Book Reviews and Short Notices

Progress in Materials Science Vol. 16.
Editors B. Chalmers, J. W. Christian and T. B. Massalski

High-Angle Grain Boundaries
H. Gleiter and B. Chalmers
Pergamon Oxford, 1972. ix + 272pp. £7.50

Professor Chalmers has been contributing to our knowledge and understanding of high-angle grain boundaries since 1937, just after Rosenhain's death and the hey-day of the amorphous cement theory. His work has ranged over the whole field – energy, melting, segregation, migration, sliding and models of structure. Many of his more recent papers have been in collaboration with Professor Gleiter, and this is just one of the more recent of many partnerships with students and associates whose names appear among the top ten in the citations of this (or any) review on grain boundaries.

It is not surprising, therefore, that the editors of Progress in Materials Science should have decided to devote the whole of Vol. 16 to a review by Gleiter and Chalmers on this topic, giving opportunity of linking Gleiter's current productiveness in the field with Chalmer's long perspective.

The promise that this preamble seems to offer is largely realized, and the review contains a great deal of information and of perceptive comment. However, I must confess to a general feeling of disappointment which is not easy to pin down to any particular feature. I hope what follows will reveal both the positive merits of the review and the basis of my disappointment.

There are eight chapters, listed here with the number of pages each contains followed by the number of references in parenthesis. Structure 12 (18); energy 30 (165); segregation 34 (249); diffusion 36 (144); melting 13 (133); migration 52 (289); sliding 39 (145); and internal friction 38 (115). I report, without necessarily implying criticism, that the following topics do not have specific sections although they may receive passing mention: grain boundaries as barriers in deformation; their role in microstructure (grain shapes and distributions, sites for precipitation or transformation nuclei, denuded zones etc.); intercrystalline fracture and cavitation and gas bubble formation; their role in sintering; corrosion.

Each chapter is more or less complete in itself, thus preserving the form of recent volumes of the series, but the chapters are not being offered for sale separately.

The reference lists contain very few dates later than 1969 although the review was published in late 1972. The dozen or so dates in 1970-72 are almost all of work by the authors themselves or their close associates. The chapter on diffusion has two references to work in 1968 and none later and the chapter on segregation only one in 1969 (other than the authors' own work).

The short opening chapter on structure is clearly designed to be the key to the whole book, although its relevance to migration is made much more obvious than to other topics (such as, for example, melting or sliding). I would have welcomed an extension of the clarity of presentation of this chapter to perhaps twice its length, particularly to include more historical background; neither earlier reviews in Progress in Metal Physics nor McLean's book are cited in this chapter. Nor – probably deliberately – does the phrase "amorphous cement" appear in it. Another curious omission is any discussion of the evidence for the width of the grain boundary; there is merely a statement that ". . . (a liquid-layer) hypothesis would suggest that the boundary is much thicker than the direct observations by field ion techniques would suggest" followed by a reference. Although Bollmann's book is cited in passing, there is no specific discussion of his formalism nor of the O-lattice. The thermodynamic description of an "average" grain boundary put forward by Bolling is also ignored, as are his more recent attempts with Aaron to characterize grain-boundary phenomena in terms of free volume. In fact this chapter sticks pretty much to development of those models which predict the so-called special orientations. These are, of course, important and fascinating and have to be explained, but it does not seem to me to have been made sufficiently clear how much these special boundaries and their properties dominate all the behaviour of all high-angle boundaries or how well models based on "mixed' special boundaries can simulate average boundaries.

Naturally it is easier to find fault in areas closest to one's own interests and it does seem to

me that the chapter on sliding is well below the standard of the others. I would not recommend it for separate purchase if the chapters were individually available. It is far less up-to-date than an earlier review by Bell and Langdon, which is not cited, and it does not add much to yet earlier reviews. There is misunderstanding of some work and a number of minor errors, including a confusing muddle whereby the ratio $\epsilon_{gb}/\epsilon_{tot}$ is introduced as "λ" and so used for most of the chapter, except for an unheralded switch to the more usual "γ" at the end.

Whilst mentioning minor but irritating errors, I have to record a number of names wrongly spelled, some crossed references and the attribution to D. McLean of papers by M. McLean. Rather more important is the frequent use of references to Ph.D. theses or departmental reports for work which has subsequently appeared in more accessible form. An example is in Chapter 6 (p. 127) where a comment is made on Bolling's work on the effect of traces of oxygen on migration in Pb, and the reference made to a quotation in an article; the work has appeared in *TAIME 224* (1962) 635.

To sum up, then, the best chapters (e.g. that on migration), are all that one would have expected from these authors and maybe it is asking too much that they should have maintained this standard over so broad a range of topics. Maybe the volume would have been closer to perfection if it had had the various sections written in conjunction with other authors, but whether this would have resulted in an even larger gap between writing and publication dates is another matter. In any case, you (or your library) will certainly wish to buy this book for the large amount of information it certainly does contain.

R.C.G.

Grain Boundaries and Interfaces

Proceedings of an International Conference on the Structure and Properties of Grain Boundaries and Interfaces, August 1971

Edited by P. Chaudhari and J. W. Matthews

North-Holland, Amsterdam

(1972), 630 pp., $43.75

A major success of materials science has been the correlation of the properties of crystals with their well characterized atomic structure. Progress in understanding the properties of crystal defects has been rather less successful where a sure knowledge of their atomic arrangements is lacking. This difficulty has particularly affected the investigations of an important area in the study of crystalline materials – the properties of the various interfaces between crystals. For many years there have been attempts to avoid this problem by treating many of these interfaces as being "structureless". This consisted of assuming a thin liquid-like layer of atoms at the interface which enabled the detailed crystallography of the adjacent phases to be ignored. The result of this idea leads directly to the conclusion that there is just one type of grain boundary in, for example, copper. Since there are five possible crystallographic variables for any internal crystal boundary the study of grain boundaries would have been very much simpler if this idea had been successful; unfortunately the experimental evidence on grain boundary migration, diffusion and energy etc. built up over the last twenty years has destroyed this liquid-layer theory for grain boundaries, and for the interfaces between different phases the same simplification was never a real possibility. There being no escape from the necessity of tackling the structure problem, the subject has required the combination of careful property measurements with parallel theoretical insight.

Direct experimental investigation of the atomic structure at internal boundaries has been almost impossible though field ion microscopy and recently transmission electron microscopy has lent some support to the theoretical ideas of structure, for example the presence of non-lattice dislocations at grain boundaries.

The major initial step was the recognition by Kronberg and Wilson in 1949 of the importance of the "coincident site boundaries" and although the idea took some time to develop from their work the last ten years have seen the subject really start to grow. This conference, whose contributors included many of the scientists who have been responsible for this new subject, provides an excellent account of the field in 1971 with full references to the earlier studies, and it is, therefore, an essential reference work for this field. Unfortunately the price is such as will deter almost all private purchase and lead to the inevitable pressure on library use. However, since it is unashamedly a conference report and not a textbook, this is probably not disastrous, though there is clearly developing a strong need for a good textbook or at least a broad review article to describe what is known of the structure and properties of interfaces, for students or

research workers about to enter the fray.

It is not possible in the space of this review to discuss in detail all the papers in this volume. However, the major topics can be listed: these include the Bollmann O-lattice theory, boundary structures based on various dislocation and disclination models, calculations of boundary structures, energies and entropies using different interatomic potentials (including the interesting case of an ionic material, MgO, where the potential is better known than for metallic materials). Experimental papers include several excellent studies using electron microscopy of the various dislocations and atomic ledges visible at interfaces, as well as outstanding papers on various boundary properties such as energy, mobility, sliding, diffusion and corrosion. The properties of the simplest interfaces of all, low-angle boundaries consisting of arrays of lattice dislocations, are also discussed by several contributors. The other subject that is included is surface structures including epitaxy and a new concept, due to Hoffman and Cahn, of a vector thermodynamics of anisotropic surfaces that extends beyond the scalar σ plot.

R. D. DOHERTY

Amorphous Materials

Edited by R. W. Douglas and B. Ellis

Wiley-Interscience, London, 1972. £9.00

This book comprises papers presented to the Third International Conference on the Physics of Non-crystalline Solids held at Sheffield University, September 1970. The contents are divided into six sections covering relaxation processes, the transformation range, viscosity and diffusion processes, NMR and ESR studies, vibrational properties and fracture. The types of amorphous materials discussed range from silicate glasses to long chain organic polymers. Thus the topics dealt with embrace a wide spectrum likely to be of interest to workers in a number of branches of Materials Science.

The papers vary widely in content and style, as is perhaps inevitable in a book of this nature. Thus reports of experimental techniques and observations are included alongside review papers summarizing current theoretical ideas on topics such as relaxation processes in glassy materials, atomic transport in simple fluids, amorphous organic polymers and neutron scattering in amorphous solids. This varied and, at first sight, somewhat inhomogeneous nature of the contents, mirrors quite well the wide-ranging current interest in the structure and properties of non-crystalline solids, areas that have long fascinated experimentalists and which are now attracting the attention of theoreticians. Notable by their absence, are papers dealing with amorphous semiconductors, a field which is of great interest at the present time. This apparent omission arose because the conference organizers deliberately excluded the topic believing it to be well catered for in other directions. A small criticism can be levelled at the book for the inclusion of one or two papers that are little more than abstracts. One would have liked to see more extensive versions if these were to be included at all.

In general it is considered that the book makes a valuable contribution to the literature on non-crystalline solids and should prove very useful as a work of reference to those directly concerned with the field as well as to those seeking a more general appreciation of the current position.

P.W.M.