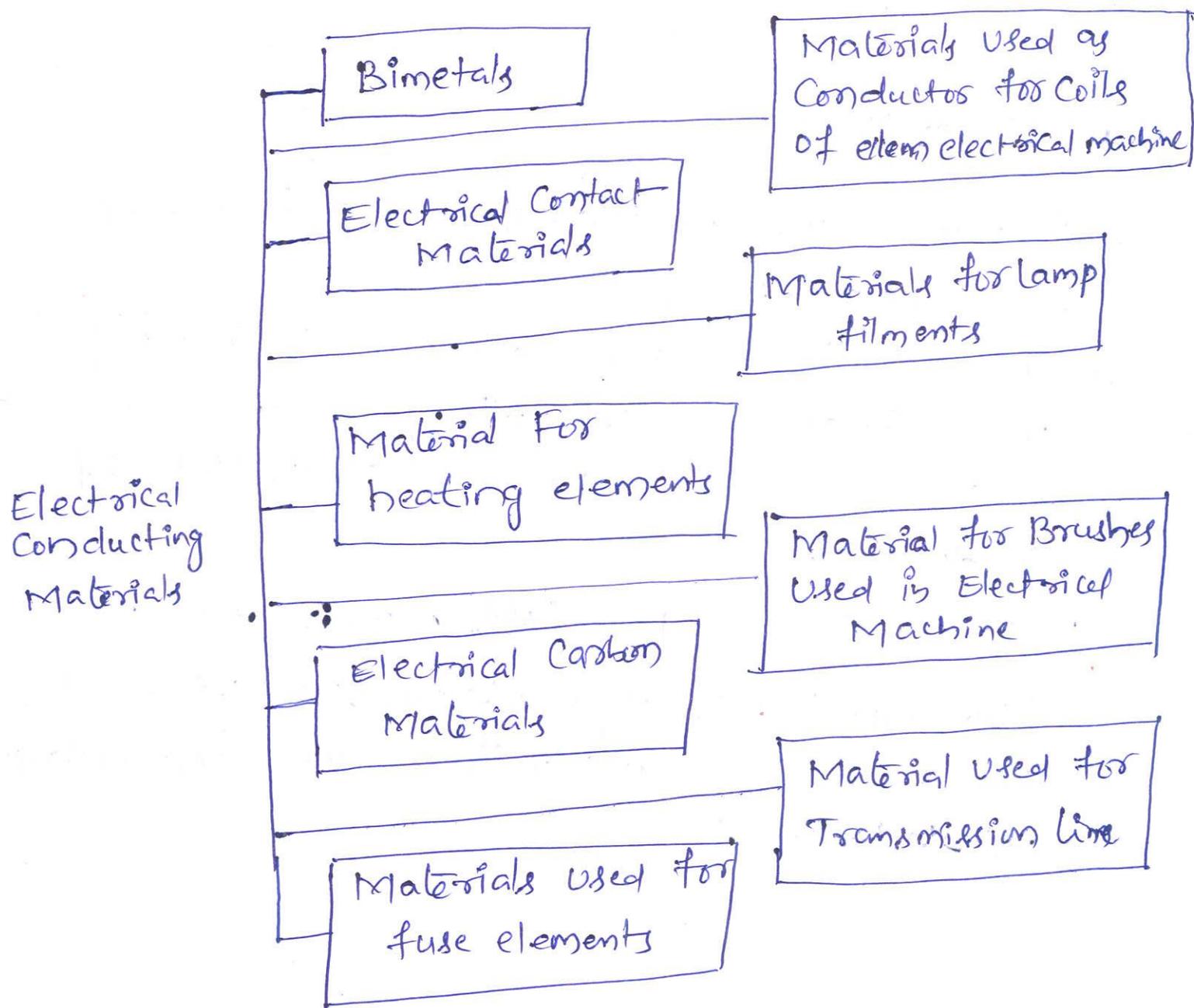


Electrical and Electronic Materials:-

Classification of Electrical Materials:-



→ Materials used in the field of Electrical Engineering are called the Electrical Engineering Materials

→ Based on properties and all of applications Electrical Engineering materials can be classified

1. Conductors
2. Semiconductors
3. Insulators
4. Magnetic Material

*1. Conductors:-

→ Conductors are the materials which have very high conductivity.

→ the number of free electrons are very high in a conductor at room temperature, which is the basic reason of high conductivity of conductors.

Ex: - Silver, Copper, Gold, Aluminium etc.

The number of free electrons are very high in silver, which makes the silver a best conductor of electricity.

Magnetic Materials:-

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- These Materials play an important role for existence of various electrical Machines.
- The Magnetic Materials having high permeability are used for building the core to form the low reluctance path for Magnetic flux.
- Magnetic Materials can be further divided in following categories

- * Ferromagnetic materials
- * Paramagnetic materials
- * Diamagnetic Materials
- * Antiferromagnetic materials
- * Ferrites

ferromagnetic Materials:-

- These materials are having very large and positive susceptibility to external Magnetic field.
- They are having a strong attraction to external Magnetic field and are able to retain Magnetism even after removal of external Magnetic field.
- This property of Materials is called Magnetic hysteresis

Exam:- Iron, Cobalt, Nickel

Unit-3, Pg-3116

Semiconductors:-

- Semiconductor are Materials which have the Conductivity between Conductors and Insulators
- Semiconductors are the elements of group - (II) group - (IV) and group - (IV), elements.
- Semiconducting materials have covalent bond.
- At normal temperature the Conductivity of semiconductors is very low.
- With increase in temperature the Conductivity of semiconductors increases exponentially.

Example:- Germanium, Silicon, Gallium ~~As~~ Arsenic

Insulating Materials:-

- The Conductivity of insulating materials is very low.
- these material are having a very high resistivity which makes them very suitable to insulate the current carrying parts from earthed metallic structure.
- In insulating materials the electrons are tightly bounded with nucleus.
- Due to which they cannot be freed for movement in materials.
- Due to which the resistivity of insulating materials is very high.

Exp:- plastics, Ceramics, PVC, etc.

Antiferromagnetic Materials:-

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- These materials are having a very small and positive susceptibility to external magnetic field. In the presence of external magnetic field.
- ~~then these~~ these materials get slightly magnetized in the direction of the external magnetic field.
- In these materials, atoms are having mixed parallel and anti parallel aligned magnetic dipole movement.

Exs:- Cr, MnO, FeO, CoO, NiO, Mn etc.

Ferrites:-

- These materials are having very large and positive magnetic susceptibility like ferromagnetic materials.
 - These materials are generally compounds which are having more complex crystal structures than a pure material.
 - As ~~compared~~ compared to ferromagnetic materials, ferrites are having lower magnetic saturation.
- Ex:- Fe_3O_4

Plaxxx

(3)

Paramagnetic Material:-

- These materials are having very small and positive susceptibility to external magnetic field.
- In the presence of external magnetic field, these materials attain very small magnetism.

Ex:- platinum, Aluminum, ~~Aluminum~~

Diamagnetic Materials:-

- These materials are having very weak and negative magnetic susceptibility to external magnetic field.
- On application of external magnetic field these are repelled slightly by the external magnetic field.
- These ~~mag~~ materials do not retain the magnetism after removal of external magnetic field.

→ Mostly all metals i.e

- silver
- Copper
- gold
- hydrogen

Pyroelectric Materials

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→ Pyroelectricity of or pyroelectric materials is an electric response of polar dielectric with a change in temperature.

→ if the temperature is return changes it causes the movement of atoms from their neutral position hence the polarization of the material changes, we observe a voltage across the material.

→ this effect is temporary now suppose the temperature remains constant at its new value

→ The pyroelectric voltage becomes zero due to the leakage current.

→ Hence pyroelectric effect takes place below the 1070 -degree F Curie temperature, so when the material is heated above Curie temperature 1070 degree F.

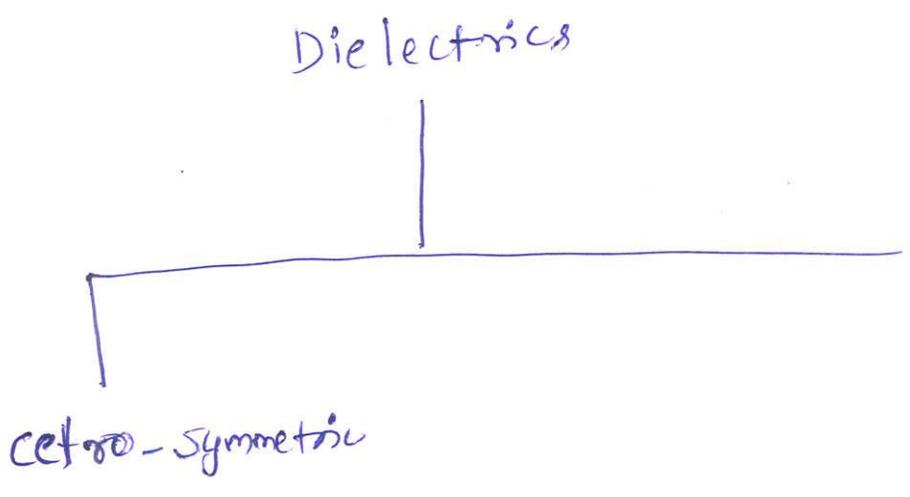
List of Pyroelectric Materials:

- Tourmaline
- gallium nitride
- cesium nitrate (CsNO_3)
- polyvinyl fluoride
- derivatives of phenyl pyridine
- cobalt phthalocyanine
- lithium tantalite (LiTaO_3)

Difference between piezoelectric, pyroelectric and Ferroelectric materials:

Parameters	Piezoelectric	pyroelectric	Ferroelectric
Function	→ piezoelectric Material generate electricity whenever Mechanical stress is applied	→ pyroelectric material generate electrical potential whenever heated or cooled	→ Ferroelectric Material exhibi. electric polarisation even in the absence of an electric field
Examples	Quartz, Crystal Ammonium phosphate	Quartz crystal Ammonium phosphate	Lithium niobate, Barium Titanate

<p>Properties</p>	<p>Non-centrosymmetric Non-polar dielectric</p>	<p>they are unidirectional polarization Non-centrosymmetric</p>	<p>they are easily polarized They are both pyro and piezoelectric in nature</p>
<p>Application</p>	<p>→ Acts like a c. Transducer → used in microphone → it generate ultrasonic ultrasonic waves</p>	<p>→ IR detectors → image tubes → Temperature sensing element</p>	<p>ultrasonic transducers → They are pressure Transducer → it acts as a memory device like a random access memory</p>



Extrinsic Semiconductor

Intrinsic Semiconductor

1) Chemically impure form of a semiconductor is called extrinsic semiconductor.

2) Conductivity is high.

3) Number of holes is not equal to the number of electrons.

4) Conductivity is mainly due to majority charge carriers.

Types of Semiconductors:

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Semiconductors can be classified as:-

- (1) Intrinsic Semiconductor
- (2) Extrinsic Semiconductor

Extrinsic semiconductor are further
classified as:-

- * a. n-type semiconductors
- b. p-type - semiconductors

(1) Intrinsic Semiconductor :-

- Silicon, germanium, and gallium arsenide are the primary materials used in semiconductor devices.
- Silicon and germanium are elements and are intrinsic semiconductors.
- In pure form, silicon and germanium do not exhibit the characteristics needed for practical solid-state devices.

(2) Intrinsic Semiconductors :-

- When a small amount of a suitable impurity is added to the pure semiconductor the conductivity of the semiconductor is increased manifold.

Extrinsic Semiconductor:

- In an extrinsic semiconducting material the charge carriers originate from impurity atoms added to the original material is called impurity (or) extrinsic semiconductor.
- this semiconductor obtained by doping TRIVALENT and PENTAVALENT impurities in a TETRAVALENT semiconductor.
- The electrical conductivity of pure semiconductor may be changed even with the addition of few amount of impurities.

Semiconductors in summary:-

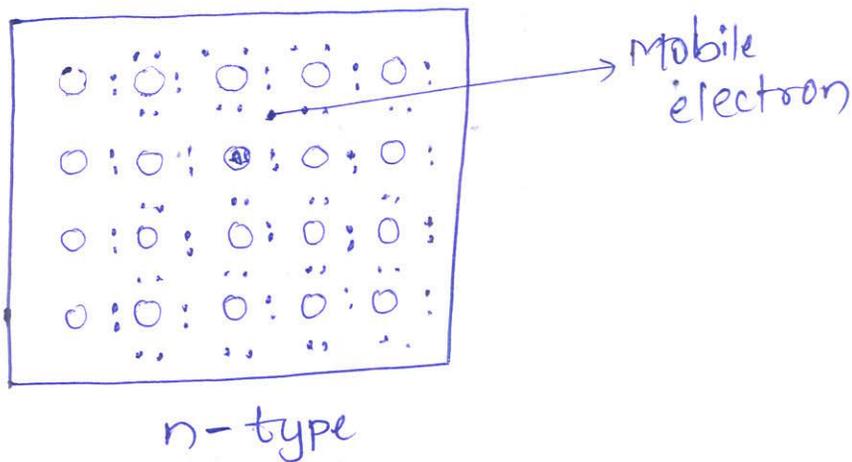
- the most widely used material is Silicon
- pure crystals are intrinsic semiconductors
- Doped crystals are extrinsic semiconductors
- Crystals are doped to be 'n' type or 'p' type
- 'n' type semiconductors have few minority carriers (holes)
- 'p' type semiconductors have few minority carriers (electrons)

semiconductor:-

these are the solids with conductivities in the intermediate range from $(10^6 \text{ to } 10^4 \text{ ohm}^{-1} \text{ m}^{-1})$

* n-type semiconductor:-

When a silicon or germanium crystal is doped with group 15 element like P or As, the dopant atom ~~forms~~ forms four covalent bonds like a Si or Ge atom but the fifth electron, not used in bonding, becomes delocalised and contribute its share towards electrical conduction. Thus silicon or germanium doped with P or As is called n-type semiconductor 'n' indicative of negative, since it is the electron that conducts electricity.



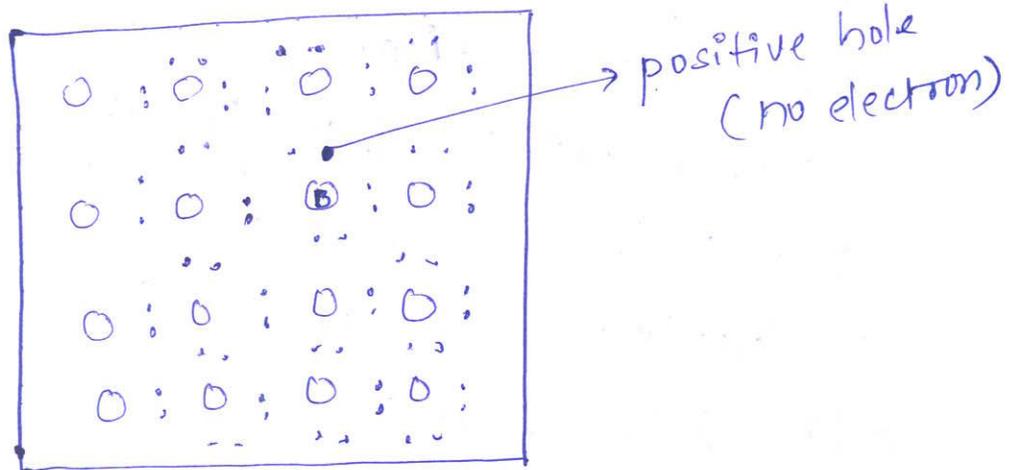
* P-type semiconductor:-

→ When silicon (or) germanium is doped with group 13 element like B (or) Al, the dopant has only with three, valence electrons.

→ An electron vacancy or a hole is created at the place of the missing fourth electron

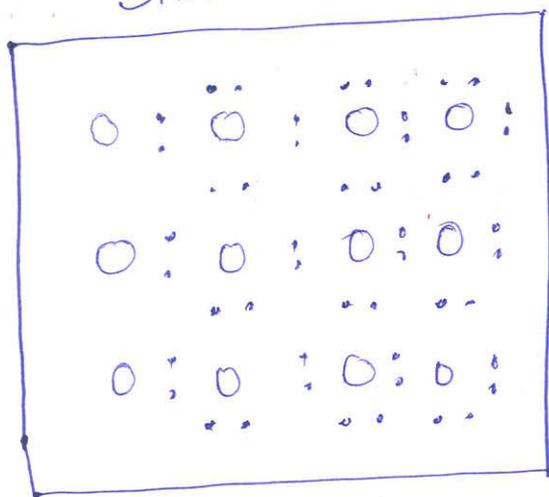
this hole moves through the crystal like a positive charge giving rise to electrical conductivity

→ Thus Si (or Ge) doped with B (or Al) is called P type of semiconductor, (P stands for positive hole) since it is the positive hole that is responsible for conduction



P-type

silicon atom



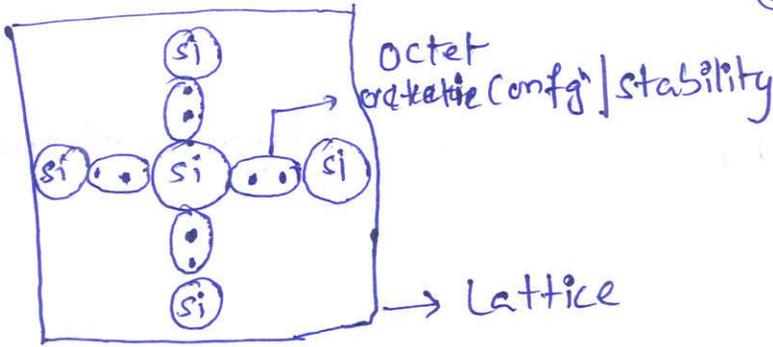
Perfect crystal

Intrinsic & Extrinsic Semiconductors:-

Intrinsic semiconductor:-

- They are pure semiconductors
- free electrons are only due to natural causes.

$Si = 1s^2 2s^2 2p^6 3s^2 3p^2$ (this is electronic configuration)
 ↑ ↑ (out most orbit)



s type - 2 } electron
 p type - 2 }

Conductor → +ve Temperature Coefficient → Temperature ↑ R ↑

Semiconductor → -ve Temperature Coefficient → Temp ↑ → R ↓

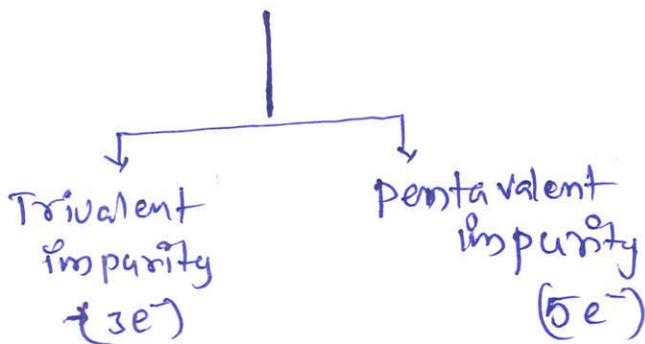
Extrinsic semiconductor:-

- Impurity atoms are added
- Two types of impurities
- process of adding certain impurity atoms to pure semiconductor is doping

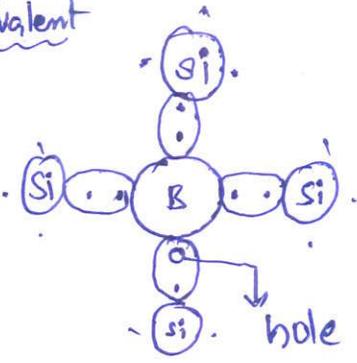
periodic Table

3G	4G	5G
B	C	N
Al	Si	P
Ga	Ge	

- Trivalent → P-type semi
- Pentavalent - N-Type semi



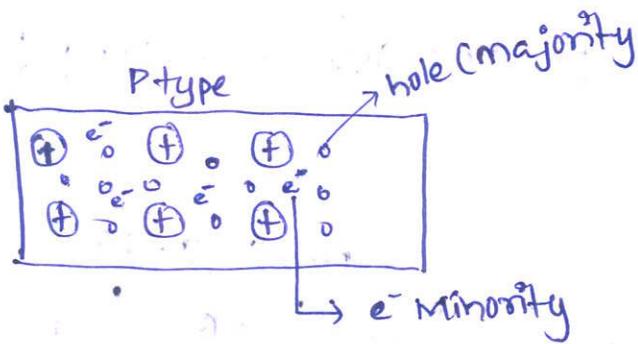
Trivalent



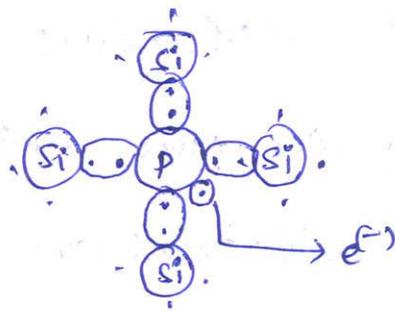
→ majority charge carrier = hole

→ P-type semiconductor

structural dig



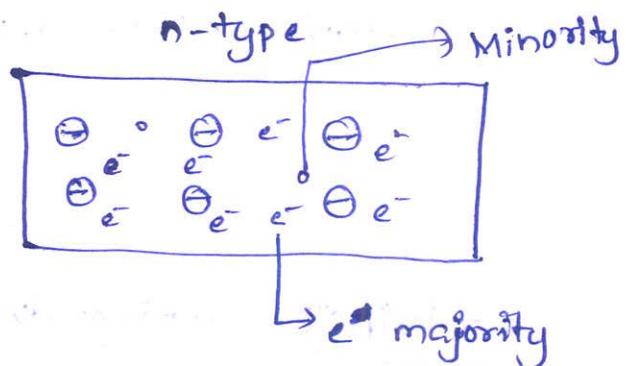
pentavalent



minority charge carrier = e^-

→ n-type semiconductor

structural dig



\oplus	→ acceptors
\ominus	→ donors