DEPARTMENTS

BOOK REVIEWS

Electro-Optics Handbook

Roland W. Waynant and Marwood N. Ediger, Eds., 1024 pages. ISBN 007-068-6637. McGraw-Hill Inc., 1221 Avenue of the Americas, New York, NY 10020 (1994) $89.50 hardbound.

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Practicing scientists and engineers as well as technical managers and advanced students often desire a single reference book that provides them with the physical principles, technologies, data, and source references that are fundamental to their work. In the past, the field of electro-optics has been served by *The Infrared Handbook*[1] and the *Handbook of Optics*,[2] as well as a number of specialty handbooks. Although the former has recently been extensively revised in multivolume form, it does not provide coverage of short-wavelength spectral regions. The latter, published in 1979, does not treat many of the emerging subfields of current interest. Accordingly, this reviewer feels the need for a new handbook devoted to electro-optics. The *Electro-Optics Handbook* is reasonably successful in filling this need.

To be useful, handbooks should provide five types of information: (1) tutorials covering basic physical principles; (2) design rules for applying these principles; (3) data on important materials; (4) descriptions of components and systems used in applications; and (5) references to more detailed treatments of these items. For the most part, the *Electro-Optics Handbook* does an excellent job in this regard. General discussions of weak and strong aspects of the volume are presented next, followed by recommendations and detailed comments on each chapter.

Assembling a handbook covering such a diverse field as electro-optics is a significant undertaking, and the common approach is to rely on contributions from many authors. While this has the strong advantage of applying the expertise of specialists in the relevant subdisciplines, it often leads to uneven treatments from topic to topic. Here, for example, some of the discussions of fundamental principles are highly detailed, while others are primarily qualitative overviews. The number of references for each chapter is also highly variable, ranging from a low of 4 for Chap. 25 (Material Processing Applications of Lasers) to a high of 280 for Chap. 11 (Optical Materials—Visible and Infrared).

The use of many authors also leads to duplication and dispersement of information. In this case, where six chapters are devoted to lasers and four to detectors, there is considerable repetition, and readers may have to study several chapters to satisfy their needs. It might have been preferable to consolidate the tutorials on lasers and detectors into separate chapters.

Another challenge facing handbook compilers is the choice of topics, given the desire that the volume be reasonable in size. Here, the selection generally includes sources, detectors, materials, and applications. Omitted topics that may have been useful include atmospherics (the preface alludes to applications in atmospheric pollution monitoring), polarization, modulation, fiber optics communications, and electro-optical systems design. Since most of these subjects are fairly mature and have been adequately covered in the previously cited handbooks, their omission is understandable. Users will still find the old handbooks necessary.

On the plus side, the *Electro-Optics Handbook* provides extensive coverage on several welcome topics including sources, detectors, and materials for the x-ray and ultraviolet spectral regions; nonlinear optics and phase conjugation; laser spectroscopy and photochemistry; medical applications; optical and optoelectronic integrated circuits; and material processing. Generally, these treatments furnish good overviews with references to current and archival literature.

Chapter 1 provides a very broad overview of the field of electro-optics as well as the handbook itself. It provides spectral summary charts on lasers, detectors, and materials. There does appear to be an error in Fig. 1.5 where the spectral range of thermopile detectors is given as extending from only 0.2 to 0.5 μm.

Chapter 2 on noncoherent sources provides a review of radiometry and photometry, discusses measurements and calibration techniques, and provides spectroradiometric data for a variety of natural and artificial sources. This chapter could have used additional editorial review to correct a number of problems with figure axis labels. [2.3, 2.22(a), and 2.27] and parameter definitions [projected area, solid angle, d in Eq. (2.15), and the use of ϕ for both radiant flux and azimuthal angle]. There is a statement that the Nernst glower and global sources produce much higher levels of radiation in the 2- to 15-μm spectral regions; this is misleading in that the comparison involves, presumably, different source temperatures.

Lasers are covered in Chaps. 3 through 8 with separate treatments of short-wavelength (UV, VUV, and x-ray), visible, solid state, semiconductor, infrared gas, and free-electron laser systems. Techniques for the generation of ultrashort laser pulses are described in Chap. 9. Most of the general laser physics is given in the short-wavelength chapter, while tutorials specific to semiconductor and free-electron lasers are contained in chapters devoted to these laser types. The discussion includes spectroscopy, pumping, resonator design, and descriptions of commercial systems. Surprisingly, Chap. 4 on visible lasers is the shortest with only nine references. The references included in Chap. 6 on semiconductor lasers are primarily texts, and these are not directly cited in the text.

Electro-optic materials for the UV/VUV and visible/IR spectral regions are covered in Chaps. 10 and 11, respectively. Each chapter provides more than 200 reference citations. Chapter 10 presents results of the Lorentz oscillator theory, the Kramers-Kronig rela-

tions, and the Sellmeier refractive index model. This chapter describes each of the most important transmissive and reflective materials and provides summary information in tabular form. Damage, durability, and fabrication issues are also addressed. The treatment in Chap. 11 focuses more on tabular data with 68 pages of tables giving physical, mechanical, thermal, and optical data for important oxide, halide, semiconductor, nonlinear, metallic, glass, and plastic materials. A notable inclusion is a listing of Sellmeier parameters for visible/IR and for microwave spectral bands. This chapter should be well used by most practicing scientists and engineers.

Chapter 12 is a tutorial on optical fibers that includes a good overview of waveguide theory, a review of important materials, descriptions of fabrication techniques, and discussions of loss and dispersion mechanisms and underlying theory. As noted earlier, it would have been useful to include a companion chapter on fiber optic communications systems.

Chapters 13 and 14 are tutorials on nonlinear optics and phase conjugation, respectively. The nonlinear optics treatment includes summaries of the harmonic and anharmonic oscillator models and discussions of effects associated with second- and third-order nonlinearities in the susceptibilities. The chapter concludes with a review of propagation through nonlinear materials. Chapter 14 on phase conjugation beings with a qualitative description of the effect, followed by a theoretical treatment of four-wave mixing. Photorefractive, stimulated scattering, and adaptive optics mechanisms for generating conjugate beams are then reviewed, and the chapter concludes with a discussion of applications.

The next four chapters are devoted to radiation detectors in the x-ray/UV (Chap. 15), visible (Chap. 16), and IR (Chap. 17) bands and to imaging detectors (Chap. 18). The x-ray/UV treatment concentrates on describing the range of device types available including those based on photographic film and on photoionization, photoemission, photoconduction, photovoltaic, and scintillation effects. Both nonimaging and imaging types are discussed. Chapters 16 and 17 describe visible and IR detectors from a user's perspective, defining performance metrics and giving engineering expressions for noise and responsivity parameters. Photographic film and photon and thermal detector types are discussed. Both chapters also provide a guide including charts and tables helpful in selecting appropriate devices for specific applications. Chapter 18 on imaging detectors begins with a tutorial overview of photosurfaces, image tubes, and solid state imagers and continues with a nice theoretical performance model of imaging systems that includes system modulation transfer function formulas.

Chapter 19 gives a very brief (17 pages including 2-1/2 pages of references) overview of holography. It includes a detailed theoretical model of holographic imaging and a simple graphic description of reflection and transmission holograms that applies to thick or thin media. A brief discussion of fabrication issues is followed by an outline of current applications of holography. Although the chapter lacks detail, a good set of references is provided.

Laser spectroscopy and photochemistry are reviewed in Chap. 20. The treatment includes descriptions of the fundamentals, apparatuses, and typical results for laser-induced fluorescence, absorption spectroscopy, multiphonon spectroscopy, and nonlinear laser spectroscopy (including CARS, saturation and coherent transient types). Photochemistry applications covered include photochemical vapor deposition, vitamin D synthesis, and purification.

Two chapters provide broad practical overviews of specific engineering applications of electro-optics. Chapter 21 covers the use of fiber optics in sensing applications including transduction techniques and sensor components. Descriptions of sensors for temperature, pressure, acceleration, rotation rate, and electric/magnetic field measurement are given. Chapter 25 covers processing of materials using lasers. The three commonly used lasers (Nd:YAG, CO_2, and excimer) are described and evaluated for various processing tasks. Qualitative discussions of surface treatment, welding, drilling, cutting, marking, and microelectronics applications complete the chapter.

Three chapters address various aspects of optoelectronics. Chapter 22 reviews high-resolution lithography techniques for fabricating optoelectronic devices, Chap. 26 discusses optical integrated circuits, and Chap. 27 treats optoelectronic integrated circuits. The lithography chapter reviews fundamentals (including special constraints for optoelectronics) and describes optical, e-beam, x-ray, holographic, and pattern transfer techniques. Fabrication examples for lasers, integrated optoelectronic devices, binary optics, and modulators are also given. Chapter 26 concentrates on optical waveguide devices and includes surveys of waveguide theory, design, and fabrication issues. Grating components and passive and functional waveguide devices are described and several optical integrated circuit systems are detailed. Chapter 27 concentrates on optoelectronic devices and systems based on III-V semiconductors and includes descriptions of basic light source, detector, and electronic devices. Fabrication techniques are reviewed and several complete integrated circuits are described.

Laser safety in research and development laboratories is discussed in Chap. 23. The treatment summarizes biological effects of radiation and reviews the development of safety standards. Tables complied from the ANSI 136 standard and FDA regulations are included, and guidelines for safe laboratory operation are given.

Medical applications of lasers are reviewed in Chap. 24. Propagation and tissue/laser interactions are discussed, and a table presents scattering, absorption, and anisotropy parameters for a wide selection of human and animal tissues at several wavelengths. Current applications of retinal photocoagulation, port wine stain treatment, blood vessel welding, angioplasty, and photochemical treatment are described.

The *Electro-Optics Handbook* will likely prove most useful to the generalist who needs information spanning a wide range of topics. The chapters on materials will likely be quite valuable to most practicing engineers and scientists and may well be worth the price of the volume. Other potential purchasers may wish to study the detailed comments presented here or to review a library copy before committing. For my part, the volume will be a welcome addition to my personal library.

References

1. W. L. Wolfe and G. J. Zissis, Eds., *The Infrared Handbook,* Environmental Research Institute of Michigan, Ann Arbor (1985).
2. W. G. Driscoll, Ed., *Handbook of Optics,* McGraw-Hill, New York (1978).

BOOKS RECEIVED

Optical Communication Systems, Second Edition, by John Gowar. xvi + 696 pp., illus., bibliographical references and problems following some chapters, summaries following each chapter, subject index, appendixes at end of book. Part of the Prentice Hall International Series in Optoelectronics. ISBN 0-13-638727-6. Prentice Hall International (UK) Ltd., Campus 400, Maylands Avenue, Hemel Hempstead, Hertfordshire, HP2 7EZ, United Kingdom (1993) $53 softbound. Covers new material on inelastic scattering, nonlinear propagation, optical amplifiers and coherent systems; emphasizes single-mode fibers and new technology; explores the physical limitations of optoelectronic components; contains selected exercises, and solutions are available.

Optoelectronics: An Introduction, Second Edition, by J. Wilson and J.F.B. Hawkes. xiv + 470 pp., illus., references/bibliographical