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Book Reviews

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Optical Fiber Sensors, Volume I: Principles and Components and Volume II: Systems and Applications

Artech House Optoelectronics Library, Brian Culshaw, Alan Rogers, and Richard Weiss, series editors. Volume I: John Dakin and Brian Culshaw, eds., xvi + 327 pp., illus., index, references, author biographies; ISBN 0-89006-317-6 (1988) \$94 hardbound. Volume II: Brian Culshaw and John Dakin, eds., xxii + 471 pp., illus., index, references, appendix; ISBN 0-89006-376-1 (1989) \$94 hardbound. Both volumes \$160. Artech House, 685 Canton St., Norwood, MA 02062.

Reviewed by Amos Gottlieb, Random Technologies, P.O. Box 170315, San Francisco, CA 94117-0315.

The editors of this two volume set have undertaken the rather ambitious task of preparing a book that they wish to be "a definitive statement of the science and technology underlying the field of fiber optic sensors." The result of their efforts in an interesting and informative collection of contributions by some of the leading experts in various aspects of fiber optic sensors. Each contribution will be a valuable resource to some portion of the multidisciplinary audience toward which the book is aimed, but the work as a whole is not comprehensive enough to meet the editors' stated goal.

The first volume, which focuses on principles and components, consists of nine chapters. The first two, "Introduction: Sensor Systems and Fiber Optics" and "Basic Concepts of Optical Fiber Sensors," were authored by the editors and are of a very general nature. Nonetheless, these two chapters provide a good warm-up for the material in the ensuing chapters.

The third chapter, "Essential Optics" by Alan Rogers of King's College London, is an excellent treatise on the basic optics related to fiber optic sensors. The material is presented with a clarity that one hopes will serve as an inspiration to future authors of introductory texts on general optics. For those who work with fiber optic sensors and have backgrounds

in fields other than optics, this chapter in itself makes the entire volume worthwhile. In addition, the accompanying bibliography will be useful to those who seek a greater depth or a more rigorous treatment than that provided here.

Chapter Four, "Optical Detectors and Receivers" by B. T. Debney and A. C. Carter, discusses many of the important issues relating to the use of solid state photodetectors in fiber optic sensor systems. In addition to general discussions on basic detection principles and materials for detectors, each important type of detector is discussed. There are very useful subsections on device capacitance, bandwidth, noise, and design considerations. The one minor shortcoming of the chapter is that there is no similar discussion concerning photomultiplier tubes (PMTs).

"Optical Sources" is the title of the fifth chapter. The authors, A. M. Yurek and A. Dandridge, cover solid state devices in some detail. Unfortunately, the discussion of white light sources is limited to one paragraph and the topic of flashlamp sources is not even broached. In light of the extensive use of these sources in some parts of the commercial sector, this will be a serious shortcoming for many potential readers of this volume.

Martin Smith authored the sixth chapter, "Material Interactions in Optical Fiber Sensors." His discussion on extrinsic, intrinsic, and evanescent sensors is quite general and will provide a good introduction to the materials basis of extrinsic and evanescent sensors based on absorption, scattering, fluorescence, phosphorescence, and surface plasmon resonance. More detailed discussions are given in various chapters in the second volume of this series.

Chapter 7, "Fiber Optic Components," was written by Nichel Dignonnet and Yuan Kim. Although the discussion is limited to single-mode fiber optic components, the chapter provides a good introduction to couplers, wave-length filters, polarization controllers, fiber polarizers, phase modulators, frequency filters, and fiber amplifiers and sources.

Chapter 8, "Optical Fibers for Sensors" by W. A. Gambling and S. B. Poole, deals with single-mode fibers in some detail and will be of use to many who use these fibers. It is quite unfortunate that this volume does not include a chapter that deals with multimode fibers in the same detail.

The final chapter of this volume was written by Ralf Kersten on the subject of integrated optics for sensors. The chapter provides a good introduction to the subject, which will educate those who are interested in this field that has so much to offer yet remains unrealized in the commercial sector.

The second volume in this series, *Systems and Applications*, includes 11 chapters and an appendix. The volume starts with "Interferometers" by D. A. Jackson and J. D. C. Jones. The chapter provides a clear discussion of the subject and includes many references to the primary literature through 1987. The next chapter, "Fiber Optic Gyroscope," was written by Hervé C. Lefèvre and is quite comprehensive. The chapter starts with a clear explanation of the Sagnac effect and takes off from there.

"Intensity and Wavelength-Based Sensors and Optical Actuators" by B. E. Jones, R. S. Medlock, and R. C. Spooncer considers intensity and wavelength modulated optical fiber sensors in a well-balanced manner. The section "Intensity-modulation limitations" begins with unbridled optimism, as the authors state that "In practice for a simple system the number of resolvable levels will be about 10^8 ." But as the section progresses with a careful discussion and analysis of the real limitations of intensity modulated sensors, a more realistic and conservative picture appears. The chapter covers a wide range of sensors and the discussion of referencing or ratio schemes is particularly welcome. In most cases the discussion is clear, but in at least one case, "Photoluminescent temperature sensors," it is so vague that it is fortunate the subject matter is also covered in another of the volume's chapters. As with many of the chapters in both of these volumes, the material is presented from a noticeably European perspective.

"Silicon in Optical Fiber Sensors" by Brian Culshaw is the thirteenth chapter. It covers the properties of silicon as well as the potential application of this material in several fiber optic sensing applications.

Chapter 14, "Point Sensor Multiplexing Principles" by Rainer Kist, is a comprehensive and timely review of the subject. The material is presented in a clear and accessible style. The more than four pages of references are current to 1988. The following chapter, "Distributed Op-

tical Fiber Sensor Systems" by J. P. Dakin, deals mainly with OTDR techniques and systems.

"Chemical, Biochemical and Medical Sensors" by Alan Harmer and Annamaria Scheggi is also quite comprehensive. Both principles and numerous applications are discussed. Various approaches to measuring parameters such as pH are compared and contrasted, and there is a very nice discussion of several approaches to temperature sensing that are actually available in the commercial market.

"Physical and Chemical Sensors for Process Control" by Kazuo Kyuma and "Applications of Fiber Optic Sensors in the Aerospace and Marine Industries" by Brian Culshaw both discuss the real application of fiber optic sensors in commercially important areas. "Some Other Applications for Fiber Optic Sensors" by A. J. A. Bruinsma and T. M. J. Jongeling discusses sensors that do not fit into the categories of the preceding chapters. Included among the topics are security and safety systems, monitoring the integrity of structures, noncontact measurements and inspection, and applications in electric power plants.

Volume II concludes with a glance at the market for fiber optic sensors by Peter McGeehin and an appendix on basic concepts of instrumentation by B. E. Jones. These volumes will certainly be of use to many who are interested in fiber optic sensors, but the lack of references to the patent literature and the inadequate indexing may limit their use as a comprehensive reference.

Quantum Electronics, Third Edition

Amnon Yariv, xx + 676 pp., illus., index, references following each chapter, appendixes. ISBN 0-471-60997-8. John Wiley & Sons, Inc., 1 Wiley Drive, Somerset, NJ 08875-1272 (1989) \$66.26 hardbound.

Reviewed by Leno M. Pedrotti, University of Dayton, Department of Physics, Dayton, OH 45469.

This is the third edition of one of the standard graduate texts on quantum electronics. Its timely appearance reflects the rapid development of the field over the past 10 years. The current version retains nearly all of the material from the previous one but includes four entirely new chapters. Specifically, the new chapters cover semiconductor lasers, free electron lasers, quantum well lasers, and phase conjugate optics. In addition, an expanded treatment of laser noise spectra and a section on squeezed states of the radiation field are included in the new edition.

Like its predecessor, the current edition of *Quantum Electronics* covers a wide range of topics related to laser physics and nonlinear optics. The emphasis is on the fundamental principles underlying the phenomena discussed, yet a large number of numerical examples reflecting the behavior of real systems is provided. When

appropriate, the author gives fully quantum mechanical treatments of given topics but does not overlook classical explanations when they are sufficient or instructive. The merits of this approach are well known to those familiar with the earlier versions of this book. In what follows, a brief description of each of the 22 chapters of this volume is presented with particular emphasis given to that material new to this edition.

The first three chapters are a review of the basic tenets and techniques of quantum mechanics. The review is quite extensive but appears to be primarily intended as reference material for the topics covered in the rest of the book. This strategy enables the author to make use of the fact that many derivations in the latter portions of the book employ the same formal techniques.

The fourth chapter covers lattice vibrations and their quantization. That this chapter appears so early presages the author's extensive treatment of solid state lasers. The comprehensive coverage of semiconductor lasers is one of the distinguishing features of this book.

Chapters 5 through 7 describe optical resonators and the propagation of the electromagnetic field. Chapter 5 includes a brief description of the quantization of the electromagnetic field that is made use of in later chapters, although not in the treatment of laser oscillation.

The next chapters are devoted to laser theory. Chapters 8 and 9 give a general semiclassical treatment of laser operation. Chapter 10 describes several common laser systems. This chapter is particularly well organized and useful as a reference source.

The next three chapters are new and deal with specific laser systems. Chapter 11 gives a comprehensive treatment of semiconductor diode lasers, with careful attention paid to both the fundamental physics of and the advantages to be found in these devices. Chapters 12 and 13 cover quantum well lasers and free electron lasers, respectively. Both are well written and essentially could be used as review articles on the subjects. This set of chapters is an extremely useful reference on these relatively new laser systems.

Chapters 5 through 13, together with Chap. 14 on the modulation of optical radiation and Chap. 20 on the Q-switching and mode locking of lasers, could compose a very thorough course on the fundamental and practical aspects of laser electronics. Chapter 22, which covers optical fibers, could also be integrated into such a course. The remainder of the book is devoted to nonlinear optics and some of the more fundamental aspects of the interaction of the radiation field with atomic systems.

Four chapters are devoted to nonlinear optics. Of these, Chap. 19 on phase conjugate optics is entirely new. It is hard to imagine that when the second edition of *Quantum Electronics* appeared only 15 years ago, phase conjugation was not yet an integral part of every text covering nonlinear optics—but such was the case. This chapter alone justifies a new edition of the book. It is an excellent exposition of the properties and appli-

cations of phase conjugating elements. The description of phase conjugate resonators in this chapter is particularly good. The other three chapters on nonlinear optics cover second harmonic generation, parametric processes, and stimulated Raman and Brillouin scattering. These are essentially unchanged from the second edition except that the current edition contains a slightly clearer discussion of the general properties of the third order susceptibility tensor as well as a new section on the generation and detection of squeezed states of the radiation field. This latter addition is especially timely and is a natural extension of the chapter on parametric processes.

The remaining chapters, Chaps. 15 and 21, deal with coherent interactions of the radiation field with an atomic system and the fundamental noise spectra of laser amplifiers, respectively. Chapter 15 is essentially unchanged from the earlier edition and treats superradiance, photon echoes, and self-induced transparency from a semiclassical point of view. Chapter 21, on the other hand, is extensively revised from the corresponding material in the second edition. It contains discussions of how the fundamental noise sources in laser amplifiers and oscillators manifest themselves in the laser spectra. This chapter includes sections on spontaneous emission noise, which it does not purport to derive from first principles, photon "shot noise," and a nice treatment of phase-amplitude coupling in laser noise.

The third edition is an improved version of what was already an excellent book. All of the added material is timely and well presented. The current version at least touches on all of the important topics in quantum electronics and gives quite extensive, self-contained treatments of many. In fact, the book covers so many topics that some judicious choices need to be made if one wishes to use it as a text for a graduate course. Fortunately, for the most part, the book is organized so that omission of selected topics can be made without seriously degrading the integrity of the remaining material. *Quantum Electronics* remains an excellent text and reference book on the subject.

Photorefractive Materials and Their Applications I: Fundamental Phenomena

P. Günter and J.-P. Huignard, eds., Topics in Applied Physics Vol. 61, xvi + 295 pp., illus., index, references. ISBN 3-540-18332-9. Springer-Verlag, 175 Fifth Ave., New York, NY 10010 (1988) \$69.50 hardbound.

Reviewed by Nils C. Fernellus, Wright Research and Development Center, Electromagnetic Materials Division, Air Force Materials Laboratory, WRDC/MLPS, Dayton, OH 45433.

This is the first book in a rapidly developing field. Photorefractive effects result from a polarization change of an electro-optic caused by a

photoinduced charge transfer. High optical nonlinearities can be obtained in photorefractive materials at milliwatt laser power levels. These nonlinearities lead to applications in optical signal processing, real-time holography, and phase conjugation. The purpose of the book is to provide background for the fundamentals in these areas.

Chapters 1 and 2 by Günter and Huignard cover photorefractive effects and materials. For large photorefractive efficiency, suitable donors or traps and efficient charge migration are necessary. Three mechanisms affect the movement of photoexcited free carriers: diffusion, drift (when an external electric field is applied), and the photovoltaic effect (a photocurrent produced with no applied voltage). These subjects, grating formation, and salient properties of various photorefractive materials are covered rather tersely.

Chapter 3, by George C. Valley and Juan F. Lam, covers the theory of photorefractive effects in electro-optic crystals. Chapter 4, by Nicolai V. Kukhtarev, covers dynamic holographic gratings and optical activity for several light beam configurations in photorefractive materials with symmetry group 3m. A number of applications are briefly mentioned. Chapter 5, "Photorefractive Centers in Electro-optic Crystals," is by E. Krätzig and O. F. Schirmer. ESR, optical absorption, Mossbauer effects, photovoltaic effects, and photoconductivity are described for various centers usually incorporating Cu or Fe impurities in LiNbO_3 and LiTaO_3 .

Chapter 6 is by Ruth A. Mullen and deals with photorefractive measurements of physical parameters. Hopping mechanisms in photorefractive charge transport are treated, and steady-state, transient, and short-pulse measurements are described. Chapter 7, by Marvin B. Klein, is on photorefractory properties of BaTiO_3 . It covers crystal growth techniques, dielectric and electro-optic properties, defect models (mainly Fe), transport measurements, beam coupling experiments, optical absorption, and EPR measurements.

A. M. Glass and J. Strait wrote Chap. 8, "Photorefractive Effect in Semiconductors." The maximum sensitivity (index change per absorbed photon density) of a material is $n^2 r_{ij} / \epsilon_j$, where n_i is the refractive index, r_{ij} is the electro-optic coefficient, and ϵ_j is the relative dielectric constant. Using this criterion, several II-VI semiconductors are better than ferroelectrics. Types of defects that provide the desired shallow donors and material response times are discussed. Several experimental arrangements including four-wave mixing and beam coupling are shown. Chapter 9, "Nonstationary Holographic Recording for Efficient Amplification and Phase Conjugation" by S. I. Stepanov and N. V. Petrov, covers the theory of holograms recorded in a steady and in an alternating electric field. Experimental results in BSO and BTO are presented.

On the whole, the book is reasonably free of misprints. While it is not easy reading in spots, it is still the best source for getting into the field.

Books Received

Laser Spectroscopy, edited by Michael S. Feld, John E. Thomas, and Aram Mooradian. Proceedings of the Ninth International Conference on Laser Spectroscopy, Bretton Woods, New Hampshire, June 18-23, 1989. xxvi + 509 pp., illus., index of authors, references. ISBN 0-12-251930-2. Academic Press, Inc., 1250 Sixth Ave., San Diego, CA 92101 (1989) \$49.95 hardbound. Sections cover new cooling mechanisms, laser spectroscopy, noise and coherence, quantum size effects, surface spectroscopy, laser light sources, trapped ion spectroscopy, ultrafast spectroscopy, fundamental measurements, molecular spectroscopy and dynamics, applications in radiation forces, highly excited states and dynamics, and laser spectroscopy for biomedicine.

Modern Optics, by Robert D. Guenther. xvi + 696 pp., illus., index, references. ISBN 0-471-60538-7. John Wiley & Sons, Inc., 1 Wiley Drive, Somerset, NJ 08875-1272 (1990) \$59.95 hardbound. Textbook includes some material not found in more conventional textbooks. Chapters cover wave theory, electromagnetic theory, reflection and refraction, interference, geometrical optics, Fourier analysis, dispersion, coherence, diffraction and Gaussian beams, Fraunhofer diffraction, Fresnel diffraction, holography, anisotropy, optical modulation, and nonlinear optics.

The Physics of Moiré Metrology, by Oded Kafri and Ilana Glatt, xiii + 194 pp., illus., subject index, references following each chapter, list of symbols after some chapters, one appendix. ISBN 0-471-50967-1. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158 (1990) \$34.95 hardbound. Discusses a new metrological approach that treats the gratings used in moiré analysis as an artificial analog to electromagnetic waves and enables comparison with conventional optical methods based on wave properties (i.e., interferometry). Includes a summary of the applications of moiré interferometry and moiré deflectometry.

Single-Mode Fiber Optics: Principles and Applications, Second Edition (Revised and Expanded), by Luc B. Jeunhomme, ix + 339 pp., illus., subject index, list of symbols, references, three appendixes. ISBN 0-8247-8170-8. Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016 (1990, first edition published in 1989) \$99.75 hardbound (U.S. and Canada) and \$119.50 (all other countries). Discusses high birefringence fibers, fiber attenuation control, dispersion-shifter fibers, standard measurement procedures, connectors and splicing equipment, long-distance terrestrial and undersea communications systems, coherent transmission systems, and the fiber optic gyro.

Physics of Semiconductor Devices, by Michael Shur, xxiv + 680 pp., illus., subject index, list of symbols, 27 appendixes, references and problems following each chapter. ISBN 0-13-666496-2. Prentice Hall, Inc., Englewood Cliffs, NJ 07632 (1990) \$57.40 hardbound. Covers new ideas, theories, models, and practical applications of semiconductor electronics as well as developments, such as amorphous silicon, compound semiconductor technologies, and novel

heterostructure transistors. Appendixes include extensive information on semiconductor parameters of many important materials.

Principles of Electronic Ceramics, by L. L. Hench and J. K. West, xviii + 546 pp., illus., subject index, one appendix, reading list, and problems following each chapter. ISBN 0-471-61821-7. John Wiley & Sons, 605 Third Avenue, New York, NY 10158-0012 (1990) \$54.95 hardbound. Discusses the physical theory underlying each type of electronic ceramic, applying quantum mechanics, statistical mechanics, field theory, and thermodynamics.

An Invitation to Cognitive Science: Visual Cognition and Action, edited by Daniel N. Osherson, Stephen M. Kosslyn, and John M. Hollerback, second volume of a three-volume set, x + 356 pp., illus., subject index, references and questions following each chapter. ISBN 0-262-15036-0 (hardbound) and 0-262-65034-7 (softbound). The MIT Press, 55 Hayward Street, Cambridge, MA 02142 (1990) \$37.50 hardbound, \$18.95 softbound. Discusses different areas of visual cognition showing how varied types of research fit together. Also covers the properties of neural circuitry, sensory receptors and muscle, the mechanics of movement, and planning and sequencing.

Adaptive Pattern Recognition and Neural Networks, by Yoh-Han Pao, xviii + 309 pp., illus., subject index, two appendixes, references following each chapter. ISBN 0-201-12584-6. Addison-Wesley Publishing Company, Inc., 1 Jacob Way, Reading, MA 01867-9984 (1989) \$35.95 hardbound. First part covers basic concepts and recent developments and the second part discusses adaptive pattern recognition as implemented with networks of elemental processors, interconnected like biological neural nets.

Fiber Optics Handbook: For Engineers and Scientists, edited by Frederick C. Allard, xiv + approximately 530 pp., illus., subject index, one appendix, references following most chapters. ISBN 0-07-001013-7. McGraw-Hill, 11 West 19th Street, New York, NY 10011 (1990) \$69.50 hardbound. Covers key aspects involved in the selection, specification, and application of fiber optics: basic fiber properties, systems, test procedures, and design parameters. Includes comparative data on the full range of components available to systems developers.

Optical Technology and Wideband Local Networks, edited by J. E. Midwinter, W. A. Gambling, C. J. Todd, and W. J. Stewart, from proceedings of a Royal Society discussion meeting held in London on June 29 and 30, 1988, first published in Philosophical Transactions of the Royal Society of London (Series A, Volume 329, No. 1603), viii + 152 pp., illus., discussion sections following most chapters. 0-85403-386-6. The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG (1989). £35.00 United Kingdom, £37.50 other countries. Offers short papers written by specialists who participated in a two-day discussion meeting. Topics covered include photoswitching, broadband ISDN, lithium niobate devices, and the role of the consumer in electronic development. ☺