

MATERIALS SCIENCE AND ENGINEERING

Sometimes it is useful to subdivide the discipline of materials science and engineering into materials science and materials engineering subdisciplines. Strictly speaking, materials science involves investigating the relationships that exist between the structures and properties of materials. In contrast, materials engineering is, on the basis of these structure–property correlations, designing or engineering the structure of a material to produce a predetermined set of properties.² From a functional perspective, the role of a materials scientist is to develop or synthesize new materials, whereas a materials engineer is called upon to create new products or systems using existing materials, and/or to develop techniques for processing materials. Most graduates in materials programs are trained to be both materials scientists and materials engineers. Structure is at this point a nebulous term that deserves some explanation. In brief, the structure of a material usually relates to the arrangement of its internal components. Subatomic structure involves electrons within the individual atoms and interactions with their nuclei. On an atomic level, structure encompasses the organization of atoms or molecules relative to one another. The next larger structural realm, which contains large groups of atoms that are normally agglomerated together, is termed microscopic, meaning that which is subject to direct observation using some type of microscope. Finally, structural elements that may be viewed with the naked eye are termed macroscopic. The notion of property deserves elaboration. While in service use, all materials are exposed to external stimuli that evoke some type of response. For example, a specimen subjected to forces will experience deformation, or a polished metal surface will reflect light. A property is a material trait in terms of the kind and magnitude of response to a specific imposed stimulus. Generally, definitions of properties are made independent of material shape and size. Virtually all important properties of solid materials may be grouped into six different categories: mechanical, electrical, thermal, magnetic, optical, and deteriorative. For each there is a characteristic type of stimulus capable of provoking different responses. Mechanical properties relate deformation to an applied load or force; examples include elastic modulus (stiffness), strength, and toughness. For electrical properties, such as electrical conductivity and dielectric constant, the stimulus is an electric field. The thermal behavior of solids can be represented in terms of heat capacity and thermal conductivity. Magnetic properties demonstrate the response of a material to the application of a magnetic field. For optical properties, the stimulus is electromagnetic or light radiation; index of refraction and reflectivity are representative optical properties. Finally, deteriorative characteristics relate to the chemical reactivity of materials. The chapters that follow discuss properties that fall within each of these six classifications. In addition to structure and properties, two other important components are involved in the science and engineering of materials—namely, processing and performance. With regard to the relationships of these four components, the structure of a material will depend on how it is processed. Furthermore, a material's performance will be a function of its properties. Thus, the interrelationship between processing, structure, properties, and performance is as depicted in the schematic

