PREFACE

The copper age, the iron age, the silicon age . . . eras defined by the materials found in nature, but manipulated by the engineers of their day. The fundamental principles of structure, defects, kinetics, and processing are generally applicable to all materials, while over time our understanding has advanced and incorporated new ideas. As a result, the observable and macroscopic behavior of materials, spanning such varied characteristics as mechanical strength and toughness, electrical conductivity, refractive index, and corrosion resistance, is both understood more deeply and related more directly to underlying atomic-level phenomena.

Our tools for characterizing and manipulating materials have also grown vastly more sophisticated, allowing for deeper insights into materials structures and phenomena. At the edge of innovation we find the discovery—or even the creation—of entirely new materials, often made possible by new processing techniques, by circumventing equilibrium to cause materials to exist in metastable states, and by developing the tools to assemble, form, and study materials at the nanoscale. It is now routine, for instance, to examine materials at the near-atomic level for both structure and composition, using techniques such as high resolution transmission electron microscopy, grazing incidence x-ray diffraction, and electron energy loss spectroscopy. At the same time, materials processing has advanced to the point where thin films just a few atomic layers thick can in many instances be grown or deposited, while three-dimensional structures with dimensions of only a few tens of nanometers or less can also be manufactured. The entire electronics industry, for instance, is based on these types of advances. Flat screen televisions, high-speed wireless data systems, portable computation and telecommunication devices, automobiles and other transportation systems . . . these and countless other technologies are all dependent on our contemporary understanding of materials.

While not all students who study materials science will be practicing materials engineers, most engineers will in fact work with a diverse materials set, comprising metals, ceramics, plastics, composites, and semiconductors, and across lengths scales from the nanoscale to the macroscale, all within a context of myriad and diverse applications. Materials are an enabling component of what engineers imagine, design, and build. The ability to *innovate* and to incorporate materials *safely* in a design is rooted in an understanding of how to manipulate materials properties and functionality through the control of materials structure and processing techniques. The objective of this textbook, then, is to describe the foundations and applications of materials science for college-level engineering students as predicated upon the structure-processing-properties paradigm.

The challenge of any textbook is to provide the proper balance of breadth and depth for the subject at hand, to provide rigor at the appropriate level, to provide meaningful examples and up to date content, and to stimulate the intellectual excitement of the reader. Our goal here is to provide enough *science* so that the reader may understand basic materials phenomena, and enough *engineering* to prepare a wide range of students for competent professional practice.

Cover Art

The cover art for the enhanced seventh edition of the text is a field-emission scanning electron microscope image showing crystals of tungsten-doped copper sulfide grown using a technique known as chemical vapor deposition. These nanoscale crystals were fabricated as part of an effort to make atomically thin tungsten sulfide photocatalysts on porous metal foams. Photocatalysts cause the intentional degradation of materials subjected to ultraviolet radiation. When the sulfur content was stoichiometrically controlled, the desired atomically thin photocatalysts were produced, whereas excess sulfur caused the formation of these fractal-like crystals. The color is false; it has been mapped to the brightness of the otherwise black/white micrograph. The image is titled "Nanosucculents" by Peter Cameron Sherrell of Imperial College London.

Audience and Prerequisites

This text is intended for an introductory science of materials class taught at the sophomore or junior level. A first course in college level chemistry is assumed, as is some coverage of first-year college physics. A calculus course is helpful, but certainly not required. The text does not presume that students have taken other introductory engineering courses such as statics, dynamics, or mechanics of materials.

New in the Seventh Edition

The beginning of each chapter includes learning objectives to guide students in their studies. New problems have been added to the end of each chapter to increase the number of problems by 15%. The breadth of Chapter 15 on ceramic materials has been extended to include crystalline ceramics, silica and silicate compounds, and other topics of interest to provide a more comprehensive view of this important class of engineering materials. Other portions of the chapter have been revised for clarity. The cost of common engineering materials in Chapter 14 has been updated. As always, we have taken great care to provide the most error-free text possible.

The enhanced seventh edition includes new digital resources and solutions for end of chapter problems. Select problems have also been updated.

Knovel™ Problems

At the conclusion of the end of chapter problems, you will find a special section with problems that require the use of Knovel (**app.knovel.com/web/**). Knovel is an online aggregator of engineering references including handbooks, encyclopedias, dictionaries, textbooks, and databases from leading technical publishers and engineering societies such as the American Society of Mechanical Engineers (ASME) and the American Institute of Chemical Engineers (AIChE).

The Knovel problems build on material found in the textbook and require familiarity with online information retrieval. The problems are also available online at **login.cengage.com.** In addition, the solutions are accessible by registered instructors. If your institution does not have a subscription to Knovel or if you have any questions about Knovel, please visit **www.elsevier.com/solutions/knovel-engineering-information**.

The Knovel problems were created by a team of engineers led by Sasha Gurke, senior vice president and cofounder of Knovel.

Supplements for the Instructor

Supplements to the text include a Solution and Answer Guide that provides complete solutions to all problems, annotated Lecture Note Powerpoint™ slides, and an image library of all figures in the book. These can be found on the password-protected Instructor's Resources website for the book at login.cengage.com.

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