SCIENCE AND ENGINEERING MATERIALS

Crystallographic Points, Directions and Planes

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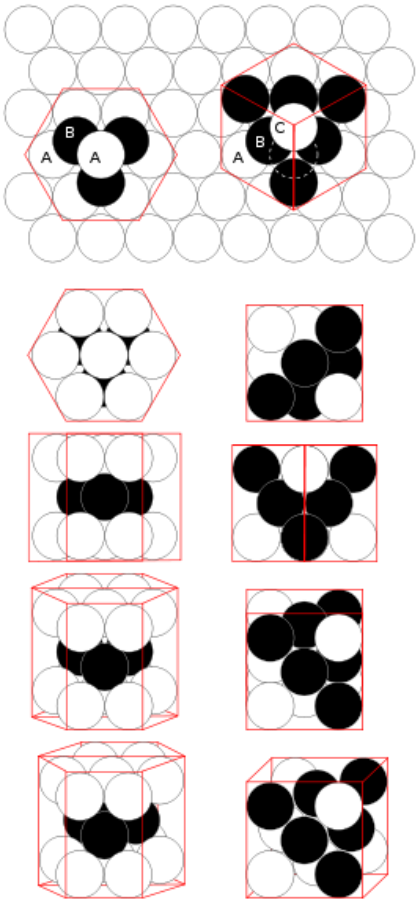
Chapter Description

- Learning Objectives
  - Understand the three-dimensional space Bravais lattices
  - Write the designation for atom position, and Miller indices (direction and plane) for cubic crystals
  - Sketch point, direction and plane in a unit cell based on Miller indices

Space Lattice and Unit Cell

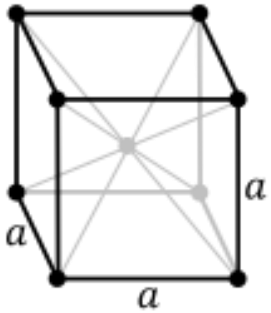


Source: Twisp; Wikimedia

- **Crystalline structure** – regular and repeating
- **Unit cell** – structural unit that is repeated by translation in forming a crystalline structure
- **Lattice constants** – length of a unit cell edge and/or angle between crystallographic axes

Seven Crystal Systems

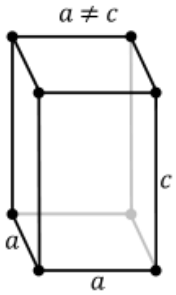
- Unique unit cell shapes that can be stacked together to fill 3-D space



Cubic: $a = b = c, \alpha = \beta = \gamma = 90°$

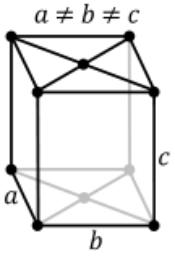
Source: Daniel Mayer and DrBob; Wikimedia

Seven Crystal Systems (Cont'd)



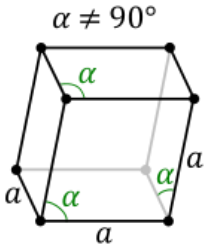
Tetragonal: $a = b \neq c, \alpha = \beta = \gamma = 90°$

Source: Daniel Mayer; Wikimedia



Orthorhombic: $a \neq b \neq c, \alpha = \beta = \gamma = 90°$

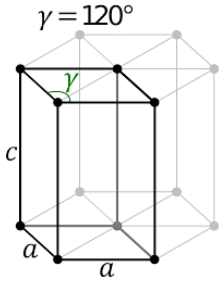
Source: DrBob; Wikimedia



Rhombohedral: $a = b = c, \alpha = \beta = \gamma \neq 90°$

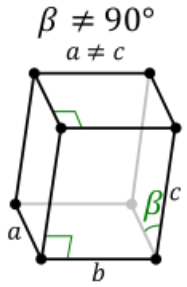
Source: DrBob; Wikimedia

Seven Crystal Systems (Cont'd)



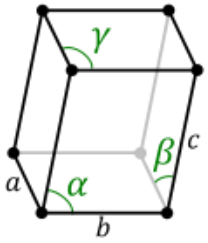
Hexagonal: $a = b \neq c, \alpha = \beta = 90°, \gamma = 120°$

Source: Bor75; Wikimedia



Monoclinic: $a \neq b \neq c, \alpha = \gamma = 90° \neq \beta$

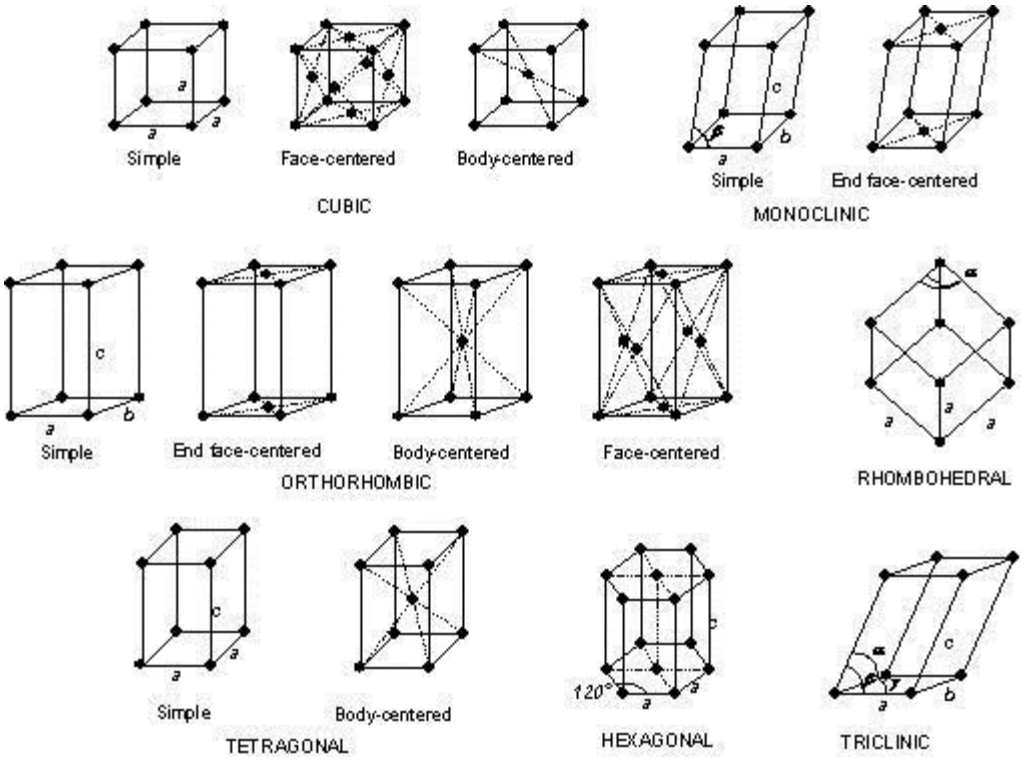
Source: Daniel Mayer; Wikimedia



Triclinic: $a \neq b \neq c, \alpha \neq \beta \neq \gamma \neq 90°$

Source: DrBob; Wikimedia

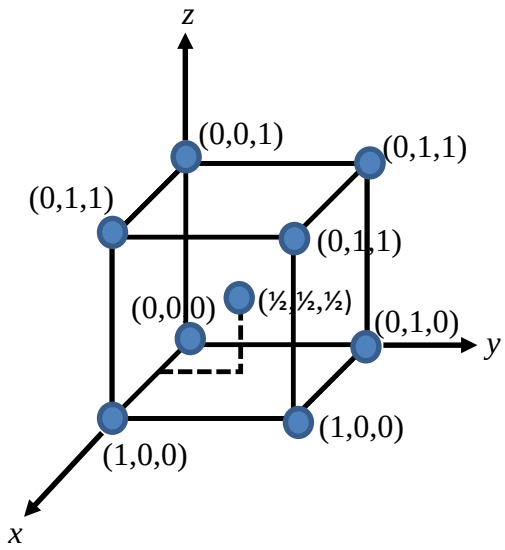
14 Bravais Lattices



Source: Sabu.R.M.; amazingsolids.wordpress.com

Lattice Positions

- Lattice points – theoretical points arranged periodically in 3-D space



Atom positions in a unit cell of body-centered cubic

Lattice Directions

- **Miller indices** is a notation system in crystallography for planes and directions in crystal unit cell.
- Procedure to determine Miller indices for lattice directions:
  1. Determine the coordinates of start and end points of the lattice direction
  2. Subtract the tail coordinates from the head
  3. Clear fraction (if any) and reduce to lowest integers
  4. Use bracket [ ] to enclose the number. Use a bar over the number if negative sign is produced

Lattice Plane

- Miller plane indices: The orientation of planes in crystal structure
- The procedure to determine Miller Plane indices:
  1. Identify the axis interception point of plane
  2. Take reciprocal of these intercepts
  3. Clear fractions (if any)
  4. Use bracket [ ] to enclose the number (without comma). Use a bar over the number if negative sign is produced

Conclusion of The Chapter

- Atom of crystal structure is arranged in a network lines called a space lattice.
- There are seven crystal system and 14 Bravais lattice system based on the geometry and interaxial angels of the unit cells.
- Crystal structure can be identified according to its lattice indexing points, directions, and planes system known as Miller index.

References

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[3] Smith, W. F. & Hashemi, J. Foundations of Materials Science & Engineering, McGraw Hill, 0071256903

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