Concordia UNIVERSITY

DEPT. OF MECH. IND. & AERO ENG.

MECH 221 - Materials Science

LECTURES: Wed and Fri H-531 from 10:15 to 11:30 am

Instructor: **Dr. Mamoun Medraj, P.Eng**
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Dept. of Mech. & Ind. Eng.,
Room, EV 12.185

Office Hours: Wednesdays 2:30 to 4:00 pm.

TEXTBOOK:

W.D. Callister, Materials Science & Engineering: An Introduction
5th to 9th ed., J. Wiley.

Handouts: Available at **http://users.encs.concordia.ca/~mmedraj/mech221.html**

MECH 221 - Materials Science

Assessment:

In-Tutorial Problems	15 %
Exams:	
• Midterm	30 %
• Final	55 %

- Assignments will not be collected but the questions will be used as the basis for the *In-Tutorial* Assignment Problems.
- Also, some of the assignment problems and tutorials questions (*or similar ones*) will be asked in the exams. The solutions will be discussed in the tutorial sessions.

The *In-Tutorial Assignment Problems* will take place **every second** tutorial. The first one will be on Monday Sep. 18th or Friday Sep. 22nd

Midterm Exam: Friday October 20th, 2017

The midterm exam is ***optional***

Students who write the midterm exam, however, will get the higher mark of the final exam plus the midterm or the final exam alone.

MECH 221 - Materials Science

- Tutorials:
- TA section
  Friday at 15:15-16:05 pm
  Rooms: H-429
- TC section
  Monday at 16:15-17:05
  Room: H-562

- TA's:
  - Rahele Nikonam
    email: rahele_nikonam@ymail.com
  - Dulani Kodippili
    email: dulanipankaja@gmail.com

What is Material?

Oils, gases, pharmaceuticals : …….
Iron, copper, polymers, cement: ……..

- *Material can be put into certain geometric shape*
- *The product has some ……..*

Old materials: metals, wood, ceramics, skins, natural fibers, (papyrus)
New materials: ……

Introduction: *Historical Perspective*

- Civilization strongly linked with materials

Stone age, iron age, bronze age …nuclear age, information age

- Sumerians: ceramics
- Egyptians: lime
- Anatolians: Iron (12^{th} century BC)
- The earliest known Bronze is from what is now Iran and Iraq

Introduction

Technological advances have been materials driven:

– Transportation; engines, airframes, auto bodies
– Space exploration; shuttle tiles, high temp alloys
– Energy; solar power, batteries
– Communications; semiconductors

• Military uses ⇒ Commercial uses

What is Materials Science ?

- Relationships between structure and …….. of materials

What is Materials Engineering ?

- Structure-property correlations

- Design the structure of a material to impart some desired properties

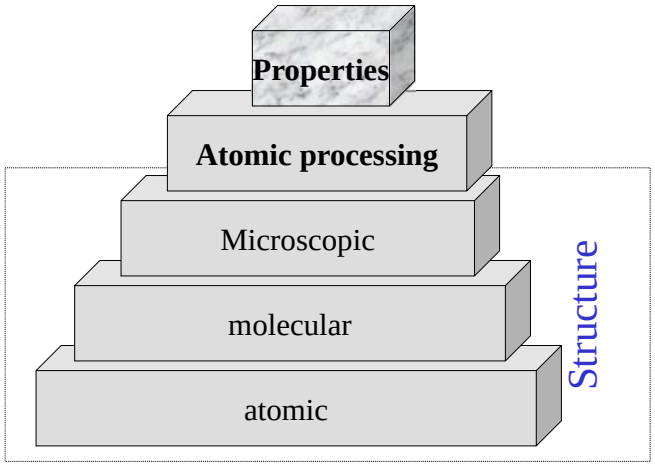
Introduction

Property: Response of a material to an external effect, such as

- Mechanical
- …….
- …….
- …….
- …….

Properties are independent of material ……..

General Course Outline:



Course Outline

Topic	Lectures
• Introduction: *Basic characteristics of metals, ceramics, polymers and composites, engineering design criteria*	1
• Chemistry Review: *Atomic structure and Interatomic Bonding*	1
• The structure of Crystalline Solids	3
• Imperfections in Crystals	2
• Diffusion	1
• Mechanical Properties of Metals	3
Midterm Exam	
• Phase Diagrams	3
• Structure, Properties, Applications and Processing of Ceramics	2
• Polymer Structures	1
• Applications and Processing of Polymers	1
• Thermal, Electrical, Magnetic and Optical Properties	4
	Σ 23

Exam→1 lecture
Review→ 2 lect's
Total: 26 lectures

Why study Materials Science?

(1) Important to understand **capabilities and limitations of materials:**

• The following are just a few examples of catastrophic failure caused by a lack of fundamental understanding of *materials, their properties, and failure modes*.

Examples of *Catastrophic Failure*

Liberty ships (WWII)

D-B-T in BCC Fe (metal)

Challenger (1986)

failure of an O-ring seal (polymer)

Examples of *Catastrophic Failure*

Hyatt Regency (KC)
walkway collapse (1981)

Overstressed steel support rods (underdesigned)

Alaska MD-80 crash (1999)

Excessive wear on stabilizer jackscrew

Examples of *Catastrophic Failure*

• **Tacoma Narrows Bridge Collapse** (1940)

poor design – .....

• **de Havilland Comet** (first commercial jet) (1954 – 55)

metal fatigue, aggravated by high stresses around rivet holes near window openings

• **United DC-10** crash (Sioux City, IA) (1989)

inclusion and cracking in primary #2 engine turbine blade

Why Study Materials Science?

(2) An understanding of Materials Science helps us to design better components, parts, devices, etc.

• how do you make something stronger or lighter?

• how do elements come together to form alloys?

• why do some materials have vastly different properties than others?

(3) It is *interesting* and helps to make you a more informed person

Classes of Materials

There are 3 major classes:

1. Metals
   Pure metallic elements or
   Combination of metallic elements (alloys)
   Large number de-localized electrons (conduct electricity)

2. Ceramics
   - Molecules based on bonding between metallic and non-metallic elements (including oxides, nitrides, carbides)
   - Typically insulating and refractory

3. Polymers
   Many are organic compounds
   Chemically based on C, H, other non-metals
   Large molecular structures

Sub-Classes of Materials

Semiconductors (ceramics)
- Intermediate electrical properties

Composites (all three classes)
- Combinations

Bio Materials (all three classes)
- Materials compatible with body tissue

Introduction

Trends in Materials Use → Materials ……

Trends in Materials Use → Materials …….

Materials Design:

- design of new materials to meet new requirements.
- design of new materials with a unique set of properties.
- design can include the development of a new or better processes for manufacturing of new or existing materials.

Introduction

MATERIALS SELECTION

Selection of the correct/appropriate or best material for the job.

Short List:
(a) Availability ?
(b) Properties ?
(c) …… ? (Usually determining factor).

➢ *In many cases a more suitable material is available but at an increased cost, e.g.*
Car bodywork/exhausts
- "mild" steel, rusts,
- stainless steel, lasts much longer

➢ *Cost not big problem in defence, sport, medicine.*

Next time: Chemistry Review