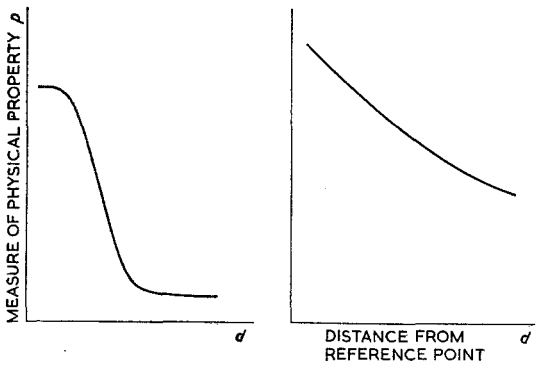
Letter

Property-graded Materials and Property-gradation – a Problem in Nomenclature

The suggestion is put forward below that there is a need for a word which will describe an attribute of materials of widespread technological significance.

The vocabulary of materials science is generally adequate, and such words as polycrystalline, monolithic, composite, anisotropic, etc are indispensable and well-understood. However, there is one omission which is noteworthy, and that is of a word or expression which will describe materials which – in the finished form – are either deliberately made inhomogeneous in terms of their physical properties or emerge in this condition after fabrication. This is shown diagrammatically in the figure. It shows two possible variations in the value of a given property along a line drawn at random through a solid.



A few examples are given below which illustrate this point.

(*a*) When a metal is case-hardened, the surface is different in properties from the bulk material.

(*b*) Glass may be toughened in a number of ways, e.g. the surface may be put into a state of compression by quenching or by diffusing into it certain cations.

(*c*) Polymer foams may show, as a result either of accident or design, a gradual change in properties proceeding from the outside to the middle of the specimens. This may take the form of a gradual change in density, modulus etc, or the surface may consist of a skin of monolithic polymer adjoining expanded material (as in bread, to take a simple example).

The number of examples could be multiplied, but these show that the present vocabulary of materials science is inadequate to describe an important real situation in materials. It is therefore suggested that *property gradation* and *property-graded* are useful additional terms for describing materials.

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Book Reviews

Science of Ceramics, Vol 4

Edited by G. H. Stewart

Pp 481 (The British Ceramic Society, Stoke-on-Trent, 1968) 105*s*

This volume is the Proceedings of the 4th International Conference on "Science of Ceramics" held at Maastricht, Netherlands, April 1967. The papers are included in five sessions viz: The Effect of Mechanical Forces during Heat Treatment; Fabrication; Reacting during Sintering; Reactions in Multiphase Ceramics during Firing; Development of Ceramics for the Newest Applications.

The original Conference Programme shows each session to have one or two Introductory Lectures; unfortunately only one appears in the final Proceedings. This lack of Introductory Lectures detracts from the most important purpose of Conference Proceedings, that is the reporting of the present state of the art. One further omission is that of the discussions following each lecture; while this is often difficult to collect it does add to the usefulness of Conference Proceedings.

Nevertheless, the present Proceedings, Vol. 4, will be a useful addition to the excellent series "Science of Ceramics". D. I. MATKIN

Modern Composite Materials

L. J. Broutman, R. H. Krock (editors)

Pp 581 (Addison Wesley, New York, 1968) 173*s*

This is a collection of review articles, covering most aspects of composite materials, written by a group of authors all of whom are well-known for their individual contributions to the literature. As the editors observe, the time was ripe for a good reference book in this field provided such a book could be produced in a time short enough to prevent its becoming almost immediately obsolete. This book could only be achieved with the co-operation of a relatively large number of authors. The editors have, I feel, achieved their objective, and have produced a book which could provide a valuable, continuing source of reference for groups of workers in any branch of composites research. Inevitably, in an edited work where many of the separate contributions base themselves on standard theories, there are some repetitions. But many more have probably been edited out, and those that remain are not obtrusive.

Composite materials work, in its full scope, is an interdisciplinary subject characteristic of the modern approach to materials science. The book certainly reflects this. It covers particulate and fibre composites, composed of metals, plastics, ceramics, and glasses, and it ranges between fundamental theories of strength and failure to surface chemistry and adhesion, touching in between on manufacture and properties of many varieties of fibre and of the composites themselves. It might be argued that because of the width of its coverage the book does not give adequate treatment in depth of some of the basic theories of strengthening. But experimental workers very often do not want to concern themselves with the minute details of the mathematical theories of, say, Hill or Hashin and Rosen, and for those that do there is a comprehensive bibliography. One fault in this respect is that there is no index of names. For a reference work of this nature such an index is probably equally as important as a full bibliography.

The book is divided into three sections dealing with fundamental aspects of composites, materials used for reinforcement, and the properties and structure of composite materials. Within these sections there is, again, inevitably some overlap, for one cannot always discuss structure and properties, for example, without referring to micromechanics, or failure mechanisms, or fibre/matrix interactions. But familiarity with the book quickly brings the ability to locate the particular information being sought, and the overlap certainly does not detract from the book's overall value.

B. HARRIS

Diffusion Kinetics for Atoms in Crystals

John R. Manning

Pp 257 (Van Nostrand, 1968) 91*s*

This book presents a systematic discussion of diffusion in crystals, based on the viewpoint that diffusion proceeds by a series of discrete random jumps. Dr Manning concentrates on the mathematical formulation of this hypothesis, and on simple modifications of it.

Thus in the first chapter he discusses the basic concepts of atomic diffusion, and briefly describes the various possible jump mechanisms, such as vacancy, interstitial, and crowdion. Chapter 2 develops the basic random walk model, while the modifications due to correlation effects are dealt with in considerable depth in the next. The more complex modifications necessary to account for driving forces such as an electric field or a chemical gradient are then introduced as well. The last two chapters present a generalised thermodynamic approach to diffusion, and a few specific topics, such as the effect of a driving force on jump frequencies, and the vacancy-impurity complex.

Both the major drawback and the major strength of this book lie in its considerable mathematical detail. I felt that for the reader who is only casually concerned with diffusion the scope is rather too limited: for example diffusion along grain-boundaries and dislocations is specifically excluded, nor is there any discussion of the atomistic nature of the point defects themselves that are so fundamental to the whole diffusion process. However, for the true diffusion man the wealth of detail is no doubt to be recommended, and Dr Manning's book should provide a welcome reference volume.

DIRCK VAN VLIET

Introduction to Plasticity

G. C. Spencer

Pp 118 (Chapman and Hall, 1968) 25*s* (paperback)

This book is intended, according to the author's preface, to bridge the gap between undergraduate courses in "strength of materials" and more advanced works on plasticity. However, it could also be usefully employed in introducing the elements of macroscopic plasticity to metallurgists, materials scientists, and others who may be only familiar with the atomistic interpretation of plastic behaviour. The book has certain limitations, which is inevitable if the cost is to be kept at 25s. But its scope is reasonably wide and the author conveys enough for an adequate understanding without indulging in the finer details of the mathematical theory.

The book begins with an introduction on the nature of plasticity. This has perhaps been unnecessarily simplified. It is here that the usual preliminary assumptions are dealt with, but the implications of these assumptions, as far as they apply to real materials, for example, could have been much more thoroughly treated. The two hundred or so words on the microscopic aspects of plastic behaviour, which are included in most books of this kind, are, as usual, too ethereal to have any real meaning for anyone who does not already know about dislocations. Students are much more likely to want to know why they are studying macroscopic plasticity, and the first chapter might usefully have contained some projected indication of what can be learned from it and what its scope might be.

In his next three chapters the author covers the requisite parts of elasticity theory, the yield criteria, and plastic stress/strain relations, before proceeding to some simple applications of plasticity, viz. beams, the plastic hinge, portal frames, and torsion problems. The last three chapters deal with applications of the theory to metal fabrication, rolling, extrusion, drawing and modern methods of plastic working, these chapters being preceded by the necessary introduction to slip line field theory and load-bounding. Slip line fields usually seem mysterious to new students, and the apparently *ad hoc* methods of constructing them are often received initially with blank disbelief. It would have been helpful to have presented some simple example of the construction of a slip line field in great detail – deformation under a flat, frictionless punch or a wedge indentor for instance – instead of proceeding from the slip line equations direct to the case of extrusion. The author might well have included a short note on experimental aids to slip line field construction. B. HARRIS

Electron Microscopy and Microanalysis of Metals

J. A. Belk and A. L. Davies (editors)

Pp 254 (Elsevier, 1968) £5 10*s*

According to the editors this book sets out to inform students of the present day usage of these electron-optical techniques and assumes very little prior knowledge of the instruments. After an introduction to electron optics, there are brief chapters dealing with electron diffraction, specimen preparation, and the use of replica methods. Further very useful chapters deal with deformation and precipitation studies and dark field analysis. The section of the book devoted to microprobe analysis includes design and operation, quantitative analysis and applications.

The overall impression gained by the reviewer in reading this book is of a very variable standard of contribution; some of the chapters such as the one by Nicholson on precipitation studies are very well written and contain a wealth of useful information, whereas others are written at a much lower standard and are often out of date.

A particular example of this is to be found in chapter 10, describing quantitative analysis with the microprobe, where the latest reference is 1964! There is no mention of the recent work of Duncumb, Reed or Bishop carried out in 1965 to 1967 and the serious problem of the atomic number correction is hardly mentioned at all, with the exception of a passing reference to the now dated work of Poole and Thomas.

One would have expected with a book of this price, that a great deal more care would have been taken in the editing stage to ensure a more up to date and uniform standard of contribution.

Another disappointing feature is to be found in the cross correlation of the text and the various

photomicrographs, for example, where are the "horns" referred to on page 54 in the photograph 4:2, also in figure 5:2 which is supposed to show an electron diffraction image one can only see the transmitted beam plus numerous scratches on the negative!

It must be concluded that this could have been a very useful book with a wide appeal, if a greater editorial effort had been made. It is a pity that the technique of scanning electron microscopy was not included as surely this is a complementary technique to those described in the book. One hopes that a second edition of this book will represent a better value for 110*s*.

R. A. FARRAR