DEPARTMENTS

BOOK REVIEWS

Electro-Optical System Design: For Information Processing

Clair L. Wyatt, xiv + 343 pages, illus., index, references, four appendixes, glossary. ISBN 0-07-072184-X. McGraw-Hill, Inc., 1221 Avenue of the Americas, New York, NY 10020 (1991). $49.95 hardbound

Reviewed by Robert M. Bunch, Rose-Hulman Institute of Technology, Department of Physics and Applied Optics, Terre Haute, IN 47803.

Electro-Optical System Design: For Information Processing is not a new book. *Electro-Optical System Design* is another printing of an older book titled *Radiometric System Design*, by the same author, but with some modifications. The original book was published in 1987 by Macmillan Publishing Company and was reviewed by W. L. Wolfe, *Opt. Eng.* 26, SR-187 (1987). I find it interesting that the older book is not mentioned or referenced in the current version.

In general I like the concept of this book, although I do not like some of the details of the presentation. I fully agree with the author's pedagogical approach: "(1) to trace the signal flow from the source through the system and (2) to develop a radiometric performance equation . . . " One of the major attributes of this textbook is the large number of sample problems in each chapter. Sample problems are essential if a book is to be used for teaching a course. There are also problems/exercises following each chapter.

My main objections to the book are the organization of topics and the emphasis placed on some of the topics. The following review includes some specific observations on the text, a description of the material covered in the book, and some comparisons to the last version of the book.

I hope that people are not misled by the title of this text. First, I must admit that my own bias is to use the term electro-optics only when discussing the electro-optic effect. However, electro-optics is a term that has been used by many people over the years to describe a system comprised of an optical subsystem combined with an electronic subsystem to form a complete system. Second, I do not understand the reasons for adding the subtitle "For Information Processing." The author has a broad definition of information processing systems that includes all optical systems other than "systems designed to utilize optical energy for work." While it is true that most optical systems are designed to transfer and/or extract information, the term information processing has more recently come to mean processing images/signals either using optical or digital techniques, as in the case of character/pattern recognition. Somehow I do not think of a laboratory spectrometer (Sec. 1.4.2) or an optical communication link (Sec. 1.4.4) as examples of information processing systems.

Electro-Optical System Design: For Information Processing is divided into two parts: (1) Figures of Merit and Feasibility Study and (2) Detailed Design. I do not understand the author's motivation for dividing the material into these parts. If I were to teach a course using this book, I would not follow the same chapter sequence.

Part 1 includes Chaps. 1 through 9. Chapter 1 is an introduction to systems and includes a number of specific examples of optical systems. An excellent overview of the design process is given in Chap. 2. This topic is rarely quantified in textbooks and will be of value to students learning about designing optical/electronic systems. Other subjects discussed in this part of the book are radiometry including radiant sources (Chap. 3), transfer of radiant flux (Chap. 4), and detection of radiant flux (Chap. 6). Chapter 6 gives a general overview of detector specifications and saves the discussion of detector types for later chapters. Design considerations of the optical and electronic subsystems are given in Chap. 5, The Optical Subsystem, and in Chap. 7, Signal-Conditioning Electronics. Part 1 concludes with a discussion on devising a radiometric performance equation for a system (Chap. 8) and a Feasibility Study (Chap. 9). The definition and characterization of noise and noise mechanisms is integrated into the discussion in several of the chapters.

Part 2 is titled Detailed Design. This part includes the topics Blackbody Radiation (Chap. 10), Optical Media (Chap. 11), and Optical Systems (Chap. 12). I do not understand why a discussion of basic optics and physics is considered detailed design. Inclusion of these topics may be necessary for completeness, but they are background material. Chapter 13 covers imaging systems from the point of view of modulation transfer function (MTF). This chapter is somewhat cumbersome to read. For example, two of the sections (13.2 and 13.5) cover the MTF of a system. The remaining topics in Part 2 include baffling in optical systems, a survey of various types of detectors and their applications, low-noise preamplifiers, and calibration and error analysis. Chapter 14 on Baffling in Optical Systems is an excellent description of the effects of baffles and overview of the characterization of stray light in optical systems. A single chapter is devoted to each of the following detector types: Thermal Detectors (Chap. 15), Photon Noise Limited Detectors (Chap. 16), Multiplier Phototube Detectors (Chap. 17), and Blocked Impurity Band Detectors (Chap. 18). Chapter 19 discusses the characteristics of low-noise preamplifiers. Chapter 20 concludes the text with a discussion of errors, system response characteristics, and calibration requirements.

At first glance, if one compares *Radiometric System Design* and *Electro-Optical System Design,* they look like the same book. Both books even have the same type font. However, on more careful examination, some differences exist. The most obvious is the insertion of a new Chap. 18 on Blocked Impurity Band Detectors. Also, Sec. 5.11 on the numerical integration of spectral response functions has been added. Several other corrections, expansions, and clarifications were made to the text. For example, Secs. 7.5 on noise and 7.6 on coherent rectification have been updated and expanded. I believe that many of the changes made in this version were done to address the comments in Wolfe's review of *Radiometric System Design,* Like the previous reviewer, I am confused by the symbols definition and terminology used in Eq. (8.2). Is f_2 the information bandwidth as given in Table 8.1 and the glossary or is it the upper frequency limit as defined in Eq. (7.3)? If they are the same value, that fact should be explicitly stated.

Again, I like the concept of this book. I particularly like the chapters that emphasize the design process. The discussions of radiometry

and detectors are at an appropriate level for students. When one understands what this book is about, the textbook could be useful in teaching a course.

Handbook of Microwave and Optical Components: Volume 4, Fiber and Electro-Optical Components

Kai Chang, Ed., xi + 484 pages, illus., index, references, contributors list. ISBN 0-471-61365-7. John Wiley & Sons, 605 Third Ave., New York, NY 10158-0012 (1991). $74.95 hardbound.

Reviewed by David L. Flannery, University of Dayton, Research Institute, 300 College Park, Dayton, OH 45469-0140.

This book is the fourth and apparently final volume of the title series; the first three volumes cover Microwave Passive and Antenna Components, Microwave Solid-State Components, and Optical Components. (Vol. 3, reviewed in the July 1990 issue of *Optical Engineering*). The book is a compendium of eight stand-alone chapters contributed by different authors, each addressing a particular component category. The chapters constitute a unique document in terms of the broad scope of devices and principles covered at levels ranging from introductory and tutorial to reviews of the state of the art. Thus the book has the potential to be a valuable reference, as implied by its handbook designation. *Fiber and Electro-Optical Components* fulfills this potential in many respects, but has significant shortfalls that will be summarized after a discussion of the individual chapters.

The first chapter, by Chinlon Lin, covers optical fibers for transmission. The chapter contains a concise summary of key theoretical results and concepts, such as numerical aperture and normalized frequency. Fiber transmission technology is briefly reviewed, including multi- and single-mode design considerations, wavelength division multiplexing, and transmission limitations due to loss and dispersion. Laser diode sources are briefly discussed. The chapter touches upon a few topics concerning future directions for optical transmission technology, just enough to give the flavor and a few key references.

The theoretical treatment would be appropriate for anyone at graduate level or beyond who is involved in optics or microwaves and wants to learn the basic equations, concepts, and design relationships quickly. This person would have to consult the cited references to verify or obtain details behind the material presented.

The author speaks authoritatively about practical fiber components and their application to transmission, but the chapter could benefit from expanded coverage in this area. A table of properties of current fiber optic components is an example of a desirable addition, and perhaps a discussion of the critical design aspects and performance of one or more actual transmission systems would work well here.

The second chapter, written by Talal K. Findakly, addresses optical channel waveguides and couplers. The chapter is 20 pages long and cites only eight references, the most recent of which is from 1978. First, a very abbreviated introduction to the theory of planar waveguides is presented. Then, channel waveguide concepts, configurations, and theoretical treatments are concisely reviewed. Very little practical information on actual materials and designs of channel waveguides is given. About half the chapter concerns optical directional couplers using channel waveguides, including a chart for calculating the parameters of Ti:$LiNbO_3$ 2 × 2 directional couplers.

Although not an expert on channel waveguides, I wonder if any subject deserving a chapter in this handbook can be adequately covered by such a short treatment using such ancient references. Perhaps no better exposition of channel-waveguides-based directional couplers was deemed to exist by the editor, in which case its inclusion is a plus and thus justified.

Chapter 3 presents planar optical waveguides and waveguide lenses and was written by Shi-Kay Yao. This chapter is one of the two longest in the book and is an excellent contribution. Yao starts with a tutorial review of planar waveguide theory and concepts (overlapping the similar section in the previous chapter). The discussion transitions into practical materials and implementations, with appropriate and generous use of tables and graphs to support the text. Another major section of the chapter covers passive optical elements, with emphasis on waveguide lenses of the refractive, geodesic, and diffractive types. Small sections on waveguide measurement techniques and applications conclude the chapter. Large doses of specific practical information and extensive use of figures and graphs characterize the entire chapter, which cites over 200 references.

The fourth chapter, entitled Optical Modulation: Electro-Optical Devices, was contributed by S. Thaniyavarn. The chapter begins with a tutorial review of the underlying theory and then presents examples of waveguide electro-optic devices fabricated on $LiNbO_3$, including phase modulators, interferometers, directional couplers, and polarization modulators. A final short section discusses high-speed modulation issues. The chapter is relatively short (30 pages) and does not cover bulk electro-optic modulation devices.

The next chapter was written by Chen S. Tsai and covers optical modulation with acousto-optical devices. Tsai starts with a brief tutorial on Bragg interactions, including anisotropic diffraction. The remainder of the chapter is concerned with acousto-optic modulation in planar waveguides. The treatment is thorough and detailed with ample supporting figures and graphs, including a chart of the relevant properties of several important acousto-optic materials and another chart tabulating measured performances with GaAs waveguide Bragg cells. Key performance parameters and design methods, including transducer designs, are covered in adequate detail. Applications to communications, signal processing, and computing are discussed. Numerous references are cited throughout. Following the pattern of prior chapters, no significant discussion of bulk acousto-optic device technology is included.

Chapter 6 concerns optical modulation with magneto-optic devices and was written by Alan E. Craig. The chapter begins with a relatively extensive presentation of theoretical background on the material physics of magnetics and optics. The 33-page length is entirely appropriate in this reviewer's opinion, because the physics of magneto-optical phenomena is not familiar to most readers. The section is detailed and well executed, with good use of diagrams.

A substantial section entitled Real Materials follows. The section presents detailed information on several important materials and includes a number of pertinent graphs showing the parametric variation of magneto-optic properties. As stated in the next section, which addresses Modern Magneto-Optic Devices, not many such devices exist. However, the author does a laudable job of discussing those few, including isolators, modulators, spatial light modulators, and magneto-optic data-recording technology. Stripe-domain and magneto-static guided wave devices are included. This chapter is distinguished from those previous in its emphasis on bulk wave devices rather than guided wave devices. The chapter is excellent; the sections provide much useful information and are well illustrated. Not only are many references cited, but an extensive listing of suggestions for further reading is provided, an item not found in any other chapter.

Chapter 7 is a brief treatment of optical detectors, written by P. K. L. Yu and H. D. Law. The first part covers terminology and material considerations and constitutes a summary of important concepts rather than a tutorial or review. Topics covered thereafter include photodiodes, PIN photodiodes, Schottky photodiodes, avalanche photodiodes (APD), and photoconductive devices, with avalanche devices getting the bulk of the coverage. One

chart giving ionization threshold energies is provided.

A final section on recent developments mentions III-V phototransistors, graded bandgap APDs, superlattice APDs, and other novel structures, all in the space of about four pages. What is presented in this chapter is good, but it falls short of handbook billing. This chapter lacks sufficient detail and practical design information (e.g., charts of available detectors), especially considering the fact that this area encompasses probably the most mature technology covered in the book.

The final chapter covers liquid crystal technology and was written by Uzi Efron. This is the longest chapter in the book (114 pages) and one of the best. The sections discuss the physical and optical properties of liquid crystals, liquid crystal spatial light modulators, and applications. The chapter concentrates heavily on spatial light modulators and puts less emphasis on ferroelectric liquid crystals than a balanced treatment would dictate, but this is a natural reflection of the author's personal experience and is compensated for by the wealth of detailed and useful information that is presented. The chapter uses many effective illustrations and cites over 200 references. A chart of material properties of important liquid crystals would have been useful in this handbook but is not included.

The chapters in this "handbook" are generally written well and provide much useful information. As mentioned earlier, several factors detract from the value of the text as a handbook. The quality and scope of the chapters are very uneven. Several of the shorter chapters provide insufficient practical design information (expected in a handbook). The book has a mysterious lack of information on bulk electro-optic and acousto-optic devices. The chapters on these modulation techniques read as if the authors were instructed to consider primarily guided wave devices, but this limitation of scope is not explained or acknowledged, and the title of the book implies a broader scope as does the wording of the preface. Although this is perhaps intrinsic to the book publishing process, this reviewer is disturbed that in a book with a 1991 copyright, almost no references with dates more recent than 1988 were cited.

Of the eight chapters in this book, about four (those concerning planar optical waveguide technology, acousto-optic devices, magneto-optical devices, and liquid crystal devices) are worthy of a handbook. The lack of detailed information in the remaining chapters, and even the lack of information on bulk devices in two of these four chapters, are serious deficiencies that keep the book from living up to the promises of the preface: ". . . this handbook covers almost all important components in . . . (the) optical frequency spectra" and "The book provides, in practical fashion, a wealth of essential principles, methods, design information, ..." Nevertheless, this is overall a good book and should constitute a useful reference for many

BOOKS RECEIVED

Introduction to Semiconductor Materials and Devices, edited by M. S. Tyagi. 669 pp., illus., references. ISBN 0-471-60560-3. John Wiley & Sons, Inc., 1 Wiley Drive, Somerset, NJ 08875-1272 (1991) $62.95 hardbound. Covers atomic structure and statistical mechanics, crystalline solids and energy bands, semiconductor materials and their properties, carrier transport in semiconductors, excess carriers in semiconductors, static I-V characteristics of p-n junction diodes, majority carrier diodes, microwave diodes, optoelectronic devices, bipolar junction transistors, junction and metal-semiconductor field-effect transistors, circuit models for transistors, technology of semiconductor devices and integrated circuits, and semiconductor measurements.

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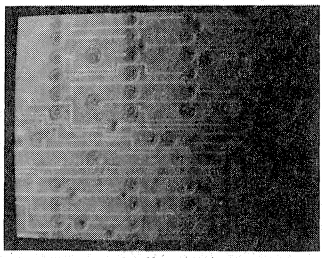

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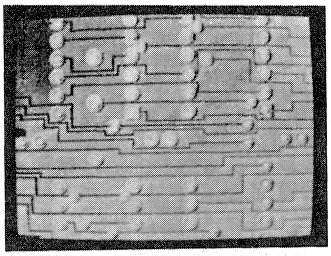

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