters.
→ corrosion resistance

application:-

→ used in commutator segment of small D.C motor (By alloying of 40% cupper to silver)
→ used in Brushes and collected in dc motor (alloy of silver by small % of graphite)

(3) Gold:-

→ It is best electrical conductor.
→ It is not in suffcient quantity to make it economical
→ It is malleable.
→ It is Ductile.
→ It is corrosion resistance.

application:-

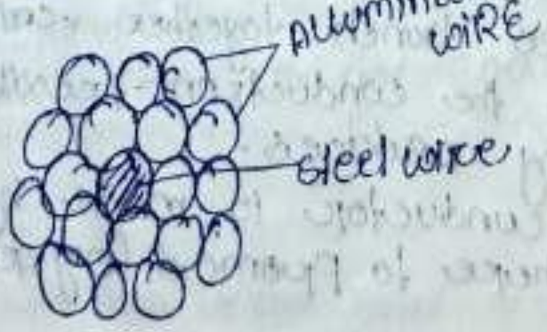
→ used as alloy to make coins & jwellary.

(9) Alluminium:-

→ It is widely in India.
→ It is used in the field of electrical engineering.
→ It is the next best conductor copper.
→ Resistivity $\rho = 2.8 \times 10^{-8} \Omega \cdot m$
→ It is lighter than copper.
→ It is easily rolled and hard drawn.
→ It can be drawn into the wires
→ Alluminium is a soft metal.
→ when alluminium is alloyed with other material like mg, si or fe its mechanical strength increase.
→ It will be useful for overhead line conductores.
→ Alluminium forms an oxide layer where expose to outer atmosphere.
→ It prevence the material from for further oxidation
→ It acts as a resistance layer to corosen.

Application:-

→ It is used in the overhead line conductors Bus-bar.
→ splirrenu indexe motor rotor bar.
→ winding of electrical mechine, as a transpermens
→ For overhead transmision lines are made of aluminium conductors with still reinforcement called ACSR.



ACSR conductor

Steel

-> Steel reinforcement is made for giving higher strength to the overhead conductor.
-> it contains iron with small percentage of carbon added to it.
-> iron it self is not very strong.
-> when carbon is added to iron, its mechanical properties are verygood.
-> it increases stainstill strength of still.
-> its ductility decreses.
-> when carbon contain is too high is iron, still, become brittle.
-> stills are classified in to.
 i. mild steel (carbon about 0.25 %)
 ii. midium steel (carbon about 0.45 %)
 iii. high carbon steel (carbon about 0.7 % and above)
-> when zinc coating is provided on its surface it is called galvanised.

Application
-> galvanized steel wire is used as overhead telephone wire and as earth wires.

Stranded conductor

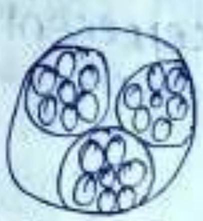
-> a single conductor has large crossection it is rediged in construction.
-> it is eliable to break while handling.
-> To avoid this, this conductor's are made of a no of thin wires bunch together, called strands
-> stranding makes the conduction flexible.
-> Risk of breaking reduces.
-> is strended conductor is made by twisting the wire togethere to fromed layers.

a. cross section of a 19 wire stranded circular conductor Having 1 wire at the centre, 6 wires in the 1st layer and 12 wires in the 2nd layer.

(b). A stranded circular conductor showing How wires are Twisted together.

(a) circular stranded conductor.

(b) compact circular stranded conductor.



(b) Typical Three

circular conductors made sector shaped.

→ A stranded stranding consist of 6 wires around one then 12 wires around the previous six, 18 wires around the 12, 24 wires around the 18 and so up.

→ number of layers will depends upon no of wire to be provided.

→ central wire is not counted as a wire

Number of wires in the centre	1 wire 6n	3 wires 3+6n	4 wires 4+6n
Number of wires in the nth layer from centre	~~1+3n(1+n)~~ 6n	~~3(1+n)²~~ 3+6n	~~(4+3n)(1+n)~~ 4+6n
Total number of wires in a stranded conductor having n layers.	$1+3n(1+n)$	$3(1+n)^2$	$(4+3n)(1+n)$
Diameter over the nth layer in centimetres, where d indicates the diameter of each wire in centimeters.	$(1+2n)d$	$(2.155+2n)d$	$(2.414+2n)d$

→ Stranded conductor are expressed as:

7/2.24, 19/2.50, 37/2.06.

1st no. 7, 19, 37 indicate total no of wire in the stranded conductor.

2nd no 2.24, 2.50, 2.06 etc represent the diameter of each wire in millimeter.

37/2.06

It has 1 wire at the centre
6 wire in the 1st Layer
12 wire in the 2nd Layer and 18 wires in the third layer.

No of layers is n=3 total no of wires:

equal to $= 1+3n(1+n)$

$= 1+3\times3(1+3) = 37$

$= 1+9\times(4)$

$= 1+36$

$= 37$

Bundle conductor:- Date-13.11.2021

→ It is used in extrahightension power transmission
→ It is used where high current carrying capacity is require to be transmited.
→ here voltage stress is reduced.
→ corona loss is smaller.
→ it is lessuitable to cause radi radiointerference

Low Resistivity cupper Alloying:

→ Alloying of cupper is done to make in mechanically hard, so there are 3 types.
① Brass ② Bronze ③ Berrilium cupper alloy.

Brass

→ when cupper is alloyed with zinc(60% cu/40% zn) it is called brass.
→ Brass has high stainstine strength.
→ It has lower conductivity then cupper.
→ it is resistant to corogen.

Application:-

→ plug points
→ cricket outlet.
→ switches
→ lamp holder.
→ fuses ~~to~~ etc

Bronze

→ when is cupper alloying with tin (8% to 16%) and a very smal persentage of a third element - cadmium beryllium, phosphorous, silicon etc is called Bronze.
→ when the third element is phosphorous it called phosphour Bronze
→ if the 3rd element is silicon and cadmium is it is called siBronze or candium bronze.
→ Bronze has high mechanical strength.
→ It has lower conductivity.

→ It is more free from corrosion.

Application

current carry, spring, sliding contact, knife switch blade

Berylium copper alloyed.

→ when copper alloyed contains beryllium it is called bronze.

→ It has high conductivity and high mechanical strength.

→ It is hardening and elistitity can be changed by given appropiat harden treatment.

Application

spring

sliding contact.

kpe switch blade

Brass = Cu + Zn
60% 40%

Bronze = Cu + Sn + third element.

High resistivity materials and their application:-

1. Tungsten.
2. carbon.
3. platinum
4. mercury.

1. Tungsten

→ It is a very hard metal.

→ Resistivity of tungsten is too high that of ~~allowing~~ alluminium.

→ Its melting point is the highest of all metal. (3300°C

→ It can be drawn in to very thin wires which is required for making filament.

→ Thinner the tungstet wire greater is it tensile strength

Application

→ incandescent lamps.

→ Heater in electrone tube.

→ Tungesten doesn't become brittle at high temp.

→ Tungsten is used in atmosphere of inere gas like n, Argon. etc or in vaccum.

→ it can reliable work at temp. like 200°c and even higher.

carbon-

→ it is manufactured from graphite and coal etc.

→ its manufacturing process include under water grinding of the row carbon material.

→ mauling of the powder carbon with a binding agent like cold tap.

→ maulting of the conmponet last baking them.

→ To Increase the conductivity of carbon it is mix to it different additibls like cu or Bronze

characteristics of carbon

→ It is high value of resitivity.

→ -ve temp coefficent.

→ pressure sensitive Cresestance Increases with the decrece in per pressure

→ low surface friction.

Application

→ Brushes for electrical mechine.

→ electrode for electric furnance.

-> Non wire resistor, menebranes etc for telecommunication equipment.

Bettry shell element -

-> Arc - clane.

-> Arc - welding etc.

plotinum -

-> It is greyish white metal.

-> it is non corrosin.

-> it is malleable.

-> it is ductile.

-> it is resistance to lost chemical.

-> it is of hevey metal.

Application

-> it is used as the heating element in labratory ovens and furnaces.

-> It is used as electrical contact material.

mercury -

-> it is the heavy silver white metal.

-> it is the only metal which is liqued at room temperature.

-> mercury is poisiones.

uses

-> mercury are rectifire.

-> gas filled tubes.

-> As a liquid contract material in electrical switches

-> it is used for makeing and breaking contact in Buchholz relay used for transformer protection

Super conductivity:

→ We know that resistivity of some metals increses with the increase in temperature and vice versa.
→ There are some metals, ~~or compounds are said~~ and chemical compounds whose resistivity become zero when their temp. is brought near 0° kelvin (-273°C). at this stage the metals or compound are said to attend super conductivity.
For example - mercury it becomes supercon ducting at approximately 4.5 kelvin.

* Transition Temperature:

→ The temperature at which the transition takes place from the state of normal conductivity to that of super conductivity that called transition Temperature.

→ There are two types of super conductors
  a. Type 1 super conductor.
  b. Type 2 super conductor.

a. Type 1 super conductor-
→ This are soft conducters metals they are usually pure elements like metals.
→ They have very little use techinical application.

b. Type 2 super conductor
→ They are hard super conductors.
→ They are usually alloys of metals with high value of resistivity in normal state
→ They are very useful

* Super conducting materials:
→ They are. Tin, load, lead and tantalum. at preasent about 30 super conductor metals and more than 600 superconductor alloys are already known.
→ The highest temp at which superconductivity are observed 20k.
For ex- Allumium, Germanium, Nibium, etc

Application

→ Electrical machines -

→ Efforts are made to develop electrical machine and transformer utilizing superconductivity.

→ It will increase the efficiency by 99.9% it will reduce the size.

power cables:-

: If it is used for power cable, it will enable transmission of power over long distance by reducing the voltage drop or power loss.

Electro Magnet -

→ super conducting solenoids don't produce any heat during operations.

Future prospects:-

→ In case of sup. conductor scientists are facing challenge to keep the conductor at 0 kelvin

→ only He is used to achive low temperature required for super conductivity.

→ He is an expensive gas.

→ Efforts are made to make helium available in cheap.

Date - 06/12/2021

Chapter - 2

Semiconducting materials -

Atom:- out of the total volume of an atom most of the volume is on occupied space betn electrons.

(Q) → what in an atom holds it together?

→ why an atom doesn't collapse?

Ans → The atom is held together by the attraction of ~~negatively charged~~ positively charge e to the +vely charged nucleus in their respective orbits. It exercizes a centrifugal force which is exactly counter balances the attractive force of the nucleus.

(2) Since nucleus contains protons which have +ve charges.
→ Hence like charges repoil with each other.

(3). The nucleus should fly apart but it doesn't why?
→ Repoiling forces in the nucleus is counter balanced by a force of attraction in the nature which is yet not understood by the scientist.

Conductors & Insulators:-

→ All matter are classified into
(i) conductors.
(ii) semi conductors.
(iii) Insulators.

This classification based on the outermost orbit of the atom.

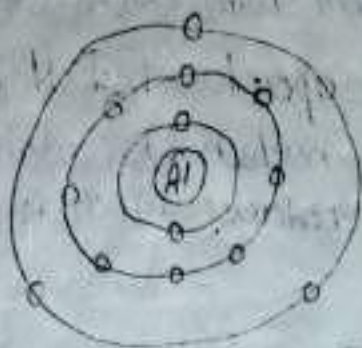
→ when voltage is applied across the material the orbiting electron in the outermost orbit experiences a force of attraction towards the +ve terminal of the applied voltage.

→ Hence the depending upon the distance betn valancy e⁻ from the nucleus and the no. of e⁻ in the valancey ring the valancy electrons may or may not be pulled out of orbits under pressure of the externally applied voltage.

→ For ex:- silver 47

cupper - 29

Al - 13



→ smaller the no° of valancy electrons greater is the tendency to leave the parent atom.
→ more no° of orbits means more is complex is the atoms.
→ when the orbit is full with all 8 electrons very high voltage has to be applied to cause the valancy e⁻ to leave their orbits
→ The best conductors are those which are more complex and have less no° of valancy electrons.

Ag > copper > Alluminium.

→ Good conductors usually haves 1, 2 or 3 valancy electrons.
→ when voltage is applied across a conductor electron flow is easily created.
Ex - silver, gold, Ag, Allumium, graphite, Ionic compund dissolved in waters.

Insulator

→ Insulators are materials that oppose the free flow of electron from atom to atom and molecule to molecule
→ Insulator does not allow free of flow of e⁻ when voltage is applied.
→ Best insulators have valancy rings continuous 8 electrons.
Example of insulators :- wood, plastic, glass, paper.

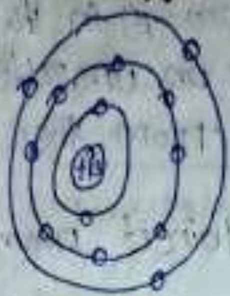
Semiconductor

A Semiconductor neither a good Conductor nor a good insulators.

Ex:- Germanium ; Silicon.

(Valancy electron is 4 for both.)

Electron energy and energy band theory -



Bohr model of AL

Simplified energy level Representation of the shell.

Date:-09.12.2021

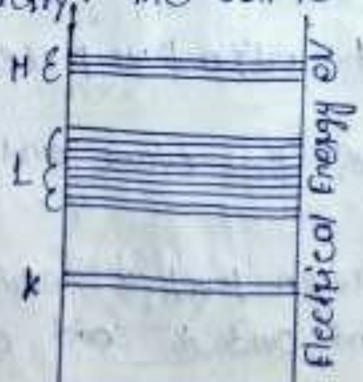
* Energy level of electron total energy -

Deffn:- An electro. revolving around the nucleus of an atom has potential energy centrifugal energy, rotational energy & magnetic energy, all of which together determine the total energy of the energy level of an electron. This value is measured in electron volts. commonly expressed as eV.

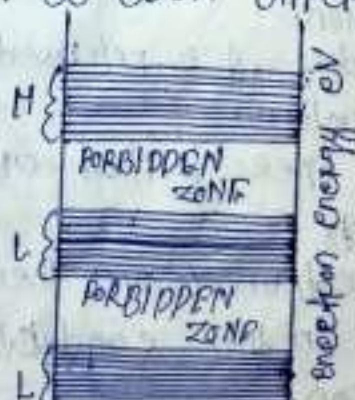
electron volt:-

→ It is defined as that amount of energy gained or lost when an electron moves with or against a potential difference of one volt.

→ The larger the orbit in which an electron revolves the greater is its en-ergy. electrons with least energy are on with the K level it is nearest with the no to electron exactly the same orbit. so each different electron.



(a) Energy levels of a Typical Atom



(b) Energy Levels Grouped as Bands

So in the diagram have been energy levels have group into energy band.

FORBIDDEN ZONE

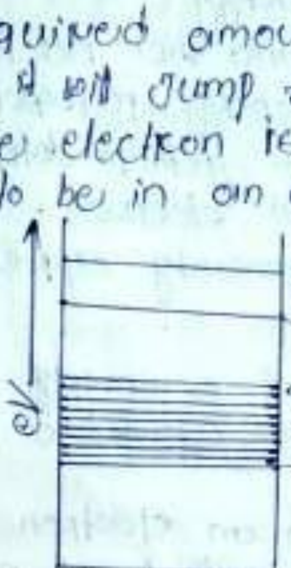
→ The area between are called energy gap FORBIDDEN ZONE. Here No of electron can have an energy.

Excitation of atoms:-

→ When each electron in an atom is in its normal orbit, the atom is said to be in an unexcited state.
→ To move an electron further away from the electron its an energy.

* The additional energy can be obtained from any of the following -
① Light. ② Heat.
③ Electrostatic. ④ Magnetic.
⑤ Kinetic.

→ If a required amount of heat energy is absorbed by electron it will jump to a higher energy level.
→ When the electron is in the higher energy level, the atom is said to be in an excited state.

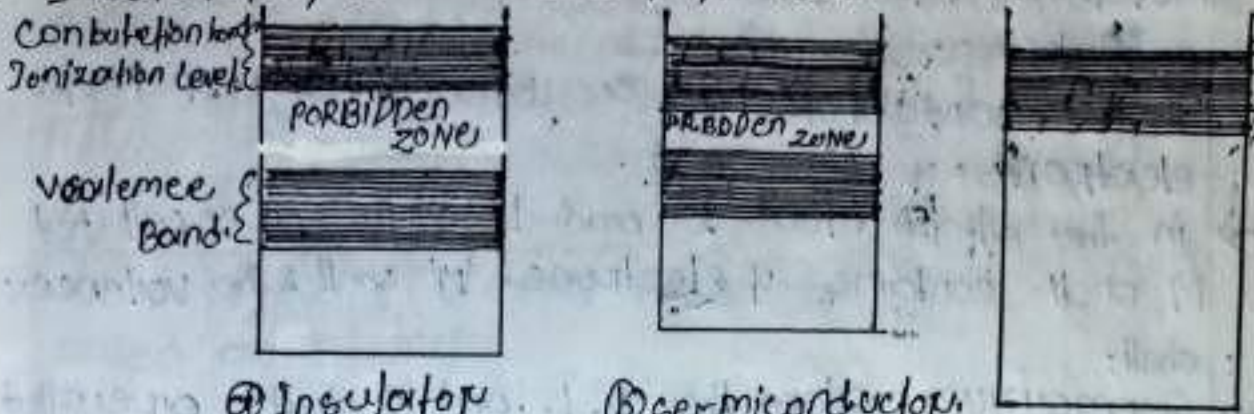


(Energy Band Representation of Ionization)

→ When required it absorbed by a valence electron it will live the valence band and may upto by the Ionization.
→ If it does, it is released from the attractive forces of the nucleus.
→ It is free to float around betn the atom and to conduct.
→ An electron above the ionization level is said to be in the conduction band and is said a free electron.

→ Ionization means when an electron of the valency valence band, the remaining atom is no longer but has a positive charge and is called a positive ion.

* Insulators, semiconductor, & conductors:-



(a) Insulator. (b) semiconductor. (c) conductor.

a. Fig 1 · Insulator -

→ Forbidden zone betn the valence band the conduction band its in quite large.

→ This indicate that electrons in the valence band require large amount of additional energy to move ~~upto the~~ and conduction become free.

→ As long as the valence electrons are unable ~~shows that in the case of semiconductors~~ to move upto the condution band there can be no electron flow.

* Conductor.

→ In a conductor.

→ In the better conductor may overlap.

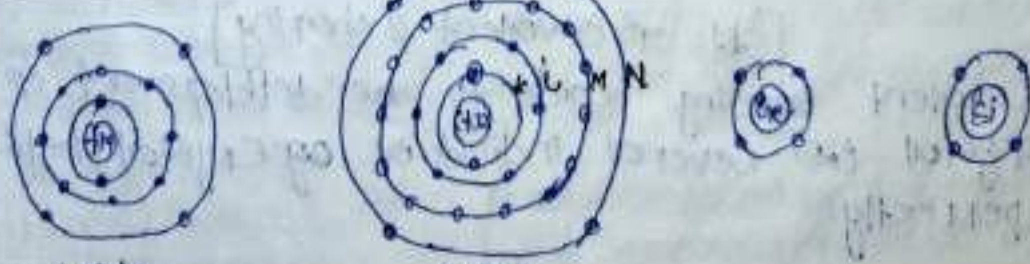
→ Electrons from the valence ring may be moved into the conduction zone by a small amount of energy.

* Semi-conductors.

→ In case of semiconductors forbidden zone is reduced.

→ Hence the valence electron required less energe to free them selfs from attractio of the nucleus.

Semiconductors materials -



(Si) (Ge)

→ The (a) shell Arrangements for silicon and Germanium) (b) (Simplified Si and Ge Atoms)

→ The electrical characteristics of semiconductor materials far between those of insulator and conductors.

→ A semiconductor has a valence ring of four electrons.

→ in the silicon atom K and L shells are full but M shell contains 4 electrons. 'M' shell is the valence shell.

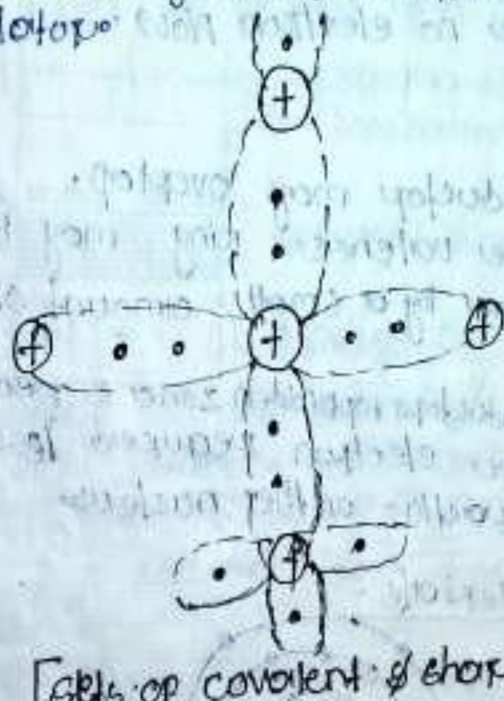
→ Germanium atom the K, L, and M shell are filled and the N shell is the valence shell containing four electrons. shell is the 'N' shell.

COVALENT BONDS –

when each atom shares electrons to fill its valancy ring with 8 electrons is called covalent bond.

→ Each bond with 2 electrons in an electron pair bond.

→ when atoms enter into covalent bonding each atom in effect has 8 valency electrons Hence is it makes it a good insulator.



[Skts of covalent & sharing]

(1) covalent bonding leads to the development of a polycrystal i.e. several individual of crystal held together perfectly.

The extra atoms are not properly loked in place and there are missing atoms in some parts of the structure.
(ii) Due to impurities their may be extra electrons which can't lock into the covalent bond structure. so, Materials having covalent bonds doesn't have a perfect crystal structure is not a good insulator but a poor insulator. It is called semi-conductors.

Intrinsic semiconductors- (silicon, germanium)

→ If a crystal contains only one type of atom it is called an intrinsic

Hole movement caused by valency electrons.

when temperature is less than 0K or -273°C this intrinsic material will act as a good insulator.

→ when intrinsic semiconductor operate on a room temperature valency electrons produces which makes it conductors.

→ when an electron is freed from the atom of an intrinsic material it breaks a covalent bond leaves a valancy called Hole.

→ The free electron and the hole form an electron hole pair.

→ Higher the temperature greater the free electrons and greater the no of holes.

(a) → what is hole?

→ It means loss of an electron & it is +vely charged.

→ when voltage is applied to an intrinsic material it acts as a conductor.

→ The free electrons move from -ve terminal to +ve terminal of the voltage source. The holes created by free-e...

fixed and don't move they appear to move from +ve to -ve terminal.

→ current flow in a semiconductor is a composed of free e⁻ movement & hole movement.

Extrinsic semiconductor –

→ Intrinsic semiconductor have less applications.

→ To make a material function as a semiconductors some impurities are add in a controlled manner.

→ This addition of impurities to an intrinsic semiconductor is called.

~~What is doping level?~~

doping –

→ A material which has be been doped is called an extrinsic material.

Imp. What is doping level?

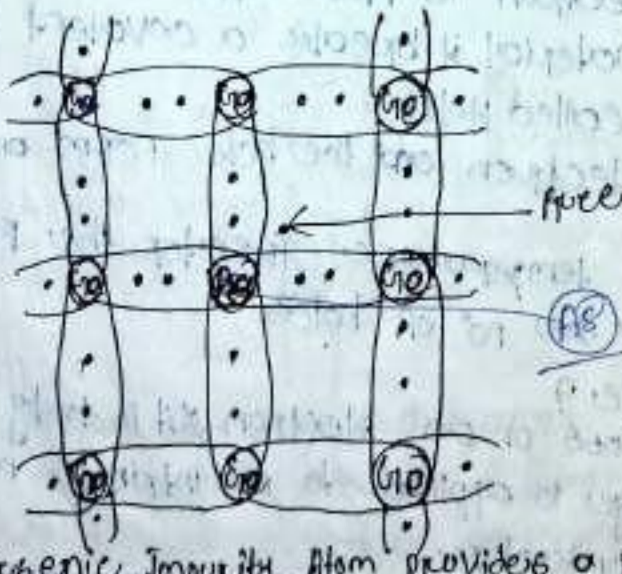
→ The extend to which the impurity has been added is called doping level.

→ Extrinsic semiconductors are of two types :-

① N-type semiconductor.

② P-type semiconductor.

① N-type semiconductor.



(Arsenic Impurity Atom provides a fifth Electron That cannot Enter the covalent Bond structure)

→ Those impurities that have 5 valency electrons is called pentavalent impurities.

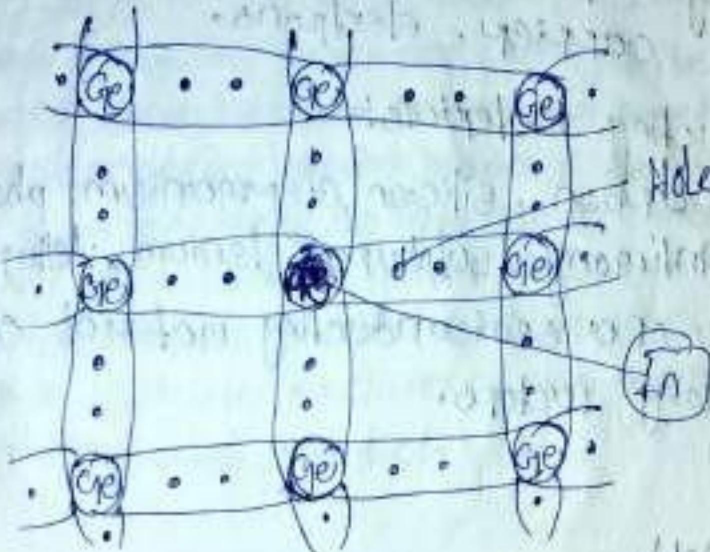
Ex:- Antimony, Arsenic, phosphours.

→ when a pentavalent impurities added to an intrinsic material only 4 of its valancy electrons lg into co-valent bond.

→ 5th valency electron of the impurity atom is free to wander through the crystal. since pentavalant atom donet an extra electron atom they are called doner impurity.

→ A material doped with a doner impurity has excess of electron in its structure is called N-type material.

<u>P-type semiconductor-</u>



(In P-Type material an Indium Impurity Atom creates a Hole in the covalent Bond structure to provided an Attraction for an electron)

→ Those Impurities that have three valancy electrons are called equivalant groups.

Ex- Alluminium, Galium, Indium.

→ when added to intrinsic materials they lock into the crystal structure.

→ Since the impurities has 3 valancy electrons there is a hole in the covalent bond due to log of an electron. Since their is lacke of electron and accepts electron from known as this type of impurities are Accepted.

→ Intrinsic materials doped with a trivalent impurity i.e called positive or p-type semiconductor.

Majority & Minority carriers:-

N-type material:-

Majority carrier - electrons.
Minority carrier - holes.

p-type material:-

Majority carrier - holes.
Minority carrier - electrons.

Semiconducting materials:-

Boron, carbon, silicon, Germanium, phosphorous, Arsenic, Antimony, sulphur, selenium, tellurium, Iodine.

→ Resistance of a semiconducting material can be contr by the following factors.

① Illumination
② voltage.
③ electric field.

Semiconductors can be classified as:-

① mono-crystals-

Ex.- carbon, silicon, germanium.

② poly-crystals-

Ex- selenium, tellurium, Antimony; Arsenic, phosphorous oxides of such metals such as copper, zinc, titanium, tungsten, molebdenum.

→ sulphides, selenides & tellurides · of lead, copper, cadmium & other elements.

→ chemical · compounds of · certain elements like alluminium, gallium, indium..

Applications of semiconductor materials -

① Rectifiers -

Germanium & silicon Rectifiers -

A p-type & N-type material are joined together to from a junction called p-n junction when an external voltage is applied across the two materials a flow of currents if the +ve & -ve terminals of the voltage source are connected to the extrinsic of p & n type material.

voltage applied in this was is called forward bais.

→ The applied voltage is reversed the positive of the supply voltage is connected to the N-side the negative of the supply voltage is connected to the N side & the -ve of the supply voltage is connected to the p side. there is no flow of current this is called reversebiasing.

→ Thus semiconductors can be used as rectifiers.

→ Modern p-N junction rectifiers use germanium or silicon as the semiconductor material.

→ surface resistance depends upon humidity.

Effect of various factors on insulation resistance–

→ Insulation resistance is affected by temp. variations.

→ Exposer to moisture decreases insulation resistance.

→ It is affected by voltage

→ Insulation decreases with ageing.

~~Dielect~~ Dielectric strength:-

→ when operating voltage in increase gradualy at some value of voltage the insulation property will damage or break down. so the property which attributes to such type of breakdown, so, property ~~will damage or break down~~, so which attributes to such type of breakdown is called Dielectrical strength.

→ Di-electric strength is the maximum potential difference that the material can without.

→ Its unit is volt per unit thickness of the insulating material.

Factors affecting di-electric strength:-

→ Di-electric strength decrease with increase in temp.

→ humidity decrease dielectric strength.

Dielectric constant:-

we know that $\boxed{Q = CV}$

where Q = storing charg

V = voltage

C = capacitance.

→ capacitance is different for different materials.

→ The property of insulating material that causes the difference in the value of capacitance, physical dimensions is remaining same is called the dielectric constant permitivity.

$$C = \frac{A}{d}$$

$$\boxed{C = \epsilon \frac{A}{d}}$$

where.

C = capacitance.

A = surface area of insulation.

d = distance betn two places.

ϵ = permittivity / dielectric constant.

$$\boxed{\epsilon = \epsilon_0 \epsilon_r}$$

ϵ = permittivity

ϵ_0 = " in vaccume.

ϵ_r = " of material.

<u>visual properties:-</u>

→ visual properties are
① appearance ⑪ colours.
③ crystalinity.

<u>mechanical properties:-</u>

→ mechanical strength :- Mechanical strength of an insulating material depends upon a Number.

1. <u>Temp rise:-</u>
Temp rise gives :