

Engineering Materials Science

Milton Ohring

(Academic Press, New York, 1995)

xviii + 827 pages

ISBN 0-12-524995-0

This book, a grand attempt at unifying a large field, could not have been written 15 years ago. An excellent text such as this only exists because in the last two decades, much effort was put into defining the field of materials science by raising the consciousness of engineers and scientists to the fact that fundamental principles of kinetics, thermodynamics, chemistry, and crystallography, for example, underlie and relate specialties such as metallurgy, ceramics, polymers, and semiconductors. Ohring has been one of the early proponents of this movement, has taught this philosophy in his classes, and has written other well-received books in the materials field. I am happy to report that this book continues that tradition.

This book will find at least three niches: as an undergraduate text for materials science students; for undergraduate engineers who would like to appreciate the bridge between the physical sciences and engineering sciences; and finally, for the graduate student or practicing scientist or engineer who would like to know something about a particular materials topic. The book is so comprehensive, covering subjects ranging from electron bonding to degradation and failure of structural materials, that it can be considered almost encyclopedic. As such, not all topics are covered with equal weight or depth, but at least all critical topics are well-treated. Several weeks ago, an electrical engineering colleague asked me to explain the fundamentals of the various hardness measurement techniques to her. In no time, I had five books opened, none of which gave her the answers she was looking for. I was delighted to see that in Ohring's book, there is a wonderful table that illustrates the geometries of six hardness techniques in a way that none of the other books did.

The book is very well-written, and the author weaves a lot of unconventional but interesting material (e.g., a discussion of the lost wax casting process) into the text. Particularly helpful are the "Perspective and Conclusion" sections at the end of every chapter. Clearly the author is an experienced teacher. The book is well-illustrated, and the author will eventually be forgiven for his whimsical inclusion of spaceships flying between atomic force microscopic images of silicon pillars. The contents are very much up-to-date for a

book that covers such a large area.

Refining and synthesizing materials to make useful "things" is a very human activity. I find it inspiring to belong to a field so important to civilization that entire stages of our development are named after materials. Anyone who shares the enjoyment of understanding the relationship between atomic structure and macroscopic properties will enjoy owning this book. I recommend it as a valuable addition to the libraries of students, scientists, and engineers.

Reviewer: Martin L. Green of Bell Laboratories/Lucent Technologies is a member of the MRS Bulletin Book Review Board.

Polymer Microscopy, Second Edition

Linda C. Sawyer and David T. Grubb

(Chapman & Hall, London, 1996)

399 pages

ISBN 0-412 60490-6

Linda Sawyer and David Grubb, two researchers active in the applications of microscopy to polymers, combine practical, industrial interests with basic understanding of polymer structure and influence of structure on properties. The second edition of their book (the first edition was published in 1987) is in response to the extremely rapid changes occurring in microscopic characterization of materials and the great benefit from submicron imaging of polymer systems. A significant portion of the new edition is very close to the original with appropriate insertions of improved interpretation; more careful discussion of beam damage issues and artifacts; new figures; five pages of color plates, some very striking; and additional references. Areas of advanced techniques included are scanning probe microscopies (SPM), low-voltage scanning electron microscopies (SEM), high-pressure environmental SEM, field-emission high-resolution SEM, and (very briefly) high-resolution transmission electron microscopies (TEM). Due to frequently nonconducting samples, SPM techniques discussed are scanning (or "atomic") force microscopy, frictional force microscopy, confocal optical microscopy, and near-field optical microscopy, although scanning tunneling microscopy is included with a limited set of examples. The treatments of these recent advances, primarily presented in an extra chapter, are limited and suffer from the difficulty of keeping up with such rapid expansion (SPM and high-resolution SEM as striking examples). For example, the issue of artifacts in SEM and TEM are discussed, but are for the most part ignored for the scanning probe microscopies. The strongest parts of the book are those carried

over (with edits) from the first edition with treatments of optical and various electron microscopies. Researchers dealing with structure-property relations, engineering applications, and failure analysis will benefit from this book. In summary, first-time readers would greatly benefit from the rich collection of images, sample preparation methods, and careful interpretive narrative, gaining from the second edition improvements and from at least an introduction to the newer techniques.

Reviewer: Tom Dickinson is a professor of physics and materials science at Washington State University. He has researched the mechanical and surface properties of polymers and interfaces, including the nanometer characterization of fracture surfaces using scanning probe microscopies.

Advances in Rapid Thermal and Integrated Processing

Fred Roozeboom, Editor

*(Kluwer Academic Publishers,**Dordrecht, 1995)*

565 pages

ISBN 0-7923-4011-6

This book is an edited version of lectures of NATO ASI series held from July 3 to 14, 1995 in Italy. Some of the contributing authors are the leading experts in the field and have done a remarkable job in writing their chapters. The editor has done pioneering work in the application of rapid thermal processing for magnetic material. This work is very well presented in chapter 17. However, the overall selection of the authors is very poor. Since some of the authors are not leading experts in the field, the chapters written by these individuals are simply some preliminary work done in their own laboratory. In some cases the quality is so poor that no device results can be found in the chapter.

The chapters written by individuals have not been edited thoroughly. On a given subject, most of the authors are starting from scratch and rarely cross-reference the work already written by others in the same book. As an example, P.J. Timans has written an excellent chapter on the thermal radiative properties of semiconductors. However, there is almost no mention of chapter 2 by the author of chapter 3 and 4. In fact, the graph of Planck radiation function (fig. 2 of chap. 2, p. 37) is shown again as figure 1 of chapter 4 (p. 126). This is not the case with veteran authors and they have cross-referenced the work of others. As an example, the author of chapter 13 did mention the work of chapter 5 on page 403. Both the authors of chapters 5 and 13 have written chapters

related to the design of RTP system in great detail. However, the actual equipment manufacturer (authors of chapter 15) did not mention chapters 5 and 13. Thus, readers have to draw their own conclusion and cannot get unified views presented by a leading expert in the field.

Some of the work is totally unrelated to the field of RTP. As an example, the use of infrared lasers and visible lasers for oxidation (chapter 9) has almost no relevance to the field of rapid thermal processing. The author did not reference pioneering work of others in this chapter.

More than half of the chapters are truly outstanding. For readers without any knowledge in the field, this book can provide some fundamental knowledge. However, it is an overpriced book (\$265.00). For those who are active researchers in the field, the book does not provide any new knowledge. The individual authors have already published in one form or another their own work in the literature.

Reviewer: Rajendra Singh is D. Houser Banks Professor of Electrical and Computer Engineering and Director of Materials Science and Engineering at Clemson University. His primary research interest is in rapid thermal processing, silicon antielectronics, and solar cells.

The Physics of Creep*

F.R.N. Nabarro and H.L. de Villiers
(Taylor and Francis, London, 1995)
xiv + 413 pages
ISBN 08-5066-852-2

F.R.N. Nabarro is an eminent physicist who has made the exhaustive study of dislocations—their fine structure, elastic interactions and dynamics—his life study, while H.L. de Villiers is a materials engineer. Though they both work in South Africa, where physical metallurgy is not widely practiced, they evince a close familiarity with the very extensive literature of creep, including many recent papers, covering both the pure physics and the engineering practicalities of the subject. The coverage of creep in this volume is magisterial: The reader is in safe hands.

Following an introductory chapter which puts creep resistance into its historical perspective, with special attention to superalloys, the authors go on to discuss the phenomenology of creep. "Phenomenology" is one of those weasel words which means x things to x people: Here it largely denotes the mathematical form of

creep curves and their relation to stress and temperature. The authors go on to solid chapters about creep mechanisms and the features of dispersion-strengthening (which last is largely an exercise in dislocation virtuosity). Such matters as the relative roles of self-diffusivity and of dislocation core structure are critically analyzed. The possible mechanisms underlying Andrade creep and Harper-Dorn creep are carefully discussed.

Chapter 5 discusses at exhaustive length the facts and theories concerning the plastic deformation of single alloy crystals having the $L1_2$ structure, presenting the strong and weak points of the many rival interpretations of the anomalous temperature variation of the yield point in some alloys with this crystal structure. One phenomenon which may not be widely known, discussed here, is the fact that below the temperature of peak strength, superalloys containing an $L1_2$ phase have a yield stress independent of strain rate. The equally detailed chapter 6 deals with "single crystals" (the quotes are in the original) of two-phase γ/γ' alloys: This is a field in which much good work has been done in recent years and the authors do full justice to this material.

A shorter chapter deals with the properties of polycrystals of the same kinds of alloys, including the well rehearsed effect of boron doping in Ni_3Al , and the last, and longest, chapter discusses "possible new high-temperature creep-resistant materials." This is essentially a critical examination of plastic flow (both fast and slow) of a variety of intermetallic phases, with a subsidiary discussion of polyphase materials (this could with advantage have been more detailed, but then much of the relevant information is extremely recent). Finally, a brief obeisance follows in the direction of alloy design by computation.

The standard of critical discussion, of both experimental facts and theory, is very high throughout and the authors rigorously eschew handwaving. Contradictions and uncertainties in experimental observations receive careful attention. In reading the analysis of theories of the anomalous yield point effect, for the first time in my life I almost felt that I understood what is going on here!

The book concludes with a full subject index and also an author index; in the latter, special reference is made to pages where possible new creep-resistant materials are discussed; this shows the importance the authors attach to this part of their book.

I predict that "Nabarro and de Villiers" will come to be the familiar abbreviation (as are "Schmid and Boas" and "Frost

and Ashby" in related contexts) for the key treatment of creep, and in view of the sharp focus here on intermetallics, this is a book that all those working on intermetallic-based creep-resistant alloys should have at their elbows (or closer).

Reviewer: Robert Cahn is a physical metallurgist turned materials scientist, currently attached in nominal retirement to Cambridge University. He has researched on intermetallics and many other metallurgical themes, has edited a number of journals and book series devoted to materials science, and has striven over the years to popularize materials science in the pages of Nature. He is a member of the Editorial Board and of the Book Review Board of MRS Bulletin.

The following recently published books and new journals, relevant to materials science, have come to MRS Bulletin's attention. Some of the books listed here may be reviewed in future issues of MRS Bulletin.

Books

Advanced Composites Manufacturing, Timothy G. Gutowski, ed. John Wiley & Sons, New York, 1997. Cloth, xiv + 581 pp., \$79.95, ISBN 0-471-15301-X.

Analysis and Deformation of Polymeric Materials: Paints, Plastics, Adhesives, and Inks, Jan W. Gooch. Plenum Press, New York, 1997. Cloth, xx + 332 pp., \$95.00, ISBN 0-306-45541-2.

The Art of Molecular Dynamics Simulation, D.C. Rapaport. Cambridge University Press, New York, 1997. Cloth, \$69.95, ISBN 0-521-44561-2; paper, \$39.95, ISBN 0-521-59942-3, xiv + 400 pp.

Cellular Solids: Structure and Properties, 2d ed., Lorna J. Gibson and Michael F. Ashby. Cambridge University Press, New York, 1997. Cloth, xviii + 510 pp., \$120.00, ISBN 0-521-49560-1.

Centrifugal Materials Processing, Liya L. Regel and William R. Wilcox, eds. Plenum Press, New York, 1997. Cloth, x + 301 pp., \$105.00, ISBN 0-306-45607-9.

Chemistry and Applications of Leuco Dyes, Ramaiah Muthyala, ed. Plenum Press, New York, 1997. Cloth, xviii + 302 pp., \$95.00, ISBN 0-306-45459-9.

Dynamic Loading and Characterization of Fiber-Reinforced Composites, Robert L. Sierakowski and Shive K. Chaturvedi. John Wiley & Sons, New York, 1997. Cloth, xiv + 252 pp., \$64.95, ISBN 0-471-13824-X.

Dynamics of Crystal Surfaces and Interfaces, P.M. Duxbury and T.J. Pence, eds. Plenum Press, New York, 1997. Cloth, xii + 247 pp., \$95.00, ISBN 0-306-45619-2.

Effect of Disorder and Defects in Ion-Implanted Semiconductors: Electrical and Physicochemical Characterization, vol. 45, Gérard Ghibaudo and Constantinos Christofides, eds. Academic Press, San Diego, 1997. Cloth, xx + 300 pp., \$115.00, ISBN 0-12-752145-3.

Effect of Disorder and Defects in Ion-Implanted Semiconductors: Optical and Photothermal Characterization, vol. 46, Constantinos Christofides and Gérard Ghibaudo, eds. Academic Press, San Diego, 1997. Cloth, xvi + 316 pp., \$115.00, ISBN 0-12-752146-1.

*This review was originally published in *Intermetallics* 4 (1996, p. 503) and is reprinted here by permission of Elsevier Science Ltd.

Elastic and Inelastic Stress Analysis, *rev.*, Irving H. Shames and Francis A. Cozzarelli. Taylor & Francis, Bristol, PA, 1997. Cloth, xvi + 722 pp., \$89.95, ISBN 1-56032-686-7.

Electromagnetics and Calculation of Fields, *2d ed.*, Nathan Ida and Joao P.A. Bastos. Springer-Verlag, New York, 1997. Cloth, xviii + 564 pp., \$79.00, ISBN 3-387-94877-5.

Electron Correlation Dynamics in Atomic Collisions, J.H. McGuire. Cambridge University Press, New York, 1997. Cloth, xiv + 288 pp., \$80.00, ISBN 0-521-48020-5.

Electronic Transport in Mesoscopic Systems, Supriyo Datta. Cambridge University Press, New York, 1997. Cloth, \$79.95, ISBN 0-521-41604-3; paper, \$34.95, ISBN 0-521-59943-1, xvi + 377 pp.

Fatigue and Fracture Mechanisms of High Risk Parts: Application of LEFM & FMDM Theory, Bahram Farahmand. Chapman & Hall, New York, 1997. Cloth, xviii + 370 pp., \$59.00, ISBN 0-412-12991-4.

Giant Molecules: Here, There, and Everywhere..., Alexander Yu. Grosberg and Alexei R. Khokhlov. Academic Press, San Diego, 1997. Cloth, xviii + 244 pp., \$39.95, ISBN 0-12-304130-9.

Handbook of Powder Science & Technology, *2d ed.*, Muhammad E. Fayed and Lambert Otten, eds. Chapman & Hall, New York, 1997. Cloth, xx + 898 pp., \$125.00, ISBN 0-412-99621-9.

Infrared and Raman Spectra of Inorganic and Coordination Compounds; Part A: Theory and Applications in Inorganic Chemistry, *5th ed.*, Kazuo Nakamoto. John Wiley & Sons, New York, 1997. Cloth, xiv + 387 pp., \$64.95, ISBN 0-471-16394-5.

Infrared and Raman Spectra of Inorganic and Coordination Compounds; Part B: Applications in Coordination, Organometallic, and Bioinorganic Chemistry, *5th ed.*, Kazuo Nakamoto. John Wiley & Sons, New York, 1997. Cloth, xiv + 384 pp., \$69.95, ISBN 0-471-16392-9.

Introductory Solid State Physics, *2d ed.*, H.P. Myers. Taylor & Francis, Bristol, PA, 1997. Paper, xiv + 522 pp., \$39.95, ISBN 0-7484-0660-3.

The Kondo Problem to Heavy Fermions, A.C. Hewson. Cambridge University Press, New York, 1997. Cloth, \$95.00, ISBN 0-521-36382-9; paper, \$49.95, ISBN 0-521-59947-4, xxiv + 444 pp.

The Materials Selector, *Vols. 1-3*, Norman A. Waterman and Michael F. Ashby, eds. Chapman & Hall, New York, 1997. Cloth, 2,680 pp., \$1400.00, ISBN 0-412-61550-9.

Mechanisms of Chemical Degradation of Cement-Based Systems, K.L. Scrivener and J.F. Young, eds. Chapman & Hall, London, 1997. Cloth, xii + 455 pp., \$75.00, ISBN 0-419-21570-0.

Molecular Beam Epitaxy: Fundamentals and Current Status, *2d ed.*, M.A. Herman and H. Sitter. Springer-Verlag, New York, 1996. Cloth, xiv + 453 pp., \$69.95, ISBN 3-540-60594-0.

Nuclear Magnetic Resonance and Relaxation, Brian Cowan. Cambridge University Press, New York, 1997. Cloth, xxiv + 434 pp., \$95.00, ISBN 0-521-30393-1.

Optical Measurement Methods in Biomechanics, J.F. Orr and J.C. Shelton, eds. Chapman & Hall, New York, 1997. Cloth, xii + 196 pp., \$84.95, ISBN 0-412-60780-8.

Phase Diagrams and Ceramic Processes, Anna E. McHale. Chapman & Hall, New York, 1997. Cloth, xvi + 184 pp., \$59.95, ISBN 0-412-13191-9.

Physical Adsorption: Forces and Phenomena, L.W. Bruch, Milton W. Cole, and Eugene Zaremba. Oxford University Press, New York, 1997. Cloth, xii + 340 pp., \$85.00, ISBN 0-19855638-1.

Physics with Answers: 500 Problems and Solutions, A.R. King and O. Regev. Cambridge University Press, New York, 1997. Cloth, \$80.00, ISBN 0-521-48270-4; paper, \$32.95, ISBN 0-521-48369-7, xii + 317 pp.

Properties of Complex Inorganic Solids, Antonios Gonis, Annemarie Meike, and Patrice E.A. Turchi, eds. Plenum Press, New York, 1997. Cloth, xiv + 510, \$135.00, ISBN 0-306-45606-0.

Rapid Thermal Processing of Semiconductors, Victor E. Borisenko and Peter J. Hesketh. Plenum Press, New York, 1997. Cloth, xxii + 358 pp., \$95.00, ISBN 0-306-45054-2.

Resin Transfer Moulding, Kevin Potter. Chapman & Hall, New York, 1997. Cloth, xiv + 246 pp., \$109.95, ISBN 0-412-72570-3.

Review of Progress in Quantitative Nondestructive Evaluation, *vols. 16A-16B*, Donald O. Thompson and Dale E. Chimenti, eds. Plenum Press, New York, 1997. Cloth, xxxviii + 2237 pp., \$395.00, ISBN 0-306-45597-8.

Rock Magnetism: Fundamentals and Frontiers, David J. Dunlop and Özden Özdemir. Cambridge University Press, New York, 1997. Cloth, xxii + 573 pp., \$125.00, ISBN 0-521-32514-5.

Science in the Making: vol. 2: 1850-1900, E.A. Davis, ed. Taylor & Francis, Bristol, PA, 1997. Cloth, xxxvi + 406 pp., \$99.00, ISBN 0-7484-0642-5.

Simulations for Solid State Physics: An Interactive Resource for Students and Teachers, Robert H. Silsbee and Jörg Dräger. Cambridge University Press, New York, 1997. Cloth, \$59.95, ISBN 0-521-59094-9; paper, \$24.95, ISBN 0-521-59911-3, xviii + 348 pp.

Soft Interfaces: The 1994 Dirac Memorial Lecture, Pierre Gilles de Gennes. Cambridge University Press, New York, 1997. Cloth, x + 117 pp., \$19.95, ISBN 0-521-56417-4.

Solid State Electrochemistry, Peter G. Bruce. Cambridge University Press, New York, 1997. Cloth, \$64.95, ISBN 0-521-40007-4; paper, \$39.95, ISBN 0-521-59949-0, xvi + 344 pp.

Spatio-Temporal Pattern Formation: With Examples from Physics, Chemistry, and Materials Science, Daniel Walgraef. Springer-Verlag, New York, 1997. Cloth, x + 306 pp., \$69.00, ISBN 0-387-94857-0.

Stability of Microstructure in Metallic Systems, *2d ed.*, J.W. Martin, R.D. Doherty, and B. Cantor. Cambridge University Press, New York, 1996. Cloth, \$100.00, ISBN 0-521-41160-2; paper, \$44.95, ISBN 0-521-42316-3, xvi + 426 pp.

Static Headspace-Gas Chromatography: Theory and Practice, Bruno Kolb and Leslie S. Ettre. John Wiley & Sons, New York, 1997. Cloth, xx + 298 pp., \$79.95, ISBN 0-471-19238-4.

Steel Design Handbook: LRFD Method, Akbar R. Tamboli. McGraw-Hill, New York, 1997. Cloth, xvi + 814 pp., \$84.95, ISBN 0-07-061400-8.

Surface Modification of Polymeric Biomaterials, Buddy D. Ratner and David G. Castner, eds. Plenum Press, New York, 1997. Cloth, viii + 206 pp., \$85.00, ISBN 0-306-45512-9.

Synchrotron Radiation Techniques in Industrial, Chemical, and Materials Science, Kevin L. D'Amico, Louis J. Terminello, and David K. Shuh, eds. Plenum Press, New York, 1996. Cloth, viii + 259 pp., \$89.50, ISBN 0-306-45389-4.

Waste Materials Used in Concrete Manufacturing, Satish Chandra. Noyes Publication, Westwood, NJ, 1997. xxii + 651 pp., \$86.00, ISBN 0-8155-1393-3.

Journals

Journal of Electroceramics, Kluwer Academic Publishers, P.O. Box 358—Accord Station, Hingham, MA 02018-0358, USA; e-mail kluwer@wkap.com; Kluwer Academic Publishers, P.O. Box 322, 3300 AH Dordrecht, THE NETHERLANDS. Three issues/volume. Subscription rate: \$95.00/NLG 165.

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