Materials Selection in Mechanical Design

Michael F. Ashby
(Elsevier Butterworth-Heinemann, 2005)
624 pages; $64.95
ISBN 0-7506-6168-2

Efficient materials and process selection is a key issue in mechanical design. For decades, this essential aspect was dealt with by using empirical rules and past expertise. With the evolution of the industrial world, and with the explosion of new materials and new processes, this conservative approach was no longer suitable for an efficient design. But the complexity of the situation, due both to the vast range of possible choices and to the complex nature of the requirements (technical, technological, and economical), made the task of developing a rigorous and objective approach to materials and process selection a real *tour de force*. Over the last 15 years, Michael Ashby has entirely renewed the field, with elegance and efficiency. The present book is the third edition (first in 1992, second in 1999) of what has now become a classic. This new edition is more than a simple update of the previous books, in which the illustrations have considerably improved and some chapters have been totally rewritten. As well as providing an excellent textbook, it brings to the reader the "state of the art" in the field to those willing to get involved in this new research topic.

Besides the now classical approach of the "performance indices" for materials comparison, the selection of processes by "attributes," and the integration in the design process of simple cost estimators, the new edition presents a whole new section on processes, which in itself could be used as an excellent introduction to a topic difficult to teach in a systematic manner. The role of shape in design, introducing the sections on hybrid materials (such as sandwiches and cables) and multimaterials selection provides an introduction to widely open questions. The progression of the book is made in such a way that the book can be used at any level in materials engineering courses, either as a final course for design engineers, or, part of it, as an introductory course on materials, leading the students to understand why such properties are important, and why such material performs well in a given application.

In parallel to the development of these methods, Ashby has been proactive in the development of computer software (Cambridge Engineering Selectors, by Granta Design) that implements these concepts and allows analysis of the most complete databases to date. This software (CES) is a natural complement to the book and makes it even more attractive to students. But the book, with many worked-out examples and case studies, can be used independently from the software.

From where the book ends, many new domains can be addressed, such as multifunctional design, selection of products, and microelectromechanical system devices. The research area is wide and still almost virgin, and many disciplines can contribute to it. For some years now, materials selection in design has made its way through the materials science curriculum. I expect this new edition, with an active pedagogy on real-life problems, will set new standards in teaching engineers in materials science. Last but not least, this text will bring to the academic community this exciting cross-disciplinary new field of research activity, and hopefully will attract new active contributors.

Reviewer: *Yves J.M. Bréchet is a professor in materials science in the Institut National Polytechnique de Grenoble, France. His research activities are in modeling in physical metallurgy (e.g., phase transformations and mechanical properties) and in methods of design.*

Kinetic Processes—Crystal Growth, Diffusion, and Phase Transitions in Materials

Kenneth A. Jackson
(John Wiley & Sons, 2004)
424 pages; $130.00
ISBN 3-527-30694-3

As the title of the book suggests, the book is concerned with diffusion, crystal growth, and phase transitions in materials. Kenneth Jackson is one of the leading international experts on crystal growth. The fundamental concepts in the book are clearly explained using plain language and numerous real, practical examples. It is intended to be a textbook on kinetics of materials processes for first-year graduate students or senior-year undergraduate students. It can also be used as a reference book for those who are interested in crystal growth and solidification of alloys. The first few chapters are devoted to basic diffusion processes in various media. The author discusses diffusion in fluids, amorphous materials, crystals, and semiconductors as well as the mathematical treatment of diffusion and its applications to moving boundary problems in phase transformations. The remainder of the book, the major portion of the book, contains an excellent collection of chapters on kinetic processes and theoretical treatment of crystal growth involved in thin-film processing and alloy solidifications.

The course "Kinetics of Materials Processes" is almost uniformly required for first-year graduate students across the materials science and engineering departments worldwide. However, the materials covered at different institutions vary significantly, and to a large degree depend on the interest of the instructor. This book reflects the interest of the author in the crystal growth of semiconductor materials. For example, there is almost no discussion of the Darken's theory of diffusion, diffusion in multicomponent systems, relationships among various diffusion coefficients (e.g., tracer, self-diffusion, vacancy, intrinsic, interdiffusion, and ambipolar). There is also very limited discussion on relationships between defect chemistry and diffusion in ionic crystals as well as on phase transformations between different structural states of a solid. Therefore, this is an excellent textbook for graduate students whose research focus is on semiconductor materials. However, for those in metallurgy or in ceramics, this book should be used in conjunction with materials from other textbooks such as *Atom Movements: Diffusion and Mass Transport in Solids* by Philibert, *Diffusion in Solids* by Shewmon, and *Solid State Reactions* by Schmalzried, to name a few.

Reviewer: *Long-Qing Chen is a professor of materials science and engineering at The Pennsylvania State University.*

Electronic Materials Science

Eugene A. Irene
(Wiley Interscience, 2005)
320 pages; $99.95
ISBN 0–471–69597–1

This book presents a concise, high-level introduction to solid-state physics and physical chemistry as they pertain to the properties of bulk electronic materials. Eugene Irene intends to provide an introductory materials science textbook for students with advanced knowledge in chemistry and/or physics. His single-semester course at the University of North Carolina at Chapel Hill (UNC) that brought about this book is described in the preface as "a fast-paced course with a dearth of descriptive material." He expects his students to have two semesters of calculus, elementary calculus-based physics, and general chemistry as well as two semesters of physical chemistry under their belts. The book occupies a previously unfilled niche. Even though the book clearly originated in the specific needs of materials science students at UNC, a wider need for such a text can be anticipated.

It is evident from the way the material is presented that the author believes in giving students of materials science a solid foundation in the underlying "classical" sciences. As a result, classical concepts such as diffraction, diffusion, phase equilibria, elasticity, and plasticity are presented center stage. The electronic properties of electronic materials are only discussed in the last third of the book (chapters 9 and 10), with interfacial and nanoscale phenomena treated somewhat as an afterthought in chapter 11. This perspective serves as a reminder that electronic materials are not all about quantum mechanics and nanoscience. Thermodynamics, kinetics, and statistical mechanics are essential tools for a well-rounded understanding of the properties and applications of electronic materials.

I find the book to be too short on interfacial and surface phenomena as well as some electronic phenomena in metals and semiconductors. Plasmons and excitons, for example, did not make it into the book at all. The concept of a Schottky barrier is described well in the book, but for whatever reason, the author appears shy about calling it by its name. Only the very last line of that section of the book admits that the resulting contacts "are called 'Schottky' contacts." I believe these shortcomings are explained by the constraints of introducing electronic materials in a single-semester course. In fact, I would wish for students taking my surface science courses to have the background covered in this book. Interfacial phenomena are briefly covered in the last chapter, and undoubtedly, students would be well-prepared for the discussion of surfaces and interfaces in electronic materials at the end of Irene's course.

Overall, this book does a good job as a thorough introductory textbook into materials science. It can be recommended for advanced students with an interest in electronic materials and for practitioners in the field (such as myself) who never took the formal route of an education in materials science. It is a welcome complement to more standard textbooks in the field.

Reviewer: *Peter Kruse is a surface chemist at McMaster University in Canada. His interests are in scanning probe microscopy and in the chemistry at (and physics of) surfaces and interfaces in electronic materials, such as carbon nanotubes, compound semiconductors, and organic electronics.*

Laser Processing of Engineering Materials: Principles, Procedure, and Industrial Application

John C. Ion
(Elsevier Butterworth-Heinemann, 2005)
556 pages; $59.95
ISBN 0–7506–6079–1

John Ion has done an excellent job in covering the exciting field of laser processing of engineering materials in this book. It will serve as an excellent undergraduate textbook as well as a very useful reference handbook for the practicing engineer. The introduction, with an anecdote of James Bond, shows how far we have developed this new processing technology for a host of applications. The book starts with a very interesting recapitulation of the history of lasers and the principles of light generation and amplification. Significant effort has been spent on solid-state semiconductor

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theory that enables the reader to get a good perspective of the principles of laser generation. Additionally, the theory of optics necessary for laser processing is very well covered. Good attention has been given to the study of phase diagrams and microstructure that are of relevance to the metallurgical aspects of laser-engineering materials interaction so that readers feel comfortable without having the need to delve into all the details. The author has used his own experience in model-based laser processing diagrams to show their usefulness in predicting behavior. Frequent use of tables to summarize applications is a nice method of presenting information in a concise manner. Chapter 7 on athermal processing is very well written in that the science, engineering, and applications of laser printing, lithography, micromachining, and shock processing are explained in a clear manner.

Structural changes that occur in laser processing are also elucidated in a succint manner and cover new technologies of nanoscale applications such as nanotubes. Adequate references are provided for readers to dig deeper into the subject matter. The next chapter on surface hardening makes use of analytical solution diagrams generated by software modeling and their application to practical industrial examples. Once again, the examples of deformation and fracture are described concisely, and the process of surface melting is also sufficiently described for different engineering materials with respect to type of laser used, with excellent reference citations. A field typically ignored is that of cladding, and chapter 12 deals with this in sufficient detail for different materials systems. Two diametrically opposite applications using lasers—namely, joining and cutting—are covered in the next two chapters with very good examples of industrial applications. The last three chapters focus on laser marking, welding, and thermal machining, and the author has been able to maintain the momentum of the use of different types of laser sources for different materials systems such as metals, ceramics and glasses, polymers, and composites. A highlight, demonstrated throughout the book, is relating laser processing to the fabrication, modification, and joining of large structural components frequently encountered in the automotive, shipbuilding, and aerospace fields.

The appendices are well laid out, serving as handy reference material including mechanical and thermal properties of a number of engineering materials, analytical mathematical treatment appropriate to the field of laser processing, good glossary of terms, and designation of various metals and alloys commonly used in industry.

To conclude, the book has a wealth of information and is an indispensable handy reference volume that hopefully the author is encouraged to update periodically as the technology of laser processing of engineering materials opens new vistas in industrial practice.

Reviewer: *Sudhi Sant is president and founder of Twin Technologies Inc. in Garden Grove, California, and has over 15 years of thin-film deposition and etching experience covering a range of processes and applications.*

Quasicrystals: Structure and Physical Properties

H.-R. Trebin, Editor
(Wiley & Sons, 2003)
672 pages; $190.00
ISBN 3-527-40399-X

A quasicrystal is one having a structure in which the atom positions are ordered, but with rotational, rather than translational symmetry: five-, eight-, ten-, or twelvefold in character, such that only a quasi-periodicity obtains. Surprisingly, although quasicrystals as a third form of solid matter, besides the crystalline and amorphous states, were not discovered until 1984, related theoretical conceptions date back to 1925! Quasicrystals are seldom found in binary alloys but more often in ternary and higher-ordered alloys. Since the initial discovery, there have been eight international conferences on the subject, 15 workshops, more than a dozen books written, and hundreds of research papers published, many of which are reviewed here.

The present book covers the work instigated in 1997 as a priority program of the Deutsche Forschungsgemeinschaft (German National Science Foundation) and carried out in 30 research groups throughout Germany between then and 2002. The 35 chapters of the work are divided into six parts: A–synthesis, metallurgy, and characterization; B–structure and mathematical modeling; C–electronic and magnetic properties; D–thermal and dynamic properties; E–mechanical properties; and F–surfaces and thin films. Each chapter begins with a general introduction to the topic to be presented before proceeding with discussion of specific experimental or theoretical results. All articles were refereed before printing by an international panel headed by A. Goldmann of the University of Kassel, and the collection was edited by Hans-Rainer Trebin of the University of Stuttgart.

The field of quasicrystals has been remarkable in that it has attracted physicists, mathematicians, crystallographers, chemists, and materials scientists. Although great progress has been made in the past 20 years in the understanding of this new state of matter, scientists are only just now beginning to develop some practical applications. The individual authors and the editor are to be congratulated for producing a volume that is at once current, comprehensive, authoritative, and understandable. Although only three of the 103 contributors to the book are native English speakers, the writing is remarkably fluent, with very few errors or awkward constructions.

While this reviewer greatly admires this volume, it is nonetheless necessary to point out some shortcomings. No author index is provided, and the subject index is inadequate with little hierarchical structure, sparse entries (only ~1 per page), and many significant omissions. A useful assist, which should have been provided, would have been a glossary defining both the many uncommon acronyms used (few of which appear in the index) as well as the many novel technical terms introduced (e.g., Delone cell, octonacci chain, Simpleton flip, and Tübingen triangle tiling) and the ordinary words with specialized meanings (e.g., window, covering, fat, and wavelet).

Reviewer: *Jack H. Westbrook is owner of and principal consultant with Brookline Technologies, a consulting firm in Ballston Spa, N.Y., where he consults on materials and technical information systems. He is chair of the* MRS Bulletin *Book Review Board and serves on the* MRS Bulletin *Editorial Board.*

The following recently published books, relevant to materials research, have come to *MRS Bulletin's* attention. Some of the books listed here may be reviewed in future issues of *MRS Bulletin*. To review a book from the list or to offer recommendations of additional books, contact K. Wilson, Editorial Assistant, *MRS Bulletin*, 506 Keystone Drive, Warrendale, PA 15086-7573, USA; e-mail bulletin@mrs.org.

Applications

Advances in Solid Oxide Fuel Cells, Dongming Zhu and Waltraud Kriven, Editors; ACerS Books, 2005, 450 pp., $129.00, ISBN 1-57498-234-6.

Elsevier Handbook of Adhesives and Sealants, *Volume 1*: Basic Concepts and High Tech Bonding, Phillipe Cognard, Editor; Elsevier, 2005, 398 pp., $165.00, ISBN 0-08-044554-3.

Biomaterials

Natural Fibers, Biopolymers, and Biocomposites, Amar K. Mohanty, Manjusri Misra, and Lawrence T. Drzal, Editors; CRC Press, 2005, 896 pp., $149.95, ISBN 0-8493-1741-X.

History, Biography, and Unclassified

Encyclopedia of Condensed Matter Physics (six-volume set), G. Franco Bassani, Gerald L. Liedl, and Peter Wyder, Editors; Elsevier, 2005, 3000 pp., $1,895.00, ISBN 0-12-227610-8.

Inorganic Chemistry, Electrochemistry, Other Chemistry, and Ceramics

5th International Conference on High Temperature Ceramic Matrix Composites, Mrityunjay Singh, Ronald J. Kerans, Edgar Lara-Curzio, and Roger Naslain, Editors; ACerS Books, 2005, 630 pp., $149.00, ISBN 1-57498-219-2.

65th Conference on Glass Problems, Charles H. Drummond III, Editor; ACerS Books, 2005, 180 pp., $79.00, ISBN 1-57498-238-9.

Advances in Ceramic Armor, Dongming Zhu and Waltraud Kriven, Editors; ACerS Books, 2005, 350 pp., $109.00, ISBN 1-57498-237-0.

Advances in Ceramic Matrix Composites XI, J.P. Singh, Narottam P. Bansal, and M. Singh; ACerS Books, 2005, 360 pp., $109.00, ISBN 1-57498-245-1.

Advances in Glass and Optical Materials, Shibin Jiang, Editor; ACerS Books, 2005, 130 pp., $109.00, ISBN 1-57498-243-5.

Cellular Ceramics: Structure, Manufacturing, Properties, and Applications, Michael Sheffler and Paolo Colombo; John Wiley & Sons Inc., 2005, 700 pp., $299.95, ISBN 3-527-31320-6.

Ceramic Armor and Armor Systems II, Eugene Medvedovski, Editor; ACerS Books, 2005, 160 pp., $109.00, ISBN 1-57498-248-6.

Ceramic Nanomaterials and Nanotechnology IV, Richard Laine, Michael Hu, and Song Wei Lu, Editors; ACerS Books, 2005, 600 pp., $129.00, ISBN 1-57498-242-7.

Characterization Techniques for Ceramists, Dennis R. Dinger; ACerS Books, 2005, 270 pp., $30.00, ISBN 1-9715696-6-5.

High Performance Cement-Based Concrete Composites, Joseph J. Biernacki, Editor; ACerS Books, 2005, 313 pp., $109.00, ISBN 1-57498-199-4.

Innovative Processing and Synthesis of Ceramics, Glasses, and Composites IX, J.P. Singh and Narottam P. Bansal, Editors; ACerS Books, 2005, 240 pp., $109.00, ISBN 1-57498-247-8.

Materials Science of Concrete VII, Jan Skalny and J. Francis Young, Editors; ACerS Books, 2005, 320 pp., $109.00, ISBN 1-57498-210-9.

Quantum Chemistry, *3rd Edition*, John P. Lowe and Kirk Peterson; Elsevier, 2005, 728 pp., $94.95, ISBN 0-12-457551-X.

Synthesis, Properties, and Crystal Chemistry of Perovskite-Based Materials, Amit Goyal and Winnie Wong-Ng, Editors; ACerS Books, 2005, 208 pp., $109.00, ISBN 1-57498-190-0.

Materials Processing

Engineering Thin Films and Nanostructures with Ion Beams, Emile Knystautas; CRC Press, 2005, 592 pp., $139.95, ISBN 0-8247-2447-X.

Environmental Issues and Waste Management Technologies XI, Connie C. Herman, Editor; ACerS Books, 2005, 240 pp., $129.00, ISBN 1-57498-246-X.

High-Temperature Glass Melt Property Database for Process Modeling, Thomas P. Seward III and Terese Vascott, Editors; ACerS Books, 2005, 291 pp., $109.00, ISBN 1-57498-225-7.

Kinetics of Materials, Robert W. Balluffi, Samuel M. Allen, and W. Craig Carter; John Wiley & Sons Inc., 2005, 645 pp., $89.95, ISBN 0-471-24689-1.

Rubber Recycling, Sadhan K. De, Avraam Isayev, and Klementina Khait, Editors; CRC Press, 2005, 528 pp., $149.95, ISBN 0-8493-1527-1.

Metallurgy

The Deformation and Processing of Structural Materials, Z. Xiao Guo, Editor; CRC Press, 2005, 331 pp., $209.95, ISBN 0-8493-2585-4.

The Science and Technology of Materials in Automotive Engines, Hiroshi Yamagata, Editor; CRC Press, 2005, 318 pp., $245.00, ISBN 0-85573-742-6.

Physics and Electronics

Advances in Dielectric, Piezoelectric, and Ferroelectric Materials, Dongming Zhu and Waltraud Kriven, Editors; ACerS Books, 2005, 500 pp., $129.00, ISBN 1-57498-235-4.

Microwave Solutions for Engineers, David E. Clark, Diane C. Folz, Carlos E. Folgar, and Morsi M. Mahmoud, Editors; ACerS Books, 2005, 450 pp., $109.00, ISBN 1-57498-224-9.

Ninth International Conference on Ferrites, Ronald Soohoo, Editor; ACerS Books, 2005, 968 pp., $275.00, ISBN 1-57498-218-4.

Organic Electroluminescence, Zakya Kafafi; CRC Press, 2005, 528 pp., $139.95, ISBN 0-8247-5906-0.

Robert Shannon and Roland Shack: Legends in Applied Optics, James E. Harvey and R. Brian Hooker, Editors; SPIE Press, 2005, 628 pp., $92.00, ISBN 0-8194-5844-9.

Polymer Chemistry

Block Copolymers in Solution: Fundamentals and Applications, Ian W. Hamley; John Wiley & Sons Inc., 2005, 300 pp., $180.00, ISBN 0-470-01557-8.

Polymers in Asphalt, Howard Robinson; Rapra Technology, 2005, 128 pp., $153.00, ISBN 0-859570507-2.

Thermal Degradation of Polymeric Materials, Krzysztof Pielichowski and James Njuguna; Rapra Technology, 2005, 306 pp., $144.00, ISBN 1-85957-498-X. □