# Department of Industrial Engineering

## Properties of Materials?!

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**Office Hours**: Sunday 9:00-10:00 am and Thursday 3:30-5:00 pm
Wednesdays 3:00 to 5:00 pm.

**TEXTBOOK:**

W.D. Callister, Materials Science & Engineering: An Introduction
5th to 8th ed., J. Wiley.

**Handouts**: ????

# Introduction

- Basically engineers do things ***with*** materials or ***with the aid of materials***.

  - **Mechanical Engineer :** Designing roller blades /dishwashers / space shuttle etc.

  - **Chemical Engineer /Biomedical Engineer-** e.g.. designing milk spray drying system /artificial kidney.

  - **Electronic Engineer** - e.g.; designing circuits, transistors, photovoltaic cells etc.

  - **Civil Engineer -** designs with steel, concrete, etc.

# Introduction: *Historical Perspective*

- Civilization strongly linked with materials

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

- Sumerians: ceramics
- Egyptians: lime
- Anatolians: Iron (12th 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 the Material Science?

- Relationship between structure and properties of materials

## What is the Material Engineering?

-Structure-property correlations

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

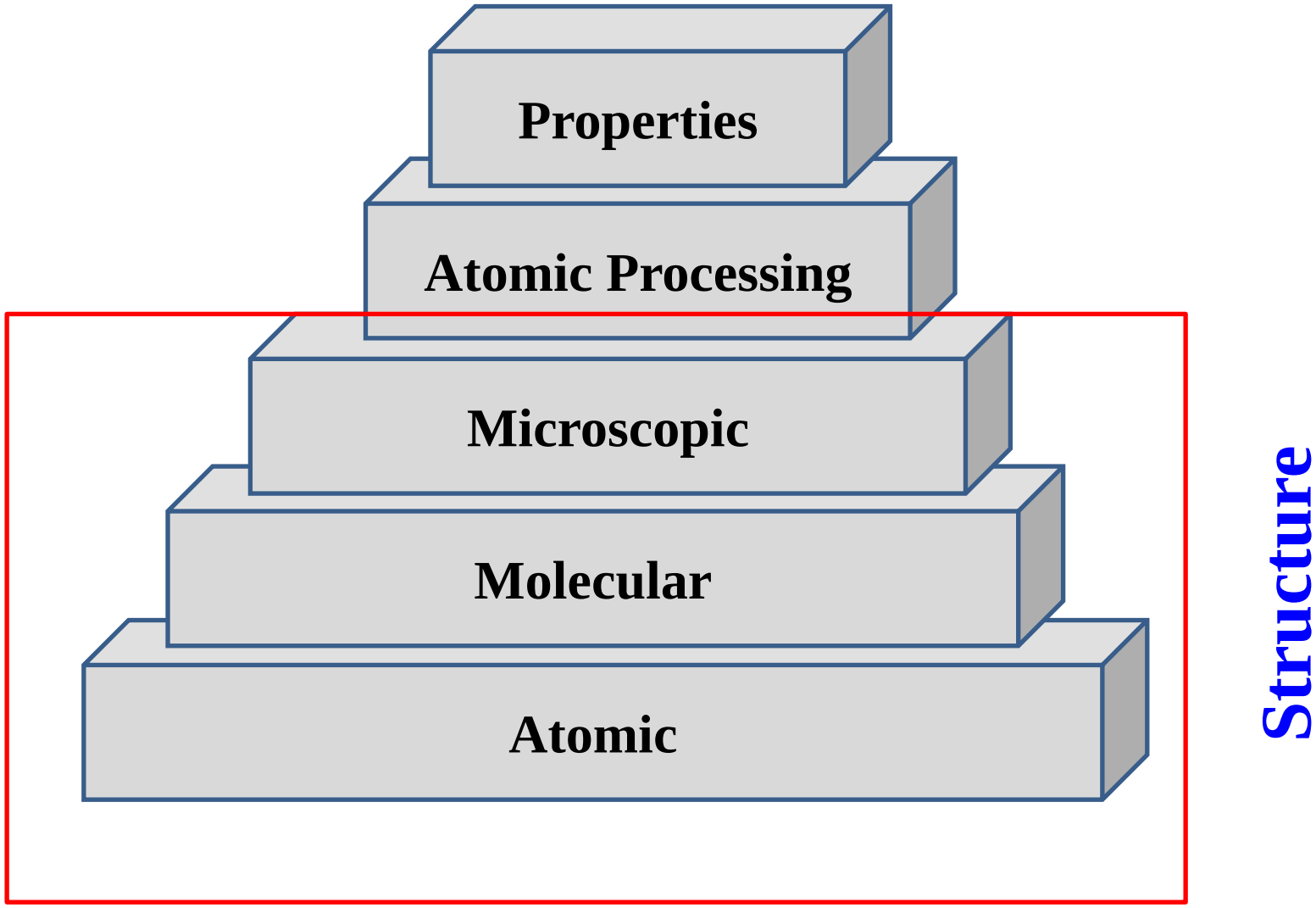
# Introduction

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

  - Mechanical
  - Electrical
  - Mangetic
  - Optical
  - Thermal

- Property is independent of material **shape** and **size**

# General Course Outline



# 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*


D-B-T in BCC Fe (metal)

failure of an O-ring seal

# Examples of *Catastrophic Failure*

**Hyatt Regency**
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 that are 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

## Advance Materials

- **Bio Materials** (all three classes) Materials compatible with body tissue.
- Shape-memory alloys
- Piezoelectric materials

# Introduction

## 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.

- *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**.

*The end*