DEPARTMENTS

BOOK REVIEWS

Photoelectronic Properties of Semiconductors

Richard H. Bube, 320 pages, illus., index, references, bibliography. ISBN 0-521-40491-6, 0-521-40491-1. University of Cambridge, 40 West 20th Street, New York 10011 (1992) $69.95 hardbound, $32.95 softbound.

Reviewed by J. Mort, Webster Research Center, Xerox Corporation, Webster, New York 14580.

I well remember when I began my PhD studies acquiring my copy of Professor Bube's book *Photoconductivity of Solids,* published by John Wiley & Sons in 1960. This was the first book that attempted a comprehensive analysis of the subject, and I still recall how fascinating and exciting it made the subject. Over the years, Professor Bube's book has remained a consistent and valued reference source, particularly with respect to the fundamental principles underlying the phenomena it considers. For these reasons, it is a pleasure to have the opportunity to comment on his most recent contribution to a field that has had extensive technical and commercial impact.

In the three decades since *Photoconductivity in Solids* was published, the field has grown enormously, both in the nature of the phenomena considered and in the range of materials investigated. The most significant change, however, has been in the area of devices and applications of photoconductivity. Principally this area has been associated with sophisticated advances that have occurred in materials processing and, leveraged from integrated circuit technology, in large-area devices. These developments have extended the technological and commercial significance of phenomena spanning photovoltaics, optical detectors, and page-size optical scanners and photoreceptors. Indeed, in combination with digital technology enabled by the silicon ship, photoelectronics is an integral and enabling component of the information age.

Professor Bube's new book is not, nor was it intended as, a compendium of the enormous field of knowledge now in existence. In this sense, much in this book will be familiar to those have read *Photoconductivity of Solids.* Thus, chapters on photoconductivity parameters, various recombination processes, and steady-state and transient photoelectronic analyses differ mainly in the experimental results used as illustrative examples, although there are interesting discussions of newly developed techniques, such as photoinduced transient spectroscopy. However, there is an emphasis on several new topics that have either emerged in the intervening years or grown in importance and interest. These topics include photoconductive effects in amorphous materials, photovoltaics, and quantum well and superlattice structures. Professor Bube's approach is unchanged, with a focus on elucidating the principles of very complex phenomena in terms of simple, physically understandable models.

The chapter on amorphous semiconductors is limited to various chalcogenide alloys and hydrogenated amorphous silicon (a-Si:H). Some discussion of photoconductivity in amorphous selenium would have been an interesting addition, given its unusual field and temperature-dependent photogeneration properties that arise from a geminate recombination process of the photoexcited pair. This process is controlling because of the small thermalization lengths associated with the low carrier mobilities in the disordered state. In the case of a-Si:H, there is an emphasis on the complex and technologically important instabilities observed in the photoconductivity arising from illumination-induced increases in defect densities. There is also a useful expansion on the subject of photovoltaic effects. After a treatment of generic phenomena, the principal focus is on one material, namely Cu_xS/CdS. The final chapter deals with quantum well and superlattice structures, which now can be built atom by atom using modern deposition processes such as molecular beam epitaxy and organometallic chemical vapor deposition. The emphasis is on the ability to tune the photoelectronic properties of heterogeneous devices by building fixed band-gap discontinuities through choice of materials or their modulation by materials engineering at angstrom levels. A variety of photoelectronic effects exhibited by these highly unusual systems are discussed along with potential technological applications.

Professor Bube has created a book that supplements his earlier one. There are copious figures to illustrate and compare theoretical predictions and experimental results. The book is also well indexed, a service to the reader that is sometimes neglected. The book is to be recommended as a resource that provides valuable insights for today's graduate students and more seasoned researchers alike. Here they will find a conceptual framework of basic principles to serve as a guide as they venture into new materials or devices or encounter unfamiliar photoconductive phenomena.

Fiber-Optic Communication Systems

Govind P. Agrawal, 445 pages, illus., index, bibliography, 3 appendixes. Wiley Series in Optical and Microwave Engineering. ISBN 0-471-54286-5. John Wiley & Sons, 605 Third Ave., New York (1992) $59.95 hardbound.

Reviewed by R. W. Tkach, AT&T Bell Laboratories, Crawford Hill Laboratory, Holmdel, NJ 07733-0400.

The field of optical communications has a large body of knowledge that is common to

those working in the field. While there are several volumes that are collections of articles written by specialists, it has been difficult to find this information collected in a single volume that is appropriate for students or researchers entering a new field. This book is an effort to fill that void. The book has the look and feel of a textbook, with careful theoretical development of basic concepts and extensive problem sets.

After an introduction that provides a historical perspective as well as an overview of the material to be presented, the book has chapters on the basic building blocks of an optical communication system: optical fibers, optical sources and transmitters, and detectors and receivers. These are followed by chapters on system design, coherent systems, and multichannel systems. The last 100 pages of the book are split between a chapter on optical amplifiers and one on soliton communication systems.

I have a few quibbles with the choice of material. In the chapter on sources, directly modulated semiconductor lasers are treated in detail, reflecting the author's expertise in that subject, while scant attention is given to external modulation of cw lasers. This technique, either with completely separate modulators or integrated laser modulators, has become essential for long amplified systems or wavelength-division multiplexing systems. A brief review of the technology can, however, be found in the chapter on coherent systems. The subject of coherent lightwave systems is given perhaps more weight than is necessary, since optical amplifiers have effectively removed the sensitivity advantage of such systems.

It is unfortunate that optical amplifiers are treated so late in the text since the availability of these devices is revolutionizing the field of lightwave communications and affecting the requirements for transmitters, receivers, and fibers. It is, of course, unfair to take the author of this volume to task for this, since much of the revolution is still being worked out in the research literature. However, in the chapter on optical amplifiers, equal weight is given to semiconductor amplifiers, Raman amplifiers, Brillouin amplifiers, and erbium-doped fiber amplifiers. From a practical point of view, the latter deserve far more attention. There is one error in the treatment of erbium-doped fiber amplifiers that is quite serious. The author suggests that there is crosstalk arising from saturation of the amplifier gain at one channel due to power at another (Sec. 8.5.5). While it is true that power at one wavelength saturates the entire gain spectrum for all channels, the time constant for saturation in these devices is on the order of milliseconds, so that for all reasonable modulation rates there is no crosstalk of information. This is one of the most fortuitous features of these amplifiers; if it were not the case, wavelength multiplexed systems would be impossible.

On the whole, this book is an excellent source for basic information on the entire field of lightwave communications and is useful both to beginners in the field and to those of us who need to reexamine fundamental issues. (I expect to make frequent use of it myself.) It should also serve well as a textbook for late undergraduate or graduate students. The extensive (more than 1000 total) references at the end of each chapter are well researched and provide an excellent way for the reader to delve further into the topics covered. This feature alone is worth the price of the volume.

BOOKS RECEIVED

Coherence Phenomena in Atoms and Molecules in Laser Fields edited by André D. Bandrauk and Stephen C. Wallace. ix + 406 pp., illus., subject index, author index, references following each chapter. Part of the NATO ASI series, Series B: Physics Vol. 287. ISBN 0-306-44190-X. Plenum Press, 233 Spring Street, New York, NY 10013 (1992) $115 hardbound. Covers inhibition of atomic ionization in strong laser fields, optical analogs of model atoms in fields, intense field dynamics of diatomic molecules, excitation of molecules and solids with intense subpicosecond ultraviolet radiation, phase effects in two-color multiphoton processes, coherent interactions within the atomic continuum, femtosecond pulse shaping and excitation of molecular coherences, time dependent quantum calculations on the femtosecond pump-probe ionization spectroscopy of molecular sodium, and femtosecond photon echo formation in liquids.

Optical and Spectroscopic Properties of Glass by Dr. Gan Fuxi. viii + 283 pp., illus., subject index, references following each chapter. ISBN 0-387-54071-7. Springer-Verlag New York, Inc., 44 Hartz Way, Seacaucus, NJ 07096-2491 (1992) $198 hardbound. Covers glass structure; light scattering in glass; Eigen absorption in glass; refractive-dispersion properties of glass; nonlinear optical properties of glass; ESR spectroscopic properties of transition elements in glass; optical spectroscopic properties of transition elements in glass; laser properties of transition elements in glass; optical and spectroscopic properties of semiconductor micro-crystallites in glass; and optical, magneto-optical, and optical recording properties of glass thin films.

Spectroscopy of Polymers by Jack L. Koenig. xvi + 328 pp., illus., subject index, references following each chapter. An ACS Professional Reference Book. ISBN 0-8-8412-1924. American Chemical Society, The Maple Press Distribution Center, I-83 Industrial Park, POB 15100, York, PA 17405 (1991) $89.95 hardbound. Covers theory of polymer characterization, vibrational spectroscopy of polymers, experimental IR spectroscopy of polymers, applications of IR spectroscopy to polymers, Raman spectroscopy of polymers, high-resolution NMR spectroscopy of polymers in solution, special editing techniques for high-resolution NMR spectroscopy of polymers, high-resolution NMR spectroscopy of solid polymers, applications of high-resolution solid-state NMR spectroscopy to polymers, NMR relaxation spectroscopy of polymers, and NMR imaging of polymeric materials.

Remote Sensing by Fourier Transform Spectrometry by Reinhard Beer, edited by J. D. Winefordner, Series Editor, and I. M. Kolthoff, Editor Emeritus. xvii + 153 pp., illus., subject index, references, bibliography. ISBN 0-471-55346-8. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012 (1992) $74.95 hardbound. Covers basic principles of Fourier transform spectroscopy, ideal Fourier transform spectrometer, the physics and chemistry of remote sensing, real Fourier transform spectrometers, case studies of remote sensing Fourier transform spectrometers, remote sensing environments, general observations and conclusions, and optimum filters.

Fiber-Optic Communication Systems by Govind P. Agrawal, edited by Kai Chang. xv + 445 pp., illus., subject index, references at end of each chapter. ISBN 0-471-54286-5. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012 (1992) $59.95 hardbound. Covers optical fibers, optical sources and transmitters, optical detectors and receivers, system design and performance, coherent lightwave systems, multichannel communication systems, optical amplifiers, and soliton communication systems.

Laser Material Processing by William M. Steen. xiii + 266 pp., illus., subject index, references at end of each chapter. ISBN 0-387-19670-6. Springer-Verlag, 175 Fifth Avenue, New York, NY 10010 (1991) $39.50 softbound. Covers background and general applications, types of industrial lasers, comparison between lasers, applications of lasers, market for laser applications, basic laser optics, refraction, optical components, laser cutting, methods of cutting, practical performance; laser welding, process variations, heat flow theory, laser surface treatment, laser automation and in-process sensing, and laser safety.