MSEG 302 Spring 2018
Materials Science for Engineers

Course Objective...

Introduce fundamental concepts in Materials Science and Engineering

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

MSEG 302 LECTURES

Lecturer: Prof. David C. Martin milty@udel.edu

Time: 12:30-1:45 PM Tues-Thurs

Location: 100 Wolf Hall

Activities:

- Present new material
- Announce reading and homework
- Take quizzes and midterms
- Hear interesting stories and funny jokes

Majors

Biomedical
Chemical
Civil & Environmental
Computer & Information Sciences
Electrical & Computer
Mechanical

Chemistry
Physics
Biological Sciences

DAVID C. MARTIN

KARL & RENATE BÖER PROFESSOR

Department of Materials Science and Engineering

Email : **milty@udel.edu**
Phone : (302) 831-6341
305 DuPont Hall

QUICK LINKS

Awards

Research Interests

Representative Publications

Curriculum Vitae

Research Group

BIOSKETCH

Dr. Martin focuses his research on organic molecular semiconductors, organic conductive polymer films, low impedance biomimetic conductive polymer coatings and bioactive hydrogel coatings for microelectrodes on biomedical devices and biosensors, electrically conductive polymer nanotubes, oriented electrospun nanofibers, multi-phasic functionalized polymer nanoparticles, and molecular simulations of polymer defects and crystal structure. Dr. Martin earned his Ph.D. in polymer science and engineering from the University of Massachusetts at Amherst. The Böer chair honors Karl W. Böer, Distinguished Professor Emeritus of Physics and Solar Energy, a pioneer in the fields of solar cells, solar energy systems, and solid state physics.

AWARDS

- University of Michigan Materials Science and Engineering Distinguished Alumni Award 2013
- President, Polymeric Materials Science and Engineering Division, American Chemical Society 2013
- Fellow, American Physical Society, Division of Polymer Physics 2010
- Karl W. Böer Chair of Materials Science and Engineering The University of Delaware College of Engineering 2009
- UM Materials Science and Engineering Distinguished Achievement Award 2008

TEACHING ASSISTANTS

Name	E-mail
David Angel	dangel@udel.edu
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Guancheng Li	guanchl@udel.edu
Zijian Wang	wangzj@udel.edu

- Round table outside 305 DuPont

DCM office hours immediately after class

Other times by appointment

COURSE MATERIALS

Recommended text:

W. D. Callister, Jr. and D. G. Rethwisch, 9th edition, Materials Science and Engineering: An Introduction John Wiley and Sons, Inc., (2014)

You can register for an electronic version at www.wileyplus.com... other optional educational resources there as well

Other books and web sites might help you understand things better…like Wikipedia and so on.. but beware that you can't trust everything you see on the internet.

COURSE WEBSITE

MSEG 302 Canvas Website: http://udel.instructure.com

- Syllabus
- Lecture notes
- Questions, Discussion, Chat
- Announcements
- Homework

Text Website: http://www.wileyplus.com

- Complete solutions to selected problems
- Links to other web resources
- Extended learning objectives
- Self-assessment exercises

GRADING

Homework and Quizzes 15%

Typically one assignment / week, perhaps some quizzes in class

Midterm #1 25%

Scheduled for Thursday before spring break (March 22nd)

Material covered: Chapters 1-6, 14 (estimated)

Midterm #2 25%

Scheduled for end of April (April 26th)

Material covered: Chapters 1-18 (estimated)

Final 35%

Tentatively scheduled for: finals period (May 17th-24th)

Material covered: Comprehensive

Detailed Schedule (Part 1)

• February 6th	Introduction, Chapter 1	Overview
• February 8th	Chapter 2	Atoms, Chemistry
• February 13th	Chapter 2, HW1 due	Bonding
• February 15th	Chapter 3	Crystals
• February 20th	Chapter 3, HW2 due	Crystal Structures
• February 22nd	Chapter 14	Polymers
• February 27th	Chapter 4, HW3 due	Defect Structures
• March 1st	Chapter 4	Defect Properties
• March 6th	Chapter 5, HW4 due	Diffusion
• March 8th	Chapter 5	Diffusion Processes
• March 13th	Chapter 6, HW5 due	Stress-Strain Behavior
• March 15th	Chapter 6	Deformation
• March 20th	Exam Review, HW 6 due	
• March 22nd	Exam I	
• March 27th	UDel Spring Break	

Detailed Schedule (Part 2)

• March 29th	UDel Spring Break	
• April 3rd	Chapter 7	Deformation Mechs
• April 5th	Chapter 7	Deformation Props
• April 10th	Chapter 8, HW7 due	Failure
• April 12th	Chapter 8	Failure Testing
• April 17th	Chapter 9, HW8 due	Phase Diagrams
• April 19th	Chapter 9	Processing
• April 24th	Exam II Review, HW9 due	
• April 26th	Exam II	
• May 1st	Chapter 12	Ceramic Structures
• May 3rd	Chapter 12	Ceramic Properties
• May 8th	Chapter 18, HW10 due	Electrical Properties
• May 10th	Chapter 18	Electrical Applications
• May 15th	Chapter 18, HW11 due	Electrical Devices
• May 17th-24th	Final Exams	

HW#1 Due by 12:30 PM Feb 13th

- **a. Atomic weights of elements with different natural isotopes**
- **b. Quantum numbers n, l, m_l, and m_s**
- **c. Percent ionic character**
- **d. Chemical composition of a molecule**

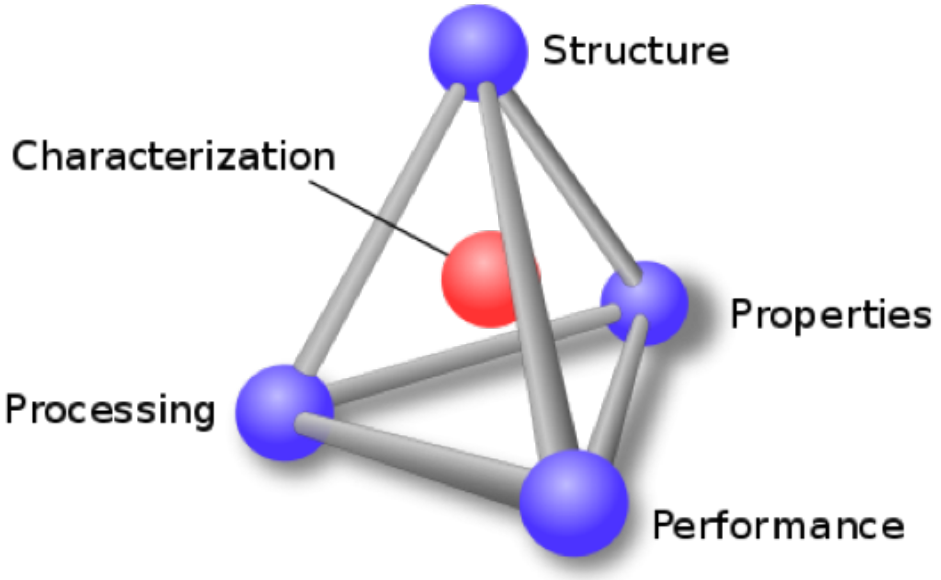
HW must be submitted in PDF file format on the course web site, deadline is the start of class period on the due date. NO late homework will be accepted. HW key will be posted to the web page after the due date.

Units!

- **Make sure your answers have the right units, or they aren't correct**
- **Keeping track of units helps insure that you have all the right information needed to get an answer (dimensional analysis)**
- **If you have to make approximations, simply state your assumptions but keep going; most times rough estimates are better than no idea whatsoever**

Chapter 1 - Introduction

- **What is Materials Science and Engineering?**
- **Why should we know about it?**
- Materials drive our society
  - **Stone Age**
  - **Bronze Age**
  - **Iron Age**
  - **Now:**
    - **Silicon**
    - **Polymers**
    - **Composites**
    - **Nanomaterials**
    - **Biological and Bio-inspired Materials**



Materials Science at Delaware (MSEG)

- www.mseg.udel.edu
- Program since 1959
- Department since 1998
- M.S. and Ph.D. Students
- Minors in MSEG
- 4+1 BS/MS: Double-count up to 6 credits for combined BS in Engineering or Science, MS in MSEG
- Undergrad BSE degree in development
  - Launch planned for fall 2019

Types of Materials

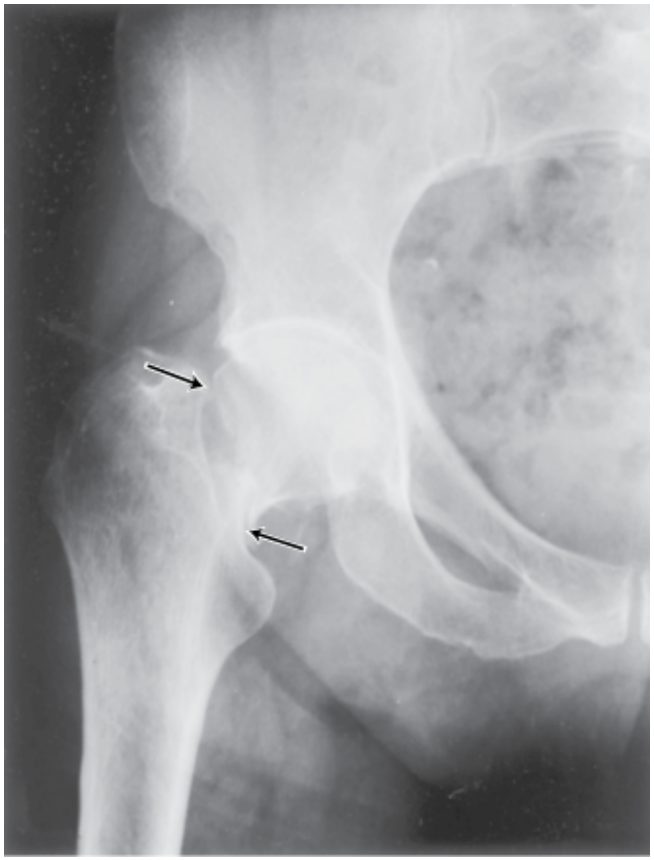
- Metals: metallic bonding, sharing of electrons in a "sea"
  - strong, ductile
  - high thermal & electrical conductivity
  - opaque, reflective

- Polymers/plastics: covalent bonding → local sharing of e's to create clusters of atoms… individual molecules or networks
  - soft, ductile, low strength, low density
  - thermal & electrical insulators (usually)
  - optically translucent or transparent (usually)

- Ceramics: ionic bonding→ compounds of metallic & non-metallic elements (oxides, carbides, nitrides, sulfides)
  - brittle, glassy, elastic
  - non-conducting (insulators, semiconductors) (usually)

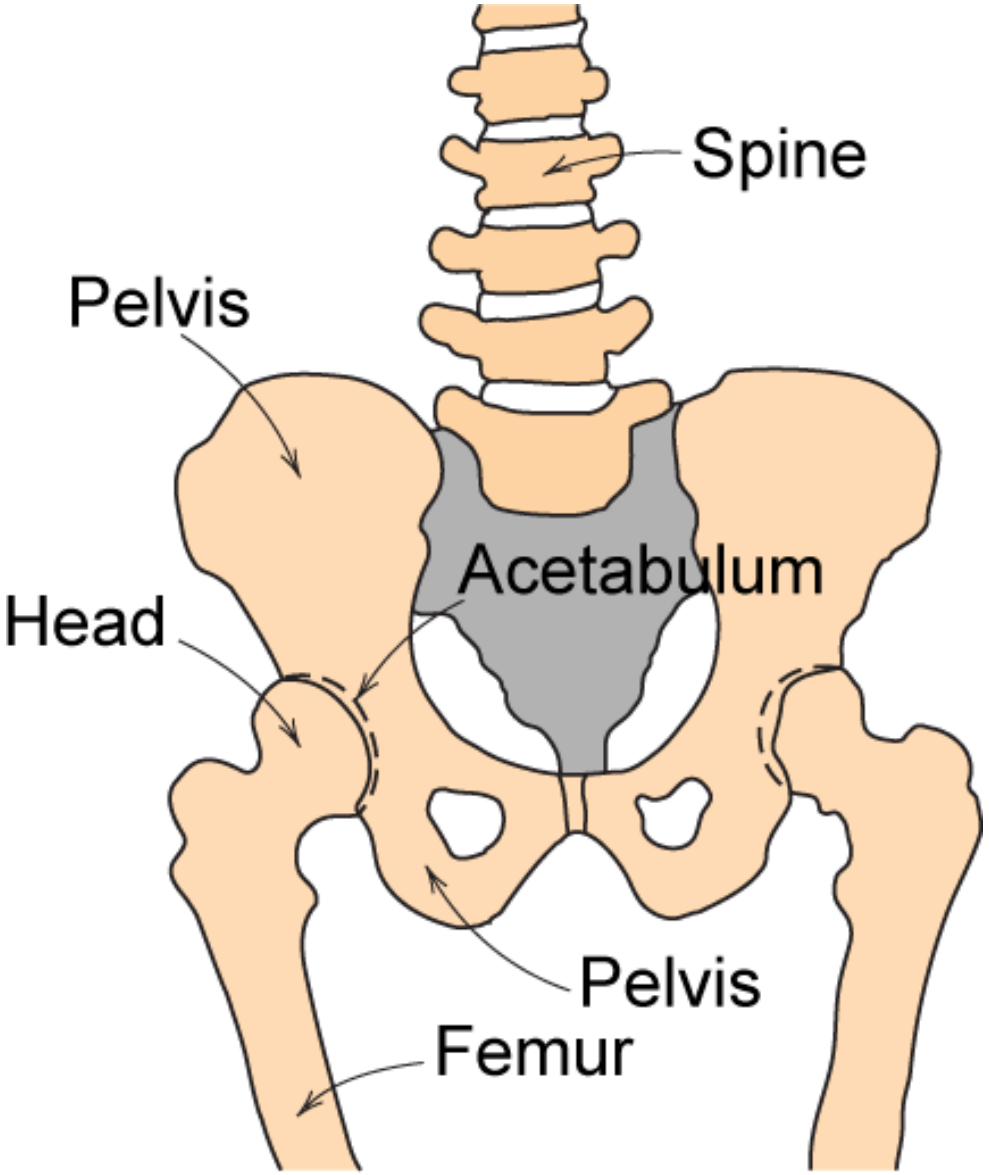
Example – Hip Implant

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

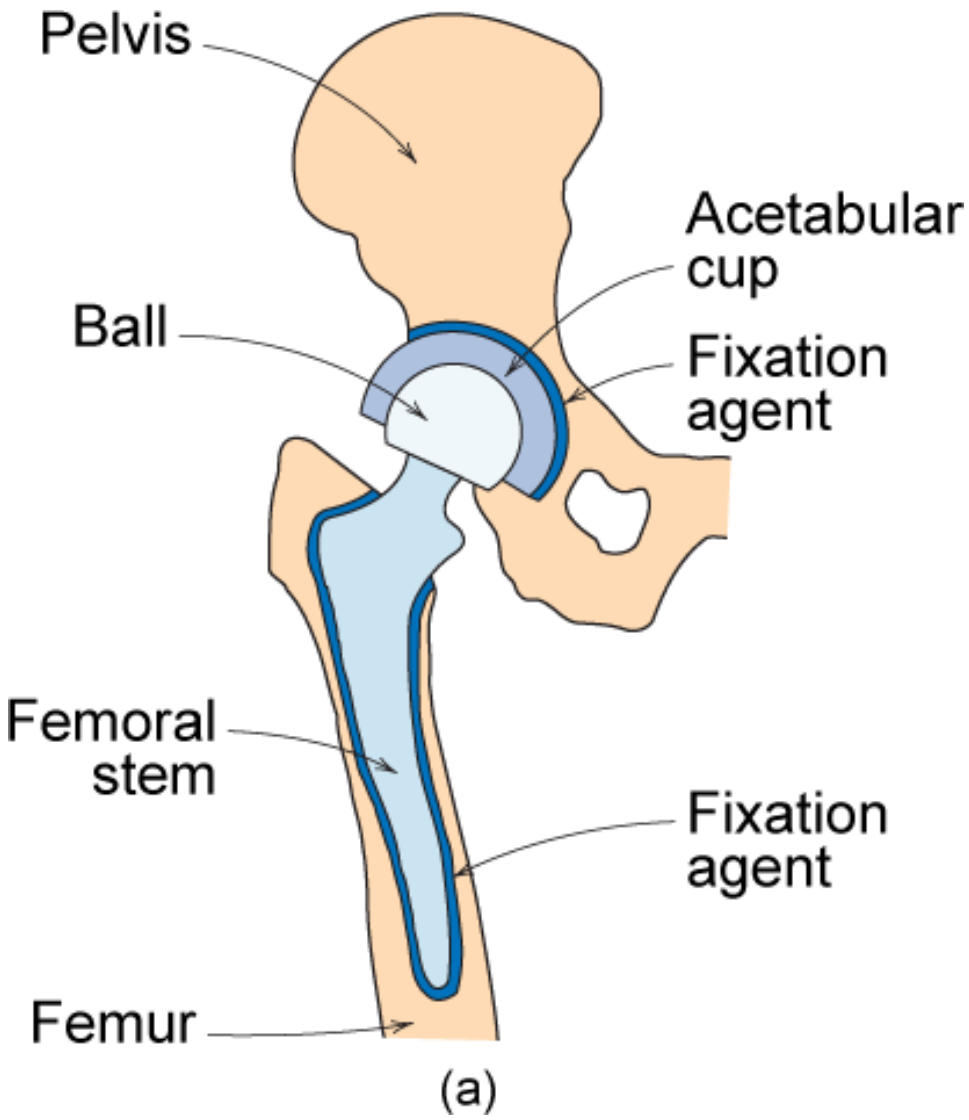


Example – Hip Implant

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



Artificial Hip Implant

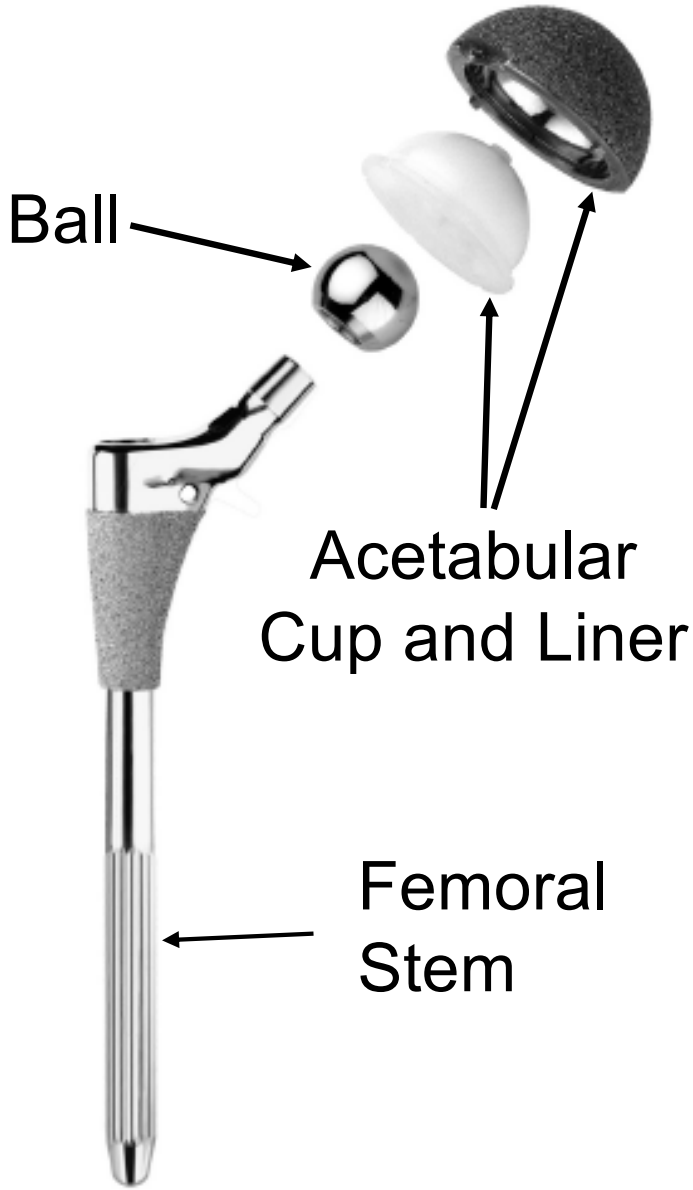


(a)

(b)

Artificial Hip Implant

- Key problems to overcome
  - light weight
  - strong
  - fracture resistant
  - fatigue resistant
  - wear-resistant cup - ball
  - secures to bone
  - minimize inflammation

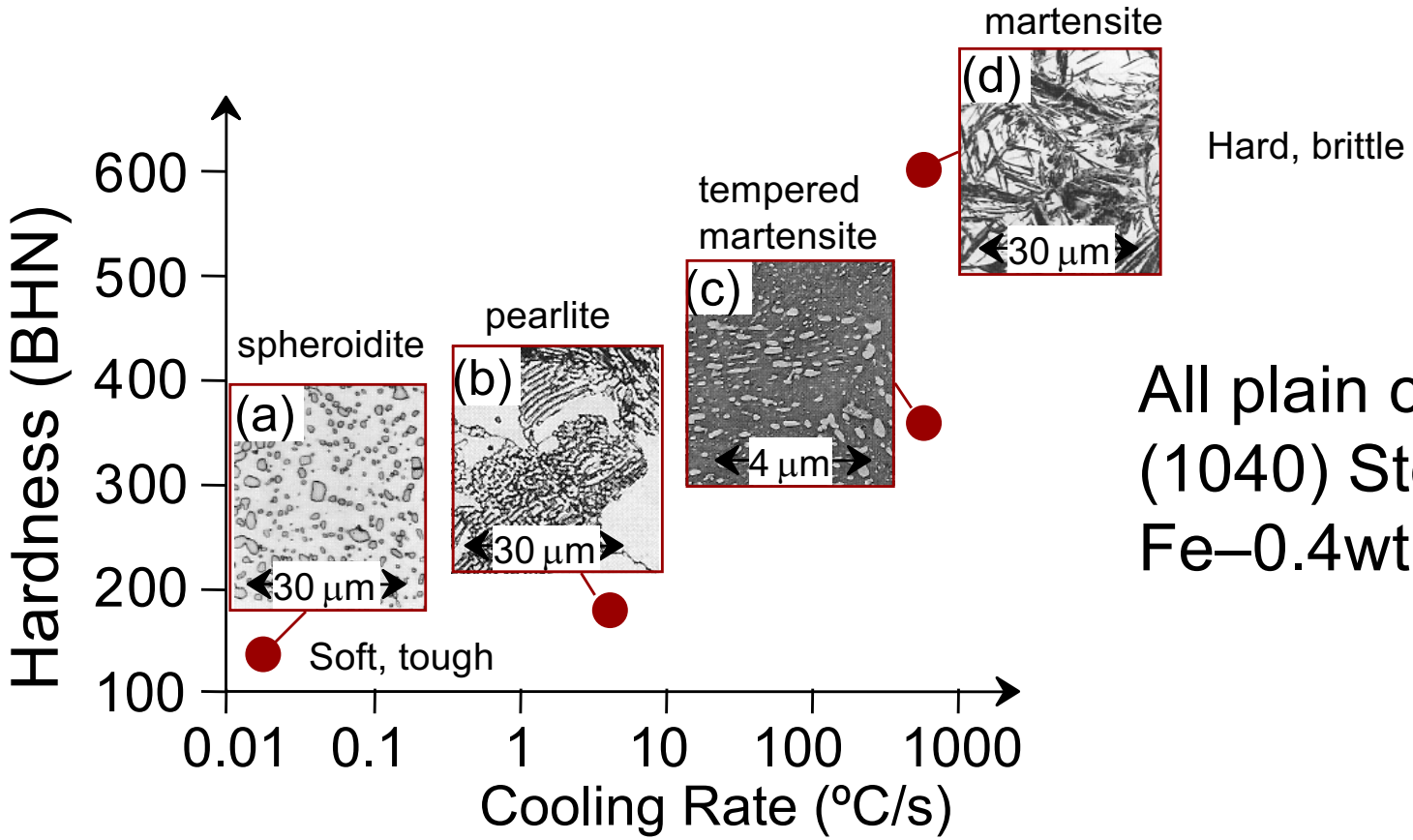


Zimmer Biomet, Smith & Nephew,
Stryker, DePuy

310,800 US surgeries in 2010, at $40k each

Structure, Processing, & Properties

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

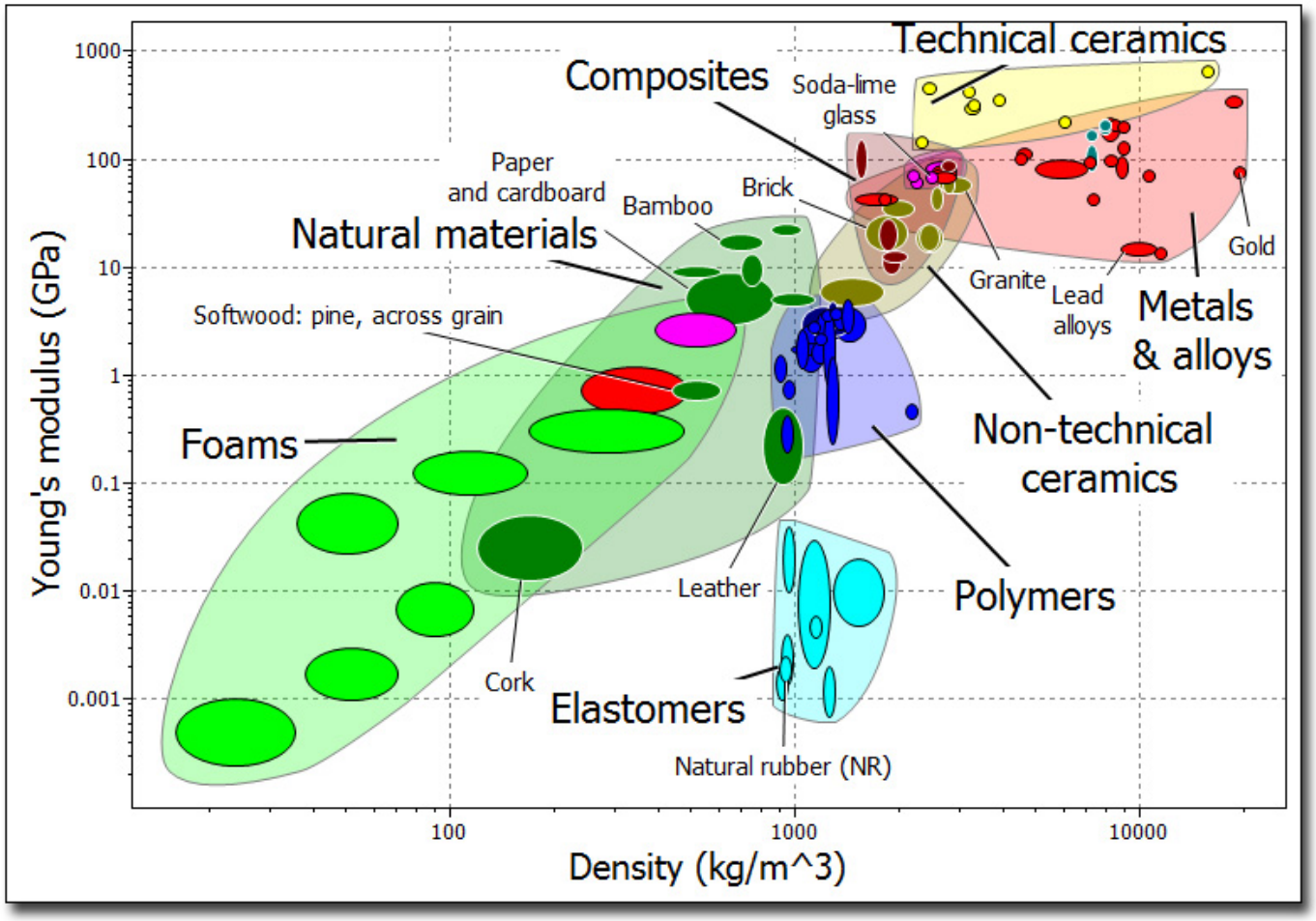


All plain carbon
(1040) Steels
Fe–0.4wt% C

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

MECHANICAL

Stiff
Light



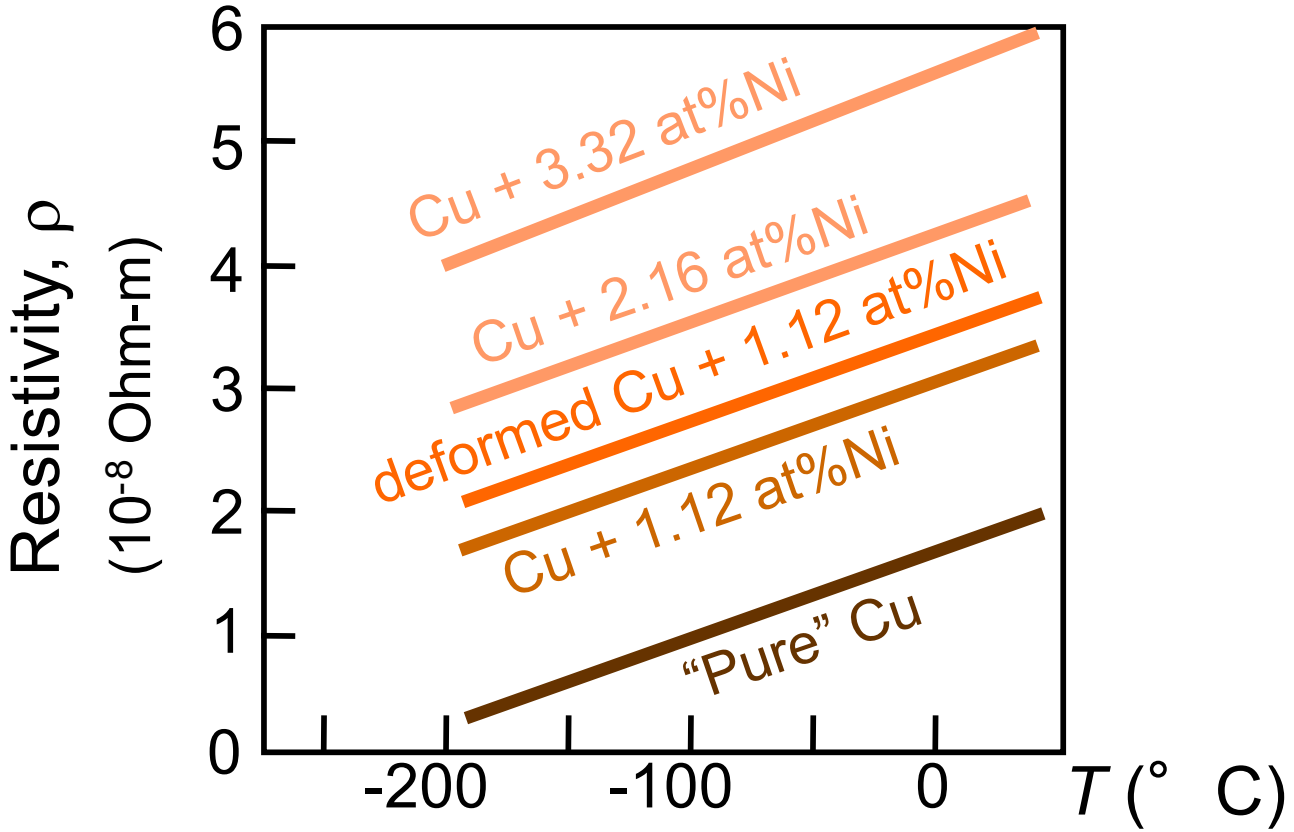
Heavy
Stiff

Soft
Light

Heavy
Soft

ELECTRICAL

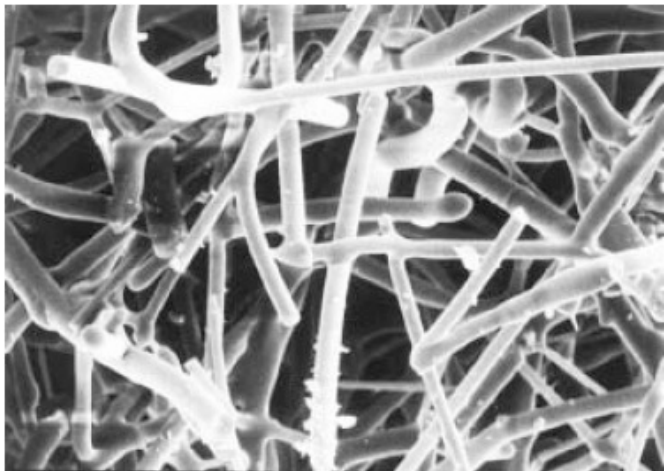
- Electrical Resistivity of Copper:



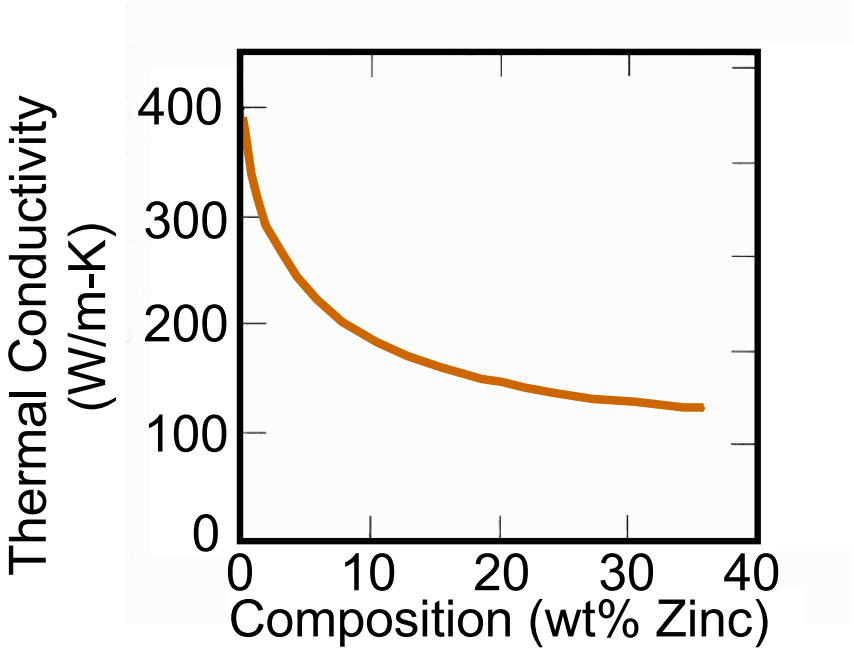
- Adding "impurity" atoms to Cu increases resistivity
- Deforming Cu increases resistivity

THERMAL

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

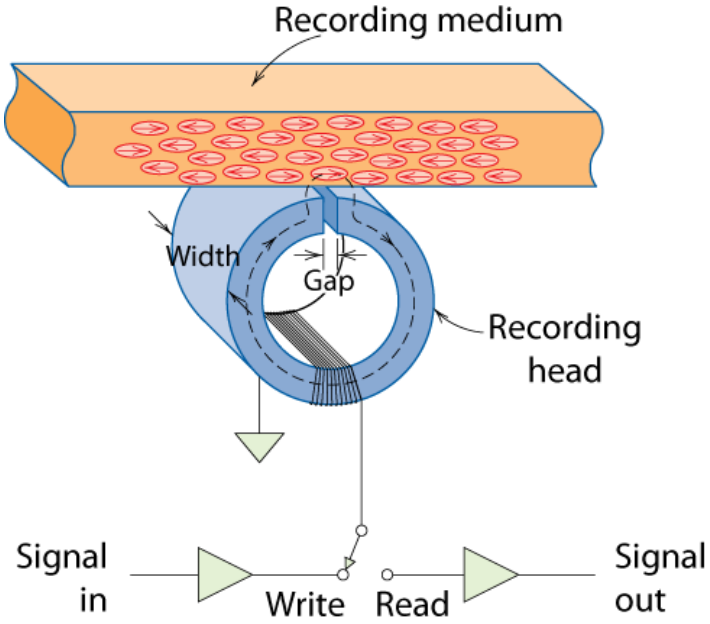


- Thermal Conductivity of Copper:
  --It decreases when you add zinc

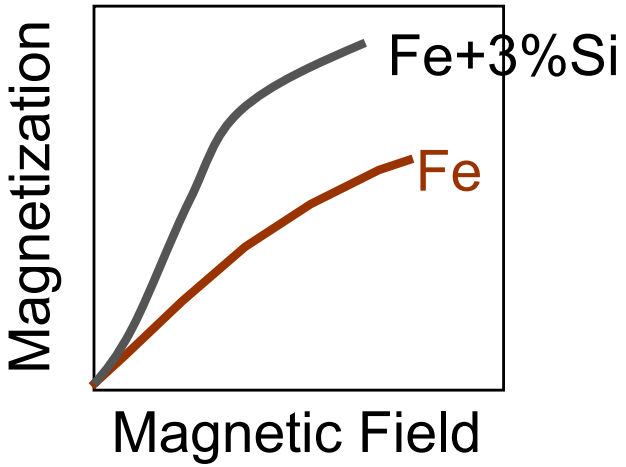


MAGNETIC

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

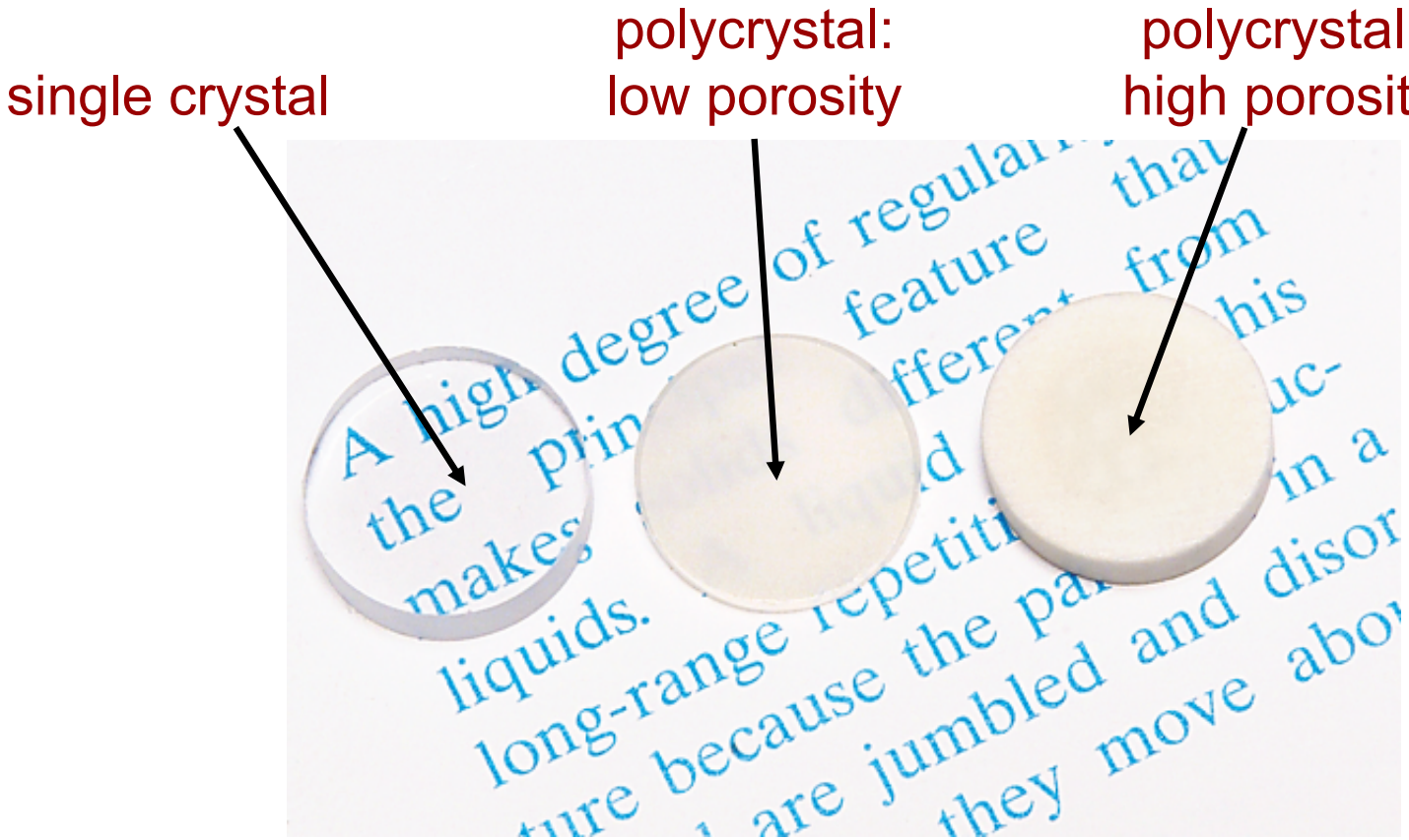


- Magnetic Permeability vs. Composition:
  --Adding 3 atomic % Si makes Fe a better recording medium



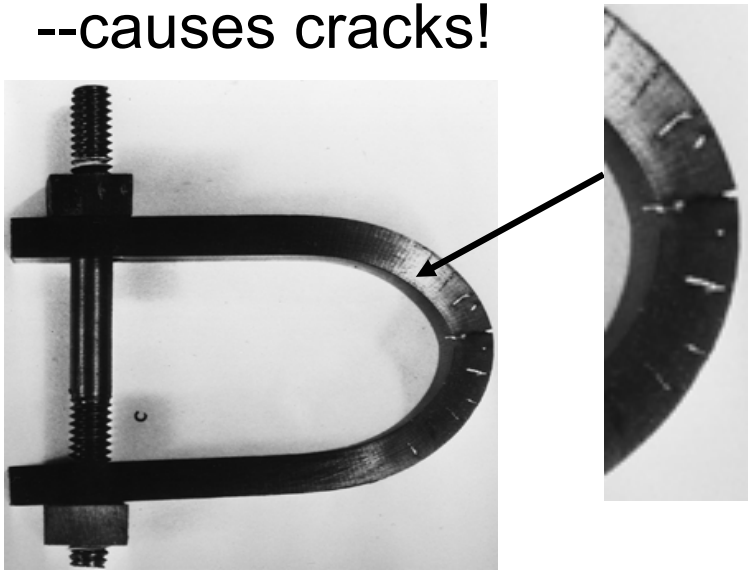
OPTICAL

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

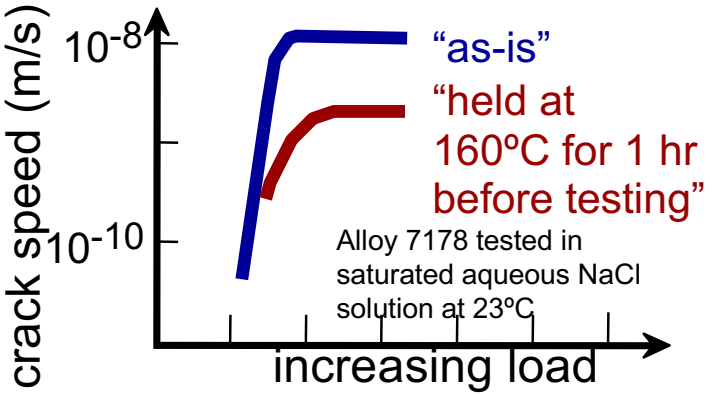


DETERIORATIVE

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

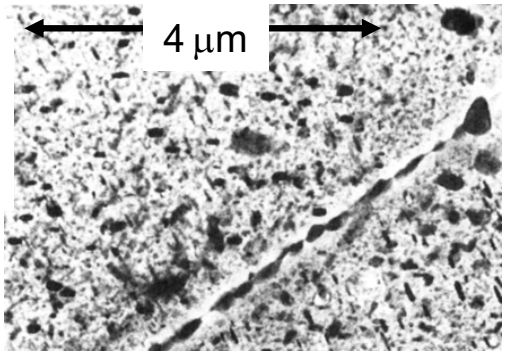


- Heat treatment: slows crack speed in salt water!



--material:

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



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.

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.