Glasses and the Vitreous State

J. Zarzycki
(Cambridge University Press, 1991, 505 pages).
ISBN: 0-521-35582-6

Among the materials competing for attention, the glasses retain a special place in the affections of the scientist/engineer because of their wide applicability and elusive structural character. Their importance and promise remain as persuasive as ever, and it is encouraging to see this rewarding volume in the Cambridge Solid State Science Series.

The text is a lightly updated translation of the original 1982 French version. Zarzycki brought to his text his years of experience first as research engineer at St. Gobain and later as founder and leader of the materials science activity at Montpelier, and the book was immediately recognized as a comprehensive and authoritative guide to the subject.

The book begins with a treatment of the nature of the vitreous state. Building on his definition of a glass as a noncrystalline solid capable of exhibiting a glass transition (i.e., a reversible change to a more fluid condition on heating), Zarzycki treats the transition itself and then the rules that can be developed for the occurrence of glass formation. He explores the methods for structural evaluation and discusses phase separation and structural modeling.

Following a classification of glass-forming systems, Zarzycki turns to glass properties including viscosity, diffusion, and the groups of thermal, optical, electrical, and mechanical properties. Closing chapters deal with the glass surface, glass ceramics, glass technology, and a central theme of Zarzycki's own research—the use of sol-gel approaches to glass synthesis.

The book is carefully organized and well illustrated. The translation is clear and unobtrusive; one of the only traces of its original language is that "Pliny" remains "Pline." Most of the references are comprehensive, although Feltz's 1983 text *Amorphe und glasartige anorganische Festkorper* is not reported. However, the references predominantly cover pre-1982 literature; in the text, "more recently" can refer to a 1972 citation. The sol-gel chapter is the clear exception in this last regard.

As always with glass, one can wish for more on favorite themes, such as the mixed alkali effect, metallic glasses, and nitrogen glasses. One also can miss the insights of more recent research, as in the work of Spaepen in resolving the microcrystalline/amorphous dilemma. But the English-speaking world can now welcome a systematic, comprehensive, and accessible treatment of the physical chemistry of glasses and their structural character in this excellent contribution to the Cambridge Series.

Reviewer: Richard J. Brook is Cookson professor of materials in the Department of Materials, Oxford University, England.

Glass Science and Technology

Edited by D.R. Uhlmann and N.J. Kreidl

Volume 4A—Structure, Microstructure, and Properties
(Academic Press, 1990, 346 pages).
ISBN: 0-12-706704-3

Volume 4B—Advances in Structural Analysis
(Academic Press, 1990, 385 pages).
ISBN: 0-12-706707-8

These two books cover almost all areas of the structure of glasses (with two exceptions mentioned later) and are required reading for anyone interested in structural discussions of or writing a scientific paper on any type of glass.

Volume 4A contains an overview and a discussion of small-angle x-ray scattering by E.A. Porai-Koshits; a chapter on properties and structure of glasses and melts versus preparation by R. Brückner; a discussion of structure and electrical properties by A. Feltz; a chapter on structure of sol-gel-derived glasses by C.J. Brinker; and a discussion of the stochastic and molecular dynamic models of glass structure by T.F. Soules.

The first four chapters offer general concepts about the structure of glasses and consider the concept of glass itself from different points of view. Chapters 5 and 6 describe methods for approaching the study of glass structures.

Similar descriptions continue in Volume 4B, with a chapter on x-ray absorption spectroscopy by G.N. Greaves; a discussion of nuclear magnetic resonance in glass by P.E. Stallworth and P.J. Bray; a chapter on electronic spin resonance by D.L. Griscom; an examination of electron-microscope studies of glass structure by J. Zarzycki; a discussion of the Mössbauer effect in glass by G. Tomandl; and a chapter on chromatography by C.R. Masson.

Both volumes would be useful to any researchers working in the field of glass, but I would particularly recommend them to graduate students. The overview presented in the first chapter defines the term "glass structure." Readers then may move to subsequent chapters to obtain detailed information on specific topics. Coverage of literature is extensive, with about 200 references listed for each chapter.

Wide angle x-ray scattering (WAXS) and infrared/Raman spectroscopy are not covered by these volumes. The reason they were omitted is clearly explained in the editors' preface which is worth reading by itself.

A great number of books on glasses have been published recently, but few are truly instructive. The present volumes, used in conjunction with complemental books on WAXS and infrared/Raman spectroscopy, can be the successor to *Glass Structure by Spectroscopy* by J. Wong and C.A. Angell, which was published in 1976.

Reviewer: Itaru Yasul is a professor in the Research Center for Advanced Materials of the Institute of Industrial Science at the University of Tokyo.

Measurement of High-Speed Signals in Solid State Devices (*Semiconductors and Semimetals, Vol. 28*)

Edited by Robert B. Marcus
(Academic Press, 1990, 438 pages).
ISBN: 0-12-752128-3

Over the past decade significant developments have been made in high-speed electronic and optoelectronic devices and circuits, which are the workhorses for future generations of high-speed computers and high-capacity communication systems. The advancement of novel semiconductor material growth technology, led by molecular beam epitaxy and fine-line (submicrometer) lithographic processing technology, introduced a new breed of ultra-fast devices, including modulation-doped heterostructure field-effect transistors, heterostructure bipolar transistors, resonant tunneling diodes, hot electron transistors, quantum well detectors, and lasers. Many of these new semiconductor devices and circuits, and other emerging solid-state devices such as superconducting Josephson-junction devices, have demonstrated very short switching times in picoseconds and very high operating frequencies up to tens and hundreds of gigahertz. To sustain the advances in device performance and exploit the underlying ultra-fast physical dynamics in the materials used to make them, new high-speed measurement techniques are needed with sub-picosecond time resolution and terahertz operation bandwidth.

At the same time, exciting breakthroughs have revolutionized the conventional methods of high-speed measurements. Conventional techniques usually involved an electronic sampling oscilloscope with limited resolution of tens of picoseconds and narrow bandwidth in tens of gigahertz. Based on these subpicosecond optoelectronic devices, new waveform probing methods such as broadband microwave probing, electro-optical sampling, and photoemissive probing have been developed to perform contact probing or contactless, non-invasive probing of high speed devices and integrated circuits.

This book provides a good reference to the operating principles and the current status of these modern measurement techniques. In view of the potential of high-resolution measurement of high-speed signals, this book perhaps is weighted more heavily toward the non-invasive electro-optical sampling technique. Nevertheless, recent developments in the more traditional methods, such as broadband microwave measurements, electronic sampling and focus electron beam measurements, are well covered. Each chapter focuses on a different technique and is authored by pioneers and major contributors to the field.

At this time, researchers probably must construct their own high-speed measurement systems with the techniques discussed in this book. The authors' detailed explanations of many of the fundamental operating principles will help readers to understand the advantages and limitations of each method, so that they can formulate a particular system to satisfy their own needs with respect to sensitivity, spatial resolution, temporal resolution, and degree of invasiveness. Each chapter concludes with one or more real examples illustrating each method's capability. These examples give readers a stimulating presentation useful to both novices and experts in the field, and the references are well furnished and current.

On the whole, the average reader would find much to appreciate in this book. It is both an excellent introduction and a good reference to modern high-speed characterization techniques.

Reviewer: Young-Kai Chen is a member of the technical staff in the Semiconductor Electronics Research Department at AT&T Bell Laboratories. His research focuses on high-speed optoelectronic devices.

Indium Phosphide: Crystal Growth and Characterization (*Semiconductors and Semimetals, Vol. 31*)

Edited by R.K. Willardson and Albert C. Beer

(Academic Press, 1990, 394 pages).

ISBN: 0-12-752131-3

This thirty-first volume in Willardson and Beer's treatise *Semiconductors and Semimetals* is required reading for anyone concerned with bulk III-V growth and characterization. Bulk growth is the focus of four of the chapters; hydride vapor phase epitaxy (VPE), metal organic chemical vapor deposition (MOCVD), and defects round out the other three chapters. The coverage of epitaxial growth is limited to vapor phase techniques, and although there is no treatment of molecular beam epitaxy, chemical beam epitaxy, or metal organic molecular beam epitaxy, the sections on characterization and native defects are excellent.

Farges' chapter is a thorough treatment of various approaches to dislocation reduction in InP bulk growth. Discussion of dislocations in epitaxial growth or the effect of threading dislocations is not included, and the practical motivation for reducing InP substrate dislocations is never presented. Farges discusses the two primary techniques for InP bulk growth: liquid encapsulated Czochralski (LEC) and vertical gradient freeze (VGF). He concludes that VGF produces superior material but is limited by the difficulty of (100) seeding under low-temperature gradients.

McCollum and Stillman's chapter on hydride VPE is thorough and readable. The first section covers the applicable reactions, drawings of reactor chamber design, the art and science of substrate preparation, and growth procedures. The real meat of the chapter is contained in the characterization section, with well-chosen examples of Hall measurements, photothermal ionization spectroscopy, photoluminescence, and deep level transient spectroscopy. Specific examples are discussed from a wide selection of reference materials.

Inada and Fukuda's contribution deals with the fascinating subject of apparent phase separation of phosphorus-rich InP melts during high pressure LEC, in-situ synthesis, and growth. Refluxing white phosphorus is returned to the melt where it is employed as the encapsulant. The quality of the synthesized InP and subsequently pulled single crystals is not yet state-of-the-art, primarily because the present axial temperature gradients are not conducive to low dislocation growth. However, these experiments raise a number of interesting questions about our understanding of the In-P phase diagram.

Coverage of the production and characterization of LEC InP substrates is most complete, with two chapters written by two teams of commercial suppliers led by Oda and Tada. The discussions start with the physical properties of InP and proceed to the synthesis of polycrystalline InP, with the curious omission of injection synthesis. Oda provides an interesting phenomenological discussion of twinning in InP, an important subject that deserves its own chapter. He then describes efforts in dislocation reduction, doping, and characterization. Both chapters include an interesting and detailed description of wafer processing and quality evaluation techniques which are seldom discussed but critical to substrate performance.

Early in her chapter, Razeghi compiles a list of 30 "firsts" achieved with low-pressure MOCVD. This ambitious contribution covers a wide range of topics, such as electronic band structure, a review of epitaxial techniques, theory and operation of the capacitance-voltage profiling plotter, the chemical properties of metallo-organic reagents, and the design and growth of optoelectronic integrated circuits. The details of growth, characterization, and application are primarily for InP homoepitaxy, but the discussion includes InP growth on alternative lattice mismatched substrates such as GaAs, GGG (gallium gadolinium garnet), Si, and InAs for optoelectronic integrated circuit applications.

The final chapter by Kennedy and Lin-Chung treats stoichiometric defects in InP. The electronic description of the defect states is clearly outlined using Green's functions with tight binding potentials. The discussion of experimental techniques such as electron paramagnetic resonance (EPR), optically detected magnetic resonance (ODMR), electron nuclear double resonance (ENDOR), positron annihilation, and extended x-ray absorption fine structure (EXAFS) is pitched at the right level and does a good job of identifying relative strengths and weaknesses. Interesting aspects of the anti-site defect, P_{In}, and its possible role in a deep trap complex are discussed.

The overall level of contributions in this book is uniformly high, and the editorial practice of providing reference titles is helpful. This book should serve as a valuable reference to those interested in the materials aspects of InP.

Reviewer: Eric M. Monberg is a member of the research staff at AT&T Bell Laboratories. His interests include the growth and VGF characterization of InP bulk crystals.