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MADE EASY
ELECTRONICS ENGINEERING
Material Science
By- Rohit Tripathi Sir

- Theory
- Explanation
- Derivation
- Example
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CRYSTAL STRUCTURE

- 1) Atomic Arrangement in Solids.
- 2) Cubic Crystal System.
- 3) Miller Indices.
- 4) Bravais crystal structure.
- 5) Structural Imperfections.

* ATOMIC ARRANGEMENT IN SOLIDS:

CRYSTAL: It is a solid material in which atomic or molecular arrangement is periodic.

* This property of crystal is known as CRYSTALLINITY.

* SINGLE CRYSTAL MATERIAL:

* If material is having only one type of periodical arrangement then material is called single crystal.

* These materials are ANISOTROPIC MATERIALS. For eg QUARTZ.

* POLYCRYSTALLINE MATERIAL:

* These materials are divided into no. of small regions. These regions are called GRAINS.

* Within each grain atomic or molecular arrangement is PERIODIC but this arrangement varies from one grain to the other.

For eg POLYCRYSTALLINE SILICON.

* These materials are isotropic materials.

Note: (Anisotropic & Isotropic material):-

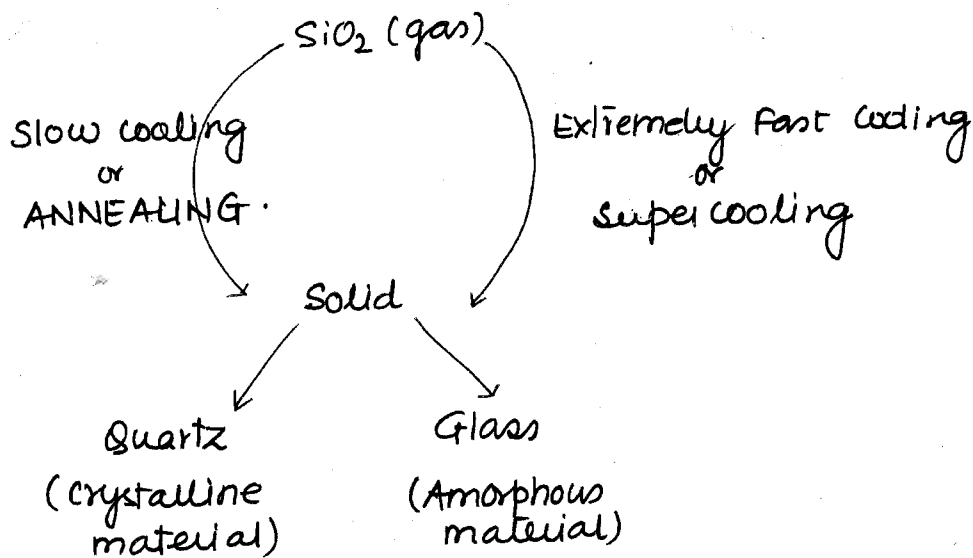
ANISOTROPIC MATERIAL :-

A material is called ANISOTROPIC if properties of material depends on the direction in which they are measured.

ISOTROPIC MATERIAL :-

* A material is called ISOTROPIC if properties of material are direction independent.

AMORPHOUS MATERIAL:



*When Atoms or molecules are not given opportunity to arrange in regular or periodic manner, an AMORPHOUS MATERIAL may be formed.

For eg: Supercooled state of SiO_2 is known as GLASS. (AMORPHOUS MATERIAL).

*Whereas on ANNEALING, SiO_2 may crystallize into QUARTZ. (CRYSTALLINE MATERIAL).

In other cases, molecules may be extremely long and irregular in shape so that periodical arrangement may not be obtained as in the case of POLYMERS.

EPITAXIAL PROCESS:

*The process of growth of a layer of Silicon on a substrate is known as EPITAXIAL PROCESS.

1) In a Si Crystal, arrangement of atoms repeats periodically. This material can be classified as:

- Epitaxial & Amorphous.
- Polycrystalline & Amorphous.
- Single crystal & Amorphous (material can't be both).
- Epitaxial & Single crystal.

CRYSTAL SYSTEM:

1) UNIT CELL:

* It is defined as the minimum Area cell in Two dimension or the minm volume cell in 3-dimension, by repetition of which a crystal may be formed.

2) PARAMETERS OF UNIT CELL:

a) CELL DIMENSION

b) Angle between axis

c) no. of atoms per unit cell.

d) Co-ordination number.

e) Atomic Packing factor (APF).

Mathematically :-

$$\text{APF} = \frac{\text{Total Atomic Volume}}{\text{Vol. of unit Cell.}}$$

$$\text{APF} = \frac{\text{No. of atoms per unit Cell} \times \text{atomic Vol.}}{\text{Vol. of unit Cell.}}$$

* Co-ordination number:

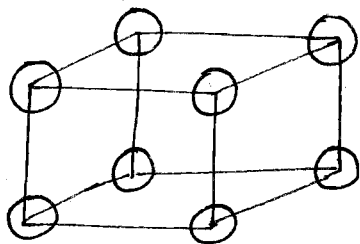
* The no. of atoms which are in physical contact with a particular atoms in a crystal structure, is known as CO-ORDINATION NUMBER:-

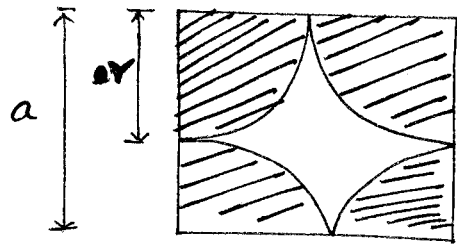
* CUBIC CRYSTAL SYSTEM:

1) SIMPLE CUBIC:

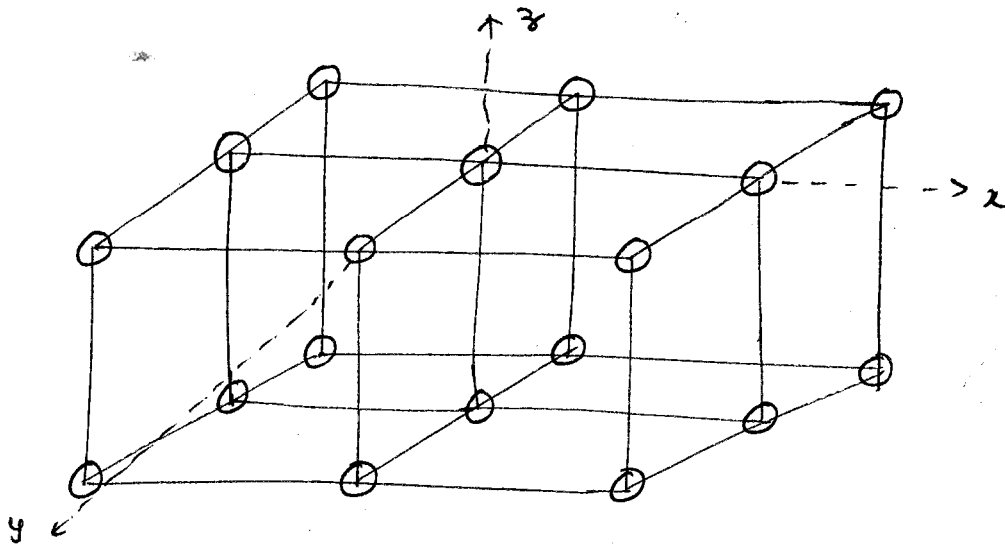
* In Simple cubic there are 8 corner atoms.

* Atoms are in physical contact along EDGE of the cube.





$$a = 2r$$



No. of atoms per unit cell = $8 \times \frac{1}{8} = 1$

$$\text{APF} = \frac{1 \times \frac{4}{3} \pi r^3}{a^3} = 0.52 ; a = 2r$$

Co-ordination number = 6. ← 2 atoms in contact in each direction.

* For eg.:

- i) Manganese
- ii) Fluorspar etc.

Body centered cubic (BCC) :-

* In BCC there are 8 corner atoms and 1 Body centered atom.

* Atoms are in physical contact along Body diagonal.