

Course Material

Name of the Course	:	Materials Engineering
Name of the Unit	:	Crystal structure
Name of the Topic	:	Metallic crystal structures and its classifications

❖ **Objectives:**

To recollect the basic concepts of different metals and its crystal structures

❖ **Outcomes:**

Upon successful completion, the student should be able to recall/regain the basic concept of crystal structure of different metals.

❖ **Pre-test:**

To recall the basic knowledge of various metallic structures

1) **Number of metallic elements in the periodic table is**

- a) 118
- b) **95**
- c) 125
- d) 145

2) **In general _____ types of metals most of the real-time applications**

- a) 2
- b) **3**
- c) 4
- d) 5

3) **Brass is an alloy**

- a) **True**
- b) False

4) **Which of the following metal is used for nuclear energy?**

- (A) Uranium
- (B) Thorium
- (C) Niobium
- (D) **All of these**

5) **The bond formed by transferring electrons from one atom to another is called**

- (A) **Ionic bond**
- (B) Covalent bond
- (C) Metallic bond
- (D) None of these

6) The unit cells

- a. Contain the smallest number of atoms which when taken together have all the properties of the crystals of the particular metal
- b. Have the same orientation and their similar faces are parallel
- c. May be defined as the smallest parallelepiped which could be transposed in three coordinate directions to build up the space lattice
- d. All of the above**

7) Macrostructure of a material is, generally, examined by

- (A) Naked eye**
- (B) Optical microscope
- (C) Metallurgical microscope
- (D) X-ray techniques

8) A material is said to be allotropic, if it has

- (A) Fixed structure at all temperatures
- (B) Atoms distributed in random pattern
- (C) Different crystal structures at different temperatures**
- (D) Any one of the above

9) Which of the following is an amorphous material?

- (A) Mica
- (B) Silver
- (C) Lead
- (D) Glass**

10) Amorphous solids have _____ structure.

- a) Regular
- b) Linear
- c) Irregular**
- d) Dendritic

Crystal structure - Theory

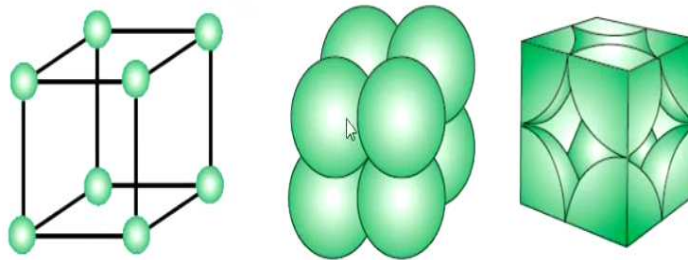
- A regular and repetitious pattern in which atoms of a crystalline material arrange themselves is known as the crystal structure.
- A crystal structure is composed of a unit cell, a set of atoms arranged in a particular way; which is periodically repeated in three dimensions on a lattice.
- In practical most of the metals crystallize in one of the three relatively simple structures namely BCC, FCC, CPH or HCP.

Need for the study of crystal structure of metals

- ❖ Difficulties in relating the properties of metals
- ❖ Solid solution preparation
- ❖ Overcome surface treatment problems like carburizing, flame hardening
- ❖ Unexpected failures of metals
- ❖ To develop new cutting tool metals with required hardness
- ❖ To avoid bulk rejection rate in the metal castings
- ❖ To support R&D for developing alternate materials in the economical way

Classification of most common metals crystal structures

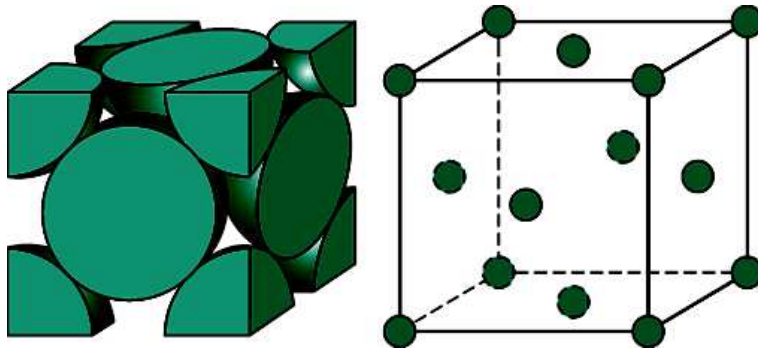
1. Simple cubic (SCC) structure



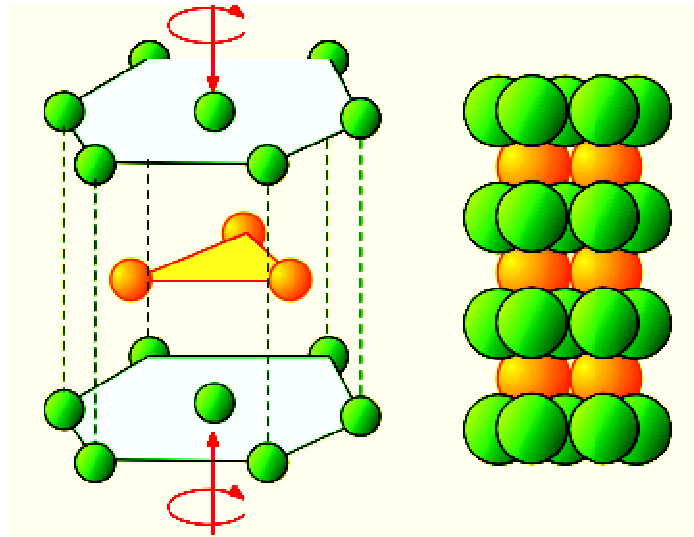
2. Body centered cubic (BCC) structure



3. Face centered cubic (FCC) structure



4. Hexagonal close packed (HCP) structure

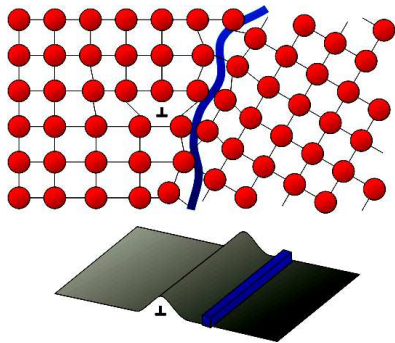


Terminology used other than normal known scientific / engg. terms and their fundamental explanations / relations:

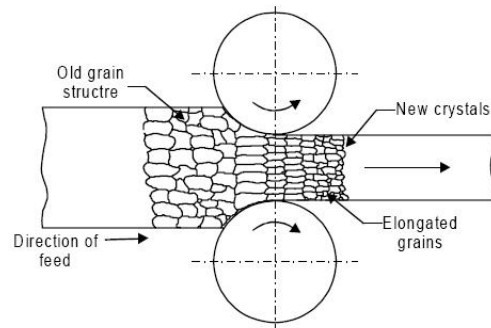
- Unit cells and bravais lattices of crystal structures, atomic packing factor, coordination number, void space and density

Application & Behaviour of crystal structures

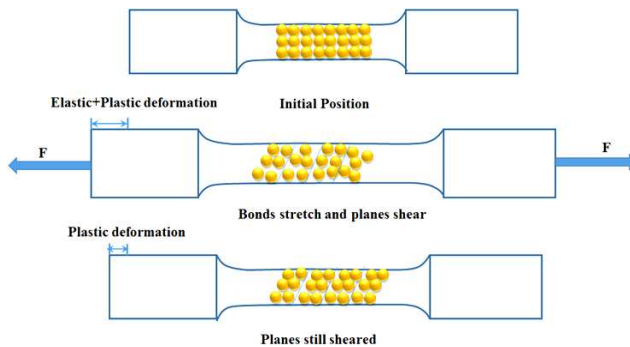
1. Bending



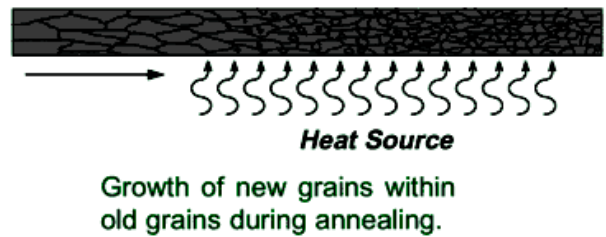
2. Rolling



3. Stretching



4. Heat treatment



Test after completion

1) Bravais lattice consists of _____ space lattices.

- a) Eleven
- b) Twelve
- c) Thirteen
- d) **Fourteen**

2) The crystal lattice has a _____ arrangement.

- a) One-dimensional
- b) Two-dimensional
- c) **Three-dimensional**
- d) Four-dimensional.

3) The smallest portion of the lattice is known as _____

- a) Lattice structure
- b) Lattice point

- c) Bravais crystal
- d) **Unit cell**

4) Crystal structure gives the details of

- a) Phases
- b) Grains
- c) **Arrangement of atoms**
- d) Porosity

5) Every point of space lattice has ----- on surroundings.

- (a) **Atoms**
- (b) Element
- (c) Lattice
- (d) Identical

Conclusion

- ✚ We have discussed in detail about crystal structure and crystal structure types such as simple cubic, body centered, face centered, and hexagonal close packed crystal structure.
- ✚ Simple cubic structure doesn't exist in any engineering material
- ✚ Metals like Cr, K, Na, V, Mo, Mn, α Fe, etc. have body centered type of crystal structure.
- ✚ .Metals like Mg,Zn,Cd etc Having hexagonal close packed type of crystal structure.
- ✚ FCC structures of the metals like Cu, Ag, Al, Pb, γ Fe, etc are more likely to be ductile than BCC, (body centered cubic) and HCP & HCP (hexagonal close packed) structure metals behave as brittle.

Demo Videos

<https://www.youtube.com/watch?v=Rm-i1c7zr6Q>

References

- [1]. Khanna, O.P. A Text Book of Material Science and Metallurgy (Material Science, Extractive Metallurgy, Physical Metallurgy, Mechanical Metallurgy). India, Dhanpat Rai, 2015.
- [2]. Raghavan V. Materials Science and Engineering: A First Course, PHI Publication , Delhi, 2015

[3]. George Ellwood Dieter, David Bacon. Mechanical Metallurgy , McGraw-Hill, 1988.

[4]. Material science and engineering, William D. Callister Jr., David G. Rethwisch. Wiley Publication, 8th edition, 2009.

Assignment questions

1. What is a Crystal? (or) What are crystalline materials? Give examples
2. What is an amorphous solid? Give example. (or) Non-Crystalline materials
3. What is meant by Crystallography?
4. What is a single crystal?
5. Define Lattice
6. What is primitive cell?
7. Name of the seven crystal system
8. What are Bravais lattices?
9. Define co-ordination number
10. Define Atomic packing factor (or) Packing density (or) density of packing
