

# DEPARTMENTS

## BOOK REVIEWS

### CRC Handbook of Laser Science and Technology Supplement 1: Lasers

Edited by Marvin J. Weber, 595 pages, illus., index, references. ISBN 0-8493-3506-X. CRC Press, Inc., 2000 Corporate Blvd., N.W., Boca Raton, FL 33431 (1991) \$249.95 U.S. hardbound, \$295 other countries hardbound.

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Approximately 10 years have passed since the publication of Vols. I and II of the *CRC Handbook of Lasers Science and Technology* in 1982. These volumes were preceded by an earlier volume: the *CRC Handbook of Lasers with Selected Data on Optical Technology*, which was published in 1971, approximately 10 years after the first working laser was demonstrated. In keeping with the theme "what a difference a decade makes," the editors at CRC have produced the most recent addition to this series, *Supplement 1: Lasers*. This reference book is intended as an extension and update of Vols. I and II and is the subject of this review.

*Supplement 1* is similar in organization and format to the earlier volumes. This book contains five major sections on the topics of (1) solid state lasers, (2) liquid lasers, (3) gas lasers, (4) other lasers (more later on this), and (5) masers. Two of the sections that appeared in Vol. I, W.F. Krupke's overview of laser sources and the section on laser safety, are not included in *Supplement 1*. Presumably, neither subject area would have received sufficient updating to justify inclusion in the new volume.

The solid state laser section opens with a 100-pp. chapter (1.1) on crystalline paramagnetic ion lasers by J. A. Caird and S. A. Payne of Lawrence Livermore National Laboratory (LLNL). This is an excellent choice for the beginning of the book, because significant advances have occurred in this area during the past 10 years. Caird and Payne attribute the strong resurgence in solid state lasers to: "(1) the development of room temperature, near infrared tunable solid state lasers based on transition metal ions, (2) the discovery of new nonradiative energy transfer schemes for efficient sensitiza-

tion of flashlamp-pumped solid state materials, and (3) the development of highly efficient diode-pumped solid state lasers." The 30-pp. text of this chapter is a good tutorial on the various energy transfer mechanisms involved in transition metal ion doped laser crystals. Figure 1.1.8 is a useful graphic presentation of the energy level transitions and wavelengths of the numerous trivalent rare-earth impurities that have been lased in crystalline hosts. The thorough presentation of this well-written chapter, which includes numerous references (almost 500!), should be quite useful to research workers in this rapidly developing field.

The next chapter (1.2) by L. F. Mollenauer (AT&T Bell Laboratories) deals with another area—color center lasers—that has experienced some exciting developments in the 1980s. Perhaps the most potentially far-reaching impact in this area is that generated by continuing developments in the color center/fiber soliton laser. Mollenauer provides some easily readable background material on short pulse formation and propagation in fibers and includes some discussion of recent experimental results, such as the transmission of soliton pulses over a 4000-km fiber path and the compression of a soliton/fiber pulse to 19 fs or about four optical cycles.

For an area that has experienced what some might term explosive practical developments and revolutionized a number of applications markets since 1980, Chap. 1.3 on semiconductor lasers by M. Ettenberg (David Sarnoff Research Center) is disappointingly short (10 pp.). The successful transition of distributed feedback lasers from the laboratory to widespread application in fiber optic communication systems in the 1980s is given a brief description. The vastly improved operating efficiencies of quantum well lasers made possible by advances in growth and processing techniques is also mentioned. Of some consolation is that many possible sources of background material and journal references (122) are offered for the interested reader.

The following chapter (1.4) on glass lasers, contributed by D. W. Hall (Corning, Inc.) and M. J. Weber (LLNL), is an update of the very

excellent chapter on this subject by S. E. Stokowski in Vol. I. This chapter is also primarily a brief update (21 pp.) of its predecessor. According to the authors, the major advances in glass lasers during the past decade have been threefold: (1) new host compositions (e.g., "athermal" phosphate glasses), (2) new lasing transitions and ions (all 13 trivalent lanthanides have now been successfully lased), and (3) new operating configurations—especially glass fiber lasers (GFL). The chapter provides a good discussion of GFLs with numerous references (60+). Table 1.4.3 is a nice summary of the various rare earth ions that have exhibited laser transitions in glass fibers. The host glass and excitation source and a follow-up reference are given for each entry.

Chapter 1.5, also by M. J. Weber, is on the subject of solid state dye lasers. This subject was not included in Vol. I, and Weber is quick to point out that the many operational difficulties with these systems have, to date, seriously limited their usefulness. Nonetheless, he does present a good overview of the topic in this seven-pp. chapter and quotes 37 references on the subject, most of them published since 1980.

The next chapter (1.6) is a 12-pp. contribution by R. H. Stolen (AT&T Bell Laboratories) and C. Lin (Bell Communications Research) on the subject of fiber Raman lasers. They point out in this highly readable chapter that the field of fiber nonlinear optics has experienced significant expansion in the 80s. The authors review the major developments in this field, which they state as: (1) the development of new materials with large Raman gain for amplifier applications, (2) the extension of wavelength ranges toward the blue and UV regions, (3) the increasing availability and use of all-fiber in-line optical components, and (4) the production of ultrashort pulses and optical solitons (a topic also touched on in the earlier chapter by Mollenauer). This chapter provides a good overview description of the above topics, spending the most time on item 4, where some very nice background material on device configurations and pulse propagation in fibers is given. The chapter concludes with 37 references, most of them recent (since 1980).

The concluding chapter (1.7) of the solid state laser section of the book is an extensive listing (about 1600 entries) of the wavelengths observed in various solid state laser systems. The chapter is organized, as was the case in Vol. I, in order of increasing wavelengths and covers the range from 0.172 nm ( $\text{Na}^3:\text{LaF}_2$ ) to the 8.5- to 32-nm band of  $\text{PbSnSe}$ . The number of entries in this table increased by more than 700 from the 1982 listings, a brief hint at the solid state laser "renaissance" of the past decade.

The approximately 100 pp. of Sec. 2 are devoted to liquid lasers. Chapter 2.1, contributed by R. N. Steppel (Exciton, Inc.), on organic dye lasers is a thoroughly written update of the subject. According to Steppel, the major advances since 1980 have been the development of improved solvents and more efficient dyes, particularly in the near IR and UV regions, the latter opening the way to excimer and YAG third harmonic pumping into the tunable UV. Steppel provides numerous recent references, together with extensive tables of laser dyes and their key performance parameters. This chapter should be a useful reference for workers in the dye laser field (78 references).

Chapter 2.2, contributed by H. Samuelson (Allied Signal, Inc.), is on liquid inorganic lasers (LIC). This brief (3 pp.) chapter indicates that the major advances have been in development work on improved solvent solutions and feasibility work on a solar-pumped, space-based LIC system. This subject area, as pointed out by Samuelson, remains largely an area of academic interest, with "substantial material and device design problems (that) remain to be solved." (The chapter cites 12 references.)

The next section is on the subject of gas lasers. This entire section, comprised of approximately 200 pp., is basically an update of the earlier Vol. II, and follows the same topic headings as its predecessor. Chapter 3.1, contributed by J. Goldhar (U. of Maryland), on neutral gas lasers, describes 140 new transitions, including transitions for two more elements—Li and Al—that have been reported during the 80s. Most of the new transitions were produced by pulsed UV photodivocited metal halides. (The chapter cites 17 references.)

Alan B. Peterson (Spectra-Physics, Inc.) reports in Chap. 3.2 on ionized gas lasers that most development work in this mature field is now concentrated at commercial laser companies. Efforts there have resulted in the measurement and cataloging of numerous noble gas ion transitions—all operating cw and observed since 1982. Peterson provides a well-organized tabulation of these results with six references.

J. G. Eden (U. of Illinois) begins Chap. 3.3.1 on electronic transition lasers with a brief overview of the basic operating principles of di-

atomic and triatomic molecular systems. He points out that a great deal of research devoted to developing new molecular electronic transition lasers has been conducted during the 80s, and he backs up this statement with an extensive listing of the new transitions that have been observed. (The chapter provides 37 tables and 107 references.)

Reporting on vibrational transition lasers in Chap. 3.3.2, T. Y. Chang (AT&T Bell Laboratories) indicates that efforts during the past decade have resulted in the observation of many new output lines from isotopic species of diatomic (HF) and triatomic ( $\text{CO}_2$ ) systems. Many previously known  $\text{CO}_2$  lines have been updated with more precisely determined line center frequencies. (The chapter provides 14 tables and 25 references.)

The penultimate chapter (3.3.3) in this section is by D. J. E. Knight (National Physical Laboratory, England) on far infrared gas lasers. Knight points out that the number of far IR laser emissions observed since 1980 has approximately tripled—from 1350 to 4555. Table 3.3.3.1 lists far IR emissions for 47 new lasing molecules. (The chapter cites 52 references.)

Section 3 concludes with an extensive listing (approximately 7800 entries) of gas laser wavelengths, ordered by increasing wavelength from 0.09 to 1615 nm. The number of entries increased by roughly 1300 since the Vol. II listings.

Section 4, with the catchall title Other Lasers, makes interesting reading. The section begins with a chapter (4.1) on free electron lasers (FELs), contributed by W. B. Colson (Naval Postgraduate School) and D. Prosnitz (LLNL). This chapter offers a very readable tutorial covering the basic operating principles of FELs. Table 4.1.2 presents a nice summary (with references) of recent FEL experiments that have produced wavelengths as short as 0.24 nm, efficiencies up to 35%, and tuning ranges from 4 to 40 nm. The chapter contains 81 references, most published since 1980.

Chapter 4.2 on photoionization—pumped short wavelengths lasers was contributed by D. A. King (Stanford University). This chapter chronicles the ongoing search for soft x-ray transitions with wavelengths shorter than 10 nm. Table 4.2.1 lists twenty soft x-ray lasing systems that have been experimentally demonstrated. King points out that this research area is a promising application for the high-intensity femtosecond pump sources that are rapidly becoming available. The chapter concludes with a list of 60 references.

Chapter 4.2 on x-ray lasers, contributed by D. L. Matthews (LLNL), is indeed a chapter for the 1980s. Most of the ultrashort wavelengths (less than 30 nm) only very recently have been demonstrated. Matthews presents a nice tuto-

rial on the physics behind these systems, most of which have been created in highly excited ion columns produced by the interaction of high-power lasers with solid targets. The chapter concludes with a listing of nine review articles and 55 journal references on this fascinating topic.

Chapter 4.4 is a listing of x-ray lasers arranged in order of increasing wavelength ranging from 3.879 ( $\text{Al}^{12+}$ ) to 28.646 ( $\text{Ge}^{22+}$ ) nm.

The concluding chapter in this section is by C. B. Collins (U. of Texas) and covers the topic of gamma-ray lasers. In a short (7 pp.) but fascinating chapter, Collins points out the tremendous potential of such systems, but qualifies that by noting that attempts to produce such a laser have been "one of the longest unfruitful efforts in the field of laser science." The recent emergence of upconversion schemes relying on lower energy input radiation has prompted renewed interest and new feasibility studies in this research area. Collins reviews these efforts and provides the interested reader with a list of 16 recent references.

The final section in Supplement 2 covers the subject of masers. In Chap. 5.1, contributed by A. E. Popa (Hughes Research Laboratories), the author notes that no reports of new maser materials have occurred since the publication of Vol. I (1982). Advances in this field have been in operational refinements and improvements, which Popa briefly (three pp. of text) summarizes. A primary focus of research has been on navigational applications, such as the Global Positioning System, which rely on the hydrogen maser as a ground-based frequency standard. This chapter, though short on text, is long on references. The chapter contains 95 recent references, conveniently divided by topic!

Chapter 5.2, contributed by J. M. Moran (Harvard-Smithsonian Center for Astrophysics), is on maser action in nature. In a brief (10 pp.) treatment of the topic, Moran presents a well-written summary on astrophysical observations of cosmic maser actions in molecular clouds. The usefulness of these observations in determining magnetic field strengths and performing stellar distance measurements with unprecedented accuracy makes for interesting reading. This chapter is also referenced well, listing 64 references, most published since 1980.

The goal of the CRC Handbook Series as stated in the preface of *Supplement 1* is "to provide a readily accessible and concise source of data in tabular and graphical form for workers in the areas of laser research and development." How well does it meet this goal? In an overall sense the book certainly does meet the intended objective. The book is well organized with numerous references (almost 1600) and also presents introductory background infor-

mation on new and developing areas in laser research. With varying degrees of success, most of the contributors to *Supplement 1* were careful to summarize the new developments occurring in their respective subject areas since the publication of Vols. I and II, thereby minimizing duplication of information already in those volumes. This is not a textbook on lasers, and the book is probably not the ultimate reference for any single subject area. However, when viewed as a general reference source covering the field of laser science and technology, the book is a valuable and convenient information resource. The \$250 price tag may be a bit steep for many personal libraries, but the book certainly deserves a place on the library shelf of every company and university involved in laser R&D. The editors and contributors to this useful reference work are to be commended for their efforts. We will all look forward to *Supplement 2* sometime early in the 21st Century!

### Optical Components, Systems, and Measurement Techniques

Rajpal S. Sirohi and Mahendra P. Kothiyal, 445 pages, illus., index, references. ISBN 0-8247-8395-6. Marcel Dekker, Inc., 270 Madison Ave., New York, NY 10016 (1991) \$110 hardbound.

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This book could have been subtitled *Highlights of Electro-Optical Techniques from the Late Twentieth Century*. While I find almost all abbreviated collections unsatisfying due to lack of depth, the book was quite nice to read. This fact may be due to my being so familiar with the detailed research that went into the development of many of the techniques discussed. The authors succeed in presenting the techniques in a well categorized and cohesive fashion so that the reader can appreciate the subtle variations between different techniques and the resulting modifications in measurement capabilities. The book, which illustrates many practical applications, would be very suitable as a reference in a graduate program in electro-optics. The text presents a good starting point for students to grasp the overall concept of various techniques, and references are given from which detailed explanations may be obtained. From my perspective as an experimentalist, one shortcoming in a book of this type would be addressed by a discussion of the difficulties encountered in the implementation of the techniques presented. This discussion would provide readers with an appreciation of instrument developers' accomplishments and would be a good starting point for new instrument developers.

The book consists of 11 chapters. The first three provide background material, and the next eight are devoted to techniques. Chapter 1 starts with a discussion of sources, detectors, and recording media, and Chap. 2 is devoted to optical components. These discussions provide review and refresh the memory of readers already having detailed understanding of the subject matter. Chapter 3 begins to consider optical system integration with discussions of physical optics systems (lenses, microscopes, and telescopes) and then basic interferometric systems.

The second section of the book deals with techniques and incorporates the fundamentals reviewed earlier. Chapter 4 is devoted to length measurement techniques, and the first half of the chapter introduces a variety of physical optical gauges for macroscopic dimensioning, providing reticle-scale resolution. The rest of the chapter looks at interferometric gauges (both single frequency and two-frequency instruments) with resolution from several wavelengths down to  $\lambda/100$  or better. Chapter 5 is devoted to alignment and angle measurement techniques. The material is illustrated using telescopes and autocollimators for lower precision alignment and interferometric techniques for higher precision alignment. Chapter 7 extends the length measurement discussion into the regime of ultraprecise surface profiling using heterodyne and phase shifting interferometry. These techniques are capable of achieving resolutions better than  $\lambda/1000$  and represent the current state of the art in optical-based techniques.

Chapter 7 discusses holographic interferometry and speckle metrology for the measurement of surface motion. Applications in the field of nondestructive evaluation provide illustrations. Chapter 9 discusses photoelastic techniques, and Chapter 10 deals with fiber optic sensors. The applications of fiber optic sensors are expanding rapidly as new materials and new modes of interaction between fibers and surroundings are developed. This material only serves to whet the appetite, but does present a starting point in a compendium. Chapter 11 is a catchall chapter devoted to miscellaneous techniques not categorizable in the main subject headings of earlier chapters.

There are many topics left out of this book, perhaps the most noticeable being a discussion of confocal microscopy. The material presented is coordinated well, and I recommend the book. I think that *Optical Components, Systems, and Measurement Techniques* would be particularly useful in conjunction with graduate electro-optics programs having an experimental emphasis. Graduate students should study the techniques presented both to test their understanding of classroom material and to appreciate the application of principles to real-world measurement systems.

### BOOKS RECEIVED

**Acousto-Optic Signal Processing: Fundamentals and Applications**, Pankaj K. Das and Casimer M. DeCusatis. 473 pp., illus., index, references, appendix. ISBN 0-89006-464-4. Artech House, Inc., 685 Canton Street, Norwood, MA 02062 (1991) \$96 hardbound. Covers fundamentals of acousto-optic interaction, interaction in solids, surface acoustic wave interaction, and acousto-optic devices and applications.

**International Trends in Optics**, edited by Joseph W. Goodman. 525 pp., illus., index, references. ISBN 0-12-289690-4. Academic Press Inc., 1250 Sixth Avenue, San Diego, CA 92101 (1991) \$64.95 hardbound. Thirty-four chapters include integrated optics, quantum optoelectronics for optical processing, optics in telecommunications, micro-optics, holographic optical elements for use with semiconductor lasers, fiber optic signal processing, optical memories, adaptive interferometry, optics in China, the opposition effect in volume and surface scattering, quantum statistics and coherence of nonlinear optical processes, optical propagation through the atmosphere, medical applications of holographic 3-D display.

**Probability, Statistical Optics, and Data Testing: A Problem Solving Approach**, B. R. Frieden. 443 pp., illus., index, references, appendix. ISBN 3-540-53310-9 (Berlin) and 0-387-53310-9 (New York). Second edition of Vol. 10 in the Springer Series in Information Sciences. Springer Verlag, Inc., 44 Hartz Way, Secaucus, NJ 07096-2491 (1991) \$59 softbound. Includes the axiomatic approach, continuous random variables, Fourier methods in probability, functions of random variables, Bernoulli trials and limiting cases, the Monte Carlo calculation, stochastic processes, estimating a probability law, the chi-square test of significance least-squares curve fitting-regression analysis, principal components analysis, and controversy between Bayesians and classicists.

**Laser and Optoelectronic Engineering**, Hrand M. Muncheryan. 371 pp., illus., index, five appendixes. ISBN 1-56032-062-1. Part of the Hemisphere Publishing Series in Electrical Engineering. Hemisphere Publishing Corporation, 1900 Frost Road, Suite 101, Bristol, PA 19007 (1991) \$99.50 hardbound. Covers fundamental information, principles of laser radiation, holography and interferometry, laser metrology, laser beam communication, military laser systems, materials processing with laser beams, system characterizations of lasers, laser instrumentation in medical surgery, laser instrumentation in dentistry, laser fusion technology, mode locking and cavity dumping, and unique laser systems.