

## Chapter no. 4

### Imperfections!

#### - Point Defects:-

- (i) Vacancies.
- (ii) Self-interstitials.
- (iii) Interstitial impurity.
- (iv) Substitution impurity.
- (v) Frenkel-point/pair defect

$\Rightarrow$  check detail from MM 101 L manual.

#### - Mathematical Formulas:-

Consider the following phenomena.

$$\textcircled{1} \quad \frac{\text{no. of defects}}{\text{(vacancies)}} = \exp \left( -\frac{Q_v}{kT} \right)$$

activation energy.

Boltzmann's constant  
 $1.38 \times 10^{-23} \text{ J/atom} \cdot \text{k}$   
 or  
 $8.62 \times 10^{-5} \text{ eV/atom k}$

$$\textcircled{2} \quad N_l \left( \frac{\text{no. of potential}}{\text{(vacancies)}} \right) = \frac{(N_A P)}{A_c u}$$

density of material

Avogadro's Number      atomic mass

$6.022 \times 10^{23} \text{ atoms/mol}$

Metals can be purified at 99.9999%

\* convert temp to K always!

## - What are the types of imperfections in crystalline solids.

Zero dimension (an atom missing)

One dimension (a segment of a line of atoms missing)

Two dimension (a part of plane of atoms missing).

Three dimension (a void, empty bubble exist inside crystal.)

## - How can we perform good substitution or good alloys? (substitution solutions).

Criteria:-

Ni (128.75pm) Example (Ni + Cu both FCC).

Near atomic size of both atoms to be alloyed.

Crystal Structure to be same (both FCC)

Close electro negativity (Cu 1.9 & Ni 1.8)

Valency should be same

(1+ or 2+ for Cu &

2+ for Ni).

$$- \text{Fe} (0.24\text{nm}) + \text{C} (0.071\text{nm}) \Rightarrow \text{Interstitial solution.}$$

At'l.

Finally :-

also;

weight %.

$$\text{C}_1' (\text{atom percent}) = \frac{\text{C}_1 \text{A}_2}{\text{C}_1 \text{A}_2 + \text{C}_2 \text{A}_1} \times 100.$$

Fe BEC at room temp dissolves roughly 21. C<sub>1</sub>. This distorted BCC and grain results.

## SPECIFICATION OF COMPOSITION:-

Concentration of alloy

Weight/mass percent

↓

Atom percent

↓

Weight %.

↓

Total alloy weight (C)

(no. of moles)

Let us say that contains 2 hypothetical atoms.

wt. is.

$$\text{C}_1 = \frac{m_1}{m_1 + m_2} \times 100 \quad \textcircled{1}$$

$$\downarrow$$

(masses of each element)

$$\text{C}_1' (\text{no. of moles of element in relation to total moles}) = \frac{n_1}{n_1 + n_2}$$

$$n_1 (\text{no. of moles of element}_1) = \frac{\text{mass in grams}}{\text{molar mass}}$$

$$\text{molar mass} = \frac{\text{mass}}{\text{atomic weight}}$$

or  
atomic weight

$$\text{C}_1 = \frac{n_1}{n_1 + n_2} \times 100 \quad \textcircled{2}$$

$$\text{wt. \%} = \frac{(\text{weight percent}) \text{C}_1}{\text{C}_1' \text{A}_1 + \text{C}_2' \text{A}_2} \times 100$$

## Dislocations:-

**It is a linear one dimensional defect around which some of the atoms are misaligned.**

### Types of Dislocations :-

#### (i) Edge dislocation.

Edge dislocation is a type of dislocation in which an extra portion of planes of atoms or half plane exist. It may terminate within a crystal.

- Edge dislocation is a linear defect that centres on a line called the dislocation line which is  $\perp$  to the plane of the page in ED.

- The magnitude of distortion decreases from atoms away from the dislocation line.

$\begin{array}{ccccccc} \circ & \circ & \circ & \circ & \circ & \circ & \circ \\ \circ & \circ & \circ & \circ & \circ & \circ & \circ \\ \circ & \circ & \circ & \circ & \circ & \circ & \circ \\ \circ & \circ & \circ & \circ & \circ & \circ & \circ \\ \circ & \circ & \circ & \circ & \circ & \circ & \circ \\ \circ & \circ & \circ & \circ & \circ & \circ & \circ \\ \circ & \circ & \circ & \circ & \circ & \circ & \circ \end{array}$   $\Rightarrow$  demonstrating edge dislocation!

### (ii) Screw dislocation ( $\sigma$ )

It derives its name from the helical/spiral path or ramp that is traced around the dislocation line.

It is the type of dislocation produced due to sheer stress that produces distortion. Due to which the upper region is shifted one atomic distance to the right relative to the bottom portion.

The atomic distortion is also linear and along a dislocation line.

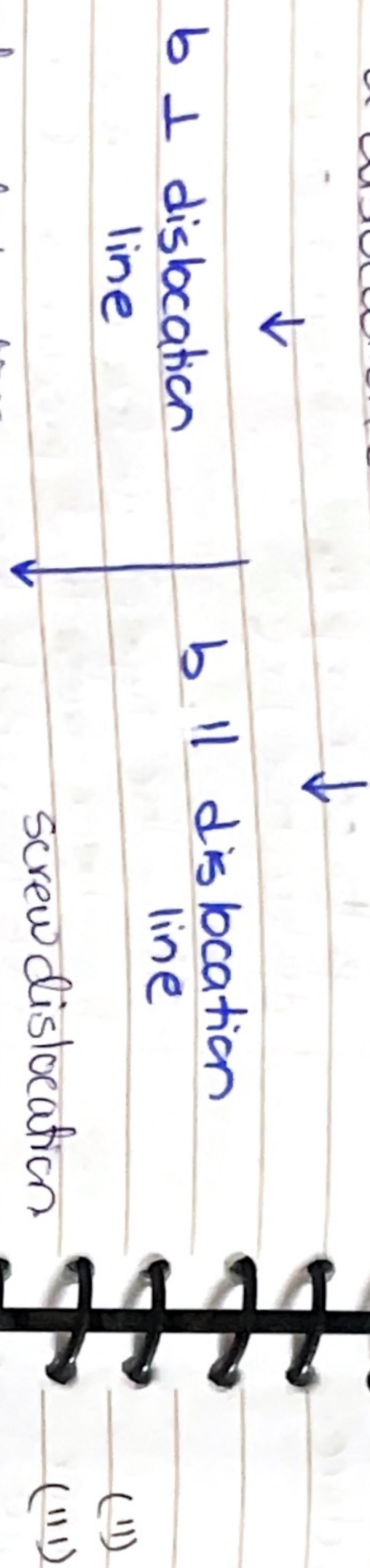
### Burger vector:-

**The magnitude & direction of lattice disassociation is expressed by a burger vector.**

The dislocation points in a

It is defined from  $\uparrow$  CP - crystallographic direction and its magnitude is equal to the interatomic spacing.

• dislocation can be characterized by the relationship of Burger vector & a dislocation line.



edge dislocations.

$b \neq X$   
dislocation  
line.

mixed dislocation.

Interfacial Defects:-

The types of defects that are a boundary separating materials having two different crystal structures or crystallographic orientation.

Types of interfacial defects.

(i) External surface:-

The surface along which the crystal structure terminates.

These are high energy regions as compared to interior atoms because of less/bonding with neighbouring atom. (not max)

The surface energy that they possess is measured with -  $J/m^2$  (erg/cm<sup>2</sup>)

(ii) Grain Boundaries. (from slides).

(iii) Phase Boundary:-

The boundaries between multiphase materials in which a different phase exists on the either side of the boundary.

Each phase has its own physical/chemical characteristics, that is why phase boundary helps to determine the characteristics of multiphase metal alloys.

(iv) TWIN / TILT BOUNDARY:-

Special type of grain boundary that has a mirror image effect on either sides of the boundary.

i.e. The atoms on one side of the boundary are located in mirror image positions to those present on the other side.

Ques

e.g Co-Zn 0.75mm  
↑  
Ans

Q. Describe the phenomena of twinning.

Twinning occurs in definite crystallographic planes and in specific directions both of which depend upon the crystal structure.

The phenomena can be achieved by;

- (i) Mechanical twins → applied mechanical shear force
- (ii) Annealing heat treatment → BCC & HCP metals.

↓ FCC structures.

### INTERFACIAL DEFECTS

STACKING FAULTS :- DOMAIN WALLS

They are found when FCC metals have an interruption in their ABCABC stacking sequence. They separate regions of different magnetization directions in ferro/ferrimagnetic materials-

\* Atom vibrate about their lattice positions but not all atoms vibrate at same frequency etc.

Q.

What cause bulk / Volume defects also give its example:- pores, cracks, foreign particles, and other phases.

- Bulk defects are caused by
  - (i) fabrication
  - (ii) processing step

## GRAIN SIZE DETERMINATION

Avg / Date

No. of grains per square inch at 100 $\times$  magnification

There are two methods of grain size determination.

(i) Linear Intercept  $\rightarrow$  boundaries intersecting

(ii) Comparison by straight line test.

$\downarrow$  comparing grain boundaries / structures with standardized charts which are based upon grain areas  
 $\hookrightarrow$  (no. of grains per unit area)

### LINEAR INTERCEPT METHOD:-

c) Straight lines of equal length are drawn across grains of micrograph randomly.

$$\bar{L} = \frac{LT}{PN} \quad \begin{matrix} \text{Total} \\ \text{length of line drawn} \\ (\text{i.e. no. of lines} \times \text{length}) \end{matrix}$$

grain size  $\downarrow$  Magnification and microscope

Total no. of grains for all lines.

$$n = 2^{G_1 - 1}$$

$G_1 \Rightarrow$  Grain size no.  
 (By intercept method)

$$\text{Avg. no. of grains per square inch if } \neq 100\text{x magnification}$$

$$G_1 = \frac{(M)}{100}^2 = 2^{G_1 - 1}$$

Magnification.