CHAPTER 1 - INTRODUCTION

Basic Definitions

materials science: study of structure-property relationships

materials engineering: study and design of material structure for desired properties

structure: refers to different scales

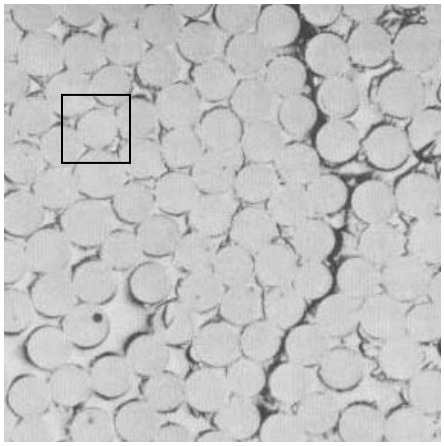
Often in engineering, "structure" refers to manufactured geometries and assemblies of parts; e.g., a bridge, a plate with a hole

subatomic: within atoms

atomic: between atoms and molecules*

microscopic: features visible under light microscope*

*traditional "material" generally defined at atomic and microscopic scale based on representative volume element (RVE), i.e., the minimum unit that represents the material, e.g., fiber composite (image adapted from Agarwal BD, Broutman LJ. Analysis and performance of fiber composites. John Wiley & Sons, 1981:44.); properties of RVE will reflect those of larger amount of material *except for processing and manufacturing flaws*.



macroscopic: visible features

Material Properties that Determine Material Application

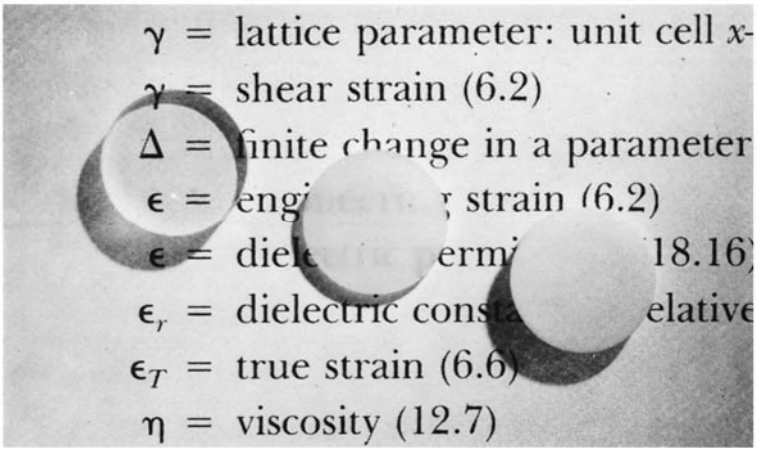
These properties determine the appropriate choice of materials for certain applications. Often, a compromise must be reached between them.

1. mechanical
2. electrical
3. thermal
4. magnetic
5. optical
6. chemical reactivity

Components of Material Design, Production, and Use

FIGURE 1.1 The four components of the discipline of materials science and engineering and their linear interrelationship.

FIGURE 1.2 Photograph showing the light transmittance of three aluminum oxide specimens. From left to right: single-crystal material (sapphire), which is transparent; a polycrystalline and fully dense (nonporous) material, which is translucent; and a polycrystalline material that contains approximately 5% porosity, which is opaque. (Specimen preparation, P. A. Lessing; photography by J. Telford.)



Criteria for Materials Selection

operating conditions
subsequent deterioration
economics

Primary Classifications of Solid Materials

metals: metallic elements and combinations; mobile electrons; strong yet deformable; good (electrical and thermal) conductors; gold, steel

ceramics: metallic and nonmetallic compounds; hard and brittle; good insulators; e.g., glass, clay

polymers: often organic compounds; large molecules; flexible; e.g., polyurethane, collagen

composites: at least two material types combined; "whole greater than sum;" e.g., carbon fiber-epoxy resin composites, bone (collagen plus hydroxyapatite plus ...)