October 15th, 2014

Imperfections in Solids

Conditions for substitutional solid solution (S.S.)

- W. Hume – Rothery rule — Important
  - 1. Δr (atomic radius) < 15%
  - 2. Proximity in periodic table
    - i.e., similar electronegativities
  - 3. Same crystal structure for pure metals
  - 4. Valency
    - All else being equal, a metal will have a greater tendency to dissolve a metal of higher valency than one of lower valency

Most satisfy all

MIDTERM – WEDNESDAY 10/22

Recap Review Monday.

Ch.3 Quiz Monday 10/20

Midterm will cover Ch 2, 3, 4

Imperfections in Solids

Application of Hume–Rothery rules – Solid Solutions

1. Would you predict more Al or Ag to dissolve in Zn?
2. More Zn or Al in Cu?

Element	Atomic Radius (nm)	Crystal Structure	Electronegativity	Valence
Cu	0.1278	FCC	1.9	+2
C	0.071			
H	0.046			
O	0.060			
Ag	0.1445	FCC	1.9	+1
Al	0.1431	FCC	1.5	+3
Co	0.1253	HCP	1.8	+2
Cr	0.1249	BCC	1.6	+3
Fe	0.1241	BCC	1.8	+2
Ni	0.1246	FCC	1.8	+2
Pd	0.1376	FCC	2.2	+2
Zn	0.1332	HCP	1.6	+2

either do not satisfy

Imperfections in Solids

- Specification of composition
  - weight percent $C_1 = \frac{m_1}{m_1 + m_2} \times 100$

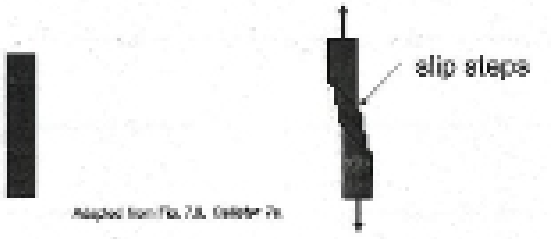
    m_1 = mass of component 1
  - atom percent $C'_1 = \frac{n_{m1}}{n_{m1} + n_{m2}} \times 100$

    n_{m1} = number of moles of component 1

Line Defects

Dislocations:
- are line defects,
- slip between crystal planes results when dislocations move,
- produce permanent (plastic) deformation.

Schematic of Zinc (HCP):
- before deformation
- after tensile elongation



Adapted from Fig. 7.8, Callister 7e.

Imperfections in Solids

Linear Defects (Dislocations)
- Are one-dimensional defects around which atoms are misaligned

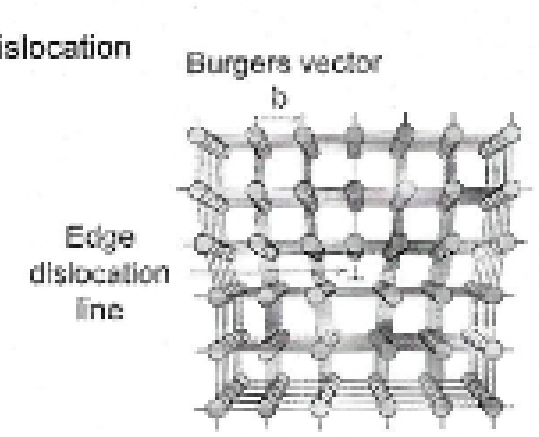
Edge dislocation:
- extra half-plane of atoms inserted in a crystal structure
- **b** ⊥ to dislocation line

Screw dislocation:
- spiral planar ramp resulting from shear deformation
- **b** ∥ to dislocation line

Burger's vector, **b**: measure of lattice distortion

Imperfections in Solids

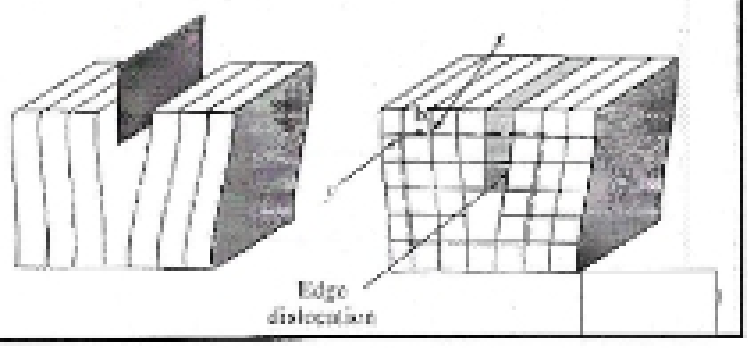
Edge Dislocation



burges vector perpendicular to dislocation line

Edge Dislocation

Insertion of an extra plane of atoms
Dislocation line – defined along edge of half plane
Localized lattice distortion around dislocation line
Designation ⊤ or ⊥



Edge Dislocation

- Do not think of an edge dislocation as caused by inserting a plane
- Causes:
  - "Accidental" crystal growth by perhaps an impurity or differential growth
  - Internal tensile and shear stresses in the crystal
  - Plastic deformation of the crystal