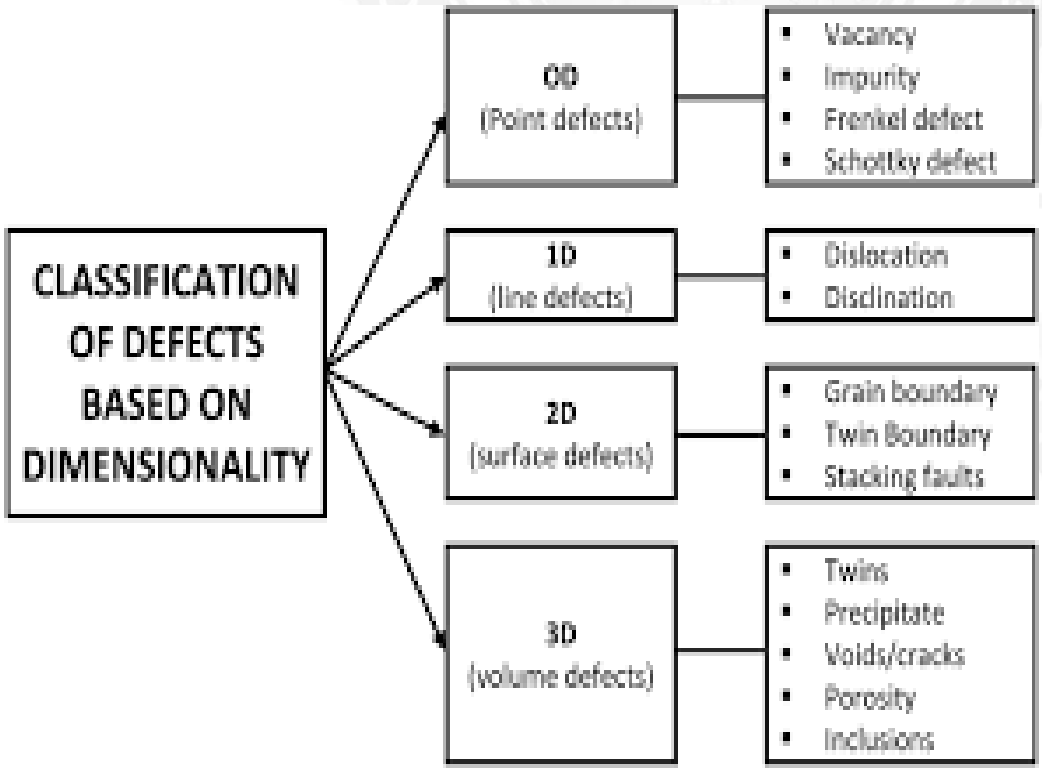
CRYSTAL IMPERFECTIONS

Any deviation in the regular geometrical arrangement of atoms in a crystalline solid is known as crystal imperfections or crystal defects.

An ideal crystal is one contains no lattice defects. However, ideal crystals neither occur in nature nor can be produced by artificial methods. Thus no crystal is perfect. The defects are always present in actual crystals and their effects are very important in understanding the properties of crystals. This is because many important properties of materials such as mechanical strength, crystal growth, magnetic hysteresis, dielectric strength, behavior of semiconductors, etc., are greatly affected by the presence of defects in crystals.

CLASSIFICATION OF CRYSTAL IMPERFECTIONS

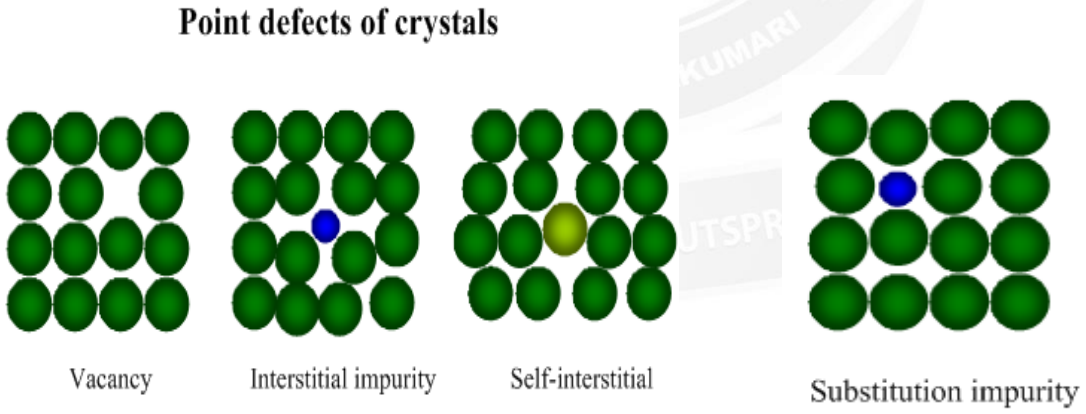


1. POINT DEFECTS

- The defects which takes place due to imperfect packing of atoms during crystallization are named as point defects.
- They are imperfect point-like regions in the crystal and hence they are called as zero-dimensional defects.
- They produce distortion inside the crystal structures.

VACANCIES

- A vacancy is the simplest point defect in a crystal. This refers to a missing of atom or a vacant atomic site.
- This defect may arise due to imperfect packing during original crystallization and thermal vibrations of atoms at high temperature.
- The vacancies may be single vacancy or di-vacancies or trivacancies and so on.

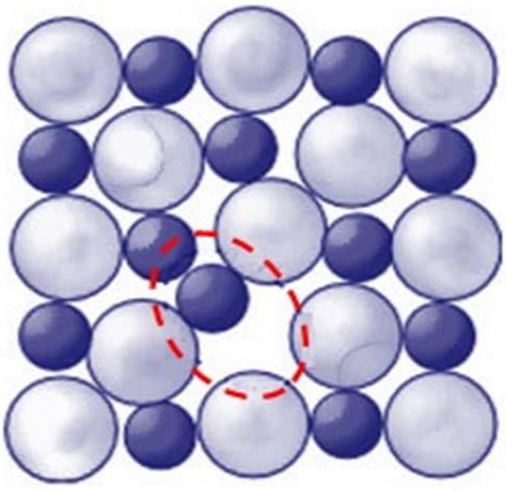


SCHOTTKY DEFECTS

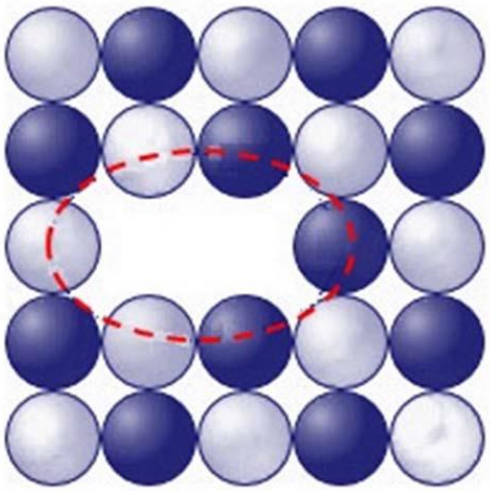
- When a pair of anions and cations is missing from an ionic crystal is called Schottky defects.
- This is equivalent to divacancies i.e., anion vacancy and cation vacancy.
- In this type of defect, the crystal is electrically neutral.

FRENKEL DEFECTS

- ✓ This is due to shift of cation from the regular site to the interstitial site.
- ✓ This is so because the cation being small, it can be easily accommodated in the void space.
- ✓ It always occurs ionic crystals.
- ✓ It is temperature dependent and electrical conductivity is increased.



Frenkel defect



Schottky defect

INTERSTITIAL DEFECT

- Interstitial defect is created when an extra atom occupies the interstitial position without replacing the parent atom in the crystals.

TWO TYPES OF INTERSTITIAL DEFECT

I. Self-interstitial defect 2. Foreign interstitial defect

SELF-INTERSTITIAL DEFECT

- If an atom from same crystal occupies interstitial site, then it is called self-interstitial defect.

FOREIGN INTERSTITIAL DEFECT

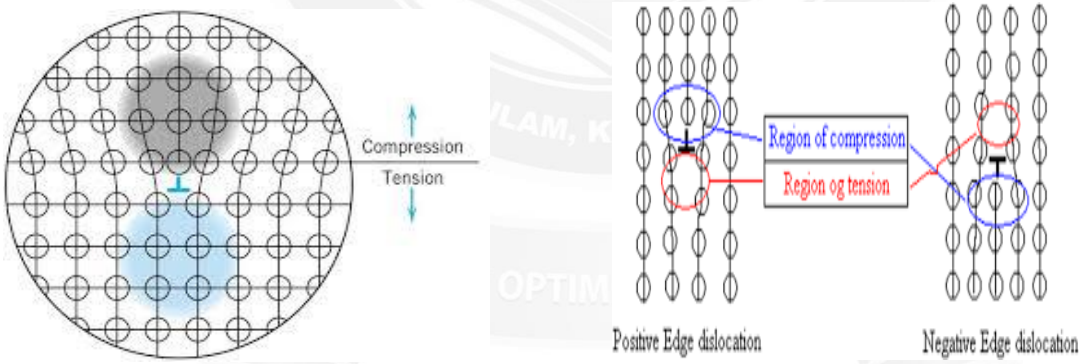
- If an impurity (foreign) atom occupies interstitial site, then it is called foreign-interstitial defect.

IMPURITIES

- ❖ Impurity defects are foreign atoms introduced into a crystal lattice either as an interstitial or a substitutional atom.
- ❖ Interstitial impurity is created when impurity atom occupies in the interstitial position without replacing the parent atom in the crystals.
- ❖ When impurity atom replaces the parent atom in the atomic lattice, substitutional impurity is formed.

II. LINE DEFECTS

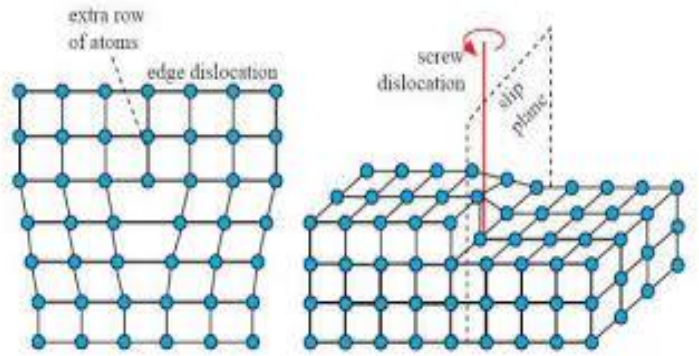
- ➢ The defects which take place due to dislocations or distortion of atoms along a line in some direction is called line defect.
- ➢ This is also called as one dimensional defects.
- ➢ The two basic types of dislocations are:
  1. Edge dislocation 2. Screw dislocation



EDGE DISLOCATION

- An edge dislocation is formed if an extra half plane of atoms is introduced between the planes of the atoms in a perfect crystal.
- The position of edge dislocation is marked by the symbols $\perp$ *or* $\top$
- If the extra plane of atoms is above the slip plane of the crystal are called positive edge dislocation.

- If the extra plane of atoms is below the slip plane of the crystal are called negative edge dislocation.
- Burger vector is always perpendicular to the dislocation line.



SCREW DISLOCATION

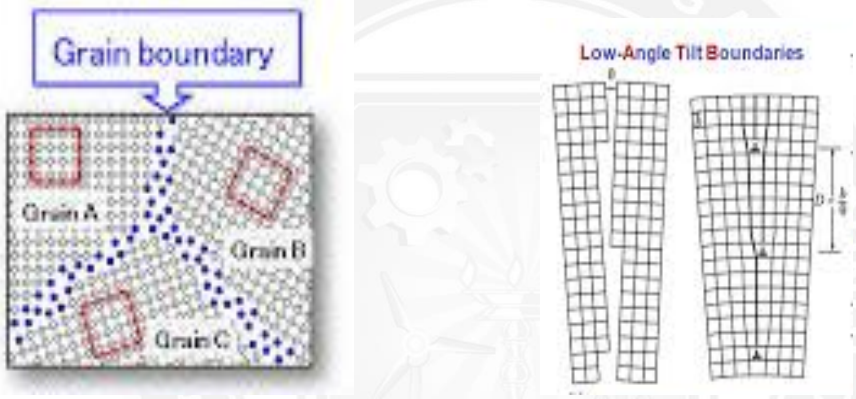
- Screw dislocation results from a displacement of the atoms in one part of a crystal relative to the rest of crystal forming a spiral ramp around the dislocation line.
- When the atoms are displaced in two separate planes perpendicular to each other, the imperfection produced is called screw dislocation.
- Burger vector is always parallel to the dislocation line.
- If the spiral motion of the dislocation line is in clockwise direction then it is called right handed screw dislocation.
- If the spiral motion of the dislocation line is in anti-clockwise direction then it is called left handed screw dislocation.

III. SURFACE DEFECTS

- ✓ The defects which take place on the surface of the materials are called surface defects.
- ✓ They are also called as two dimensional defects.
- ✓ The following are the different types of surface defects.

GRAIN BOUNDARY

- Whenever grains of different orientation separate the general pattern of atoms and exhibits a boundary, the defect caused is called grain boundary.
- This type of defect generally takes place during the solidification of the liquid metal.
- Two types of grain boundaries are 1.High angle boundaries 2.Low angle boundaries



HIGH ANGLE BOUNDARIES

- If the orientation difference between two crystals is greater than $10-15^{\circ}$ then the grain boundary are called high angle boundaries.

LOW ANGLE BOUNDARIES

- If the orientation difference between two crystals is lesser than 10° then the grain boundary are called low angle boundaries.

TILT BOUNDARIES

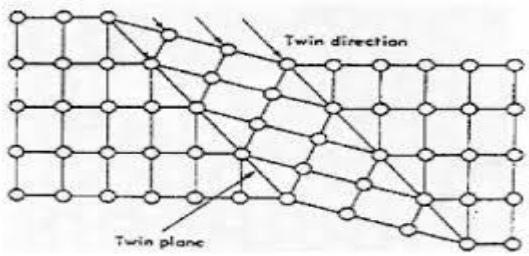
- Tilt boundaries are low angle grain boundaries. It is an array of parallel edge two dislocations of same sign arranged one above other in an array.

TWIST BOUNDARIES

- Twist boundaries are low angle grain boundaries. It consists of atleast two sets of parallel screw dislocations lying in the array.

TWIN BOUNDARIES

- If the boundaries in which the atomic arrangement in one side of the boundary is the mirror image of the atoms on the other side. The defect caused is called twin boundaries.

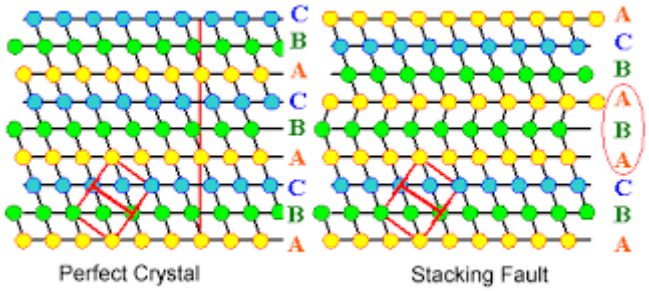


BURGER VECTOR

The vector which indicates the direction and magnitude of the shift of the lattice on the slip plane is called Burger vector.

STACKING FAULT

- It is a type of surface imperfections.
- Whenever the stacking of atoms is not in proper sequence throughout the crystal, the defect caused is known as stacking fault.
- Figure shows the proper sequence of atomic planes ABC ABC ABC ……. in a FCC structure. But figure shows the sequence of atomic planes ABC ABA BCA…..the region in which stacking fault occurs AB AB forms a thin region of HCP in a FCC crystal.



IV. VOLUME DEFECTS

- Volume defects are mainly due to porosity, inclusions and cracks.
- These defects form during manufacturing processes for various reasons and are harmful o the material.
- Presence of a large vacancy or void such as cluster of atoms missing is also considered as a volume imperfection.