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:

Crystalline 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√2*

Association: *unit cell has four equivalent atoms (i.e. [1/8 x8]+[1/2 x6])*

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

Atomic Packing Factor(APF): *APF = (volume of atoms in a unit cell)/ (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/√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 ([12x1/6] + [2x1/2] + 3)*

Co-ordination #: *12*

APF: *0.74*

Density Computation:

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

p *= 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 *= [ρc (ρs – ρa)] / [ρs(ρc – ρa)]x100*

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*
	Formed by: *Solidification & Atomic Vibration*
Equilibrium number of vacancies (N^V):	*$N^V = N \times e^{(-Qv/kT)}$*
	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:

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.*
Grain Size determination:	***N** = 2^{n-1}*
	N : *Average number of grains per in^2 at 100X magnification.*
	n : *Grain size #*

Composition / Concentration

	***C1** = m1/(m1+m2)x100*
	***nm1** = $m1 \times N^A/A1$*
	***C1'** = nm1/ (nm1+nm2)x100*
	***ρ ave.** = 100 / (C1/p1 + C2/p2)*
	***A ave.** = 100 / (C1/A1 + C2/A2)*

CHAPTER 4

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