Polycrystalline Semiconductors, Grain Boundaries and Interfaces

Edited by H.J. Möller, H.P. Strunk, and J.H. Werner

(Springer-Verlag, Berlin, 1989), 391 pages.
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While the study of semiconductor grain boundaries and interfaces has a long history, especially for silicon, the advent of atomic-scale, high-resolution microscopies has allowed a detailed correlation of their defect microstructure with fabrication conditions and electrical properties. The papers in this proceedings (the international symposium was held in Malente, W. Germany, August 29 - September 2, 1988) exploit this new level of characterization, and this is easily the book's outstanding feature. Nearly half of the figures, numerous at about one per page, are electron micrographs. There is even one paper with color plates of spectroscopic STM (scanning tunneling microscopy) images of grain boundaries in silicon and $CuInSe_2$.

However, the papers do not deal exclusively with microscopy. Indeed, one of the delightful discoveries for the reader is the degree of intra-paper comparison of grain boundary and interface microstructure with other properties. The significance of these comparisons is enhanced, especially in the first sections on fundamental properties, by experiments on bicrystals with a coincident site lattice. These special crystallographic orientations permit, in principle, experimental growth duplication and further characterization by other groups and specific theoretical treatments. The topics treated in this part of the proceedings include grain boundary aperiodicity and atomic reconstruction; chemistry and electronic properties; and segregation, activation, and passivation.

According to the editors, the international symposium was organized to "try to bridge the gap between fundamental research and technological aspects of polycrystalline semiconductors with emphasis on physical properties." Accordingly, the second half of the book deals with technological aspects, with papers on thin-film growth, interfacial reactions, crystallization, and effects on microelectronic devices. There is also a full section on transport properties highlighted by a review paper by Greuter and Blatter.

Although (not surprisingly) most of the papers deal with silicon, a multitude of grain boundary and interface properties is covered in this proceedings. Also, most of the current scientific and technological issues associated with general polycrystalline semiconductors are represented there. This inclusive, if not comprehensive, feature of the proceedings makes it an excellent source of reference for state-of-the-art research, not to mention the intrinsic value of the reported results. Nevertheless, the utility of this proceedings, for any purpose, would have been increased substantially by the addition of a subject index which referenced specific techniques and properties.

The papers are primarily written at the specialist level as one would expect for a symposium. However, included are 12 papers written by invited speakers which review the current status of knowledge and ongoing investigations of semiconductor grain boundaries and interfaces, and which should be generally comprehensible to materials scientists at even the graduate level.

Reviewer: Gordon E. Pike, supervisor, Electronic Properties of Materials Division, Sandia National Laboratories, has published experimental and theoretical papers on the electronic properties of semiconductor grain boundaries, especially related to silicon and ceramic ZnO varistor materials.

Structural Ceramics

Edited by J.B. Wachtman Jr.

(Treatise on Materials Science and Technology, Volume 29, Academic Press, 1989), approximately 379 pages
ISBN: 0-12-341829-1

The mechanical properties of ceramics has been an active area of research in the last 20 years; this thrust stems from their potential for use as structural components at high temperature. Unfortunately, much of the information on this research has not been gathered together into critical assessments. Such is the aim of this book, and this in itself represents a timely and worthy purpose. The book's approach considers the technological applications regarded as significant in structural ceramics, techniques needed to design with brittle materials, and the fabrication and properties of specific materials or classes of materials.

The opening chapter gives heed to a variety of specific applications for ceramics and the advantages that would be gained in their use. The discussion is informational, thoughtful, and indicates the incremental staging that must be performed in order to minimize costs while simultaneously gaining the necessary performance benefits. The second chapter also considers specific applications for structural ceramics, but primarily as engine components. The major aim of this chapter, however, is to explain the design methodology required for brittle materials. In this respect, the chapter is quite successful, laying out the necessary theory and illustrating the approach with a simple example. The "textbook" approach of this chapter is instructive—one ends up wishing for more. Indeed, this chapter, if expanded, would be a suitable topic for a complete text. The only important omission from this chapter was the methodology that has been advanced recently for time-dependent strength effects, e.g., stress corrosion.

The next two chapters look at specific non-oxide ceramic materials, the silicon carbide and silicon nitride families of materials. These chapters emphasize approaches used in the fabrication of these materials and discuss their resulting mechanical properties. Both chapters provide a useful set of references for these materials. The chapter on silicon carbide provides a very extensive review of the research effort, while that on the silicon nitride materials is rather terse. In both chapters, the approach tends to be an overview of prior work rather than a discussion of the underlying scientific principles.

Chapters 5 and 6 discuss two classes of structural ceramics identified with particular toughening mechanisms; transformation- and fiber-toughened ceramics. Substantial developments have been made in these materials very recently. Both chapters are reasonably up-to-date and do discuss the principles involved in the toughening phenomena.

The final chapter of the book considers tribological effects in ceramics but from a rather fundamental viewpoint. The emphasis is on single-crystal studies and vacuum effects. Very little attention is given to the structural materials discussed in the preceding four chapters. This chapter, though informative, seems a little out of place with respect to the rest of the book.

In conclusion, the book seems to have met its aim reasonably well, the information is relatively current and the quality of the writing is good. One disappointing aspect was poor reproduction of some of the figures. The book should, however, be a useful reference source for scientists and engineers involved with the fabrication and use of structural ceramics.

Reviewer: David J. Green, associate professor of ceramic science and engineering at the Pennsylvania State University, works on the interrelationships between fabrication, microstructure, and mechanical properties of ceramics. □

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