MADE EASY

Mechanical Engineering

Toppers Handwritten Notes

Material Science

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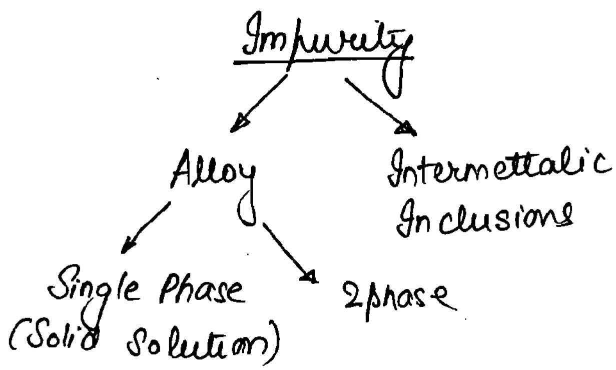
MATERIAL SCIENCE

- Material
- Metrology
- M/c tool

24K gold - 100% Pure

22C gold - $\frac{22}{24} \times 100 = 91.6\%$ 916 KDM ↳ Cadmium



To form alloy: → Hume Rothary Rule: Substitutional impurity not interstitial

(i) radius difference < 15%
(ii) Same valancy
(iii) Electronegativity & → attract other nucleus e^-
Electron affinity should be comparable

- Two materials will combine together and form alloy only when conditions of Hume Rothry rule are satisfied. The most important condition for any alloy is its crystal structure should be same following are conditions of Hume - Rothry Rule:

1. Diff. in atomic radius < 15%.
2. Valency of both materials should be same
3. Electronegativity & electron affinity of both material should be comparable

but their are alloys in which Hume-Rothary rule is not followed. When two elements combines in such a way that they form bond and produces a uniform mixture and impurity material become part of the solution. It is called an alloy

Alloy exhibit the property of individual element

When two elements combines in such a way that the product forms a distinct element having the properties alltogether diff. from the individual element is called compound.

Some of the intermetallic inclusions are compounds

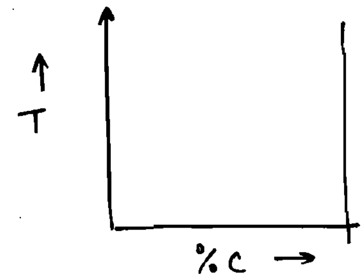
<u>Phase diagram:</u> It is a plot on temperature, composition, space showing the stability of various phases. It tells us what will be the M.P. of a particular alloy [P+F = C+2]

<u>Classification based on # components:</u>

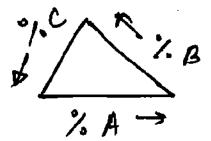
(i) C=1 {unary phase diagram}

T.D

(ii) C = 2 {Binary phase diagram}



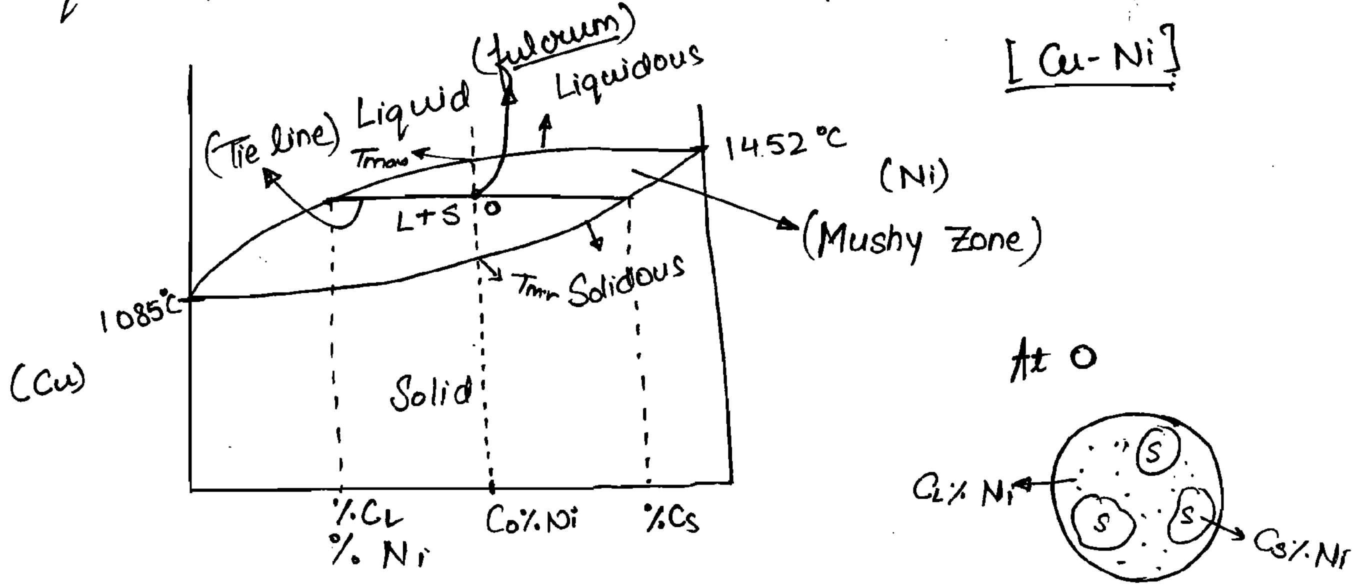
(iii) C = 3 {Ternary phase diagram}



→ **Classifications of Binary Phase Diagrams**

TYPE-1: Materials that are completely soluble both in liquid as well as in the solid state [ISOMORPHISM]

[Cu-Ni]



① If two elements combine in such a way that in the solid state it produces a single phase, it is called solid solution or solutionizing.

② All the lines on the phase diagram are the property of that particular alloy and doesn't change.

③ Mushy zone is the region where there is a mixture of liquid + solid, larger is the extent any alloy exhibit

Mushy zone, lesser will be the fluidity of that alloy

4) ** Due to the appearance of Mushy zone in any alloy, lesser will be the fluidity. and M.P. is not fixed, there will be a range of temp. at which liquification and solid^n are taking place

5) Any line on the phase diagram that seperates a solid phase with Mushy zone is called solidus & any line seperating liquid phase with Mushy zone is called liquidous.

<u>From the phase diagram:</u>

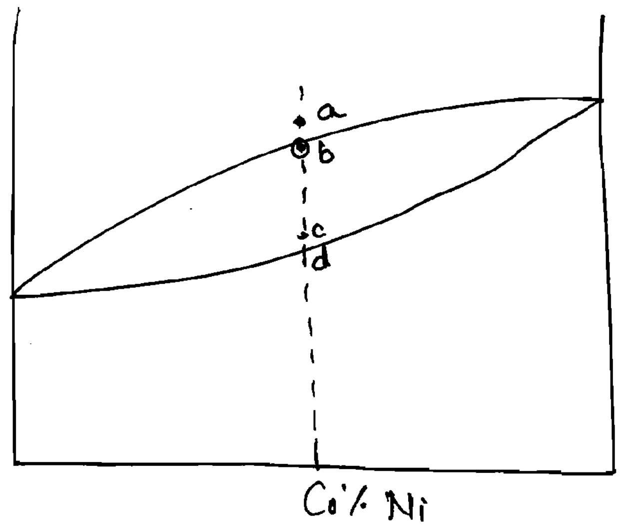
m_s = mass fraction of solid
m_l = mass fraction of liquid.

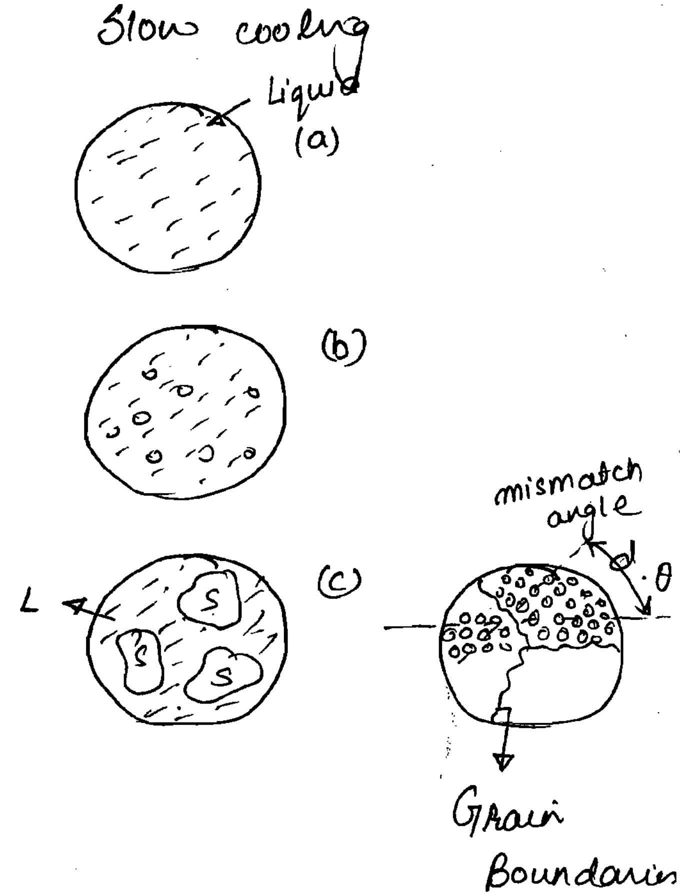
$$m_s + m_l = 1 \quad \text{---} (1) \qquad m_l = (1 - m_s)$$

$$m_s C_s + m_l C_L = C_0 \quad \text{---} (2)$$

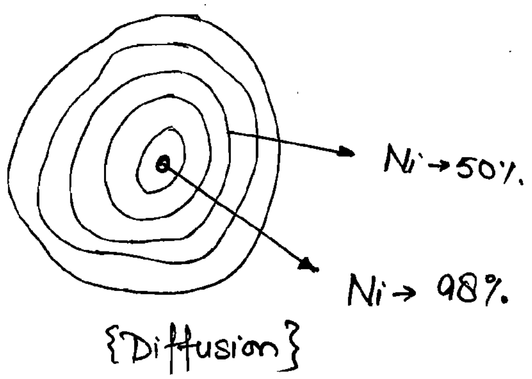
$$m_s (C_s - C_L) + C_L = C_0$$

$$\Rightarrow \boxed{m_s = \frac{(C_0 - C_L)}{(C_s - C_L)}} \quad \text{Lever rule} \quad \boxed{m_l = \frac{C_s - C_0}{(C_s - C_L)}}$$





Solidification front:



A sample of Cu and Ni with Co% Ni is cooled slowly along line a-d and its micro-structure is observed. At point a entire sample will be in the liquid state and the moment temp of the sample slightly decreases below liquidous line to point b. Solid start nucleating in the microstructure. Upon dec. the temp slowly from point b to c following conclusions can be drawn by using the lever rule:

1> As the temp dec. mass fraction of solid ↑

2> The moment solid nucleates % Ni in the solid is quiet high. As the Temp decreases, % Ni in solid also decreases and approaches towards overall composition Co.

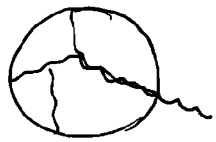
At high temperature a phenomena called diffusion appears in the material. It is said that for every 20° inc. in temperature diffusion multiplies by "two".

Diffusion initially tries to stabilise the phase but when the phases are stable it tries to homogenise the composition. So, due to diffusion, Ni will diffuse from the centre of the solid phase in the outward direction and the copper will diffuse towards the centre. So, composition within the solidification front will be uniform.

Each solidification front will have particular packing of atoms. The moment when the Temp of ~~solution~~ sample slightly reduces below solidus line to d. All the solidification front will combine together and entire material will convert into solid phase. The regions where different solidification fronts are fusing there will be mismatch in the orientation of atoms will called grain boundaries.

FRACTURE:

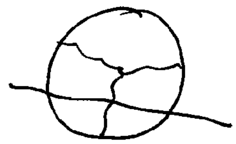
Ductile



Intergranular fracture

cup and cone fracture

Brittle



Transgranular fracture

Cleavage fracture

SEM

Scanning e⁻ Microscope

TEM

Transmission e⁻ microscopy

↓

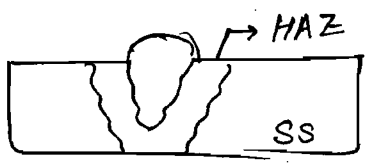
Crystal Structure

X-Ray diffraction

<u>Stainless Steel</u>: 18% Cr 8% Ni

Cr - α - phase stabiliser

Ni - γ - phase stabiliser

* 

Welding → weld decay

→ Sensitization

① Type of fracture can be seen only under SEM and if we are able to see cup and cone it is called ductile fracture but if we are able to see cleavages it is called a brittle fracture.

② Upon decreasing the temp. of any material, there will be a temp below which strength of grain & grain boundaries become uniform. This temp is equi-cohession temp. Below this temp fracture will always be in brittle mode [TITANIC].

3) Atoms present at the grain boundaries will have a larger bond length so, atmospheric oxygen first attacks the grain boundary atoms and the material will be corroded.

Grain boundaries are highly reactive thats why we say atoms at grain boundaries are at high energy level.

To increase the corrosion resistance of any material chromium is added in it. Chromium after reacting with atmospheric oxygen produces chromium oxide and being the foreign element it will be accumulated at the grain boundaries. So due to Cr_2O_3 grain boundary atoms are not exposed to atmosphere. This increase the corrosion resistance

- Nickel stabilises that phase at room temp.

) Upon welding SS, in the HAZ Cr_2O_3 after combing with the carbon present in the material converts into chromium carbide and it appears as a dust on the surface of material. After some time this heat affected zone material start corroding. This phenomena is called

<u>Sensitization (or) Weld decay</u>

The material in which there are no grain boundaries is called a superalloy. If superalloys are in thin section. It is called a whisker. These materials are used in aerospace applications