Lecture 12

$$\begin{aligned}\rho_v = \frac{n_v}{v} &= \frac{n_{total} * 2.29 * 10^{-5}}{v} \\ &= \frac{(n_{Al} * n_v) * 2.29 * 10^{-5}}{v} \\ &\approx \frac{n_{Al} * 2.29 * 10^{-5}}{v}\end{aligned} \tag{1}$$

$n_{Al} = \frac{m}{A} * N_A$

$$\begin{aligned}A &= 26.98\frac{g}{mol} \\ N_k &= 6.022 * 10^{23}\frac{1}{mol} \\ \rho^{25} &= 2.90\frac{g}{cm^3} \\ \rho^{400} &= ?\end{aligned} \tag{2}$$

Insert a picture of a 1x1x1 cm cube here that weighs 2.7g

$$\begin{aligned}m &= \rho * v \\ \rho^{600} &= \frac{2.70g}{(1.008625cm)^3} \\ &= 2.63\frac{g}{cm^3}\end{aligned} \tag{3}$$

$$\begin{aligned}dl &= L_o \propto (t_1 - t_0) \\ &= 0.008625cm\end{aligned} \tag{4}$$

Thus

$$\begin{aligned}\rho_v &= 1.34 * 10^{18}\frac{\text{vacant sites}}{cm^3} \\ n_{Al} &= 5.87 * 10^{22}\text{atoms}\end{aligned} \tag{5}$$

Physical Defects

One Dimensional Imperfections

Burgers Vector

Similar to a closed loop in physics. This is the Edge dislocation designated by a T̈s̈hape

1. Create a stepwise loop around a perfect structure
2. Now do so around the defect. The vector b that is required to end back up at the start is the magnitude of the defect.

Screw Dislocation

Comes as a result of shearing in the structure. Must step down after one turn of the loop.

Physical Defects

Two Dimensional Imperfections

Planar defects: interfaces between crystals
Can form during the following solidification processes.

1. solidification start swith molten material
2. crystals grow until they meet
3. Grain boundaries form when the crystals meet

Grain Boundaries

Twin boundary: like a mirror reflection of the crystal.
Tilt boundary: small tilt between crystal interfaces.

Physical Defects

Three Dimensional Imperfections

Orderliness is defined over 2 ranges:

1. Short range ordered. Comparable to interatimic distances **SRO**
2. Orderliness repeated over long distances is called Long range ordered **LRO**

Amorphous Metals or Metallic Glasses
Melting then cooling very rapidly (quenching). This produces amorphous metals, if you melt and reheat again this will produce a crystal again this is called not thermodynamically stable.

This process decreases the atomic packing factor that is responsible for immediately transfering energy. The gaps between atoms make the performance better. Like diamond that has very low atomic packing factor.

Module 5 - Diffusion

Issues to address:

1. How does diffusion occur?
2. What does diffusion depend on?
3. How can diffusion rate be predicted?
4. Why is this important?

Definition: Diffusion is the movement of atoms from an area of high concentration to a lower concentration area. This is a time dependant process.

Diffusion Mechanisms

Gases & Liquids: Diffusion is easy due to the large spaces betweens atoms.
Solids:

1. Diffusion is difficult
2. Nearly impossible in crystal structures
3. Point defects are required for diffusion to occur

Mechanism #1: Vacancy Diffusion

1. Atoms exchange with vacancies
2. Applies to substututional impurities
3. Rate depends on:
4. Number of vacancies
5. Activation energy to exchange

Mechanism #2: Interstitial Diffusion

Smaller atoms can diffuse though the interstitial sites inbetween larger atoms.

Thermal Production of Point Defects

1. The generation of point defects is a thermally activated process
2. How can we quantitatively determint point defect generation?

The rate of the thermally activated process is given by the **Arrhenius Equation**

$$\begin{aligned} \text{rate} &= Ce^{\frac{-Q}{RT}} 5.1 \\ ln(\text{rate}) &= ln(C) - \frac{-Q}{RT} \end{aligned} \tag{6}$$

The line yields intercept and the slope (The pre-exponential constant and activation energy)

Thermal Activation at the Atomic Scale

$$\text{rate} = Ce^{\frac{-q}{kT}} 5.1 \tag{7}$$

Instead using the new Boltzmann Constant.

Activation Energy

The minimum amount of energy that is required to activate atoms, ions or molecules to make a chemical or physical process occur.