Material Science
ME 221

Fall 2020

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Outline

- Introduction to Material Science
- Material Science and Engineering
- Classification of Materials

Course Syllabus

Introduction to Material Science

- **Historical perspective**
  - Materials affect everything in our lives.

"The development and advancement of societies have been intimately tied to the members' ability to produce and manipulate materials to fill their needs"

Stone Age, Bronze Age, Iron Age

"The approximate dates for the beginnings of the Stone, Bronze, and Iron Ages were 2.5 million BC, 3500 BC, and 1000 BC, respectively"

Materials Contents in this Slides adapted from : Materials science and engineering: an introduction / William D. Callister, Jr., David G. Rethwisch.–8th ed.

Introduction to Material Science

- Nature materials
  - stone, wood, clay, skins, ….etc
- Evolved materials
  - Pottery, plastics, glasses,…etc
- Materials properties can be changed:
  - Heat treatments
  - Addition of other substances (alloy)

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Introduction to Material Science

- Material properties and structure

“This knowledge, acquired over approximately the past 100 years”

“Tens of thousands of different materials have evolved with rather specialized characteristics that meet the needs of our modern and complex society; these include metals, plastics, glasses, and fibers”

- For example, automobiles
  - Would not have been possible without the availability of inexpensive steel

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Material science and Material Engineering

Materials science

Investigating the relationships that exist between the structures and properties of materials.

Materials Scientist

Develop or synthesize new materials

Materials Engineering

Designing or engineering the structure of a material to produce a predetermined set of properties

Materials Engineer

Create new products or systems using existing materials, and/or to develop techniques for processing materials

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Science and Engineering of Materials Components

- Processing
- Structure
- Properties
- Performance

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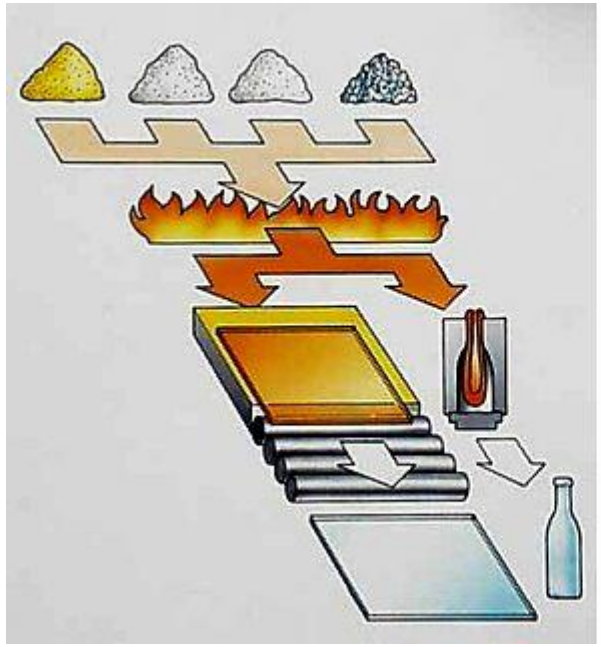
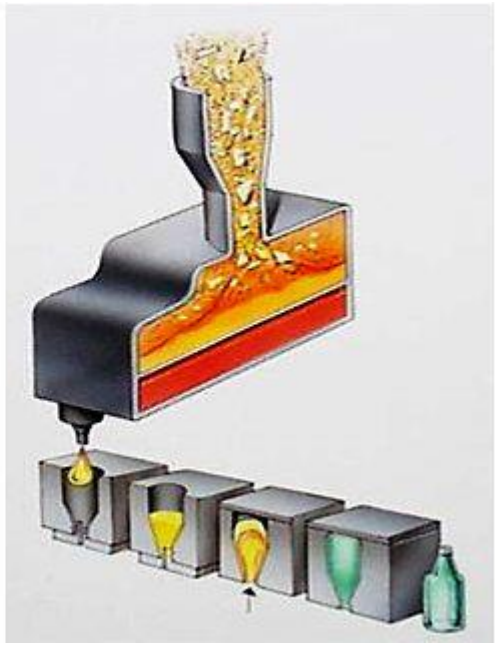
Material Processing





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Material Structure

- Structure of material is the arrangement of its internal Components

- Levels of Material Structure
  - Subatomic Level
    - Involves electrons within the individual atoms and interactions with their nuclei
  - Atomic Level
    - Organization of atoms or molecules relative to one another
  - Microscopic Level
    - Observation using some type of microscope
  - Macroscopic Level
    - Structural elements that may be viewed with the naked eye

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Material Property

- Property is a material trait in terms of the kind and magnitude of response to a specific imposed stimulus.

- For example:
  - Specimen subjected to forces will experience deformation
  - Polished metal surface will reflect light.

Categories of Material Properties

- **Mechanical Properties**
  - Deformation to an applied force.
- **Electrical properties**
  - Electrical conductivity.
- **Thermal Properties**
  - Thermal conductivity.
- **Magnetic Properties**
  - Response of a material to the application of a magnetic field.
- **Optical Properties**,
  - Reflectivity
- **Deteriorative properties**
  - Chemical reactivity of materials.

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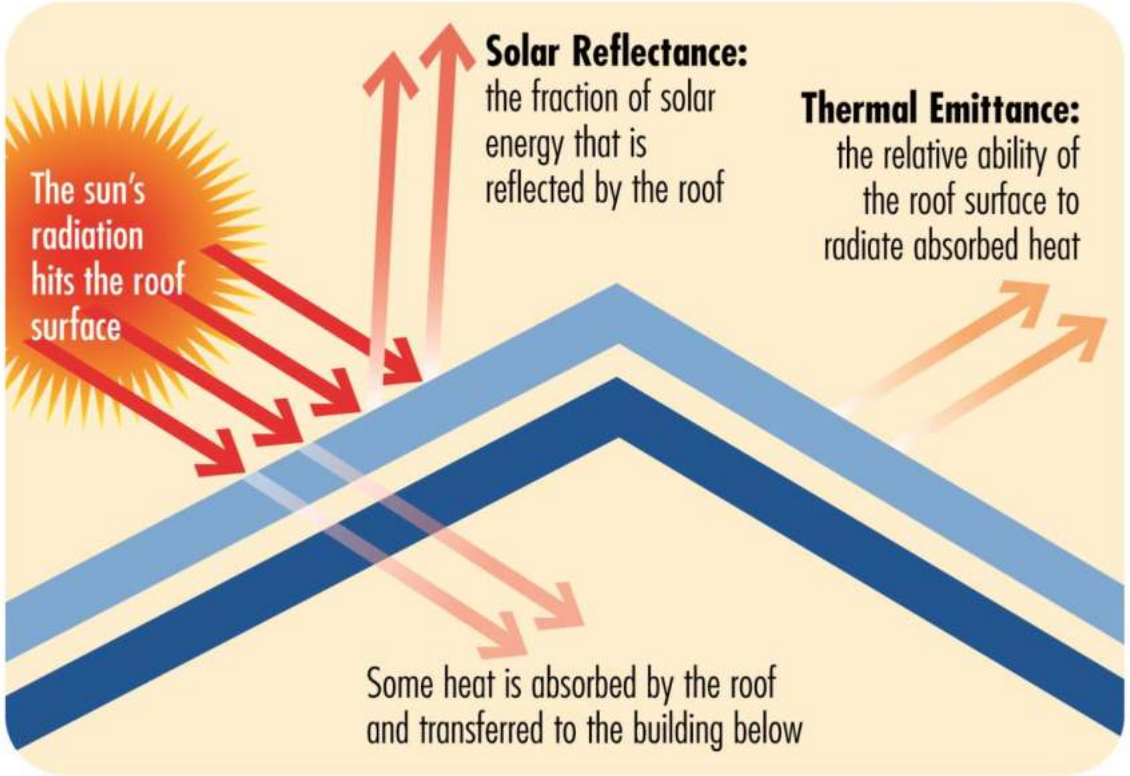
Material Performance



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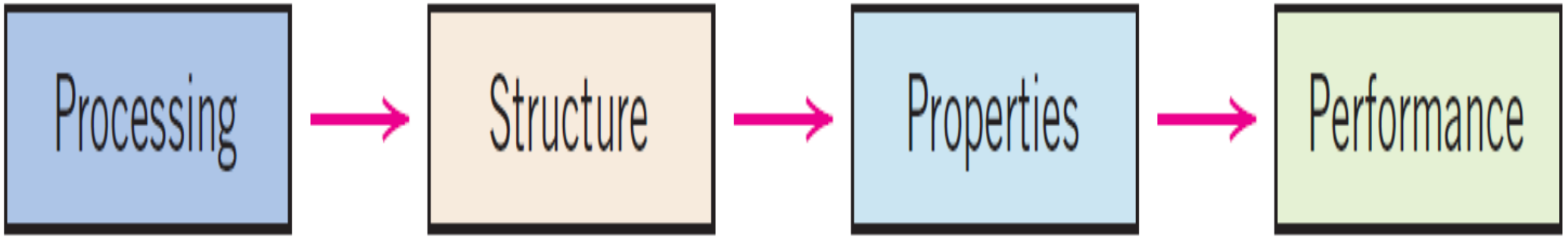
Science and Engineering of Materials Components



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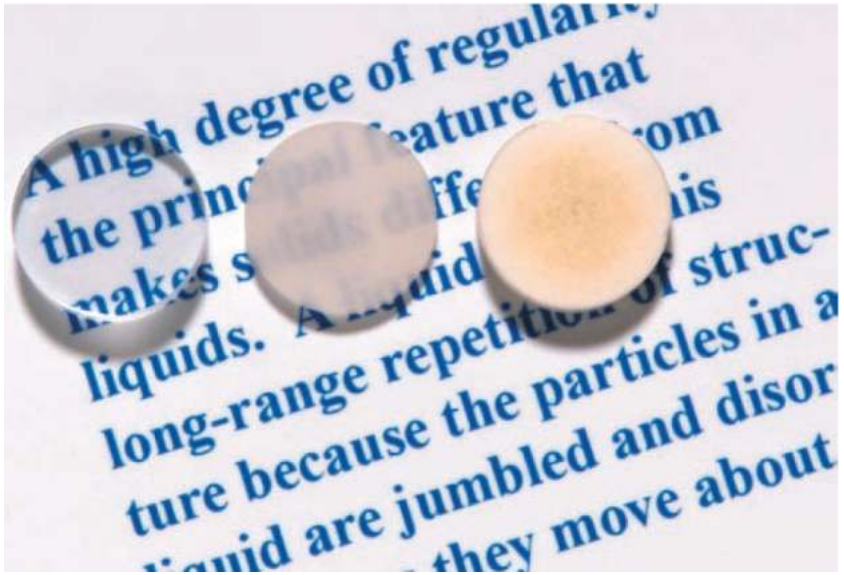
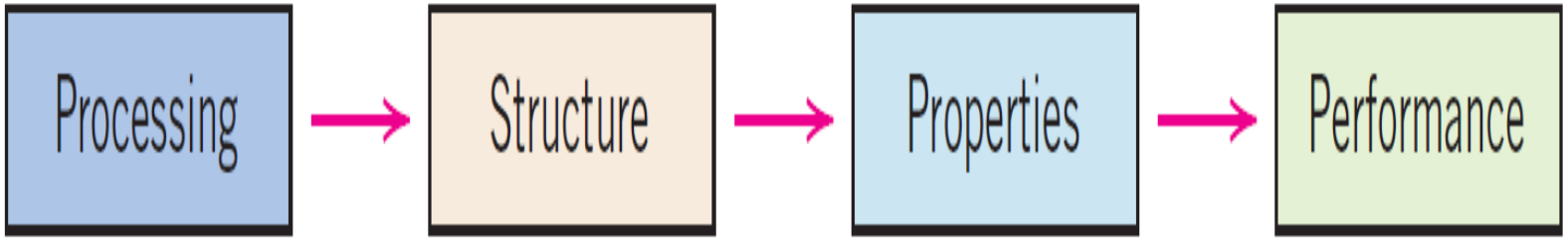
Science and Engineering of Materials Components

- Aluminum Oxide





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Why study Material Science & Engineering?

- To design and produce material considering:
  - ➢ Material property
  - ➢ Deterioration
  - ➢ Cost

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Classification of Materials

- Based on Chemical Property and Atomic Structure
  - Metal
  - Ceramic
  - Polymer
- Engineered Materials
  - Composite,
  - Semiconductor
  - Biomaterials
  - Nanomaterial

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Classification of Materials

- Metals
  - Composed of one or more metallic elements (e.g., iron, aluminum, copper, titanium, gold, and nickel)

- Ceramics
  - Compounds between metallic and nonmetallic elements; (aluminum oxide (or *alumina,* Al2O3),

- Polymers
  - Organic compounds that are chemically based on carbon, hydrogen, and other nonmetallic elements (plastics and rubber)

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Engineered Materials

➢Composite

- Composed of two (or more) individual materials to achieve a combination of properties that is not displayed by any single material

e.g. fiberglass (glass + Polymer), steel (iron + carbon) ….

➢Semiconductors

- Intermediate between the electrical conductors (i.e., metals and metal alloys) and insulators (i.e., ceramics and Polymers). Used in electronics and computer industries.

➢Biomaterials

- Any type of material BUT must not produce toxic substances and must be compatible with body tissues.

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Engineered Materials

- Nanomaterial
  - Can be any type of materials (metal, ceramic,…etc)
  - They are classified based on their size (Nano-)

"*nano*-prefix denotes that the dimensions of these structural entities are on the order of a nanometer (10^{-9} m)—as a rule, less than 100 nanometers (equivalent to approximately 500 atom diameters)"

- Dramatic changes in the physical and chemical characteristics takes place as particle size approaches atomic dimensions.

  For example, materials that are opaque in the macroscopic domain may become transparent on the nanoscale; e.g. gold.

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Summary

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