

Chapter 1 + 2:

CHAPTER 1:

Material Science: Investigates the relationships that exist between Structure & Properties of materials.

Material Engineering: Designing the structure of a material to produce required set of properties.

Classification of materials: Metals, Ceramics, Polymers & Composites

Advanced materials: Semiconductors, Biomaterials, Smart materials & Nano-materials

CHAPTER 2:

Solid Materials Classifications:

Crystal line Materials: Atoms are situated in a repeating/periodic array over large atomic distances.

Examples: All metals, many ceramics, and some polymers

Lattice: 3D array of points coinciding with atom positions.

Unit Cells: The basic structure unit or building block of the crystal structure

Metallic Crystal Structures:

FCC: Face-Centered Cubic

Chapter 1 + 2: (cont)

Atoms located at each corners and center of each face

Edge Length: $a = 2R\sqrt{2}$

Association: unit cell has four equivalent atoms (i.e. $[1/8 \times 8] + [1/2 \times 6]$)

Co-ordination Number: Each atom has the same number of nearest- neighbor or touching atoms, FCC has 12

Atomic Packing Factor(APF):
 $APF = (\text{volume of atoms in a unit cell}) / (\text{volume of unit cell})$
 FCC is 0.74

BCC: Body-Centered Cubic

Cubic unit cell with atoms located at each corner and a single atom at the cube center.

Edge length: $a = 4R/\sqrt{3}$

Association #: 2 (1 atom from 8 corners + 1 single center atom)

Co-ordination #: 8

APF: 0.68

HCP: Hexagonal Closed-Packed

Chapter 1 + 2: (cont)

Regular hexagons on top & bottom faces with one atom located at each corner (6 corners) and a single atom in the face center. Another plane provides 3 additional atoms is located between top and bottom faces.

Association #: 6 ($[12 \times 1/6] + [2 \times 1/2] + 3$)

Co-ordination #: 12

APF: 0.74

Density Computation:

$$\rho = (n \times A) / (V^C \times N^A)$$

ρ = Density

n = number of cells associated

A = Atomic weight

V^C = Volume of unit cell

N^A Avogadro's number
 (6.023×10^{23})

Volumes (V^C):

FCC + BCC: a^3

HCC: $6R^2 C\sqrt{3}$

Crystalline and Noncrystalline Materials

Single Crystals:

Chapter 1 + 2: (cont)

When the periodic and repeated arrangement of atoms is perfect or extends throughout the entirety of the specimen without interruption, the result is a single crystal.

Polycrystalline:

Composed of a collection of many small crystals or grains; such materials are termed polycrystalline.

Polymer Crystallinity:

Molecular substances of small molecules (as H₂O, CH₄,...) are totally Crystalline (as solid) or totally Amorphous (as liquids)

% crystallinity = $[\rho_c (\rho_s - \rho_a)] / [\rho_s (\rho_c - \rho_a)] \times 100$

Degree of crystallinity depends on:

Cooling rate during solidification

Chain configuration

Noncrystalline Solids:

Chapter 1 + 2: (cont)

Lacks of systematic and regular arrangement of atoms over relatively large atomic distances.

Amorphous : meaning literally without form (non-crystalline structure)

Super-cooled liquids : their atomic structure resembles that of liquids

CHAPTER 3 + 4

CHAPTER 3

Imperfections In Solids

Perfect order throughout crystalline materials on an atomic scale does not exist, all contain large numbers of various **defects** or **imperfections**.

Crystalline defect: Lattice irregularity in one/more of its dimensions on the scale of atomic diameter.

Classification of crystalline imperfections:

Point defect:

associated with one/more atomic positions

Types:

Vacancy: An atom is missing from one normally occupied site

CHAPTER 3 + 4 (cont)

Formed by: Solidification & Atomic Vibration

Equilibrium number of vacancies (N^v): $N^v = N \times e^{(-Q_v/kT)}$

N : Total number of atomic sites

Qv : Energy required for vacancy formation

T : Absolute Temperature

k : *Boltzmann's Constant (1.38×10^{-23} J/atom K or 8.62×10^{-5} eV/atom K)

Self-Interstitial: It means an atom is crowded into an interstitial site

Linear defects:

It is 1D defect

Burgers Vector (BV): Gives the magnitude & direction of lattice distortion associated with a dislocation.

Types:

CHAPTER 3 + 4 (cont)

Edge dislocation: Linear crystal-line defect associated with the lattice distortion produced in the vicinity of the extra half-plane of atoms within a crystal.

BV : Perpendicular to the dislocation line.*

Screw dislocation: A linear crystal-line defect associated with the lattice distortion produced when normally // planes are joined together to form a helical ramp.

BV : // to the dislocation line.

Interfacial defect:

It is 2D defect.

Grain Boundaries: It is the boundary separating two small grains/crystals having different crystallographic orientation in polycrystalline materials.

CHAPTER 3 + 4 (cont)

Grain Size determination: $N = 2^{n-1}$

Size determination:

N : Average number of grains per in^2 at 100X magnification.

n : Grain size #

Composition / Concentration

$C1 = m1 / (m1+m2) \times 100$

$nm1 = m1 \times N^A / A1$

$C1' = nm1 / (nm1+n- m2) \times 100$

ρ ave. = $100 / (C1/\rho1 + C2/\rho2)$

A ave. = $100 / (C1/A1 + C2/A2)$

CHAPTER 4

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