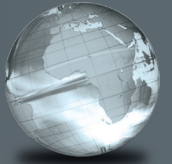


GLOBAL
EDITION



Introduction to Materials Science for Engineers

Ninth Edition

James F. Shackelford



NINTH EDITION
GLOBAL EDITION

Introduction to MATERIALS SCIENCE FOR ENGINEERS

James F. Shackelford

University of California, Davis



Introduction to Materials Science for Engineers, Global Edition

Table of Contents

Cover

Title Page

Copyright

Dedication

Contents

Preface

Chapter 1. Materials for Engineering

1.1 The Material World

1.2 Materials Science and Engineering

1.3 Six Materials That Changed Your World

Steel BridgesIntroducing Metals

Transparent OxidesIntroducing Ceramics

Smartphones And TabletsIntroducing Glasses

Nylon ParachutesIntroducing Polymers

Kevlar®-Reinforced TiresIntroducing Composites

Silicon ChipsIntroducing Semiconductors

1.4 Processing and Selecting Materials

1.5 Looking at Materials by Powers of Ten

Part I: The Fundamentals

Chapter 2. Atomic Bonding

2.1 Atomic Structure

2.2 The Ionic Bond

Coordination Number

2.3 The Covalent Bond

2.4 The Metallic Bond

Table of Contents

2.5 The Secondary, or van der Waals, Bond

2.6 MaterialsThe Bonding Classification

Chapter 3. Crystalline StructurePerfection

3.1 Seven Systems and Fourteen Lattices

3.2 Metal Structures

3.3 Ceramic Structures

3.4 Polymeric Structures

3.5 Semiconductor Structures

3.6 Lattice Positions, Directions, and Planes

3.7 X-Ray Diffraction

Chapter 4. Crystal Defects and Noncrystalline StructureImperfection

4.1 The Solid SolutionChemical Imperfection

4.2 Point DefectsZero-Dimensional Imperfections

4.3 Linear Defects, or DislocationsOne-Dimensional Imperfections

4.4 Planar DefectsTwo-Dimensional Imperfections

4.5 Noncrystalline SolidsThree-Dimensional Imperfections

Chapter 5. Diffusion

5.1 Thermally Activated Processes

5.2 Thermal Production of Point Defects

5.3 Point Defects and Solid-State Diffusion

5.4 Steady-State Diffusion

5.5 Alternate Diffusion Paths

Chapter 6. Mechanical Behavior

6.1 Stress Versus Strain

Metals

Ceramics And Glasses

Polymers

6.2 Elastic Deformation

6.3 Plastic Deformation

6.4 Hardness

6.5 Creep and Stress Relaxation

6.6 Viscoelastic Deformation

Inorganic Glasses

Table of Contents

Organic Polymers

Elastomers

Chapter 7. Thermal Behavior

7.1 Heat Capacity

7.2 Thermal Expansion

7.3 Thermal Conductivity

7.4 Thermal Shock

Chapter 8. Failure Analysis and Prevention

8.1 Impact Energy

8.2 Fracture Toughness

8.3 Fatigue

8.4 Nondestructive Testing

8.5 Failure Analysis and Prevention

Chapter 9. Phase DiagramsEquilibrium Microstructural Development

9.1 The Phase Rule

9.2 The Phase Diagram

Complete Solid Solution

Eutectic Diagram With No Solid Solution

Eutectic Diagram With Limited Solid Solution

Eutectoid Diagram

Peritectic Diagram

General Binary Diagrams

9.3 The Lever Rule

9.4 Microstructural Development During Slow Cooling

Chapter 10. KineticsHeat Treatment

10.1 TimeThe Third Dimension

10.2 The TTT Diagram

Diffusional Transformations

Diffusionless (Martensitic) Transformations

Heat Treatment Of Steel

10.3 Hardenability

10.4 Precipitation Hardening

10.5 Annealing

Cold Work

Table of Contents

Recovery

Recrystallization

Grain Growth

10.6 The Kinetics of Phase Transformations for Nonmetals

Part II: Materials and Their Applications

Chapter 11. Structural MaterialsMetals, Ceramics, and Glasses

11.1 Metals

Ferrous Alloys

Nonferrous Alloys

11.2 Ceramics and Glasses

CeramicsCrystalline Materials

GlassesNoncrystalline Materials

Glass-Ceramics

11.3 Processing the Structural Materials

Processing Of Metals

Processing Of Ceramics And Glasses

Chapter 12. Structural MaterialsPolymers and Composites

12.1 Polymers

Polymerization

Structural Features Of Polymers

Thermoplastic Polymers

Thermosetting Polymers

Additives

12.2 Composites

Fiber-Reinforced Composites

Aggregate Composites

Property Averaging

Mechanical Properties Of Composites

12.3 Processing the Structural Materials

Processing Of Polymers

Processing Of Composites

Chapter 13. Electronic Materials

13.1 Charge Carriers and Conduction

13.2 Energy Levels and Energy Bands

13.3 Conductors

Table of Contents

Thermocouples

Superconductors

13.4 Insulators

Ferroelectrics

Piezoelectrics

13.5 Semiconductors

Intrinsic, Elemental Semiconductors

Extrinsic, Elemental Semiconductors

Compound Semiconductors

Processing Of Semiconductors

Semiconductor Devices

13.6 Composites

13.7 Electrical Classification of Materials

Chapter 14. Optical and Magnetic Materials

14.1 Optical Materials

Optical Properties

Optical Systems And Devices

14.2 Magnetic Materials

Ferromagnetism

Ferrimagnetism

Metallic Magnets

Ceramic Magnets

Chapter 15. Materials in Engineering Design

15.1 Material PropertiesEngineering Design Parameters

15.2 Selection of Structural MaterialsCase Studies

Materials For Hip- And Knee-Joint Replacement

Metal Substitution With Composites

15.3 Selection of Electronic, Optical, and Magnetic MaterialsCase Studies

Light-Emitting Diode

Glass For Smart Phone And Tablet Touch Screens

Amorphous Metal For Electric-Power Distribution

15.4 Materials and Our Environment

Environmental Degradation Of Materials

Environmental Aspects Of Design

Recycling And Reuse

Appendix 1. Physical and Chemical Data for the Elements

Table of Contents

Appendix 2. Atomic and Ionic Radii of the Elements

Appendix 3. Constants and Conversion Factors and the Periodic
Table of Elements

Appendix 4. Properties of the Structural Materials

Appendix 5. Properties of the Electronic, Optical, and Magnetic
Materials

Appendix 6. Glossary

Answers to Practice Problems (PP) and Odd-Numbered Problems

Index