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国外大学优秀教材——材料科学与工程系列（影印版）

Donald R. Askeland, Pradeep P. Phulé

材料科学与工程（第4版）

The Science and Engineering of Materials

Fourth Edition

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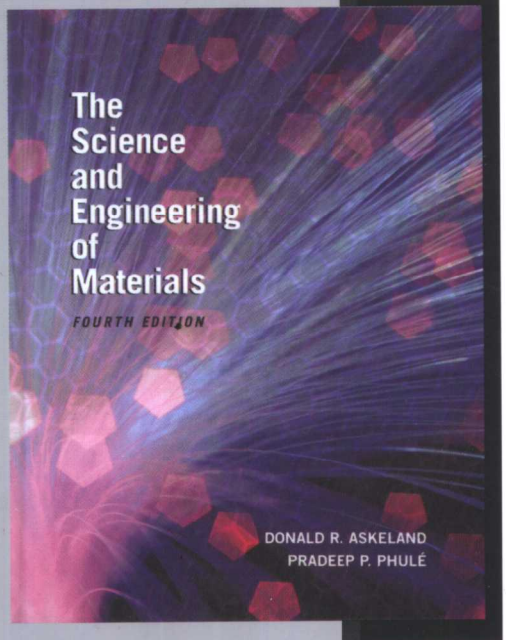

清华大学出版社

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（第4版）

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英文影印版序 1

我自 1995 年在美国大学为工学院本科生教授“材料科学与工程”至今已经快十年了，这门课程在全美国的工学院里既是作为材料专业的必修课，也是为其他专业（比如化工、机械、航空）的学生学习有关材料的知识而设置，但侧重点有所不同。比如对于冶金工程专业的学生，该课的教程会把重点放在金属材料的章节里；而对于非材料专业的学生，整个课程会广泛地介绍现代工业应用的一般材料，包括陶瓷、玻璃、高分子，以及复合材料，课时为 3 个学分（即 1 周 3 次课，每课时 50 分钟），一般在大学三年级完成该课程。

“材料科学与工程”这门课所用的同类型教科书有许多种。我在选择教材时至少审阅过十多本。*The Science and Engineering of Materials*（作者 Donald Askeland）在美国是这门课所用的教科书中最为流行的，现在已经是第 4 版了。但第 3 版与第 4 版之间没有主要的区别。它主要分五个部分：（1）晶体结构、缺陷和原子扩散；（2）微观结构控制与机械性能；（3）工程材料；（4）工程材料的物理性质；（5）腐蚀与磨损。其中第一部分主要讲解材料的原子结构，如单胞、密勒指数、X 射线结构分析等，这些都是材料学中最为基础也是必须掌握的基本概念。在这个部分里，还初步介绍了晶格缺陷中的位错和塑性变形的基本概念。第一部分中的扩散一章，虽然阐述得十分清楚、详细，但由于课时限制，往往跳过。因为一般大学材料系均会设置专门的扩散理论课。第二部分主要侧重材料的机械性能的测量、合金强化机制、相图分析、相变与热处理。对于机械性能的测试，可用于所有工程材料，包括陶瓷和高分子材料。关于微观结构的控制、相图分析以及强化理论的内容，则主要侧重于金属合金。可以认为，第一和第二部分为本书的基础内容，是材料科学与工程中至关重要的核心和基本概念，所以也是“材料科学与工程”课教学中的重点。

第三部分囊括了工业应用中大部分工程材料，并详细介绍金属、陶瓷、玻璃、高分子、复合材料以及建筑材料。这些章节不仅给出了这些重要材料的美国标定、规格和类型，而且阐述了它们的特性、应用范围和制备条件。比如陶瓷玻璃的特殊高温行为、碳化硅晶须的微结构，以及这些材料的热加工过程。对于工业应用中的重要材料——高分子，该部分也做了十分详尽的描述，包括高分子材料的结构特点、合成方法、温变行为以及力学变形机制。因而，第三部分对于非材料专业的工科学生，尤其对于那些需要在工程实践中广泛接触材料应用的专业，比如航空、机械、土木、环境和化工等，在掌握工程材料的一般知识方面有着极为重要的意义。

我在美国工学院的教学过程中，针对美国工科专业的特点和工业界的需求，为材料专业的本科生开设了一门题为“固体的物理性质”的课程作为毕业班的必修课。而这门课的主要教学内容和教材来自于本书的第四部分——工程材料的物理性质。在这个部分里，主

要介绍工程材料的电、磁、光和热学特性。与物理专业的“固体物理”课相比较，本书更侧重于物理特性的宏观与唯象描述和这些材料的工业应用，比如电子器件的制备和检测。虽然美国工学院电机系自己设有专门的“固体物理”和“量子力学”课程，但其他系的学生很少接触物理性质方面的知识。况且美国工学院的教授大多来自传统的工程教育背景，非电机系出身的老师一般很少开设这方面的课程。但是，美国工业界在近几十年来，功能材料飞速发展，尤其电子材料，包括智能材料、纳米电子器件、传感器、医用感应器等。这些器件材料大多是根据许多物理的基本原理和新概念而设计的。虽然工科非电机专业的学生并不一定直接涉及这些元器件的设计和制造，但在日常的工程实践中会经常接触到相关材料和器件的应用，比如测温、测压，磁场、光电参数的测量，以及通信和医疗过程中使用的设备和系统。这就要求工学院的非电学专业的学生能够对材料的物理性质和概念有一定的掌握。本书的第四部分就是按照这种需求而设置的。

第五部分主要讨论材料在特定环境下的腐蚀、磨损和防护，有针对性地讨论在腐蚀气氛下材料的破损机制和保护方法，属于比较特殊的课题。对于材料专业的学生，这类知识一般都会有专门的课程和教材讲授。而且这一部分内容篇幅较短，只能作为参考材料。

我在这门课的教学过程中曾经选用过类似的其他教材。但在教学实践中最终选用了这本书。这完全是根据多年来反复的比较、学生的反映和我所任教的学校课时的特点而决定的。本书条理有序，结构清晰，内容丰富，浅显易懂，十分适合于一般工学院的材料导论类课程。同时，它也适用于材料专业的初级课程。我在材料系还为本科生开设了一门“金属导论”的课程，也用这本书的第一、二部分的基础概念和第三部分的金属材料章节，学生反映极好。尤其本书所给出的思考作业题，内容十分广泛，而且重点突出，切题实用。在为其他非材料专业开设的“材料科学与工程导论”课程中，我的教学大纲会包括第一、二部分的一些主要内容，比如晶体结构、点阵缺陷、力学性质、相图分析和微观结构控制，加上第三部分的陶瓷、玻璃以及高分子材料等内容。对美国 11 周、3 学分课时的学期建制，选择这些内容是比较合适的。正是由于学时的限制，单一的课程无法囊括本书的所有部分和章节。但我认为，如上所述，第一、二部分应该是材料学初级课程的重点，第三部分的选择应该根据学生专业的特点和区别择重、择量、择优取用。

University of Missouri-Rolla 以其在金属冶金方面的建树而在美国著称。本书的作者 Donald Askeland 博士也是这个领域十分著名的专家。但我认为，他在本书里不仅对金属材料部分的介绍有独到的见解和非常精彩的阐述，而且对陶瓷、玻璃、高分子、复合材料等领域也作了极为详尽的描述。本书的第四部分——物理性质，并不是材料和非电学工科专业的重点。但作者也以自己博学的知识和深厚的研究经历对工程材料的物理性质给出循序渐进的讲解和较为深刻的理论探讨。更为可贵的是本书引入大量现代科技最新发展的成果，比如高温超导体、新一代数字芯片技术、高密度磁记录，等等。这对开拓学生眼界、熟悉相关领域动态、掌握现代工业发展有着极为积极的意义。

清华大学出版社在中国工业飞速发展的今天，十分及时地引进 *The Science and Engineering of Materials* 一书的版权，并作为中国大学材料科学与工程专业的主要英文原版教科书，有着非常重要的现实意义。它不仅可以在国内英文教学方面树立一个具有国际工程院系的教学标准，也为大专院校和科技单位的研究工作者提供了一本内容丰富又极具科研价值的参考书。我衷心祝愿本书的英文影印版受到中国师生以及科研同行的欢迎，并在教学和科研中发挥较大的作用。

时东陆
美国俄亥俄州立辛辛那提大学工学院
材料科学与工程教授
2004 年

英文影印版序 2

本书是美国密苏里-罗拉大学唐纳德·R. 阿斯克兰德教授和匹兹堡大学普拉迪普·P. 福勒教授撰写的大学教科书，为 2003 年出版发行的第 4 版。本书于 1984 年、1989 年、1994 年分别出版过前三版。1988 年宇航出版社曾出版由刘海宽等按第一版译出的《材料科学与工程》。

正如本书序言所述，全书有两个主题：

第一个主题延续前三个版本，力图清晰地表述材料的结构、加工工艺与材料性能之间的关系。材料科学家和工程师的主要目标：一是使现有材料优化，二是开发新材料，即从现象入手，通过发明、发现等，研究开发新材料、新器件和新应用等。所有工程技术人员，无论服务于哪一个领域，都可以从材料科学的基础知识中受益。材料科学支撑着许多技术的进步，例如能源、信息和环境科学等。对材料及其应用有一个全面、透彻的了解，不仅是一个训练有素的工程师必不可少的，而且对于任何器件及应用的筹划、设计乃至制作都是大为有益的。对于当今的工程技术人员来说，充分了解材料的性能，熟悉其长处和短处，以便为给定的用途选择最佳材料是极为重要的。我们确信，那些对原子和分子结构有透彻了解，而且熟悉哪些材料性能可实现最有效和最经济加工制作的工程技术人员，完全有能力设计出最优产品并达到最佳应用效果。

本书的第二个主题是，把本领域中大量振奋人心的事例和最新成果，献给有志于学习和钻研材料科学的大学生，激发他们的学习热情和献身动力。作者花了很大的力量激励学生们的学习兴趣，如将材料的现代应用纳入到基本理论框架进行讨论，目的是在基础理论和实际应用间建立密切的联系。材料应用的多样性和某一种材料使用的择优性在每一章的实例部分表现得淋漓尽致，其目的在于说明，为什么一个优秀的工程技术人员需要全面了解及如何应用材料科学与工程的原理。近年来，纳米技术信息领域、能源领域和生物工程领域等都取得突破性进展，在本书第 4 版中，读者会看到许多直接与这些领域相关的实例。

本书具有下述几个特点：

（1）覆盖面宽，兼顾基础性和前沿性

全书的内容包括五大部分。第一部分涉及原子结构、原子排列和原子运动；第二部分涉及材料的力学性能和微观结构控制；第三部分论述工程材料；第四部分介绍工程材料的物理性能；第五部分讨论材料劣化、失效及防护等。全书共计 22 章，内容涉及材料领域理论和实践的每一个方面。书中涉及的语言（word and language）、概念（concepts）、原理（principles）、性能（properties and performance）等犹如盖楼房用的砖瓦灰石，需要学生们透彻理解，牢固掌握。

本书论述教材的覆盖性主要表现在：材料的任何性能都可以在其结构上找到原因；学生遇到的任何问题都可以在本教材中找到答案；由本教材学习的内容可以终生受用。

传统课程为适应早年开发基础材料的要求，一般是针对某一类材料叙述得较为详细，但面窄且内容不够鲜活。但实际应用往往是各类材料的综合。本书把金属及合金、陶瓷和玻璃、聚合物、半导体、复合材料等各类材料综合在一起，经整体优化，重新熔炼，归纳出共性规律进行讨论。本教材涉及的内容是学生学习其他专业课的基础，也是今后从事材料应用、开发和研究等的基础。相应的课程既是“入门课”，又是“看家课”。

新材料更新换代快，式样多变；其制备和生产往往与新技术、新工艺紧密相连；其研制及在高技术中的应用需要更综合的知识和能力。为了适应这种特点，本教材中及时引进时代特点更为鲜明的知识，特别是新材料、新方法、新概念、新应用等，以适应本学科探索性、前沿性、创新性的要求。传授这些前沿内容，使学生“眼观六路，耳听八方”，可以提高兴趣，激活热情，增强震撼力，更重要的是可增强学生的创新意识和能力。

（2）内容上“少而精”，兼顾“浅、宽、厚”

“少而精”是相对于材料科学与工程学科内容繁杂、覆盖面广而言的。本书在内容选择上避免现象罗列，材料堆积，特别避免按不同材料种类“开中药铺”，在“少而精”的同时做到提纲挈领，纲举目张。

本书在内容安排上做到“浅、宽、厚”。共性的问题是材料宏观性能与微观结构之间的关系。范围宽、基础厚不等于深奥难懂，“浅”是宽和厚的前提，以“浅”入手，重基础，宽口径。针对具体内容，有些章节采用深入浅出，以理明技，有些章节采用由浅入深，循序渐进。书中省略掉扩散方程的推导及繁琐的位错理论。例如，第 5 章在讨论材料中原子和离子的运动时，不是从扩散方程的推导讲起，而是针对生产实际中常见的实例，如隔膜的渗气、钢表面渗碳、半导体掺杂元素的扩散等，建立边界条件和初始条件，分别求出扩散方程的解，并分别讨论各种情况的物理意义。这样做的结果，不仅理论联系实际，加深对已修课程的理解，而且能提高同学分析问题、解决问题的本领。

（3）叙述生动活泼、形象直观

本书讲解简明扼要，深入浅出，语言通俗易懂，简单明快。文中有大量插图，可使读者对内容得到明晰确切的理解。第 4 版中，重新绘制的图表更加形象直观。全彩色的插图清晰地展示出最终产品是如何根据材料的结构、材料的加工工艺和材料的性能这三者之间的关系，达到最佳效果。

（4）强调实践性、参与性

每章都有总结、名词术语解释、进一步学习的参考文献以及大量例题和练习题。第 4 版中还增加了设计问题特别是利用计算机的设计问题。这些设计问题包括案例设计、材料选择设计、开放性的案例设计等。后者具有许多可能的解，它们取决于工作条件，但这些条件并未在案例中给出，由学生自己选择确定。读者可以发现，包括例题、练习题和案例

设计等在内的许多内容都有着坚实的应用背景，或来源于高新技术生产实践，或来源于最新的科研成果，或来源于新的发明或发现。有些曾在历史上争论不休的问题，在本教材中也可以找到明确的答案。

配合此教材，还有以 CD-ROM 形式提供的 CaRlne 软件和网址可提供给学生；对教师而言，还有解题补充教案和图表用 PDF 文件等。

本教材通过多种形式，加强理论与实践的联系，创造师生互动的条件，改变单一传授知识型教材的模式，强调学生参与。这种以学生为主体，以教师为主导的基于探索和研究的教学模式，利于培养学生独立思考、发现问题和解决问题的能力。

本教材作为清华大学材料科学与工程系《材料科学基础》课程的主要参考书，试用多年，效果很好，特此推荐。

田民波
北京清华大学
材料科学与工程教授
2004 年

Preface

The Fourth Edition of *The Science and Engineering of Materials* has two primary objectives. The first continues the theme of earlier editions by providing a clear presentation of the relationship between the structure of a material, its processing, and its properties (see Chapter 1). The principal goals of a materials scientist and engineer are to make existing materials better and to invent or discover phenomena that will allow development of new materials, devices, and applications. All engineers, in all specialties, can benefit from a thorough knowledge of materials science. Materials science underlies many technological advances related to energy, information, and the environment. Having a basic understanding of materials and their application not only makes for a better engineer, but also aids in the design process **for any device or application under consideration**. It is important for today's engineers to understand the constraints of material behavior in order to select the best material for a given application. We believe that engineers who have a thorough understanding of the basic concepts of atomic and molecular structure, and who know which material properties lend themselves to the most efficient and cost-effective processes, will make design decisions to develop the best products and applications.

The second objective of this text is to motivate engineering students to want to study and understand materials science using exciting and current developments in the field. Considerable effort has been spent to bring interesting and modern applications into discussions about basic theoretical presentations in order to tie the theory to actual applications. The diversity of applications and the unique uses of materials are presented in the Example sections of each chapter in order to help illustrate why a good engineer needs to thoroughly understand and know how to apply the principles of materials science and engineering. Considerable advances have occurred in the areas of nano-technology information technology, energy technology and biomedical engineering. In this edition you will see many examples that directly relate to these areas of technology.

Audience and Prerequisites

This text is intended for engineering students who have completed courses in general chemistry, physics, engineering and calculus. Most students will take this course when they are sophomores or juniors and the presentation has been carefully geared towards this audience. To facilitate understanding, a brief description of key ideas from earlier prerequisite courses is provided to help students refresh their memories. The text does not presume that students have had any of the prerequisite engineering courses in statics, dynamics, or mechanics of materials.

We feel that while reading and using this book, students will really find materials science and engineering very interesting, and they will clearly see the relevance of what they are learning. We have presented many examples of modern applications of materials science and engineering that impact students' lives. Our feeling is that, if students recognize that many of today's technological marvels depend on the availability of engineering materials, they will be more motivated and remain interested in learning about materials science and materials engineering.

Changes to the Fourth Edition

The Fourth Edition of *The Science and Engineering of Materials* has been thoroughly revised to include discussions of recent breakthroughs in materials science such as nanomaterials and micro-electro mechanical systems (Chapter 1), flexible micro-electric circuits comprised of polymers (Chapter 18), smart materials (Chapters 11 and 18), fiber optics (Chapters 2 and 20), carbon nanotubes (Chapter 18), polymers as semiconductors (Chapter 15), and advanced electronic, magnetic and photonic materials, just to name a few. Every chapter presents examples of the latest exciting real-world applications.

Our text continues to be in five parts, as in previous editions, and we have combined our discussions of failure with our discussions of properties and behavior to create a revised Chapter 6. The Third Edition Chapter 23 on failure has been eliminated. Based on user feedback, we decided the discussion of failure is better suited to appear with the discussion of material properties and testing. These topics have been integrated with Chapters 6 and 22. We have expanded and thoroughly updated our discussions of ceramics (Chapter 14), polymers (Chapter 15), composites (Chapter 16), electronic materials (Chapter 18), magnetic materials (Chapter 19), and photonic materials (Chapter 20) to reflect recent developments and applications. We have also made a deliberate effort to integrate the applications of fundamental concepts, as opposed to strictly compartmentalizing them as ceramics, metals and polymers.

New Features

We have added many new and unique features to the Fourth Edition:

CD-ROM Included with the Text The accompanying CD-ROM contains many helpful software tools:

- One of the most useful tools is a student version of CaRIne Crystallography™. This is computational materials science software designed to aid students in the visualization of the basic concepts of atomic and molecular structure and material properties. We feel that the inclusion of CaRIne will be invaluable in those learning concepts related to crystal structures.
- A collection of QuickTime™ animated visualizations development by Dr. John Russ (North Carolina State University) covering such important material science concepts as crystal deformation, phase diagrams, shearing, and molecular bonding.

Chapter Opening Photos and Captions Each chapter begins with a photo and caption illustrating an interesting application. This provides an extra tidbit of information designed to pique the reader's curiosity about the material presented in that chapter.

Have You Ever Wondered? Questions The opening chapter photo is followed by a section entitled "*Have You Ever Wondered?*" These questions are designed to arouse the reader's interest, put things in perspective, and form the framework for what the reader will learn in that chapter.

Chapter Introductions The chapter introductions provide a breakdown of how the material will be presented in the chapters, as well as providing important information for the student to consider while reading the chapter. This section is not gratuitous, as the chapter material is developed from these introductory discussions.

Examples As mentioned before, many real-world Examples have been integrated to accompany the chapter discussions. These Examples specifically cover design considerations, such as operating temperature, presence of corrosive material, economic considerations, recyclability, and environmental constraints. The examples also apply to theoretical material and numeric calculations to further reinforce the presentation.

Chapter Summaries The Summaries at the end of the chapters have been expanded and are more thorough than those in previous editions.

Glossary The Glossary terms at the end of the chapters have been expanded. All of the Glossary terms that appear in the chapter are set in boldface type the first time they appear within the text. This provides an easy reference to the definitions provided in the end of each chapter Glossary.

Additional Information At the end of each chapter, we have provided a list of references for the chapter. These references can be used, by students or instructors, for further reading on chapter subjects. We have refrained from making specific references to web sites, as these often change and it is quite easy for most users to find the information using the Internet.

End-of-Chapter Problems More than 150 new end-of-chapter problems have been added to give the student practice in applying the principles presented in each chapter. We have added more Design Problems, as well as Computer Problems. The instructor can choose to assign these Design and Computer Problems as requirements or as extra credit material. Enhanced computer skills and familiarity with the use of softwares and databases are considered as highly desirable by most employers and we feel that the computer problems can help students develop these skills. The use of computers can be an important consideration in the ABET accreditation process. We feel that the problems suggested here would be useful in this regard as well.

Art and Photo Program The art program has been completely redrafted and over 50 new photographs and micrographs have been added. Many new photographs illustrate fascinating real-world applications. Many new illustrations communicate technical concepts in a clearer fashion.

Four-Color Insert The full-color insert shows photographically the relationship between the structure of a material, the processing of that material, and how the properties of the material can then be used in a final product.

Periodic Table We have provided the Periodic Table as a two-page spread in Chapter 2 and tinted the pages with blue to the edge to provide a quick and easy reference to this important item. This Periodic Table includes helpful information such as the atomic number, electron configurations, melting point, boiling point, atomic mass, oxidation states, density, and electronegativity.

Answers to Selected Problems The answers to the selected problems are provided at the end of the text to help the student work through the end-of-chapter problems.

Appendices and Endpapers Appendix A provides a listing of selected physical properties of metals, Appendix B presents the atomic and ionic radii of selected elements, and Appendix C provides the electronic configuration for each of the elements. The Endpapers include SI Conversion tables and Selected Physical Properties of elements. One of the endpapers contains a useful illustration that helps answer the question most often posed by students—"What is materials science and engineering?"

Chapter Outline

Part I introduces the student to Atomic Structure, Atomic Arrangements, and Atomic Movements:

Chapter 1—Introduction to Material Science and Engineering: This chapter presents an introduction to the study of material science and engineering using the MSE (Material Science and Engineering) tetrahedron to explain the interconnections between composition, structure, synthesis, processing, and performance. Chapter 1 goes on to discuss the classification of materials (functional and structure), as well as material design and selection. These principles of materials science and engineering are illustrated through several real-world applications,

Chapter 2—Atomic Structure: This chapter introduces the student to the basics of a material's atomic structure and bonding mechanisms. Many examples of how bonding affects the properties of materials are discussed.

Chapter 3—Atomic And Ionic Arrangements: This chapter discusses atomic and ionic arrangements, including short-range versus long-range order; lattices, unit cells, crystal structures, points, directions, and planes. This chapter also covers amorphous materials, allotropic and polymorphic transformations, and crystal structures of ionic- and covalent-bonded structures.

Chapter 4—Imperfections in the Atomic and Ionic Arrangements: This chapter continues the discussion of atomic and ionic arrangements with discussions of imperfections such as point defects, dislocations, crystal structures, and surface defects.

Chapter 5—Atom and Ion Movements in Materials: This chapter covers the basic concepts of diffusion—the movement of atoms and ions. The discussion of diffusion includes applications, mechanisms, activation energy, rate, and factors affecting diffusion. Discussion of Fick's First and Second Laws and the permeability of polymers is also included.

Part II introduces the student to the concepts of Mechanical Properties of Materials and Controlling the Microstructure:

Chapter 6—Mechanical Properties and Behavior: This chapter introduces the student to the properties and behavior of various materials through the examination of testing methods and the reasons for failure. Discussions include the terminology of mechanical properties, the tensile test, the bend test, true stress-true strain, hardness, impact, fracture mechanics, Weibull statistics, fatigue, creep, stress rupture, and stress corrosion.

Chapter 7—Strain Hardening and Annealing: This chapter introduces the student to the concepts of strain hardening and annealing through discussions of cold working, the stress-strain curve, strain-hardening mechanisms, texture strengthening, the three stages of annealing, control of annealing, hot working, and superplastic forming.

Chapter 8—Principles of Solidification: This chapter introduces the student to the concept of solidification. Discussions include nucleation, growth mechanisms, time and dendrite size, cooling curves, cast structure, defects, casting processes, continuous and ingot casting, directional solidification, single crystal growth, epitaxial growth, solidification of polymers and glasses, and joining of metallic materials.

Chapter 9—Solid Solutions and Phase Equilibrium: This chapter introduces the student to the important concepts of phase diagrams and solid solutions. Discussions include phases, unary phase diagrams, solubility and solid solutions, conditions for unlimited solid solubility, solid solution strengthening, isomorphous phase diagrams, properties and phase diagrams, solidification of solid solution alloys, non-equilibrium solidification and segregation. Examples include discussions on phase diagrams of metallic, ceramic and polymeric systems.

Chapter 10—Dispersion Strengthening and Eutectic Phase Diagram: This chapter continues the discussion of phase diagrams to introduce and discuss dispersion strengthening, intermetallic compounds, three-phase reactions, the eutectic phase diagram, eutectic alloys, eutectics and materials processing, nonequilibrium freezing, and ternary phase diagrams.

Chapter 11—Dispersion Strengthening by Phase Transformations and Heat Treatment: This chapter continues the discussion of dispersion strengthening by phase transformation, but also includes a discussion of heat treatment. Discussions include nucleation and growth in solid-state reactions, age and precipitation hardening, effects of aging temperature and time, the eutectoid reactions, the martensitic reaction, and shape-memory alloys.

Part III introduces the student to Engineered Materials:

Chapter 12—Ferrous Alloys: This chapter introduces the designations, classifications, and heat treatments used for steels, cast irons, and metallic alloys. The synthesis and processing of these materials are also introduced.

Chapter 13—Nonferrous Alloys: This chapter introduces the designations, classifications, and treatments of nonferrous alloys.

Chapter 14—Ceramic Materials: This chapter introduces the student to the applications, properties, synthesis and processing of advanced ceramic materials. Concepts related to powder synthesis and processing are also introduced.

Chapter 15—Polymers: This chapter introduces the student to the classifications,

structure, mechanical properties, processing techniques, and recyclability of polymers. Several examples illustrate applications of engineered plastics.

Chapter 16—Composites: Teamwork and Synergy in Materials: This chapter introduces the concepts of dispersion-strengthened, particulate, fiber-reinforced, and laminar composites.

Chapter 17—Construction Materials: This chapter introduces the basic material properties and behavior of construction materials such as wood, concrete, and asphalt.

Part IV introduces the student to the Physical Properties of Engineering Materials:

Chapter 18—Electronic Materials: This chapter introduces the student to electrical behavior and properties and how they can be applied to materials science. Discussions include Ohm's Law and electrical conductivity; band structures of solids; conductivity of metals and alloys; superconductivity; conductivity in other materials such as plastics, semiconductors and insulators; dielectric properties; electrostriction; piezoelectricity; ferroelectricity and pyroelectricity.

Chapter 19—Magnetic Materials: This chapter introduces the concepts of magnetism within materials and their classifications. Discussions include magnetic dipoles and moments, magnetization, permeability, diamagnetic, paramagnetic, ferrimagnetic, ferromagnetic and superparamagnetic materials, domain structure and the hysteresis loop, the Curie temperature, and metallic and ceramic magnetic materials. Applications of magnetically hard and soft materials are also discussed.

Chapter 20—Photonic Materials: This chapter introduces the student to behavior and properties of photonic materials and how they are used in industry, including fiber optic communication systems.

Chapter 21—Thermal Properties of Materials: This chapter discusses the thermal properties of materials including heat capacity, specific heat, thermal expansion, thermal conductivity, and thermal shock.

Part V includes a discussion on the Protection Against Deterioration and Failure of Materials:

Chapter 22—Corrosion and Wear: This chapter covers the topics of corrosion and wear. Discussions include chemical corrosion, electrochemical corrosion, microbial degradation, biodegradable polymers, oxidation, gas reactions, wear, and erosion. Strategies for prevention of corrosion are also discussed.

Strategies for Teaching from the Book

All of the material presented here admittedly cannot or should not be covered in a typical one-semester course. By selecting the appropriate topics, however, the instructor can emphasize the desired materials (i.e., metals, alloys, ceramics, polymers, composites, etc.), provide an overview of materials, concentrate on behavior, or focus on physical properties. In addition, the text provides the student with a useful reference for subsequent courses in manufacturing, design, and materials selection. For students specializing in materials science and engineering, or closely related disciplines, sections related to synthesis and processing could be discussed in greater detail.

Supplements

Supplements for the student include:

- As noted before, one of the most useful additions to the CD-ROM is the CaRIne software. This will really enable students to better understand crystal structures and related concepts.
- A student website at: www.brookscole.com/engineering_d/.

Supplements for the instructor include:

- The Instructor's Solutions Manual that provides complete, worked-out solutions to selected text problems and additional text items.
- PDF files of all figures from the textbook in a multimedia presentation format.

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