MSE XXX: Introduction to Materials Science & Engineering

Course Objective...

Introduce fundamental concepts in Materials Science

You will learn about:

- material structure
- how structure dictates properties
- how processing can change structure

This course will help you to:

- use materials properly
- realize new design opportunities with materials

LECTURES

Lecturer:

Time:

Location:

Activities:

- Present new material
- Announce reading and homework
- Take quizzes and midterms*

*Make-ups given only for emergencies.

*Discuss potential conflicts beforehand.

RECITATIONS

Instructor:

Times and Places:

___.	X:XXam	_____ XXX
___.	X:XXpm	_____ XXX
___.	X:XXpm	_____ XXX
___.	X:XXam	_____ XXX
___.	X:XXpm	_____ XXX

Purpose:

- Discuss homework, quizzes, exams
- Hand back graded quizzes, exams
- Discuss concepts from lecture

Recitations start *next* week.

Try to attend your registered recitation.

If necessary, attend an alternate recitation.

LABORATORY SECTIONS

Instructor:

Location:

Purpose: To learn more about materials by relating lecture material with observations. Also to learn to properly formulate and write engineering reports and proposals.

TEACHING ASSISTANTS

Name	Office	Tel.	E-mail
_____	_____ XXX	X-XXXX	_____
_____	_____ XXX	X-XXXX	_____
_____	_____ XXX	X-XXXX	_____
_____	_____ XXX	X-XXXX	_____
_____	_____ XXX	X-XXXX	_____

Teaching Assistants will

- participate in recitation sessions,
- have office hours to help you with course material and problem sets.

Office Hours

X:XX-X:XX each weekday**

_____.	_____ XXX	_____
_____.	_____ XXX	_____
_____.	_____ XXX	_____
_____.	_____ XXX	_____
_____.	_____ XXX	_____

**Contact professors for special arrangements

Activities:

- Discuss homework, quizzes, exams
- Discuss lectures, book
- Pick up missed handouts

COURSE MATERIALS

Required text:

- *Materials Science and Engineering: An Introduction*
  W.D. Callister, Jr., 7th edition, John Wiley and Sons, Inc. (2007).

Optional Material:

- _____
  _____.
- _____
  _____.
- _____
  _____.

COURSE WEBSITES

Course Website: http://www.xxx.edu/xxxxx

- Syllabus
- Lecture notes
- Answer keys
- Grades
-

Text Website: http://www.wiley.com/college/callister

- Additional Chapters (Chapters 19-23)
- Complete solutions to selected problems
- Links to other web resources
- Extended learning objectives
- Self-assessment exercises

GRADING

Weekly in-lecture quizzes XX%

Held on _____ at the beginning of class

Based on core homework problems

Your lowest quiz grade will be dropped

Midterm #1 XX%

Tentatively scheduled for:

Material covered:

Midterm #2 XX%

Tentatively scheduled for:

Material covered:

Final XX%

Tentatively scheduled for:

Material covered:

READING SCHEDULE

Week	Topic	Chapter
1	General Intro; Atomic Bonding	1,2
2	Crystalline Structure; Imperfections	3,4
3	Diffusion; Mechanical Properties	5,6
4	Strengthening Mechanisms; Failure	7,8
5	Phase Diagrams	9
6	Kinetics & Phase Transformations	10
	Processing & Applications of Metals	11
7	Struc., Prop., Proc., Applic. of Ceramics	12,13
8	Struc., Prop. of Polymers; Composites	15,16
9	Corrosion; Elec. & Thermal Prop.	17,18,19*
10	Magnetic & Optical Prop.	20*,21*
	Materials Selection; Econ. & Envir. Issues	22*,23*

Lectures: will highlight important portions of each chapter.

*These chapters available at website www.wiley.com/college/callister.

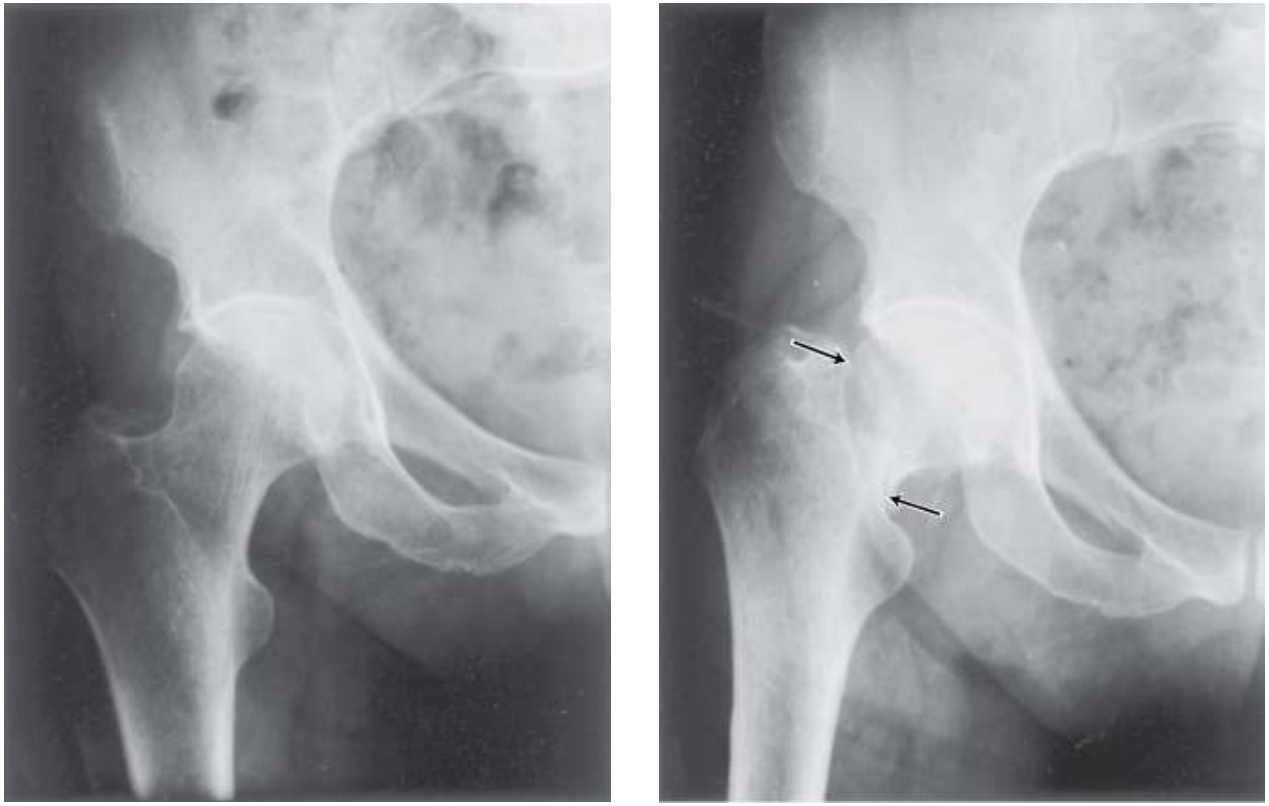
Chapter 1 - Introduction

- **What is materials science?**
- **Why should we know about it?**

- Materials drive our society
  - **Stone Age**
  - **Bronze Age**
  - **Iron Age**
  - **Now?**
    - **Silicon Age?**
    - **Polymer Age?**

Example – Hip Implant

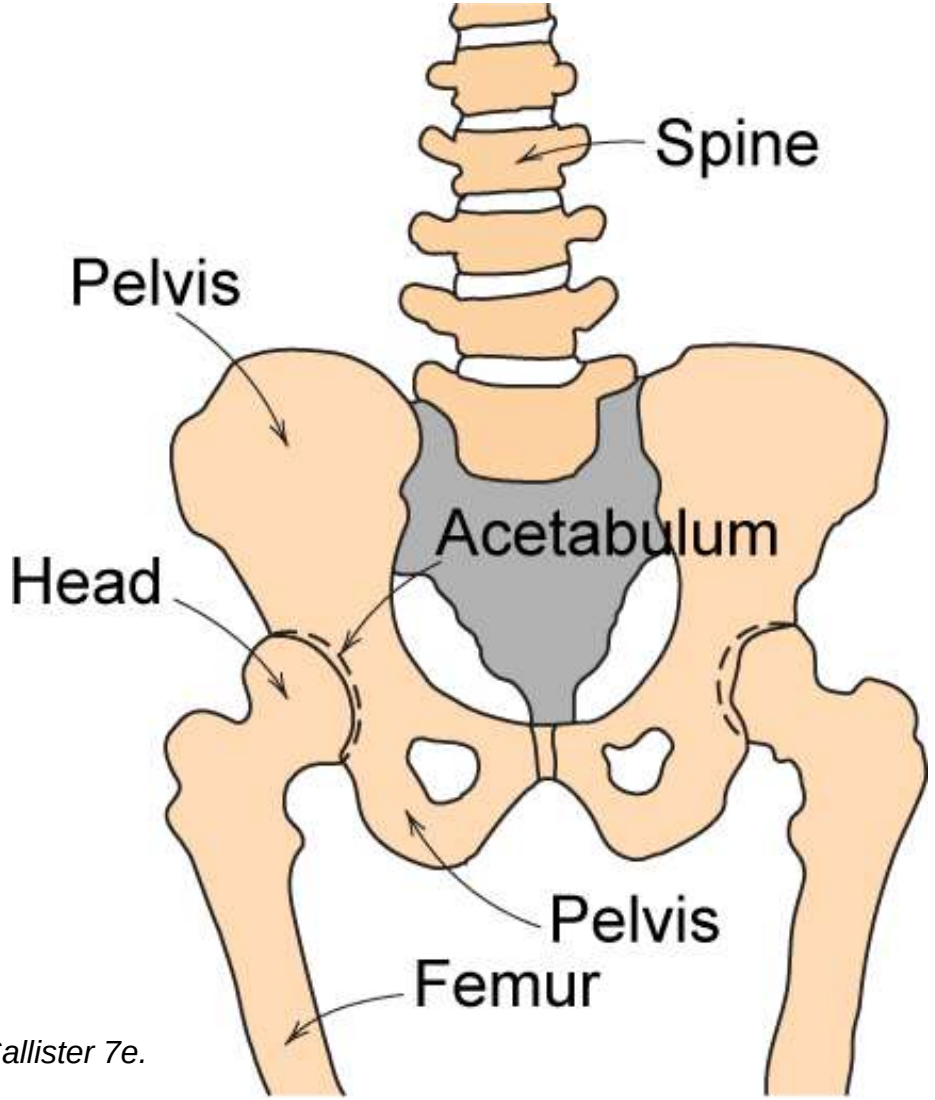
- With age or certain illnesses joints deteriorate. Particularly those with large loads (such as hip).



Adapted from Fig. 22.25, *Callister 7e.*

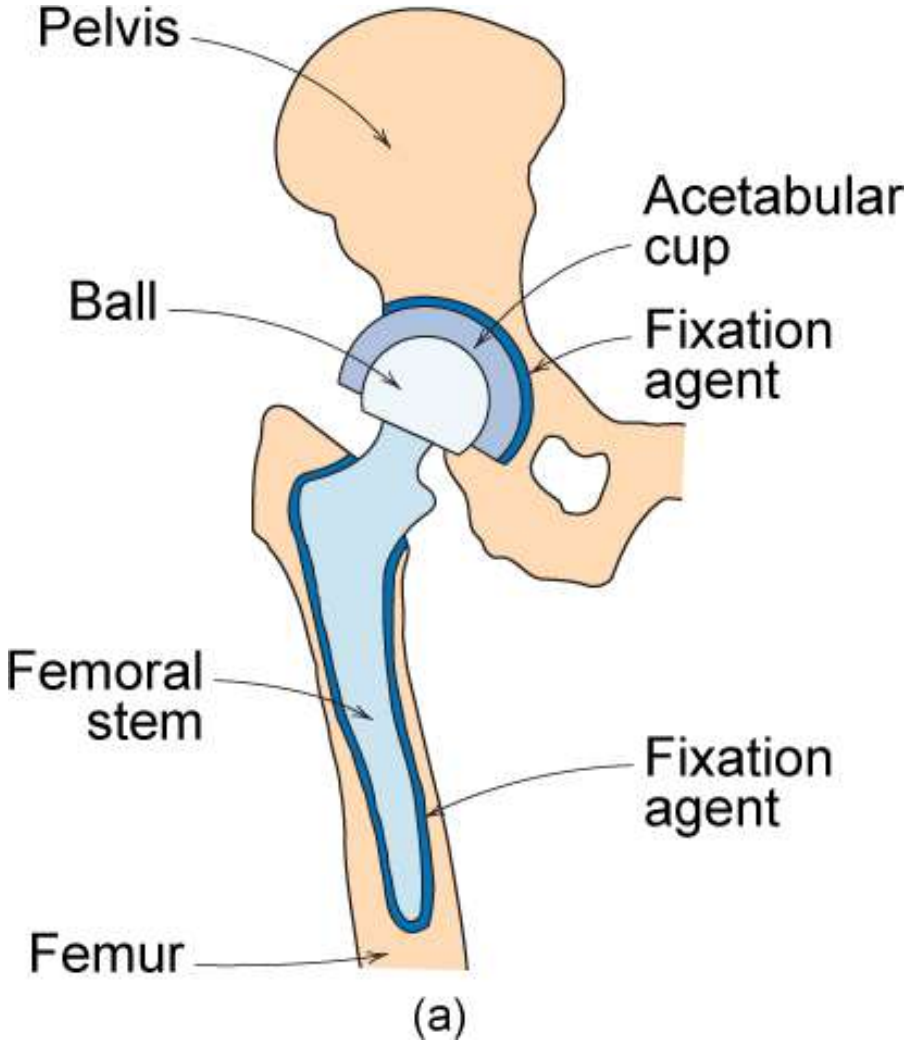
Example – Hip Implant

- Requirements
  - mechanical strength (many cycles)
  - good lubricity
  - biocompatibility



Adapted from Fig. 22.24, *Callister 7e.*

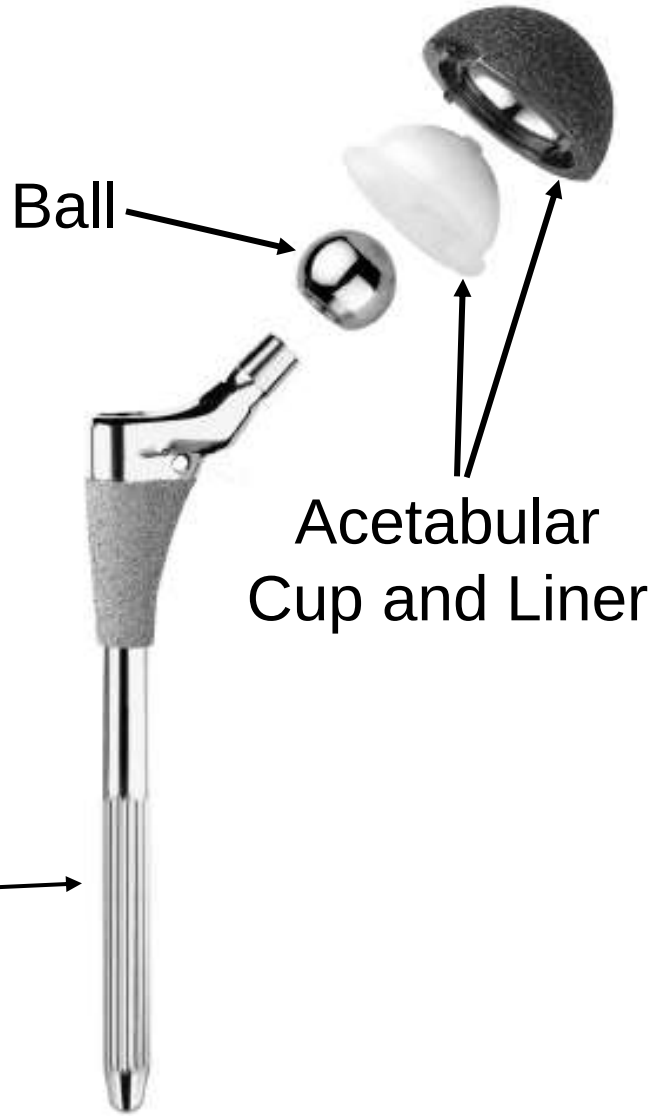
Example – Hip Implant




(b)

Hip Implant

- Key problems to overcome
  - fixation agent to hold acetabular cup
  - cup lubrication material
  - femoral stem – fixing agent ("glue")
  - must avoid any debris in cup



Adapted from chapter-opening photograph, Chapter 22, *Callister 7e.*

Example – Develop New Types of Polymers

- Commodity plastics – large volume ca. $0.50 / lb

  Ex. Polyethylene
  Polypropylene
  Polystyrene
  etc.

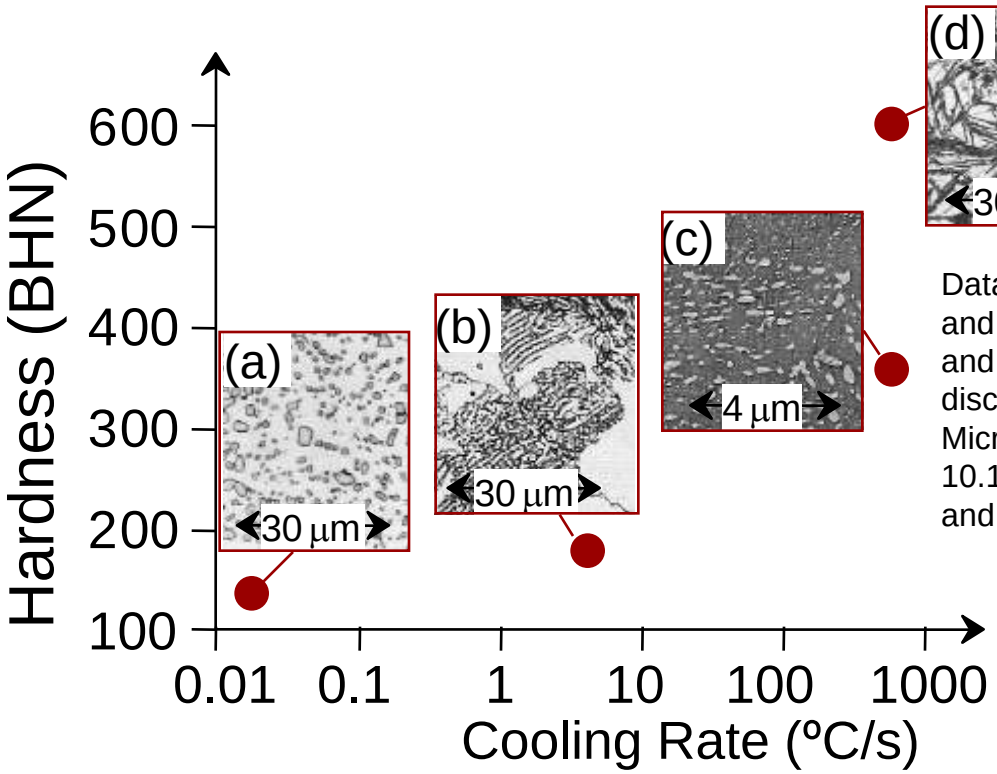
- Engineering Resins – small volume > $1.00 / lb

  Ex. Polycarbonate
  Nylon
  Polysulfone
  etc.

Can polypropylene be “upgraded” to properties (and price) near those of engineering resins?

Structure, Processing, & Properties

- Properties depend on structure
  ex: hardness vs structure of steel



Data obtained from Figs. 10.30(a) and 10.32 with 4 wt% C composition, and from Fig. 11.14 and associated discussion, *Callister 7e*. Micrographs adapted from (a) Fig. 10.19; (b) Fig. 9.30;(c) Fig. 10.33; and (d) Fig. 10.21, *Callister 7e*.

- Processing can change structure
  ex: structure vs cooling rate of steel

Types of Materials

- Metals:
  - Strong, ductile
  - high thermal & electrical conductivity
  - opaque, reflective.

- Polymers/plastics: Covalent bonding → sharing of e's
  - Soft, ductile, low strength, low density
  - thermal & electrical insulators
  - Optically translucent or transparent.

- Ceramics: ionic bonding (refractory) – compounds of metallic & non-metallic elements (oxides, carbides, nitrides, sulfides)
  - Brittle, glassy, elastic
  - non-conducting (insulators)

The Materials Selection Process

1. Pick Application ⟶ Determine required Properties

   Properties: mechanical, electrical, thermal, magnetic, optical, deteriorative.

2. Properties ⟶ Identify candidate Material(s)

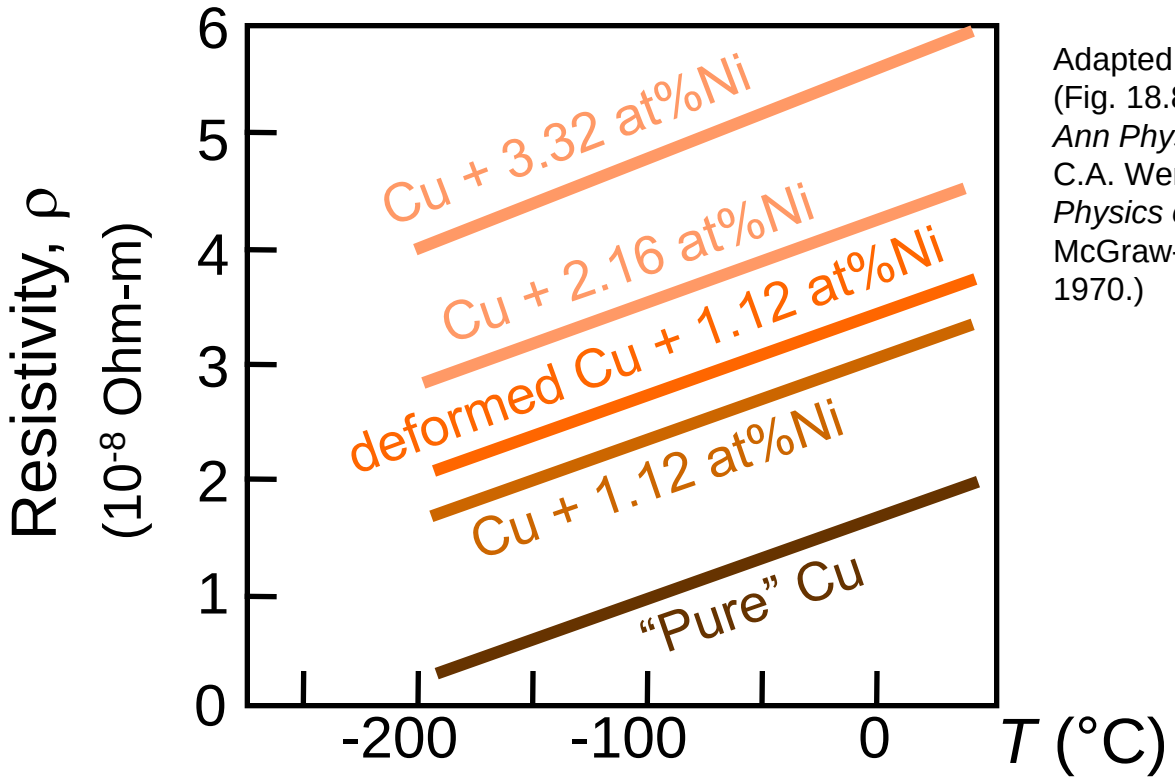
   Material: structure, composition.

3. Material ⟶ Identify required Processing

   Processing: changes *structure* and overall *shape*
   ex: casting, sintering, vapor deposition, doping
   forming, joining, annealing.

ELECTRICAL

- Electrical Resistivity of Copper:



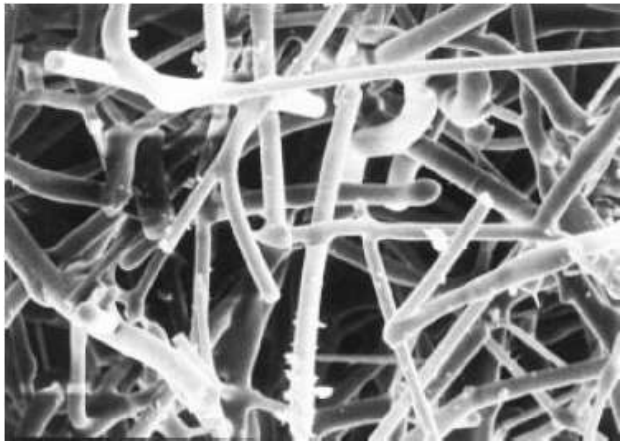
Adapted from Fig. 18.8, *Callister 7e.* (Fig. 18.8 adapted from: J.O. Linde, *Ann Physik* **5**, 219 (1932); and C.A. Wert and R.M. Thomson, *Physics of Solids*, 2nd edition, McGraw-Hill Company, New York, 1970.)

- Adding "impurity" atoms to Cu increases resistivity.
- Deforming Cu increases resistivity.

THERMAL

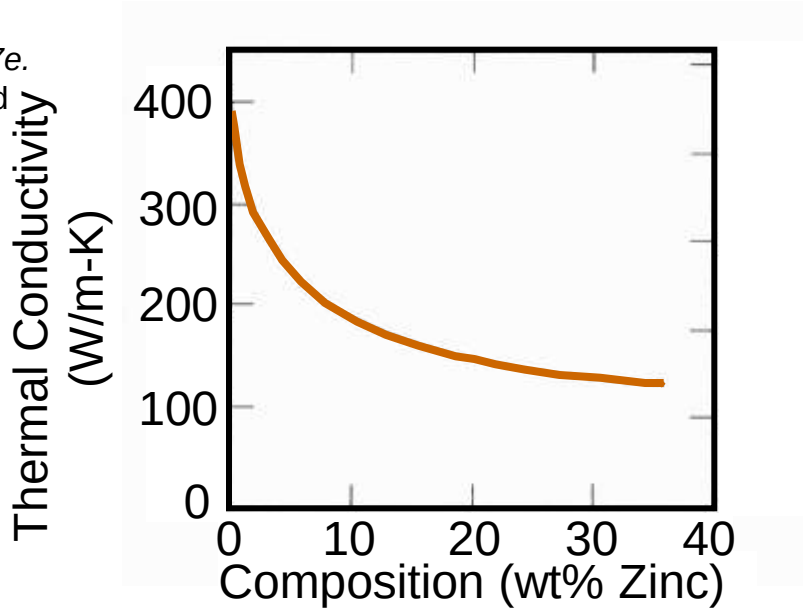
- Space Shuttle Tiles:
  --Silica fiber insulation offers low heat conduction.

Adapted from chapter-opening photograph, Chapter 19, *Callister 7e.* (Courtesy of Lockheed Missiles and Space Company, Inc.)



Adapted from Fig. 19.4W, *Callister 6e.* (Courtesy of Lockheed Aerospace Ceramics Systems, Sunnyvale, CA) (Note: "W" denotes fig. is on CD-ROM.)

- Thermal Conductivity of Copper:
  --It decreases when you add zinc!



Adapted from Fig. 19.4, *Callister 7e.* (Fig. 19.4 is adapted from *Metals Handbook: Properties and Selection: Nonferrous alloys and Pure Metals*, Vol. 2, 9th ed., H. Baker, (Managing Editor), American Society for Metals, 1979, p. 315.)

MAGNETIC

- Magnetic Storage:
  --Recording medium is magnetized by recording head.

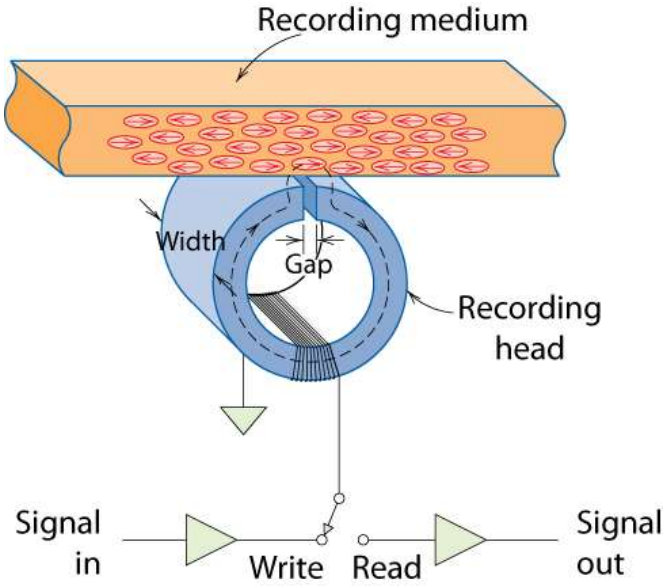
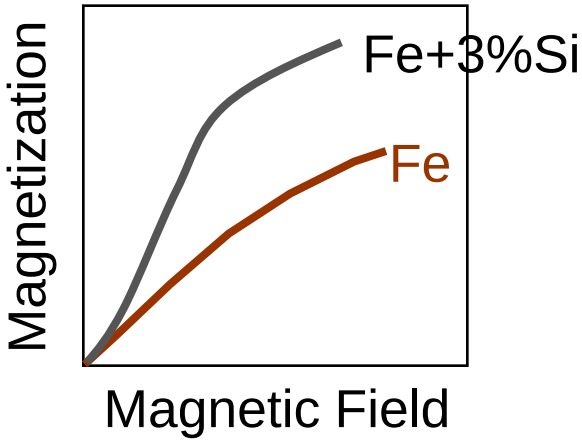


Fig. 20.23, *Callister 7e.*
(Fig. 20.23 is from J.U. Lemke, *MRS Bulletin*, Vol. XV, No. 3, p. 31, 1990.)

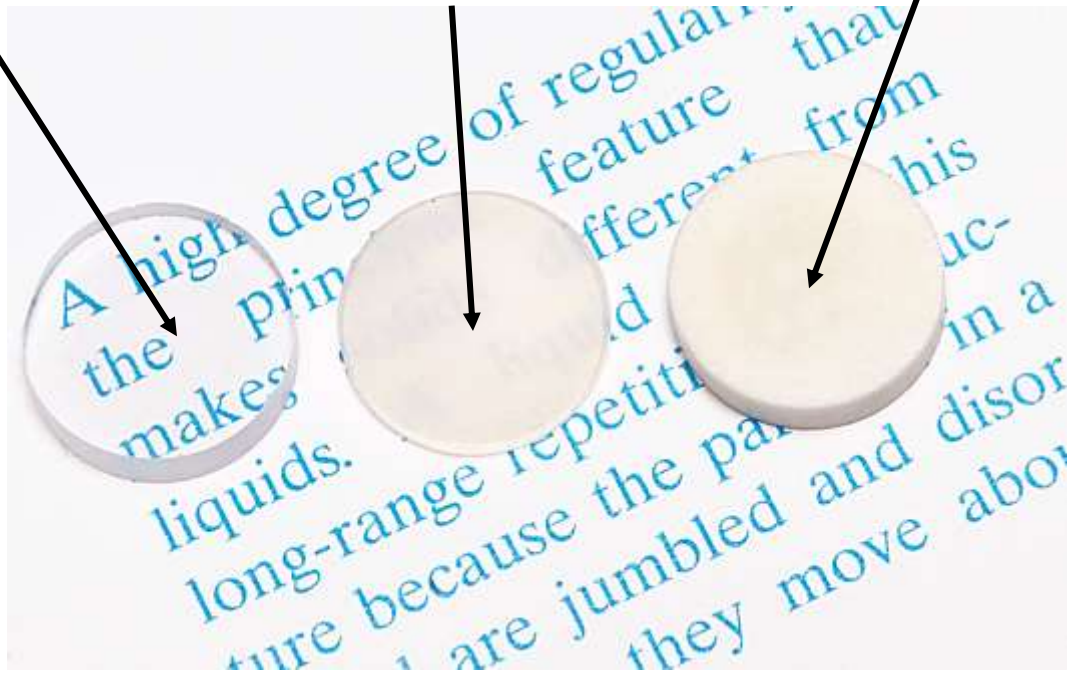
- Magnetic Permeability vs. Composition:
  --Adding 3 atomic % Si makes Fe a better recording medium!



Adapted from C.R. Barrett, W.D. Nix, and A.S. Tetelman, *The Principles of Engineering Materials*, Fig. 1-7(a), p. 9, 1973. Electronically reproduced by permission of Pearson Education, Inc., Upper Saddle River, New Jersey.

OPTICAL

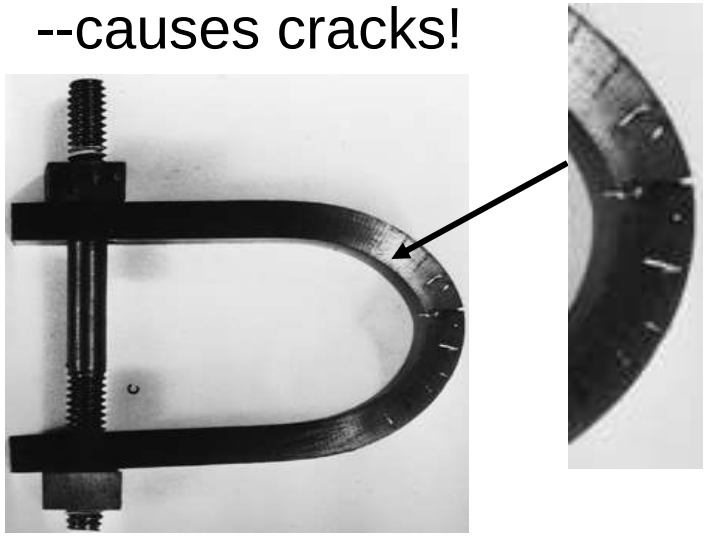
- Transmittance:
  --Aluminum oxide may be transparent, translucent, or opaque depending on the material structure.



Adapted from Fig. 1.2, *Callister 7e.* (Specimen preparation, P.A. Lessing; photo by S. Tanner.)

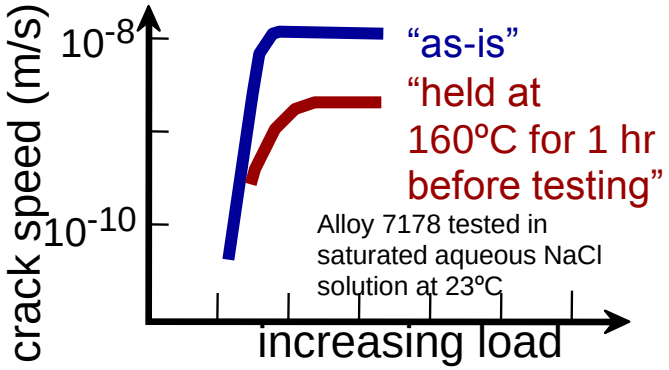
DETERIORATIVE

- Stress & Saltwater...
  --causes cracks!



Adapted from chapter-opening photograph, Chapter 17, *Callister 7e.*
(from *Marine Corrosion, Causes, and Prevention*, John Wiley and Sons, Inc., 1975.)

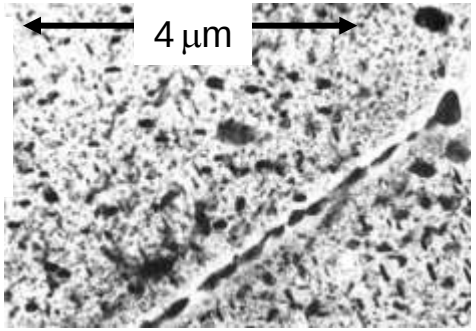
- Heat treatment: slows crack speed in salt water!



Adapted from Fig. 11.20(b), R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials" (4th ed.), p. 505, John Wiley and Sons, 1996. (Original source: Markus O. Speidel, Brown Boveri Co.)

--material:

7150-T651 Al "alloy"
(Zn,Cu,Mg,Zr)



Adapted from Fig. 11.26, *Callister 7e.* (Fig. 11.26 provided courtesy of G.H. Narayanan and A.G. Miller, Boeing Commercial Airplane Company.)

SUMMARY

Course Goals:

- Use the right material for the job.
- Understand the relation between properties, structure, and processing.
- Recognize new design opportunities offered by materials selection.