MSE200

Lecture 5 (CH. 4.3-4.4)

Crystal Imperfections (Defects)

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Objectives/outcomes: You will learn the following:

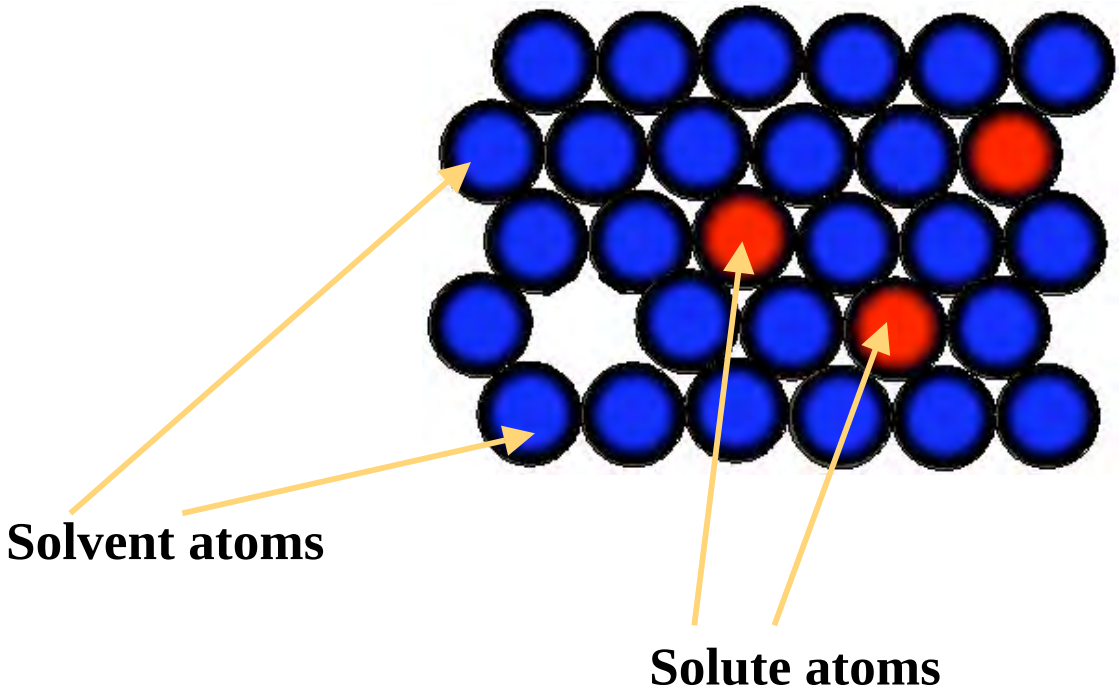
- Describe point defects, solid solutions, vacancies and interstilialcies
- Describe line defects (dislocations), Burger's vector, edge and screw dislocations.
- Describe grain boundaries and grain size.
- Understand metallography.

Metallic Solid Solutions

- **Solid solution is a simple type of alloy in which elements are dispersed in a single phase.**
  - **The crystal structure of the solvent is maintained**
- **Why do we care?**
- **There are two types of solid solutions**
- **Example:**
  - ➢

Substitutional Solid Solution

- **Solute atoms substitute for solvent atom in a crystal lattice.**
- **The structure remains unchanged.**
- **Lattice might get slightly distorted**



Substitutional Solid Solution (Cont..)

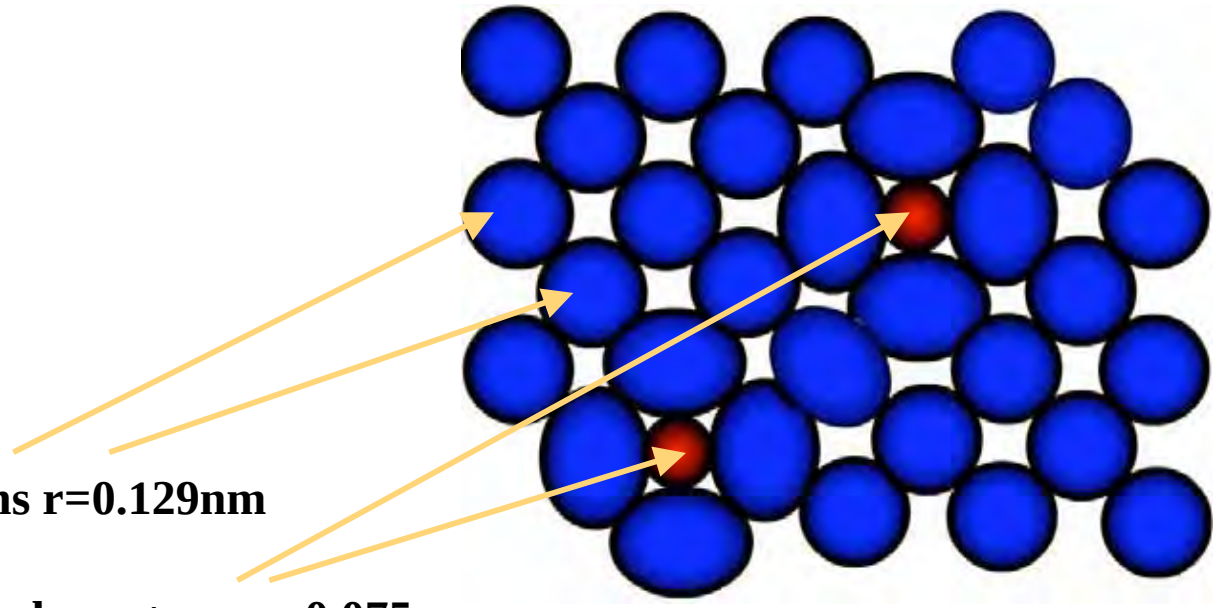
- **The solubility of solids is greater if**
  - **Similar diameter (difference < 15%)**
  - **Same crystal structures**
  - **Similar electronegativity (else compounds will be formed).**
  - **Same valence.**

- **Examples:-**

System	Atomic radius Difference	Electro-negativity difference	Solid Solibility
Cu-Zn	3.9%	0.1	38.3%
Cu-Pb	36.7%	0.2	0.17%
Cu-Ni	2.3%	0	100%

Interstitial Solid Solution

- **Solute atoms fit in between the voids (interstices) of solvent atoms.**
- **Solute atoms is much smaller than solvent atoms**
- Calculate the radius of the biggest interstitial void
  - Example problem 4.3



Iron atoms r=0.129nm

Carbon atoms r=0.075nm

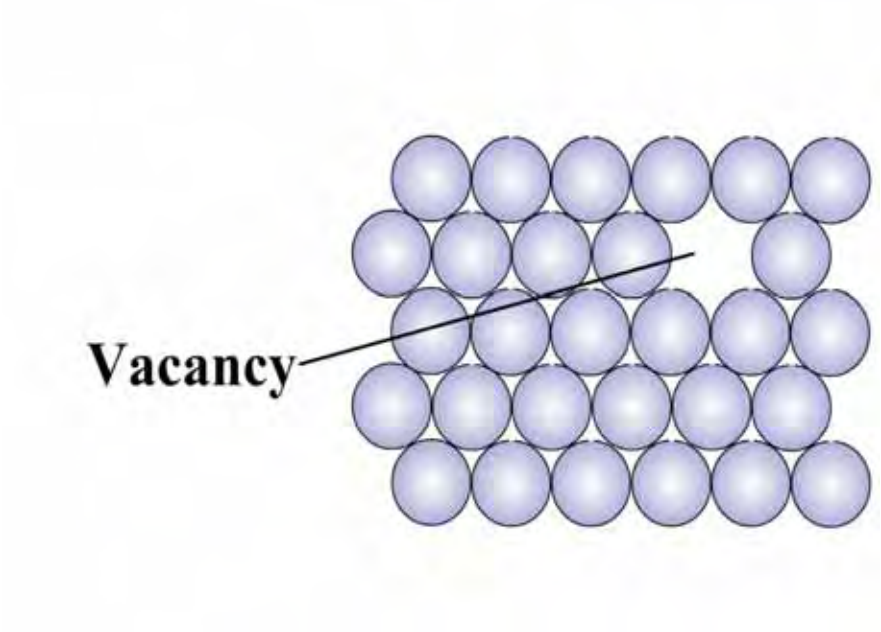
Crystalline Imperfections (defects)

- **No crystal is perfect.**
- **Why do we care about defects?**

- **Imperfections can be classified as**
  - **Zero dimensional point defects.**
  - **One dimensional / line defects (dislocations).**
  - **Two dimensional defects (grain boundaries).**

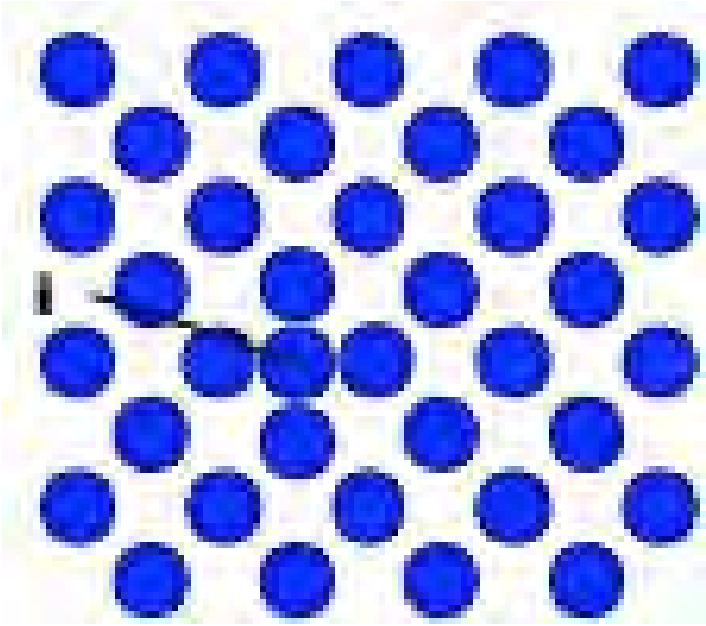
Point Defects – Vacancy

- **Vacancy is formed due to a missing atom.**
- **Vacancies are equilibrium defects**



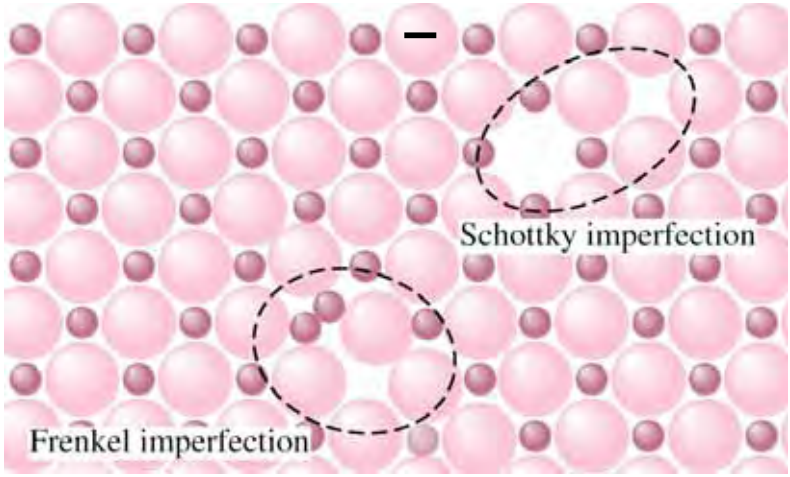
Point Defects - Interstitials

- **Atom in a crystal, sometimes, occupies interstitial site.**
- **How can this happen:**
- **Effect on crystal lattice:**



Point Defects in Ionic Crystals

- **Complex as electric neutrality has to be maintained.**
- **If two appositely charged particles are missing, cation-anion divacancy is created. This is Schottky imperfection.**
- **Frenkel imperfection is created when cation moves to interstitial site.**

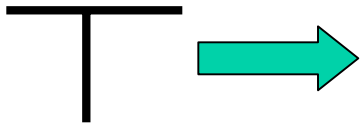


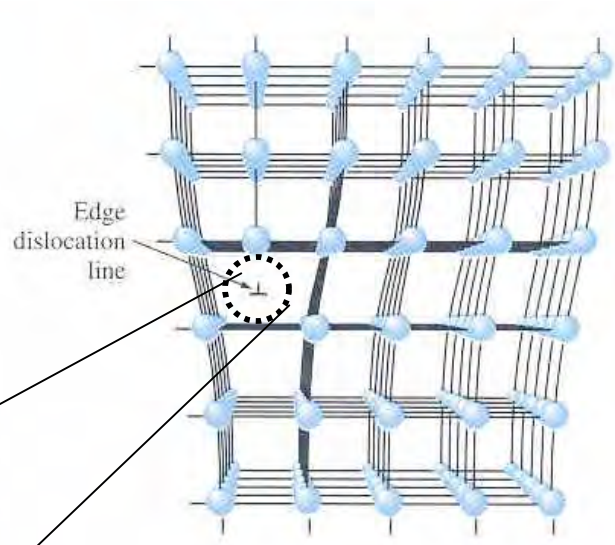
Line Defects – (Dislocations)

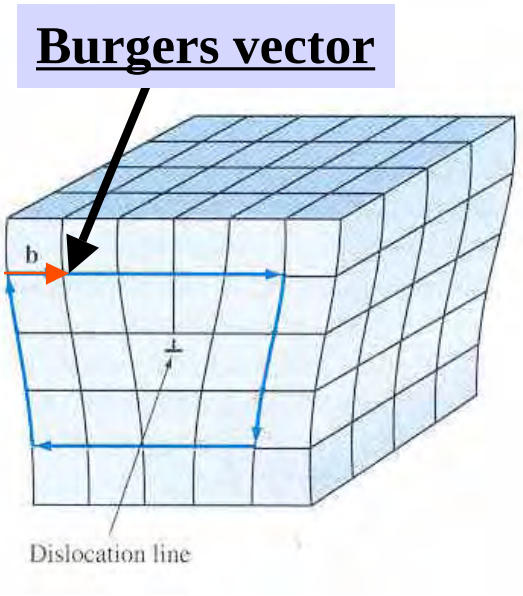
- **Lattice distortions are centered around a line.**

- **Different types of line defects are**
  - **Edge dislocation**
  - **Screw dislocation**
  - **Mixed dislocation**

Edge Dislocation

- **Created by insertion of extra half planes of atoms.**
-  **Positive edge dislocation**
-  **Negative edge dislocation**
- **Burgers vector Shows displacement of atoms (slip).**

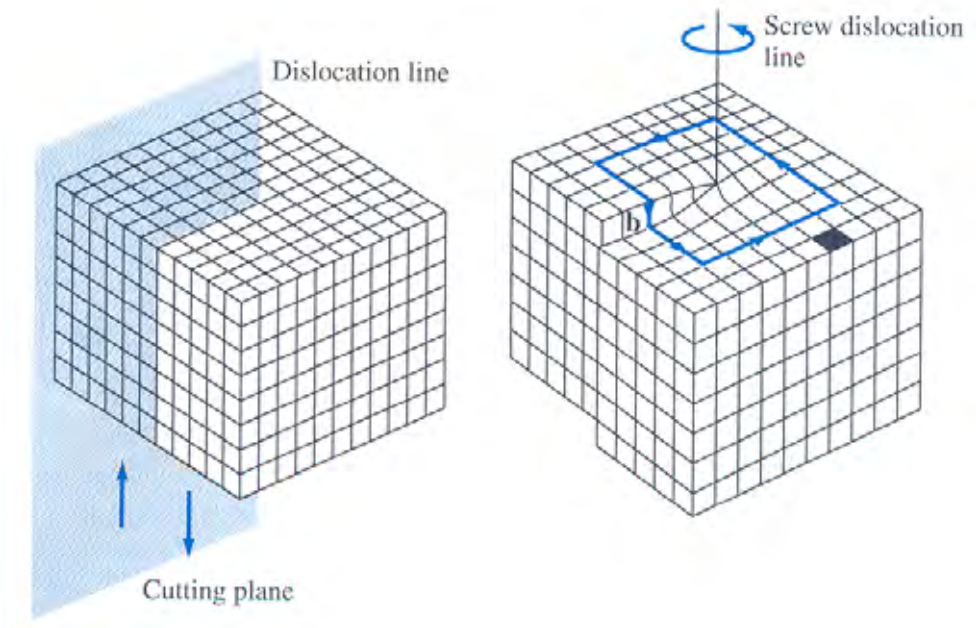




The Burgers Vector is perpendicular to the dislocation line

Screw Dislocation

- **Created due to shear stresses applied to regions of a perfect crystal separated by cutting plane.**
- **Distortion of lattice in form of a spiral ramp.**



The Burgers Vector is parallel to the dislocation line

Mixed Dislocation

- **Most crystal have components of both edge and screw dislocation.**
- **Each dislocation has only one Burgers vector, b**
- **Dislocation appear as dark lines when observed under electron microscope.**
- **When a dislocation glide across a crystal, it produce a plastic deformation by b**
- **Examples of edge, screw and mixed dislocations:**

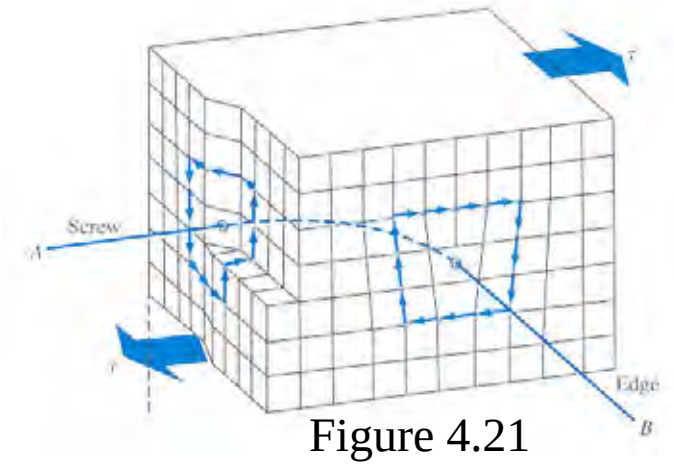
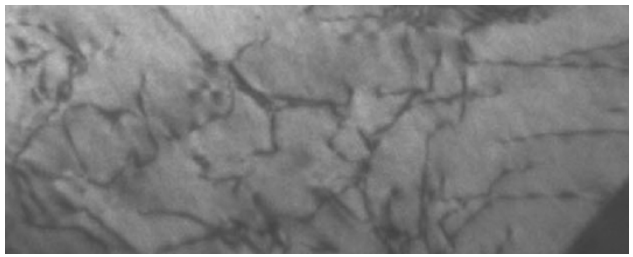


Figure 4.21



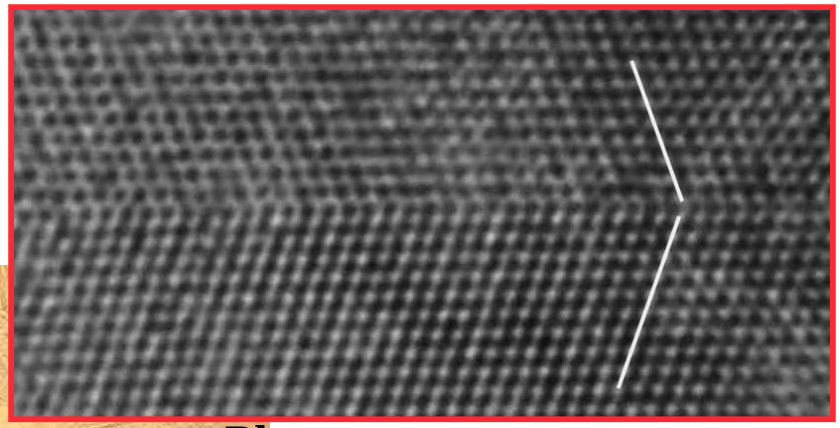
http://video.google.com/videosearch?gbv=2&hl=en&q=interstitials&um=1&ie=UTF-8&sa=N&tab=wv#q=dislocation&hl=en&emb=0&start=20

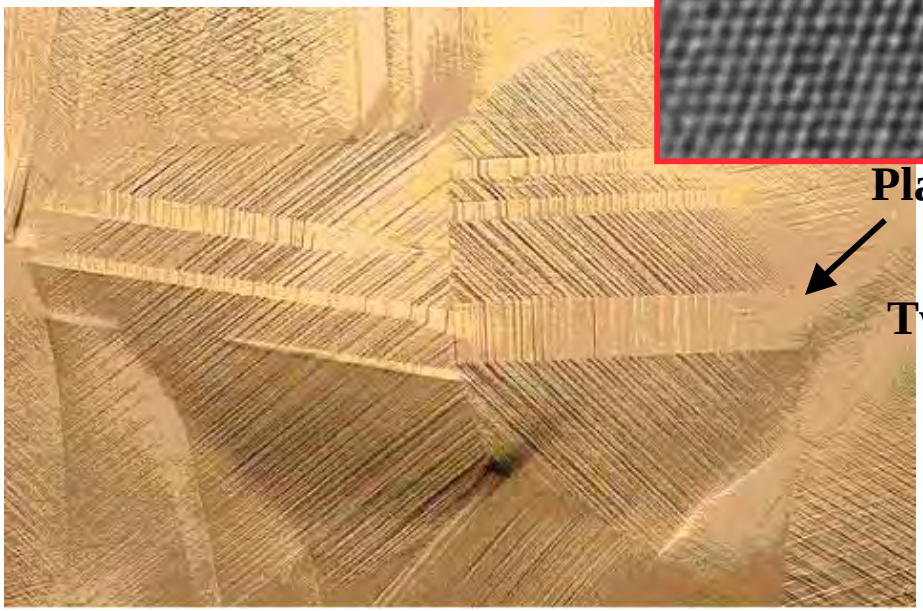
Grain Boundaries

- **Grain boundaries separate grains.**
- **Width = 2-5 atomic diameters.**
- **Atoms in grain boundaries have higher energy.**

Twin Boundaries

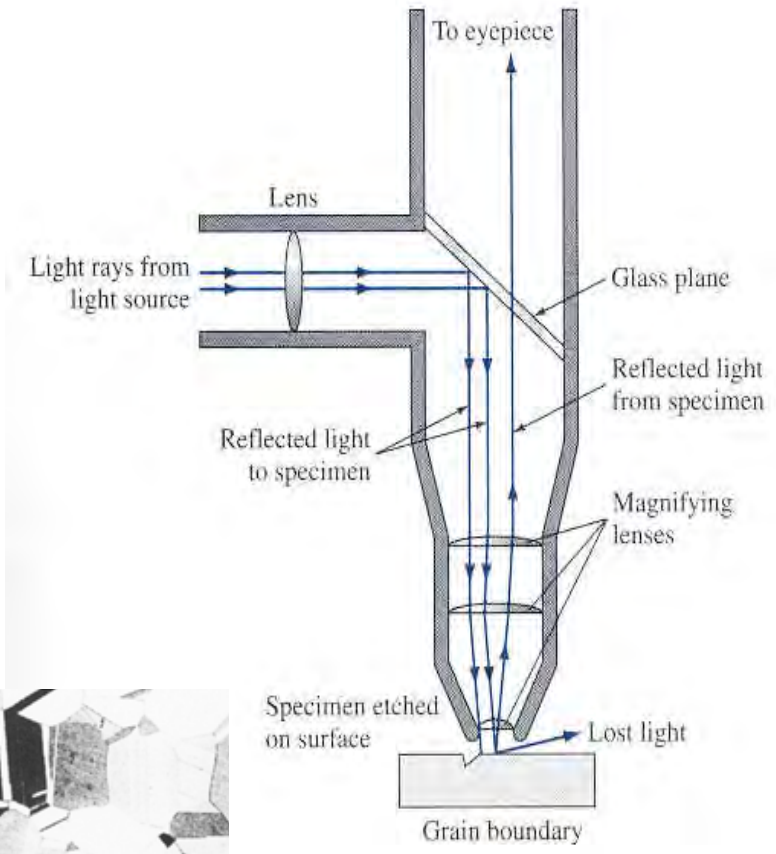
- **Twin: A region in which mirror image pf structure exists across a boundary.**
- **Formed during plastic deformation and recrystallization.**
- **Strengthens the metal.**

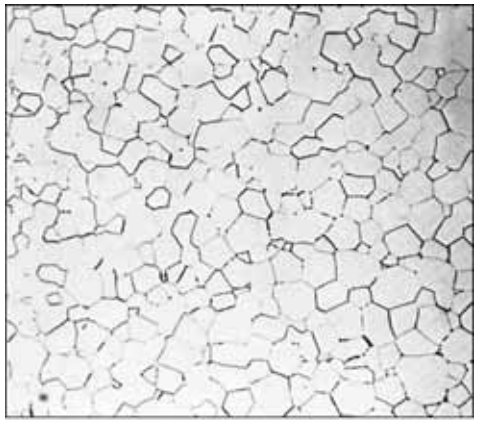




Observing Grain Boundaries - Metallography

- **Sample surface is polished**
- **The surface is then etched chemically.**
- **Tiny groves are produced at grain boundaries.**
- **Groves do not intensely reflect light. Hence observed by optical microscope.**





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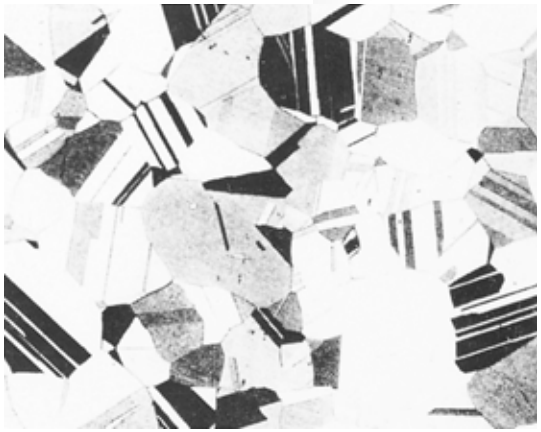

Grain Size

- **Why do we care?**
  - **Smaller grains lead to stronger materials**

Homework

Example Problems: 4.3,
Regular Problems, Chapter 4: 17, 19, 21, 22, 24,
Reading assignment for the next class: 5.1-5.4