

# MSE 170A Midterm review

- Exam date: 10/27/2008 Mon, lecture time
- Place: Here!
- Close book, notes and no collaborations
- A sheet of letter-sized paper with double-sided notes is allowed
- Material on the exam will be taken from the text book reading, lecture notes, homework, and lab
- Bring a calculator and straight edge/triangle
- The review materials are not comprehensive, there may be questions on the exam on topics not listed here



# Bonding and atomic forces

- The periodic table
- What types of bonding are there?
- How does bonding affect materials properties?



# The Periodic Table

- Columns: Similar **Valence** Structure

columns: Similar Valence Structure

The periodic table is color-coded to show valence electron configurations. Groups 1 and 2 are highlighted in red, indicating they 'give up' 1 and 2 electrons respectively. Groups 13-15 are highlighted in light blue, indicating they 'give up' 3 electrons. Groups 16 and 17 are highlighted in medium blue, indicating they 'accept' 2 and 1 electrons respectively. Group 18 is highlighted in dark blue, indicating they are 'inert gases'. A legend shows three types of boxes: a light blue box for 'Metal', a medium blue box for 'Nonmetal', and a diagonally split box for 'Intermediate'.

IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
1 H	2 He											5 B	6 C	7 N	8 O	9 F	10 Ne
3 Li	4 Be											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
11 Na	12 Mg											31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
55 Cs	56 Ba	Rare earth series	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg						
87 Fr	88 Ra	Actinide series	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds								

Adapted from  
Fig. 2.6,  
*Callister 7e.*

Electropositive elements:  
Readily donate electrons  
to become + ions.

Electronegative elements:  
Readily acquire electrons  
to become  $-$  ions.



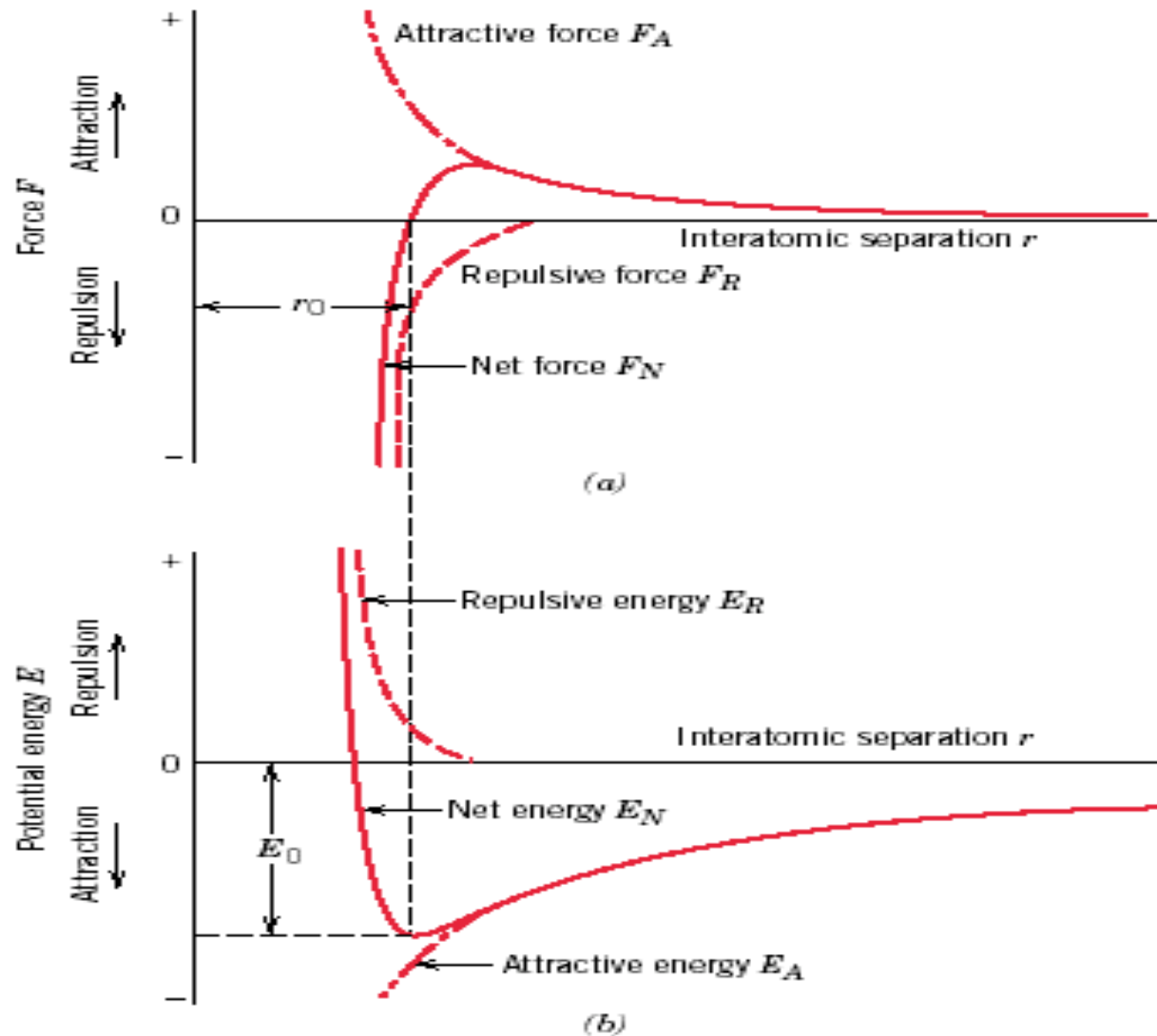
# Bonding and atomic forces (continued)

- Atomic forces & potential vs interatomic distance



# Atomic bonding in solids

- Bonding forces and energies

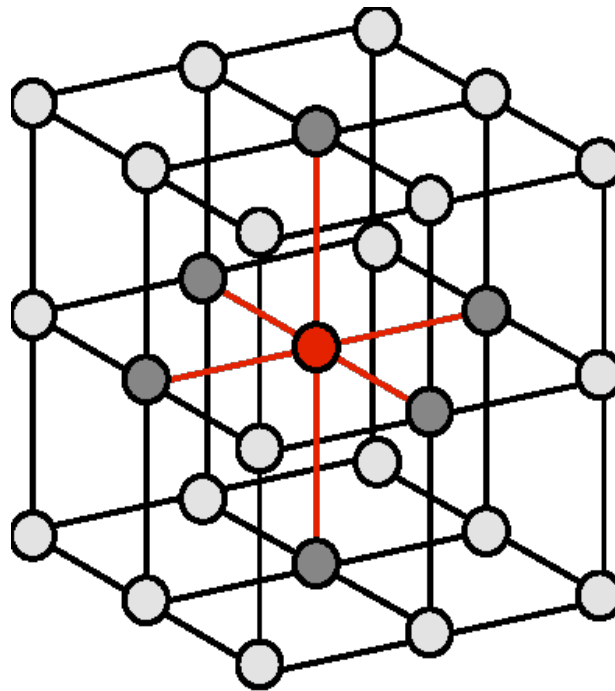


# Crystal structure

- Determine #atoms/unit cell, CN#, APF and density
- Draw and index crystallographic direction and planes
- Close-packed plane and stacking sequence
- Crystal systems

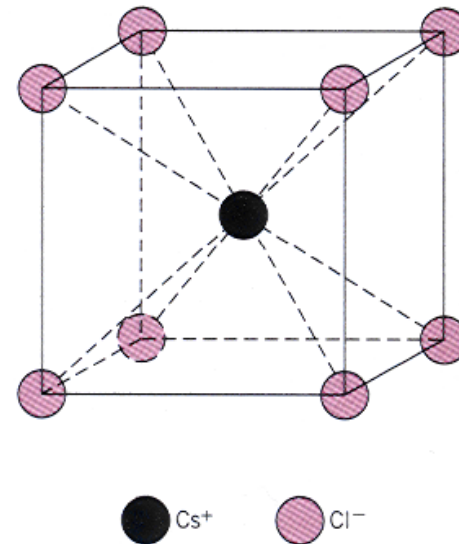


# Crystal Structures



# Crystal structures (*ceramics*)

- Know the types of ceramic structures and identify their unit cells
- Determine coordination number for ceramic structures based on ionic radii and charge





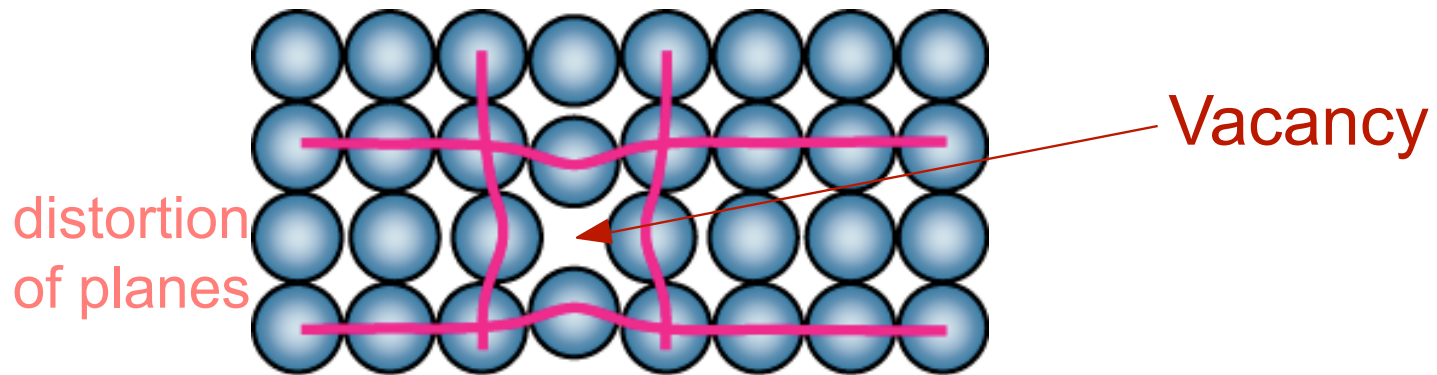
# Defects

- Distinguish point, linear (dislocation 1D), interfacial(2D), volume(3D) defects
- Draw and describe edge and screw dislocations
- Burgers circuits and vectors
- Understand equilibrium of vacancies and effect of T

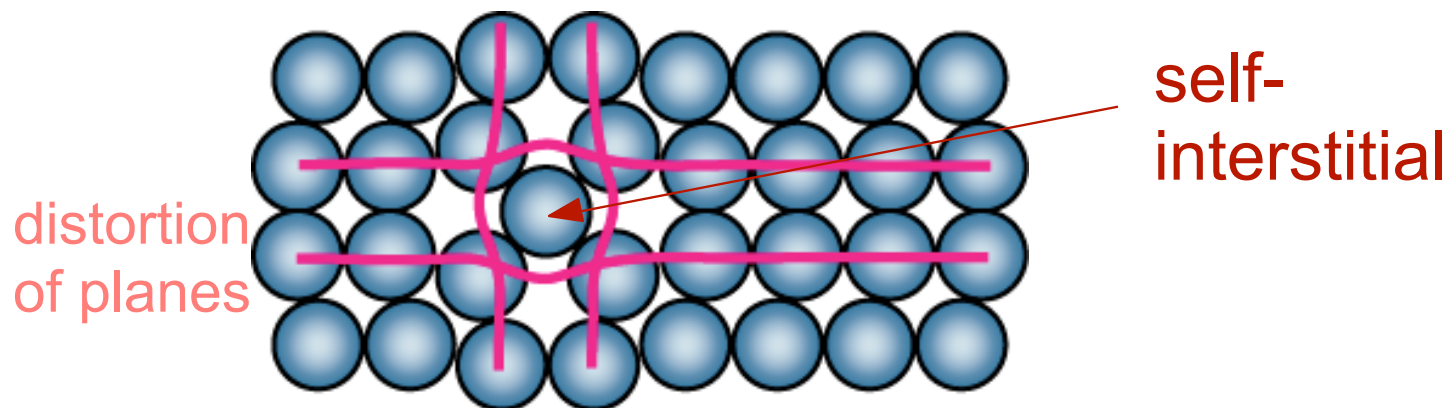


# Point Defects

- **Vacancies:**  
-vacant atomic sites in a structure.



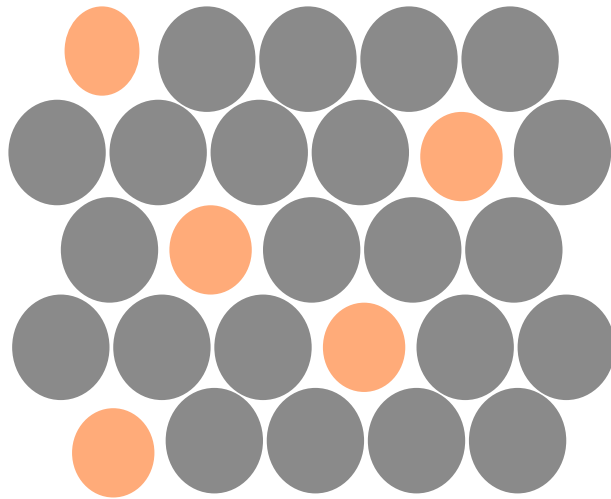
- **Self-Interstitials:**  
-"extra" atoms positioned between atomic sites.



# Point Defects in Alloys

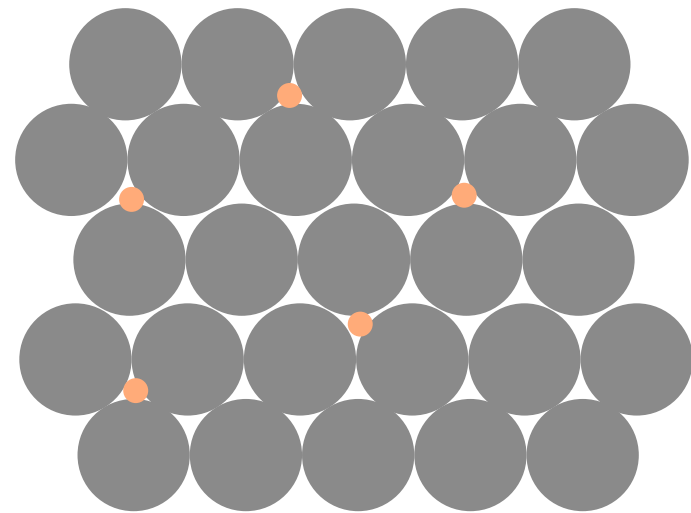
Two outcomes if impurity (B) added to host (A):

- **Solid solution** of **B** in A (i.e., random dist. of point defects)



**Substitutional** solid soln.  
(e.g., **Cu** in Ni)

OR



**Interstitial** solid soln.  
(e.g., **C** in Fe)

# Imperfections in Solids

## Edge Dislocation

- extra half-plane of atoms inserted in a crystal structure
- $\mathbf{b} \perp$  to dislocation line

Edge  
dislocation  
line

Burgers vector

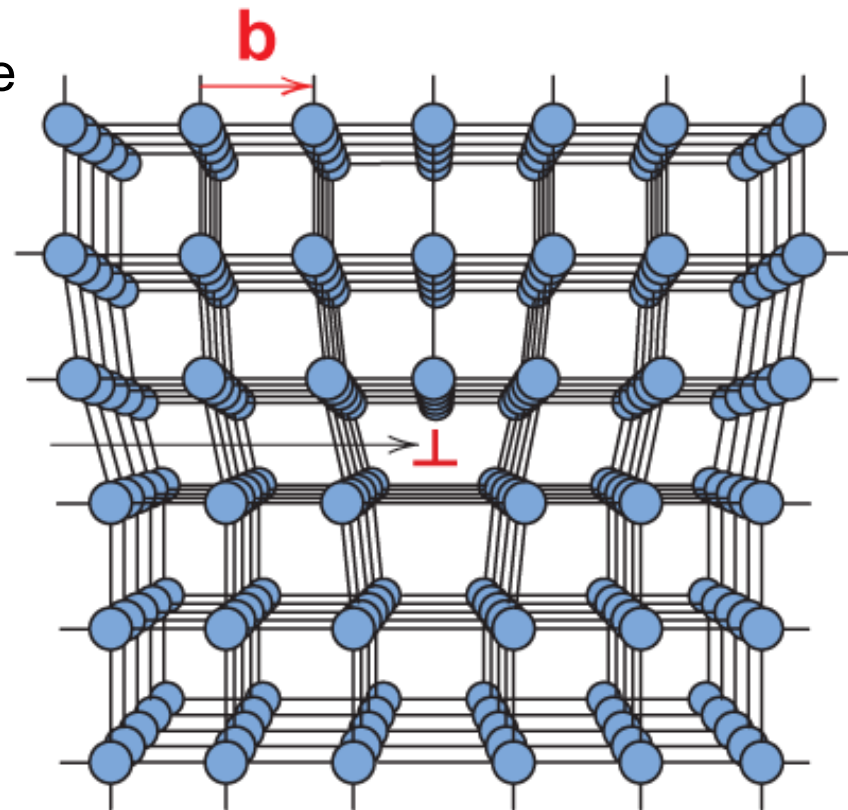


Fig. 4.3, Callister 7e.



# Diffusion

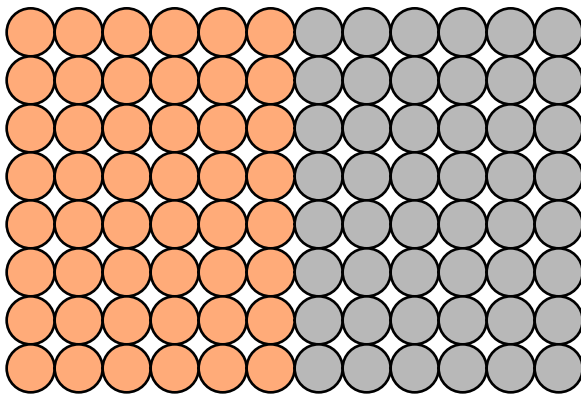
- Mechanisms, concentration gradients, diffusion coefficient
- Ficks laws
- Effects of T on diffusion coefficients



# Diffusion

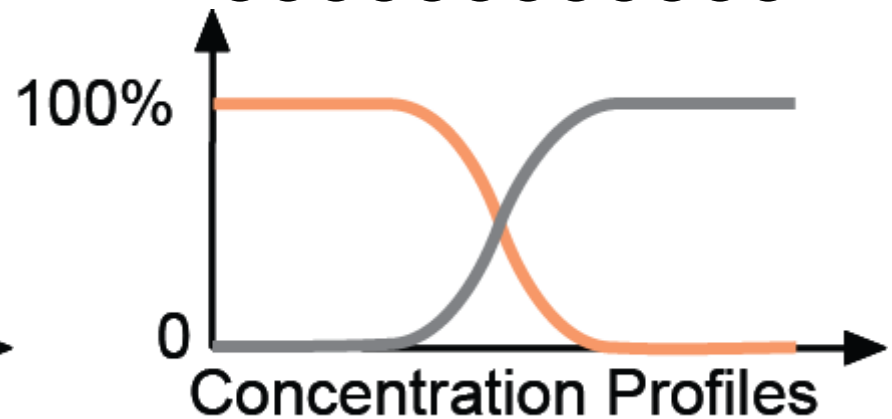
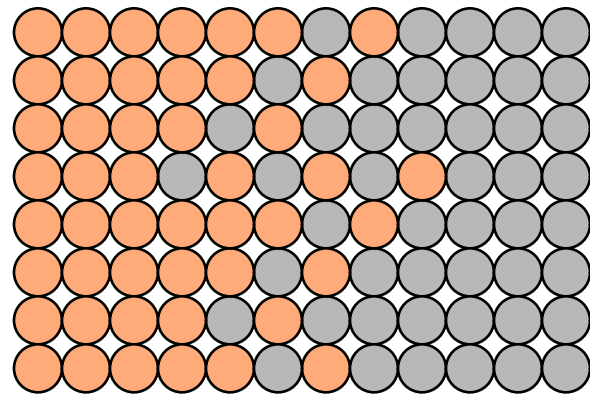
- **Interdiffusion:** In an alloy, atoms tend to migrate from regions of high conc. to regions of low conc.

Initially



Adapted from  
Figs. 5.1 and  
5.2, Callister  
7e.

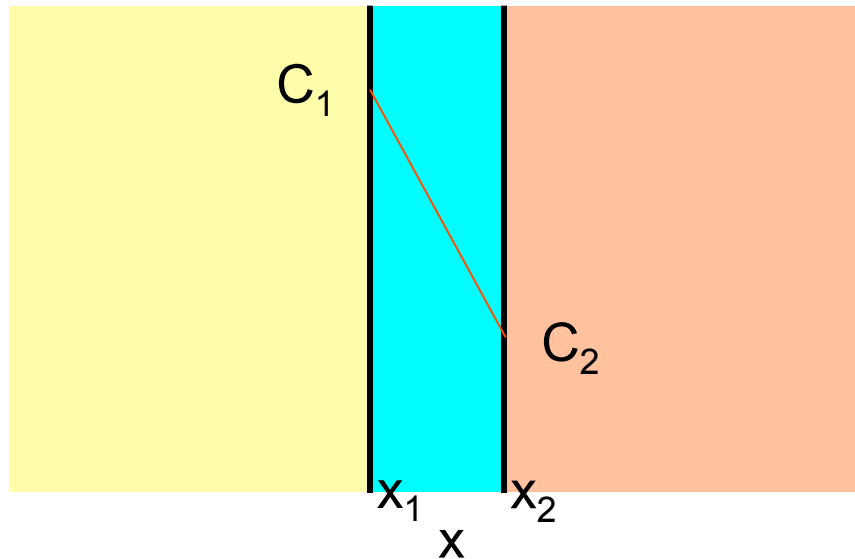
After some time



# Steady-State Diffusion

Rate of diffusion independent of time

Flux proportional to concentration gradient =  $\frac{dC}{dx}$



Fick's first law of diffusion

$$J = -D \frac{dC}{dx}$$

if linear  $\frac{dC}{dx} \cong \frac{\Delta C}{\Delta x} = \frac{C_2 - C_1}{x_2 - x_1}$

$D \equiv$  diffusion coefficient

# Non-steady State Diffusion

- The concentration of diffusing species is a function of both time and position  $C = C(x,t)$
- In this case **Fick's Second Law** is used

Fick's Second Law

$$\frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial x^2}$$



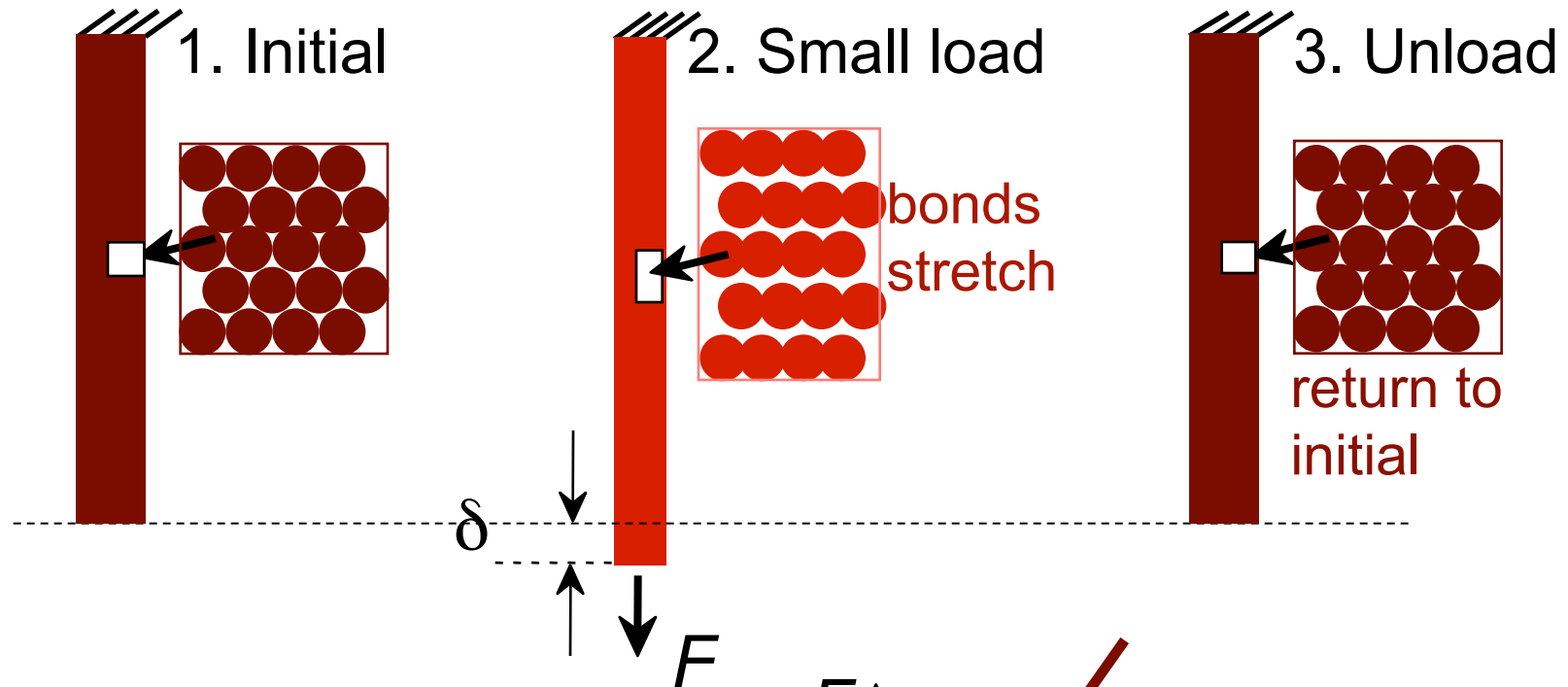


# Mechanical properties

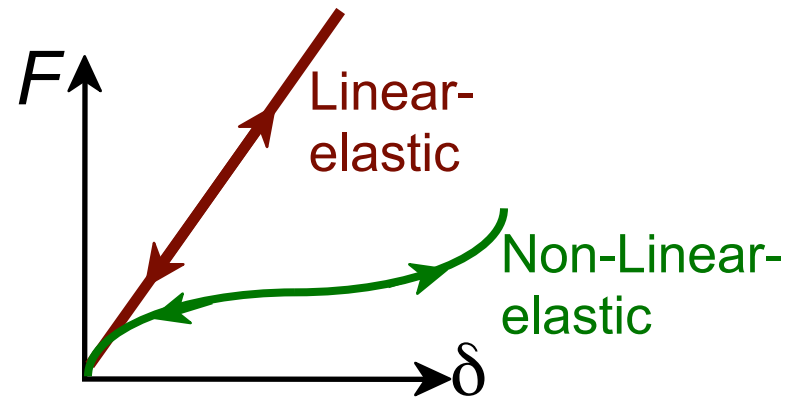
- Definition of stress, strain, elastic modulus
- Analysis of stress-strain curves
- Yield strength, tensile strength, Poisson's ratio, ductility, resilience, and toughness
- Hardness



# Elastic Deformation



Elastic means **reversible**!

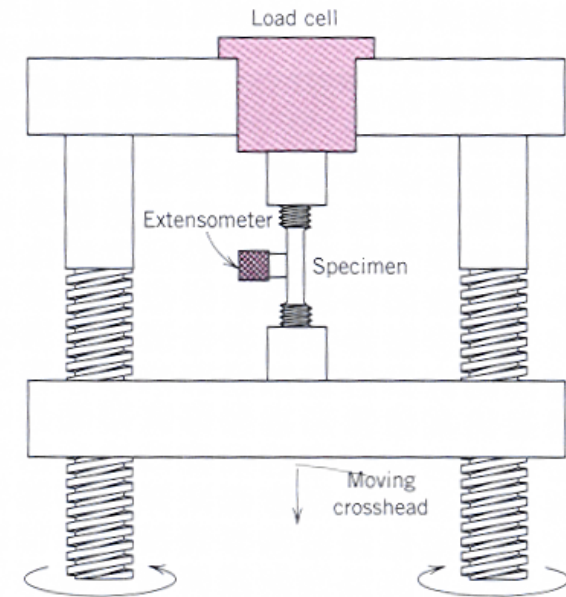
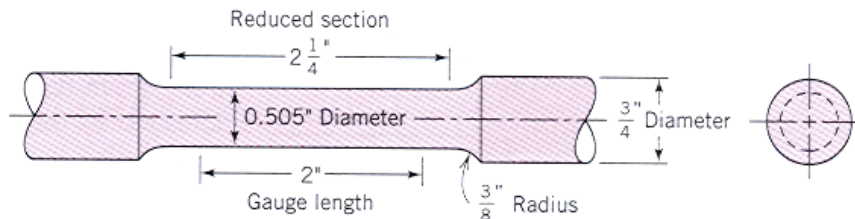


# Concepts of stress and strain

- Tension tests
  - engineering stress
  - engineering strain

$$\sigma = \frac{F}{A_0}$$

$$\epsilon = \frac{l_i - l_0}{l_0} = \frac{\Delta l}{l_0}$$

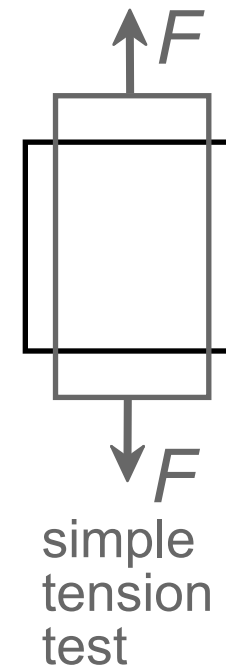
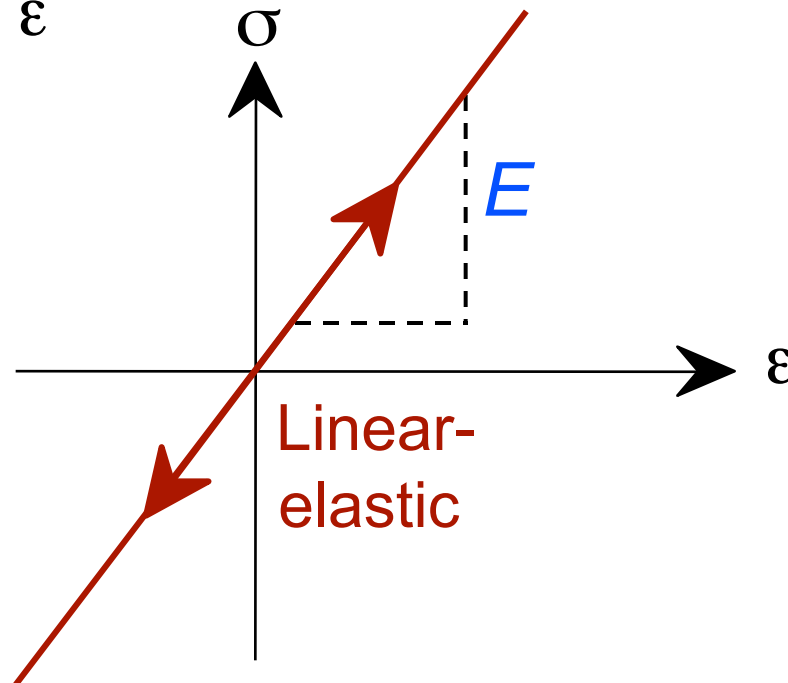


- Compression tests

# Linear Elastic Properties

- **Modulus of Elasticity,  $E$ :**  
(also known as Young's modulus)
- **Hooke's Law:**

$$\sigma = E \epsilon$$

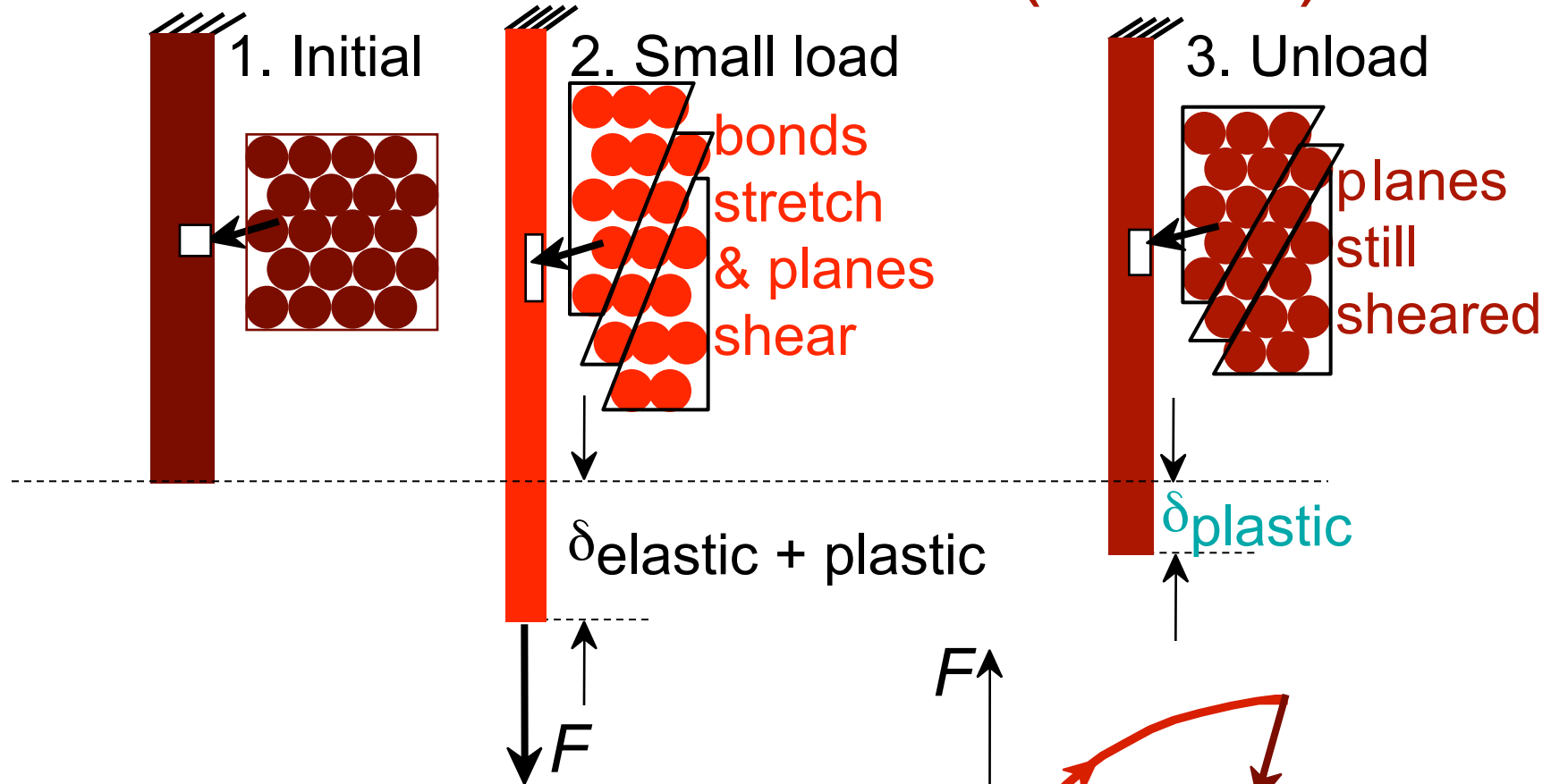


# Plastic deformation

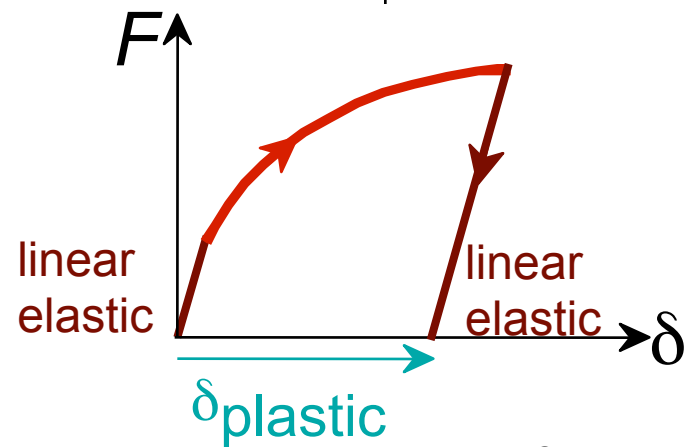
- Slip plane, direction and system, resolved shear stress
- Mechanism of plastic deformation
- Strengthening mechanisms
- Recovery, recrystallization, and grain growth



# Plastic Deformation (Metals)



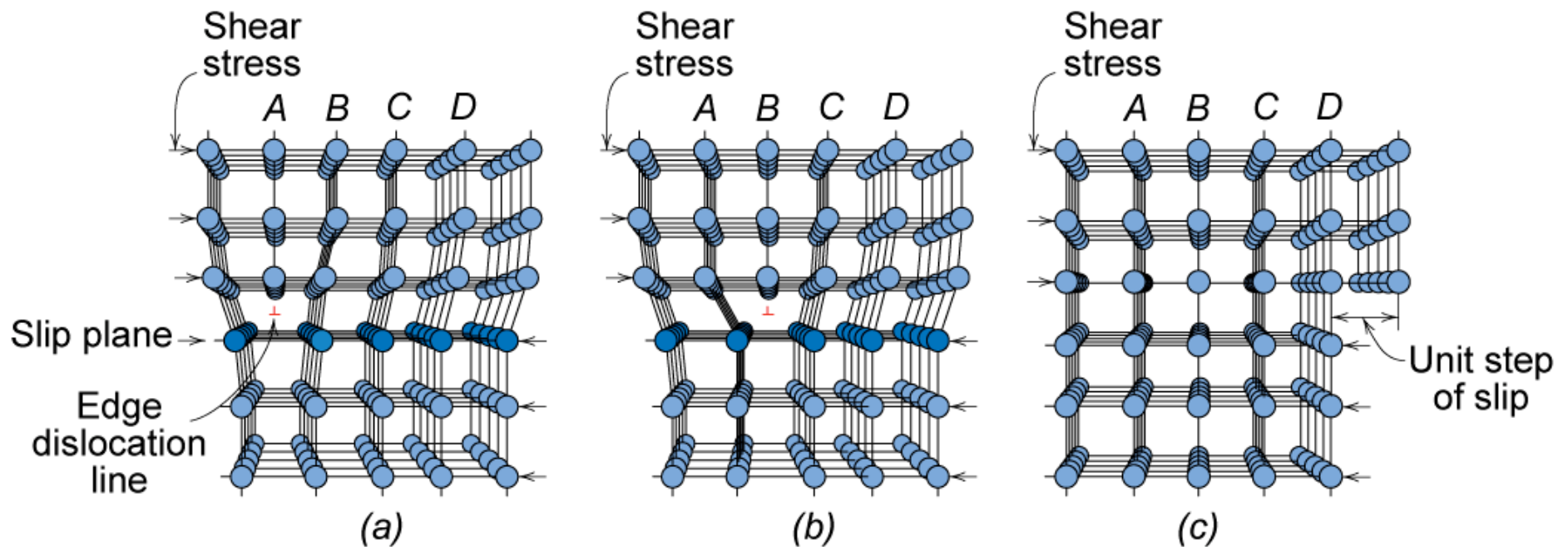
Plastic means **permanent!**



# Dislocation Motion

## Dislocations & plastic deformation

- Cubic & hexagonal metals - plastic deformation by **plastic shear or slip** where one plane of atoms slides over adjacent plane by defect motion (dislocations).



- If dislocations don't move, deformation doesn't occur!

Adapted from Fig. 7.1,  
Callister 7e.

Chapter 2 - 23



# Failure

- Ductile vs brittle fracture
- Stress concentrations and fracture toughness
- Creep and fatigue failure

