MATERIAL SCIENCE AND ENGINEERING

ENCH 201

Lecture : 3
Tutorial : 1
Practical : 0

Year : II
Part : I

Course Objectives:
The objective of this course is to familiarize the students with the relationship among structure, properties, processing and application of materials. After completion of this course, the students are able to evaluate criteria for selection of materials in various industrial sectors.

1 Introduction and Classification (5 hours)

1.1 Historical perspective, significance of material science and engineering, materials science tetrahedron
1.2 Classification of materials based on structure: Metal, ceramics, glass, polymer and composite materials
1.3 Advanced materials: Semiconductors, biomaterials, smart materials, nanomaterial

2 Atomic and Crystal Structure (8 hours)

2.1 Structure of atoms and molecules, atomic bonding in solids, types of bonds and comparison of bonds
2.2 Crystals, crystal lattice, unit cell, 2D and 3D lattice systems, symmetry operations, atomic packing factor and density, miller indices, methods of determining crystal structure
2.3 Imperfections in crystals, types of imperfection (Defects): Point defect, line defect, surface defect and volume defect

3 Phase Diagrams and Transformations (8 hours)

3.1 Phase diagram definition and concept, phase equilibrium, types of phase diagrams
3.2 Phase rule, unary, binary phase diagrams, thermal equilibrium diagrams, eutectic phase diagrams, Cd-Bi, Pb-Sn, Cu-Ni, Ag-Cu, Fe-C or Fe-Fe3C-phase diagrams
3.3 Phase transformation, energetics of transition, nucleation and crystal growth and overall transformation, concept of freeze drying
3.4 Time-temperature-transformation (TTT) diagram, nucleation rates, homogeneous and heterogeneous nucleation

4 Electrical, Magnetic and Thermal Properties of Materials (8 hours)

4.1 Electrical properties of materials: Ohm's law, electrical conductivity, electronic and ionic conduction, energy band structure in solids, electron mobility, electrical resistivity of metals and alloys

4.2 Semi conductivity: Intrinsic semiconductors, extrinsic semiconductors, temperature dependence of carrier concentration, Hall effect, polarization, piezo and ferro-electricity

4.3 Magnetic properties: Paramagnetism, diamagnetism, ferri and ferromagnetism, soft and hard magnetic materials

4.4 Thermal properties: Thermal conductivity, specific heat capacity, thermal expansion

5 Mechanical Behavior of Materials (6 hours)

5.1 Deformation-concept of stress and strain, elastic and plastic deformation in materials, stress-strain curve

5.2 Dislocation in metals-characteristics, slip systems, slip in single crystals, fracture-ductile and brittle, fatigue (S-N curve), crack initiation and propagation, creep, Griffith's criterion

5.3 Corrosion and mechanical strength, dependence of mechanical strength on thermal properties

6 Processing and Selection of Materials (10 hours)

6.1 Processing of metals and alloys: Casting, forming, powder metallurgy

6.2 Processing of polymers: Thermoforming, molding (Compression, injection, blow, transfer and extrusion molding), casting, calendaring, fiber spinning

6.3 Processing of glass and ceramics: Glass-forming, particulate forming, cementation

6.4 Criteria for selection of materials in chemical process industry

Tutorial (15 hours)

1. Introduction and classification, advanced materials: Semiconductors, biomaterials, smart materials, nanomaterials
2. Atomic and crystal structure, symmetry operations, atomic packing factor and density, miller indices
3. Phase diagrams and transformations, phase rule, binary phase diagrams, Time-temperature-transformation (TTT) diagram
4. Electrical, magnetic, and thermal properties of materials, electrical, magnetic, and thermal properties calculation of different materials
5. Mechanical behavior of materials, slip systems, S-N curve, creep, Griffith's criterion
6. Processing and selection of materials, criteria for selection of materials in chemical process industry

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	5	5
2	8	10
3	8	10
4	8	10
5	6	10
6	10	15
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Callister Jr, W.D., Rethwisch, D.G. (2020). Fundamentals of materials science and engineering: an integrated approach. John Wiley & Sons.
2. Puri, R.K., Babbar, V.K. (2008). Solid state physics and electronics. S. Chand Publishing.
3. Mitchell, B.S. (2004). An introduction to materials engineering and science for chemical and materials engineers. John Wiley & Sons

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