Materials Science and Technology: A Comprehensive Treatment

R.W. Cahn, P. Haasen, and E.J. Kramer, Editors
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The vision of the editors of this series (Professors Cahn and Kramer, and the late Professor Haasen) has been to provide a comprehensive reference to the developing subject of Materials Science and its more practical aspect of Materials Technology. The project has been developing over several years, and it continues to evolve as additional volumes appear. Consequently, this review can only be an impression of a project nearing its consummation.

The scope of the series is too extensive to allow a detailed technical review. Some 20 volumes with a total of some 12,000 pages covering structure, properties, and processing of metals, ceramics, glasses, and polymers is beyond the capability of this reviewer. Consequently, I append brief reviews from colleagues at Imperial College on specific volumes. Here I concentrate on the overall structure and the evenness and appropriateness of coverage.

The structure of the series follows a clear logic. Volume 1 defines the common features of structure of solids, while Volumes 2A and B constitute a comprehensive review of techniques available for experimental characterization of materials. Volumes 3–6 deal in detail with different types of properties of materials and various types, including electronic, phase transformations, and mechanical behavior. The largest group has volumes dedicated to the structure and properties of different types of materials: steels, nonferrous alloys, glasses, ceramics, polymers, and composites (volumes 7, 8, 9, 11, 12, and 13). The volumes dealing with Nuclear and Medical/ Dental Materials (volumes 10 and 14) are the only books dedicated to specific technological applications. The final set of volumes (15–18) addresses the important problem of processing in order to develop the optimum microstructure for various applications.

The editors have clearly achieved a comprehensive coverage. The more important question is whether the quality of the texts is sufficiently high and sufficiently even to make the series the preeminent reference that was intended. The series editors have ensured the necessary quality by having each volume individually edited by a recognized international expert. Of course, in an enterprise of this scale it would inevitably be possible to focus on a few individual areas of weakness or where the reviewer would have structured the coverage differently. That would detract from the undoubted achievement of the series in producing an unmatched coverage of a subject of growing importance.

Unfortunately the extent of the series brings with it a very high cost; $300 per volume (except volume 16 which is $415) or $250 ($345 for volume 16) if the entire series is purchased. Realistically, the series will only be afforded by institutional libraries. All such libraries should place the series high on their acquisition list. The merger of the U.S. branch of VCH with Wiley and Sons makes the series readily available in the United States.

The series editors should be congratulated on their vision and perseverance in devising and bringing to fruition a reference treatment of the subject that will be enduring. It constitutes an appropriate memorial to Peter Haasen whose untimely death in 1993 occurred during the preparation of the series.

Structure of Solids (Volume 1)

V. Gerold, Editor

The introductory volume establishes a framework which necessarily defines the basic structural elements of solids in order to explain the behavioral aspects addressed in subsequent volumes. W. Steeuer provides a comprehensive treatment of crystallography extending from conventional crystals to quasicrystals. This is complemented by Pettifor's account of electron theory of solids explaining the basis of stability of various structures. Chapters 3 and 4 give clear treatments of structures of intermetallics and amorphous alloys that are currently attracting considerable attention. The key role of defects in solids is recognized in the later contributions on lattice vibrations, point defects, and dislocations. This is an admirable series of articles that provide a compact reference which students (and their teachers) will find invaluable. The volume concludes with excellent reviews on the structures of surfaces and solid/solid interfaces. Gerold has provided a well-structured treatise and has persuaded eminent contributors to produce texts at a very even level of detail.

Characterisation of Materials (Volumes 2A and 2B)

E. Lifshin, Editor

These volumes provide an excellent reference source on a wide range of techniques for the characterization of materials or, in some cases, characterization of specific systems such as polymers and surfaces. The volumes contain 21 chapters describing the principles of commonly used techniques such as light microscopy to more sophisticated methods such as neutron diffraction analysis. Each chapter is written by a recognized authority and contains the fundamental basis of the method and its application. The chapters begin with a simple description of the method and finish with advanced applications enabling a reader unfamiliar with the technique to build the appropriate level of knowledge and a reader with existing knowledge to answer specific questions. As a result, the texts are versatile and can be used at the undergraduate, postgraduate, and research levels for information on materials characterization.

Plastic Deformation and Fracture of Materials (Volume 6)

H. Mughrabi, Editor

A systematic treatment of various specific aspects of deformation and fracture in engineering materials is preceded by an overview of the relationship of microstructure to mechanical properties by the volume editor, H. Mughrabi. This introduces the principal concepts, such as the role of defects on fracture strength, work hardening and its relationship to geometrical instabilities, crystallographic factors in shear deformation, dislocations and hardening mechanisms, and strain localization due to material heterogeneities and its implication for damage development and failure. This is followed by a series of chapters that provide in-depth treatment of individual aspects of deformation and strengthening mechanisms in materials.

Chapter 2 on flow stress and workhardening by J. Gil Sevillano is a comprehensive review extending from simple crystallographic concepts to detailed treatments of dislocation interactions with barriers of various types (e.g., solute atoms, jogs, vacancies) in both athermal conditions and when there is thermal activation. The effects of large strain plastic deformation on the development of crystallographic textures is dealt with by Aernoudt et al. in Chapter 3, while L.P. Kubin's contribution on dislocation patterning (Chapter 4) addresses factors controlling the configuration of dislocations from both energetic continuum and numerical simulation standpoints.

Chapters 5 and 7 deal with solid solution (H. Neuhausser and C. Schwink) and particle strengthening (B. Reppich), respectively, each covering the range of factors contributing to strength in low and high temperature conditions. Chapter 6 on deforma-

tion of intermetallic compounds by Y. Umakoshi appears to be out of its natural sequence; however, it is an excellent paper extending from the fundamental concepts of ordering in relation to strength and deformation, to the relationship of these phenomena to the engineering potential of modern structural intermetallics.

In Chapter 8, W. Blum reviews high-temperature deformation and creep in crystalline solids, dealing with mechanisms and behavior in pure metals, solid solutions, and particle-strengthened materials; considerable emphasis is placed on the evolution of a dislocation substructure in each category and its relationship to high-temperature deformation. A.K. Mukherjee considers the phenomenon of superplasticity in a wide range of materials in Chapter 9, ranging from fundamental concepts and mechanisms to their use in applied technology. Chapter 10 by A.S. Argon constitutes an innovative treatment of inelastic deformation and fracture in glassy solids. This is followed by two excellent contributions on more conventional aspects. S. Suresh deals in Chapter 11 with cyclic deformation and fatigue in metals, ceramics, and polymers from both a mechanics and micromechanic perspective. Fracture mechanisms are addressed by H. Riedel in Chapter 12 in a comprehensive manner extending over cleavage, void growth, creep fracture, chemical effects and nonlinear fracture mechanics. The final chapter by K. Kato deals with friction and wear, covering the nature of the surfaces in relation to chemistry and segregation and the range of models that are currently invoked to account for the observed friction and wear behavior.

This volume is a monograph of outstanding quality and depth. Its contributors are among the major figures in research in the individual topics covered in the various chapters, and they mostly present their subjects with a combination of clarity and rigor.

Structure and Properties of Non-Ferrous Alloys (Volume 8)
K.H. Matucha, Editor

This volume is extremely well-written, presenting very useful information in a readable form. It provides a general overview of nonferrous alloys to nonspecialists, along with an excellent source of information for the materials scientist specialist.

My only criticisms would be that the diagrams and figures are disappointing, and in several places wrongly titled (i.e., page 432, figures 8.22 and 8.23). Additionally the relative industrial importance of each class of material is not reflected in the amount of space given in the book (e.g., magnesium-based alloys are allocated 100 pages, while aluminum alloys only receive 64 pages).

One particularly good feature about this volume is that recent noncommercial alloy/process developments are highlighted, making the reader aware of these developments without belaboring the point, and providing references for those readers who wish to examine the area more closely.

In summary this volume would make a very useful addition to any engineering/science library, and is a must for a materials science library.

Structure and Properties of Ceramics (Volume 11)
M. Swain, Editor

This is an excellent example of the best type of reference book. There are 15 chapters in the 800 page book, each chapter lengthy enough to provide details of the composition-atomic structure-microstructure-properties relationships that are the essence of materials science. The complete field of technical ceramics is covered from a summary of crystal structures to oxide ceramics, glass-ceramics, and non-oxides. Each of the major classes of electronic ceramics are reviewed in separate chapters. Excellent review of mechanical properties, toughening mechanisms, and diffusion are also included which make it possible to cross-reference in this one volume the interdependence of structure-property relations from many different volumes, such as conference symposia. Although each chapter is written by a different author, each an expert in the subject, the style of writing, presentation of the material, and scope is remarkably uniform and easy to read; obviously this does not happen by accident and is a tribute to a diligent volume editor and series editors. The references are thorough and not overwhelming. A particular delight is the number and quality of the illustrations which aid immensely in following such a comprehensive treatment. The volume is a must for anyone involved in the field of technical ceramics from the postgraduate student to the advanced research or manager.

Structure and Properties of Composites (Volume 13)
T.W. Chou, Editor

A notable group of authors, headed by one of the founders of modern composite theory, A. Kelly FRS, provides a comprehensive review, in 13 chapters, of the major types of composite materials, polymer-, metal-, and ceramic-based, together with processing methods, structure, and properties of materials employing whisker, short and long fiber, and particulate reinforcements. Due emphasis is given to the interface between reinforcement and matrix and to the modeling and measurement of mechanical behavior. The text ranges from the highly theoretical to the practical aspects of composites and provides and excellent reference source for this diverse range of engineering materials.

Processing of Ceramics, Parts I and II (Volumes 17A and 17B)
R.J. Brook, Editor

These volumes will be of great value to anyone wanting to make new ceramic materials or existing ceramics but of better quality, to make ceramics more efficiently, to prepare a lecture course, or just to browse. The chapters in the two books cover a wide range of materials processing techniques, from biomimetic processing (P. Calvert), which deals with biological ceramics from how they are produced in nature and how these processes might be imitated, to the more mundane but important topics of die pressing and isostatic pressing (D. Bortzmeyer). I was glad to find an excellent chapter on vitrification (F. Cambier and A. Leriche), an undeservedly unfashionable topic.

A first impression is that some of the chapters appear to be closely based on earlier reviews by the same authors, bringing together a comprehensive collection of topics. Others are, to the best of my knowledge, newly compiled. Outstanding among these are the chapters on tape casting (H. Hellebrand) and functionally graded materials (T. Hirai). The first chapter "Microstructural Targets for Ceramics" (R. Morrell) provides a most useful overview of the objectives in making an advanced ceramic and sets the scene for the 20 chapters which follow.

The pair of volumes forms a worthy successor to *Concise Encyclopaedia of Advanced Ceramic Materials*, which Brook also edited. The new work is indeed most comprehensive and its format is easier to follow. The standard of writing and editing is very high throughout and the text is greatly recommended.

Review Team: *Malcolm McLean, R.J. Dashwood, Judith Driscoll, Harvey Flower, Larry L. Hench, P.S. Rogers, and B. Shollock of the Imperial College of Science, Technology, and Medicine.*

[Editor's Note: Volume 16 on semiconductor processing, edited by K.A. Jackson, has been published, and the last two volumes, 18A and 18B, on polymer processing, edited by H.E.H. Meijer, are scheduled to be published this spring. See MRS Bulletin, *December 1992, page 51, for a review of volumes 3A, 4, 5, 7, 9, 14, and 15.]*