DEPARTMENTS

BOOK REVIEWS

Semiconductor Optics

Claus F. Klingshirn, 490 pages, illustrations, index, and references. ISBN 3-540-58312-2. Springer Verlag, Berlin, Heidelberg (1995) $54.50 hardbound.

Reviewed by Juergen Gutowski, University of Bremen, Institute of Solid State Physics, Optics of Semiconductors, FB 1, P.O. Box 330 440, D-28334 Bremen, Germany.

Semiconductor optics is probably the field in condensed matter physics that has been most intensely treated by a large number of scientists in recent decades. It offers to both evolve fundamental physical concepts and to develop a number of device ideas covering the most sophisticated uses in research laboratories and applications in daily life. One may think of telecommunication techniques, LEDs, or laser diodes for CD-players, for example. Thus, semiconductor optics has become one of the most outstanding topics to be taught in university courses on solid state physics. However, most textbooks deal with solid state optics on a quite basic and general level. Only very few combine the necessary development of general concepts with a large number of descriptive and vivid examples.

The book by Klingshirn fills a gap between fundamental textbooks and literature for the specialist. It takes the reader from the introduction of the general problems of the field, to Maxwell's equations and interaction of light with matter via solid state concepts important for semiconductor optics, then on to oscillators, lattice vibrations and photos, electrons in a periodic crystal lattice, and excitons, then finishes with a broad treatment of applications in linear and nonlinear optical spectroscopy.

The structure of the book is quite different. The basics are introduced step by step as they are needed for explanation of the optical properties of semiconductor material. This keeps the reader curious from chapter to chapter about the next steps. The level on which the basic concepts of solid state physics are discussed remains a little bit rough; however, this is absolutely sufficient for the purpose of this book. What is missing in the book are some clear hints on high-quality textbooks treating these concepts in more detail. This is especially true for the field of low-dimensional structures, in which very good textbooks have recently been published. In particular for students, such remarks would be much more helpful than the special literature often cited by the author on these chapters.

After the reader knows the main essentials of oscillators, photons, electrons and holes, and excitons as far as necessary to understand their impact on optical properties of matter, the topics are treated in detail by means of a wide variety of examples from published special literature. Chapters 13 through 17 are devoted to linear optics and deal with optical properties of photons and plasma, and intrinsic, bound, and localized excitons. Chapter 16 presents excitons under magnetic, electric, and strain fields. The mix of experimental examples is extraordinarily nice, illustrating the particular properties of very different semiconductor materials with and without reduction of dimension. Concepts often difficult to understand for students are introduced on an intuitive level easy to take for graduate students, making it a pleasure even to look into tricky problems of semiconductor linear optics. It was a perfectly nice idea to finish this part of the book with a short chapter ''Review of the linear optical properties,'' to sum up the essentials.

The following chapters (Chaps. 18 to 23) are devoted to the nonlinear optics approach. This is systematically introduced by a short general scenario after elucidating the basics of virtual excitation (response to instantaneous field amplitudes) resulting in the Chi-2 and Chi-3 processes, followed by the treatment of really or incoherently excited carriers or photons. Their nonlinear contributions are related to their lifetime. The next chapter, ''Intermediate density region'' (Chap. 19), comprises exciton scattering, biexcitons, the AC Stark-effect, Bose-Einstein condensation, and photothermal effect, followed by a treatment of the electron-hole plasma at extremely high excitation densities (Chap. 20).

The scientific part of the book closes with three chapters on stimulated emission, ultrafast spectroscopy, and optical bistability (Chaps. 21, 22, and 23, respectively). Again, these chapters are neatly written, introducing the reader to many aspects of modern basic and applied nonlinear semiconductor optics. The practical examples used throughout these chapters, however, are a little too dominated by the love of the author for the wurtzite II-VI semiconductors. By citing many of his own high quality papers on these materials and taking an extraordinarily large number of figures from them, the author may give the impression that most breakthroughs in nonlinear semiconductor optics have been achieved on hexagonal II-VIs, accompanied by some relevant studies on III-V materials. This holds in particular for the chapter ''Optical bistability'' being a CDs chapter. In Chap. 21, it would have been a little more adequate to treat the most interesting developments in epitaxial ZnSe/ZnCdSe based laser diodes instead of showing less interesting data on bulk CDs and ZnO, for which no applications are in sight. Regarding ultrafast phenomena, most revolutionary results have been derived for III-V materials at least until 1994, the latest year of cited papers in the book. Most recently the epitaxially grown ZnSe based binary to quaternary compounds offered much more fundamental insights into coherent phenomena than did the II-VIs any time before. However, this selection being a little too subjective does not seriously hinder the comprehension of the main aspects of modern nonlinear semiconductor optics from this book. Finally, two chapters on experimental techniques (Chap. 24) and group theory (Chap. 25) make complete the impression of the whole book as a round presentation where no essential topics are missing.

In summary, this book is very clearly written and illustrated with many principle diagrams and experimental data. It definitely profits from the long experience of the author in overcoming students' problems of comprehension. It tells a very interesting and fascinating story of the development of semiconductor optics, touching all basic physical concepts necessary in the field. It is definitely not the task of the respective basic chapters of the book to replace standard textbooks on solid state physics, but it will be easy for the readers to make their own combination of necessary literature. I strongly recommend this book as a big help for advanced graduate and postgraduate students' courses in semiconductor optics.

Compact Sources of Ultrashort Pulses

Irl N. Duling III, Ed., 430 pages, illustrations, index, and references. ISBN 0-521-46192-8. Cambridge University Press, The Pitt Building, Trumpington Street, Cambridge, CB2 1RP, United Kingdom (1995) $79.95 hardbound.

Reviewed by Martin Guy, Femtosecond Optics Group, The Blackett Laboratory, Imperial College, Prince Consort Road, London, SW7 2BZ, United Kingdom.

The area of ultrashort pulse generation has made considerable progress in the last few years, with the focus of attention shifting away from dye lasers and concentrating on the use of solid state media. Research interest has mainly been directed toward three key areas: the mode locking of bulk solid state lasers, fiber lasers, and semiconductor lasers. Each of these areas has yielded novel innovations and deeper understanding of the underlying physical processes, and thus generated a large associated body of literature. The stated aim of this book is to provide a ''comprehensive survey'' of the field and ''review the state of the art in compact mode-locked laser systems.''

The book consists of nine chapters, each written by well-known workers in their respective fields. They cover the theory of short pulse generation with mode-locked lasers, passively mode-locked bulk solid state lasers, diode-pumped solid state lasers, mode-locked fiber lasers, vertical cavity semiconductor lasers, external cavity semiconductor lasers, and monolithic colliding pulse mode-locked (CPM) diode lasers. This approach has produced a book that is effectively a collection of monographs on the respective authors' work. The result of this is that, although in general each chapter is clearly and authoritatively written, the view presented of each topic tends to be rather subjective, and experienced workers in the field may find other reviews available in journals to be more objective and all-encompassing.

My main criticism of the book, however, is in the choice of subject areas covered. It would seem natural to include fiber lasers mode locked through nonlinear polarization rotation in the chapter on all-fiber mode-locked lasers, and a source based on a diode laser with an external fiber grating cavity in the chapter on external cavity semiconductor lasers, rather than dedicate separate chapters to these two topics. This would have allowed space for greater coverage of techniques for ultrashort pulse generation other than mode locking, such as optical beat conversion and direct modulation of cw narrow linewidth sources, which are relatively neglected.

These criticisms aside, however, the book does provide a reasonable ''snapshot'' of the areas of research it covers, although in such a fast moving field it is a pity that some of the chapters could not be more up to date. The most recent work referred to dates from 1993, which means that a number of significant results since that time have been omitted, particularly in the field of diode-pumped solid state lasers, but this is perhaps inevitable in any book. As each chapter is more or less self-contained, it is quite easy to dip into the book for information on a specific topic, but this also means that there is a higher degree of repetition of fundamental principles, which can prove frustrating to a more committed reader. Within each chapter, there is a good balance between theoretical background and experimental results and, in general, each topic is explained clearly and logically without becoming too dry. The level of presentation is such that the book should be accessible to readers new to the field as well as established workers, and as this book represents the only collection of recent work in the areas covered currently available, it will undoubtedly be of value to many graduate students, researchers, and engineers.

Finally, it should be noted that there is no overall conclusion as to the ''best'' approach to short pulse generation, and in any case, the most appropriate approach will ultimately depend on the given application. This is still a very active and lively area of research and there will definitely be scope for a similar updated book in just a few years.

BOOKS RECEIVED

Quantum Dynamics of Simple Systems, G. L. Oppo, S. M. Barnett, E. Riis, and M. Wilkinson, Eds. x+373 pp., illus., subject index, list of participants, references following each chapter. The Forty-Fourth Scottish Universities Summer School of Physics Proceedings. ISBN 0-7503-0-351-4. Institute of Physics Publishing, Techno House, Redcliffe Way, Bristol BS1 6NX, (1996) $180 hardbound. Contains contributions from many leading experts in the field of quantum systems. The main objective is to provide an overview of the present range of quantum toys and to instruct newcomers in their use and exotic behaviors. Covers specific subjects of quantum dynamics in a competent and detailed way with the emphasis on simple systems where few atoms or electrons are involved.

Diffraction of X-Ray Optics, by A. I. Erko, V. V. Aristov, and B. Vidal. xiv +162 pp., illus., subject index, references at end of book, list of symbols. ISBN 0-7503-0359-X. Institute of Physics Publishing, Techno House, Redcliffe Way, Bristol BS1 6NX, United Kingdom (1996). A detailed description of the main principles, technology, and applications of Bragg-Fresnel multilayer optics and x-ray Fourier optics is presented. Special attention is paid to coherent phenomena in the x-ray region including x-ray holography. Other chapters cover x-ray interaction with matter, planar and volume diffraction, fabrication techniques, and x-ray microscopy.

Ultrashort Laser Pulse Phenomena: Fundamentals, Techniques, and Applications on a Femtosecond Time Scale, by Jean-Claude Diels and Wolfgang Rudolph. viii + 581 pp., illus., subject index, bibliography at end of book, problems following each chapter, five appendixes. From the Optics and Photonics Series. ISBN 0-12-215492-4. Academic Press, Inc., 525 B Street, Suite 1900, San Diego, CA 92101-4495 (1996) $95 hardbound. An introduction to the ultrashort laser phenomena, it explains how it can be used to help examine problems in areas such as electromagnetism, optics, and quantum mechanics. Provides the background and tools necessary for designing experiments involving ultrashort pulses. All aspects of design are covered, from the construction of the source, to the amplifier, diagnostic method, and design of the experiment in any modern field of experimental science.