ESO 205A (P)

Nature and Properties of Materials

Interaction session: 6:30 – 7:20 pm Thursdays

Microstructure evolution-Identification and Quantification

Identification of Microstructure of Metals and Alloys

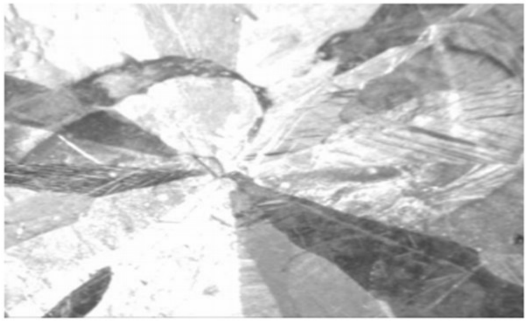
- When two or more elements are combined in such a way that the elements are mixed on an atomic scale, then the formed product is called an alloy or solid solution.

- Unlike pure metals, alloys freeze over a range of temperature.

- Solidification of an alloy introduces compositional inhomogeneity.

Columnar Grains: Macrostructure of Pure Zn

- Large undercooling occurs on container walls when melt is poured in container of much lower temperature than the melt.
- At the beginning of solidification, nuclei form at the contact of melt and container wall.



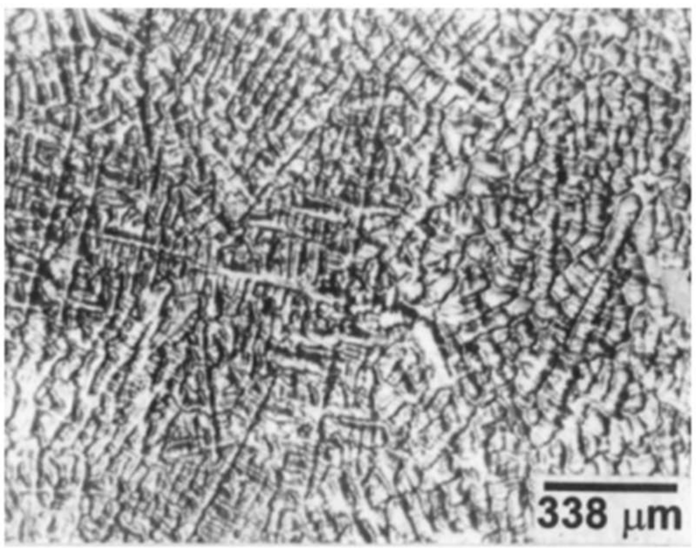
- Growth of crystals formed near the mold wall continue inwards.
- Direction of crystal growth is opposite to direction of the heat flow.
- Sidewise growth is inhibited by neighboring grains.
- Grains in the columnar zone have different orientations from each other as they are differently oriented in the plane normal to the heat direction.

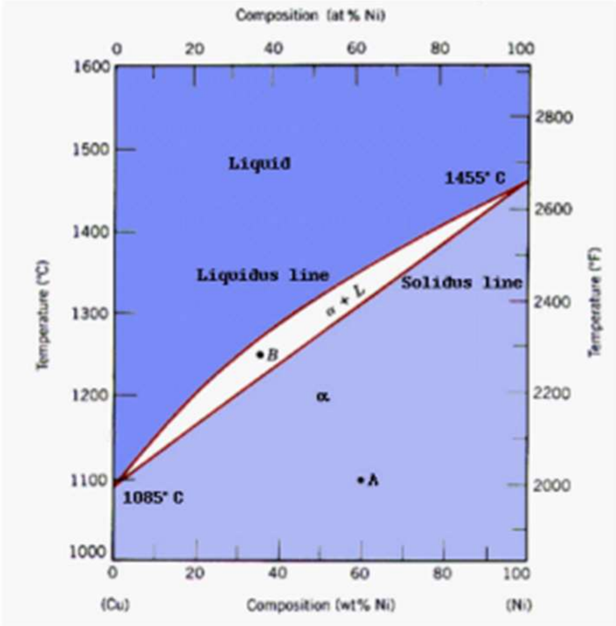
Dendritic Growth: Microstructure of Cu-Ni

- During the period of columnar growth, the solid phase develops protuberances
- Solute atoms are rejected during the formation of the solid phase.
- Liquid in the immediate vicinity of the interface is enriched with solute with lower freezing temperature
- Interface is at equilibrium and the actual temperature gradients quite small
- The liquid ahead of the interface is supercooled and the supercooling increases with the distance from the interface.
- Region above liquidus line is liquid and below solidus line is solid
- Intermediate region is called the mushy zone where liquid and solid co-exist.

Dendritic Growth: Microstructure of Cu-Ni

- At temperature higher than 1455 ˚C (M.P. of Ni) it is totally liquid
- At temperature below 1085 ˚C (M.P.Cu) the alloy is totally solid and single phase

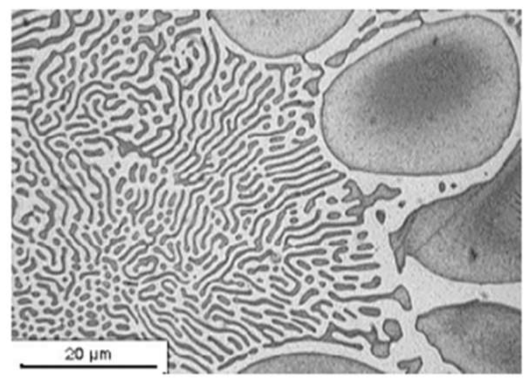


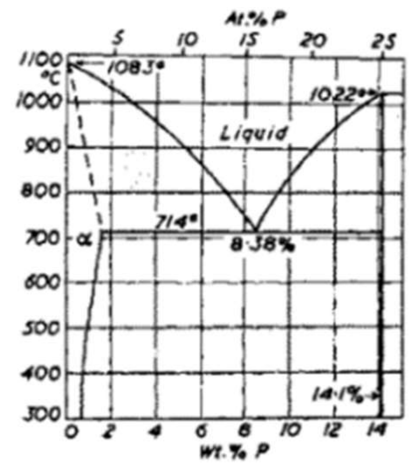


Two phase structure

i) Eutectic structure: Microstructure of Cu-P

- Liquid phase transforms into a mixture of two solid phases: Liquid→ α + β
- α crystal causes the surrounding liquid to be super saturated in β
- Microstructure of Cu/8.4 wt % P alloy shows the grains composed of colonies of fine eutectic structure
- Lamellar pattern is seen consisting of crystals of copper rich solid solution (dark) and copper phosphide (Cu_3P) (white)

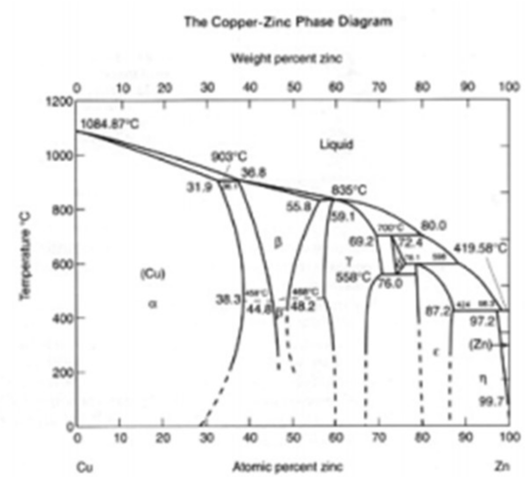




Two phase structure

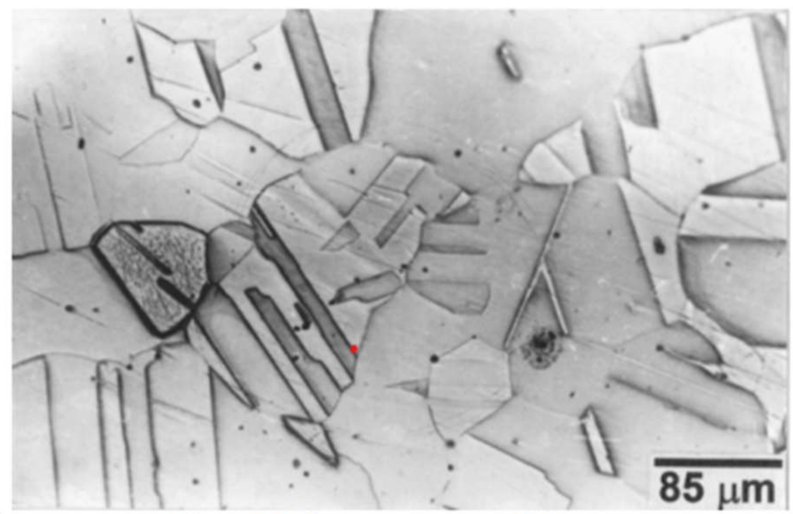
ii) Peritectic Structure: Microstructure of Cu-Zn

- Solid and a liquid phase react to produce another solid phase: α +Liquid → β
- β starts to form at the interface between α and liquid at temperature below Tp
- Growth is dependent on the diffusion of atoms on one side of β to the other
- Diffusion is slow in solid state
- Equilibrium microstructures are rarely obtained



Polycrystalline Structure: Microstructure of Cu

- Material is composed of many small regions called grains
- Between the grains are grain boundaries, regions of extreme disorder in the crystal structure
- Acids and other etchants typically attack the grain boundary material first
- The grain boundaries are visible in an optical microscope
- Polycrystalline metal strength increases as the grain size decreases, Hall-Petch effect



Quantification of microstructure (Measuring volume Fraction)

Volume Fraction, Areal Analysis

- Trace the structure onto paper and weight the paper
- Cut out the parts containing the phase of interest and weigh these parts
- Weight fraction equals the area fraction of phase in this section
- Average of a number of area fraction measurements gives one the volume fraction of phase
- Etch the specimen to color each phase differently
- Measure the area of each phase
- Average of number area fraction measurements is equal to the volume fractions of phases

Volume Fraction, Linear Analysis

- Uniformly distributed but randomly oriented lines
- Average length of the line segments crossing the selected phase is equal to the area fraction of the phase viewed in the planar section
- Average of number area fraction measurements is equal to the volume fractions of phases

Volume Fraction, Point Count

- Fraction of a number of points which fall on the selected phase is equal to the area fraction of that phase
- The average of a number of area fraction measurements is equal to the volume fractions of phases

Recommended Method

Measurement of Volume Fraction of Phases using the Systematic Point Count Method

- Based on the fact that the average fraction of points which fall on grains of a particular phase is equal to the area fraction of the phase in the polished section
- Average of these area fractions is equal to the volume fraction of the phase
- This method entails selecting a suitable array of points, overlaying it on the specimen and counting the points which fall on the selected phase
- Selecting a new area and counting again, and again until the desired error is obtained

Procedure

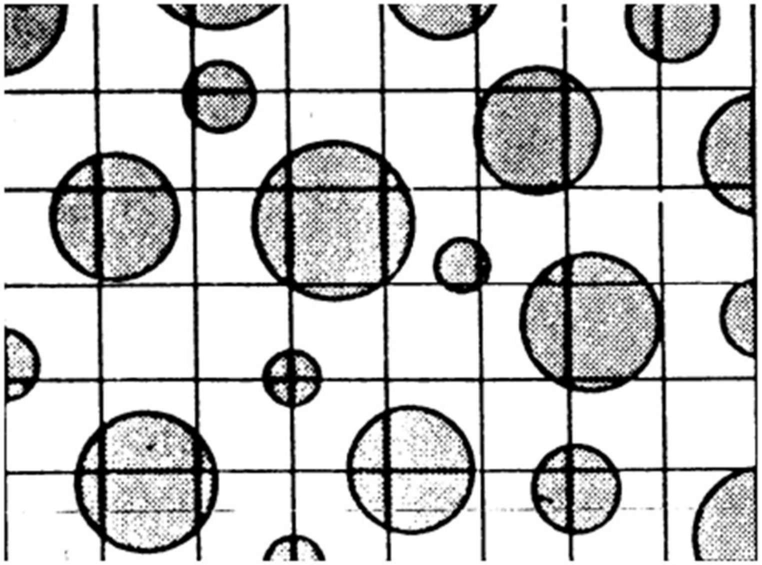
- Most efficient method will requires least effort per observation
- Using a reticule grid and observing the polished sample is more efficient than using a micrograph
- A square array of points is simple, symmetric and easy to obtain
- Optimum number of points in the grid large minimizes the effort of changing views and minimum to reduce the effort of counting
- Select an area on the specimen where counts are to be made
- Count each point which falls on the selected phase.

- Assign a count value of ½ to points which fall on inter phase boundaries
- Tabulate the Results
- Compute the mean
- Divide these by the number of points in the

grid and multiply them by 100

- Results received in terms of the volume perc

of phase.



Stay safe and take care
Get vaccinated

Thank you