Understanding Materials: A Festschrift for Sir Peter Hirsch

C.J. Humphreys, Editor
(Maney Publishing, for the Institute of Materials, London, 2002)
ix + 343 pages, $115.00
ISBN 1-902653-58-0

Peter Hirsch is one of the giants of modern materials science. He is not only the prime begetter of transmission electron microscopy, both experiment and (especially) theory, but also a resolute and effective student of crystal defects and of radiation damage, a field closely linked to crystal defects. These topics are treated in 15 of the 16 chapters of the book under review; the 16th deals with very recent developments in materials science that have surfaced since the occasion which gave rise to the book, namely, a symposium and party to mark Peter Hirsch's retirement from his Oxford chair in September 1992. Anyone who has ever edited a work like this knows the desperate difficulty of extracting texts from hyperbusy scientists; this is clearly the reason for the 10-year delay between stimulus and conclusion! In spite of the delay, most of the chapters carry citations to work up to and including 2000.

Ugo Valdré's splendid, impressionistic opening chapter is entitled "Understanding Peter: A Recollection of Facts and Anecdotes about Sir P.B. Hirsch." It tells us a great deal about early days in Cambridge, including a formidable array of miniature portrait photographs of no fewer than 61 distinguished physicists. The chapter even discusses the architecture of Peter's house in Cambridge! The early Cambridge work is treated in depth by Mike Whelan, and his is followed by five chapters dealing with highly technical aspects of electron microscopy, such as weak-beam and convergent-beam methods. These will be of interest mostly to people who have worked in depth with electron microscopes. After this, several chapters deal with defect analysis and with plastic behavior—in metals, ceramics, and semiconductors—which was and is an important interest of Peter's. These chapters in turn are followed by three more that deal with more technological issues… sialon ceramics, particle-hardening in metals, and the relation of crystal defects to nuclear technology, before the editor wraps up the proceedings with a discussion of ultramodern power-station turbines and solid-state lighting, followed by a curriculum vitae and publication list for Hirsch.

The book is beautifully produced on high-quality paper, so that the many micrographs are clearly reproduced. There are numerous typos (more in some chapters than in others); for some reason, everyone seems to be determined to render Alfred Seeger as "Seegar," but none of the misprints impairs clarity.

Both active researchers and older people with developing historical interests will find much to interest them in this book; and while the price is steep, it is not unreasonable for what is offered.

***Reviewer:** Robert W. Cahn is a materials scientist attached to Cambridge University. He is a member of the Editorial Board of* MRS Bulletin *and was a Volume Organizer for 2002.*

Introduction to Macromolecular Science, *2d Ed.*

Petr Munk and Tejraj Aminabhavi
(John Wiley & Sons, New York, 2002)
609 pages, $99.95
ISBN 0-471-41716-5

The problem with a broad polymer course is finding the right balance between synthesis, characterization, properties, and applications. The answer will differ depending on whether the course is in chemistry, chemical engineering, or materials departments. It will also depend on the specific interests of the course organizers and what they envisage for the future of their students.

In this case, both authors are professors of chemistry: Munk is professor emeritus at the University of Texas at Austin, and Aminabhavi at Karnatak University in India. Aminabhavi has published extensively on controlled-release systems and membranes, especially those based on alginate and other natural polymers. Munk works particularly on block-copolymer micelles and inverse gas chromatography for the study of the thermodynamics of mixtures.

Of the five chapters, the first covers molecular structure, including sequences, coils, and molecular weights as would be expected, but with unconventional sections on biopolymers and aggregates. This chapter is better than the rather perfunctory first chapters of many polymer texts. The second chapter is a good standard treatment of polymerization, with new topics such as metallocenes and living free-radical polymerization.

Chapter 3 on macromolecules in solution is the largest. The section on solution viscosity and flow are especially thorough, and there are novel sections on nucleic acids and on electrophoresis. The last two chapters on bulk properties and applications are relatively brief and conventional.

As a course text, this book would fit well into a chemical engineering department where the focus of interest might be polymers in solution or into a chemistry department where the main interest is on physical chemistry rather than on synthesis. Polymer texts tend to be like a snake that has eaten a pig—there is a big bulge around the research area of the authors. If one were to buy this book as one of a set of references from which to build a course, then buy it for Chapter 3.

***Reviewer:** Paul Calvert is a professor in the Materials Science and Engineering Department at the University of Arizona. His research interests are in the areas of biomimetic materials, diffusion and permeability in polymers, intelligent materials, conducting polymers, solid freeform fabrication, and inkjet printing.*

Electrochemistry of Nanomaterials

Gary Hodes, Editor
(Wiley-VCH, Weinheim, 2001)
xvi + 310 pages, $149.95
ISBN 3-527-29836-3

This book provides a comprehensive introduction to the current frontiers of the electrochemistry of fabrication, the electrochemical and solid-state properties, and the implementation of select groups of nanomaterials for a variety of applications. Each chapter, contributed by researchers at the forefront of their fields, includes a review of the subject matter (with good bibliographies) as well as a more detailed explanation of the principles of formation or of the unique properties resulting from nanoscale effects.

The first three chapters offer a detailed explanation of the principles of electrochemical deposition of semiconductor nanocrystals (ZnO, CuI, CdS), aggregates and quantum dots (CdS, CdSe), and superlattices and multilayers (metal oxides). The fabrication techniques described allow fine control over the distribution of crystallite size, which is important for applications. The pure bandgap luminescence properties of the semiconductor nanocrystals are particularly striking, where the emission energy depends upon the particle radius. Because the aggregates and quantum dots were deposited on nontransparent substrates, scanning-probe microscopy and photoelectrochemical photocurrent spectroscopy revealed new features related to surface states and charge-transfer mechanisms.

The next three chapters are devoted to nanoporous, nanocrystalline semiconductors. The review chapter briefly touches upon a host of materials, providing good references but very little depth. A chapter devoted to the electrochemical formation and properties of porous Si describes in detail the principles of formation but only mentions the interesting properties. I found the following chapter on charge transport to provide a clear description of the unique electronic properties of the semiconductor, liquid-electrolyte, and semiconductor/back-contact interface. The final chapters provide descriptions of specific applications of these nanostructured films: dye-sensitized solar cells, electrochromic and photochromic films, and charge transfer and storage.

Overall, I would recommend this research monograph to advanced graduate students or researchers with a background in condensed-matter physics and electrochemistry. It will appeal to those who are looking for a well-written introduction to the field or who want to have a compilation of the relevant references.

Reviewer: *Nancy Missert is a principal member of the technical staff in the Nanostructure and Semiconductor Physics Department at Sandia National Laboratories in Albuquerque, New Mexico. Her current research interests include understanding the fundamental mechanisms of corrosion in aluminum and the identification and characterization of electronic defects in gallium nitride.*

Introduction to Solid-State Lighting

Arturas Zukauskas, Michael S. Shur, and Remis Gaska
(John Wiley & Sons, New York, 2002)
207 pages, $49.95; ISBN 0-471-21574-0

Solid-state lighting is the term increasingly being used for applications of solid-state semiconductor chips to "power lighting," or illumination. In these applications, users are not looking at the chip itself, as they would for "low-power" signaling or display applications, but at objects that the chip is illuminating, as they would for "high-power" white lighting. This exciting new technology has extraordinary potential: reduced energy consumption and associated environmental pollution and improved quality of the human visual experience. However, it also cuts across a wide range of disciplines, including semiconductor materials, optoelectronic physics and engineering, wavelength-conversion materials and packaging, and human factors.

This is the first book to seriously try to review this new technology in a comprehensive way. Its organization reflects this attempt, with chapters on colorimetry, bulbs and tubes, semiconductor light-emitting diodes (LEDs), light extraction, white-light production, and applications. Previous books, white papers, and technical review articles have had more depth, but only in particular aspects of the technology. None have the breadth of this book. For example, I believe this book contains the first treatments, in the context of solid-state lighting, of the physics and design of high-light-extraction-efficiency chips, of colorimetry, and of applications.

However, as is often the case with first books in new technologies, some major topics are missing or treated sparsely, such as organic LEDs, substrates and buffer layers in AlGaInN semiconductors, phosphors, high-power packaging, lasers, and directional emitters. These deficiencies are actually quite major—these topics are extremely important to the future development of solid-state lighting technology. Also, this is not a book that emphasizes in a textbook-like way fundamental principles that have stood the test of time. This is understandable, though, as the field is still young and evolving.

Nevertheless, as a first attempt at a thorough review, this is an important and useful book. It will be especially useful to semiconductor technologists and graduate students interested in a snapshot of the current state of the art in LED design and looking to expand outward into the larger world of solid-state lighting. It will also be useful, though less so, to businesspeople or non-semiconductor technologists looking for an overview of the entire world of solid-state lighting; for this audience, Chapters 1–3, 6, and 7 will likely be of most interest, while Chapters 4 and 5 will likely be too detailed.

This book provides a good overall summary of the state of the art in solid-state lighting, although skewed toward semiconductor-chip physics and colorimetry.

Reviewer: *Jeff Tsao is a principle member of technical staff at Sandia National Laboratories, where he is working in the area of solid-state lighting science and technology. He recently edited the "LEDs for General Illumination Roadmap Update 2002" on behalf of the Department of Energy and the Optoelectronics Industry Development Association.*

Mesoscopic Systems: Fundamentals and Applications

Yoshimasa Murayama (Wiley-VCH, Weinheim, 2001)
viii + 245 pages, $99.95; ISBN 3527293760

Murayama's goal in this text is to describe mesoscopic systems that bridge the classical and quantum regimes. In these intermediate-scale, submicron systems, neither classical nor quantum mechanical pictures in and of themselves provide a complete description of observed physical properties. A theme throughout the book is the coherence of electrons in a given system and the tendency for scattering to occur and, hence, for electrons to lose coherence. Sometimes, the contrast or integration of classical and quantum descriptions is not as explicit as it could be throughout the text, but these themes are conveyed more strongly in the early and late chapters of the volume.

Individuals with a graduate-level quantum mechanics background and a basic course in solid-state physics will best appreciate this text. The author spends over a third of the text on a broad review of introductory solid-state physics, with a focus on the effects of quantization as dimensions are reduced. The text provides a broad, shallow review of many concepts related to mesoscopic systems.

Several of the chapters include extensive reference lists. One strength of the text is that Murayama summarizes many different concepts and includes references to papers or texts where the reader may uncover more detail as desired. Murayama links references to current work and paints a picture of important work in mesoscopic systems that has occurred in the past two to four decades. In places, the book seems to catalog many formulae or discoveries, but other sections better motivate the topics discussed, such as the discussion of electrical conductivity.

Many figures are unclear, primarily due to lack of adequate captions or in-text descriptions of the concept being illustrated, although Figure 10.3, which demonstrates the operating principle of the Esaki tunnel diode in various configurations, is a notable exception. In the same vein, not all mathematical symbols or conventions are adequately defined in the text or appendices. While there are a number of typographical errors throughout the text, the careful reader should be able to determine the author's intent from the context and previous physical or mathematical knowledge.

The appendices provide additional detail for the reader interested in more background or explicit mathematical derivation on individual topics. On rare occasions, such as the description of absorption coefficients for excitons in various dimensions, some mathematical detail that would have been better relegated to an appendix was included in the text. The outlines of how to solve Schrödinger's equation under a variety of approximations (e.g., effective mass) or boundary conditions were useful and provide a good starting point for a student or researcher new to mesoscopic systems.

Reviewer: *Linda Olafsen is an assistant professor in the Department of Physics and Astronomy at the University of Kansas. Her semiconductor-physics research is focused on the study of optical and electronic properties of antimonide-based heterostructures for the development of more efficient high-temperature semiconductor lasers and detectors.*