

# DEPARTMENTS

## BOOK REVIEWS

### **Coherent Optics: Fundamentals and Applications**

Werner Lauterborn, Thomas Kurz, and Martin Wiesenfeldt, X+294 pages, illustrations, index, references, lists of additional readings, two appendixes, problems following each chapter (except Chap. 2), and solutions at the end of book (Appendix 2). ISBN 3-540-58372-6. Springer Verlag, 175 Fifth Avenue, New York 10011 (1995) \$49 hardbound.

**Reviewed by Minhua Liang**, Neuristics Corporation, 110 West Road, Suite 435, Baltimore, MD 21204-2316.

This book is planned by the authors "to promote the foundations of coherent optics" and to "enable the reader to follow the contemporary literature from a firm basis." After I finished reading it, I found that this book does indeed serve this purpose. The authors' research and teaching experiences have made this book a good form of presentation. I recommend this book as an introductory text book to junior undergraduates majoring in natural science or engineering and having interests in coherent optics, and as a supplementary reading material to senior undergraduates and graduates in the fields related to coherent optics.

*Coherent Optics: Fundamentals and Applications* covers a wide area, including the history of optics, the classification of optical fields, fundamentals of wave optics, coherence, multiple-beam interference, speckle, holography, interferometry, Fourier optics, nonlinear dynamics of the laser, nonlinear optics, and fiber optics. There's no doubt that such a wide area of content cannot be covered in a detailed fashion and it has to be concise. Although the selection of the contents was subject to the authors' opinions, they are actually quite comprehensive. The authors try to give the reader a whole view of the area that coherent optics can mainly cover, so that a newcomer to the field of optics will not be tangled by several specific problems, although these specific problems may turn out to be very important.

The style of this book is concise, fundamental, and easy to understand. Each chapter starts with basic concepts and principles that are usually described by concise mathematical equations. These equations are also easy to follow and not intimidating.

The physical meanings of the basic concepts and principles are well explained. Some typical applications of the basic concepts and principles are introduced. To help the reader to understand well and know more, the authors also furnished problems, references, and additional readings at the end of each chapter.

There are two chapters that have relatively richer contents than the other chapters. They are Chap. 7, "Holography" and Chap. 9, "Fourier Optics." These two chapters have more detailed presentations in the aspects of principles and applications. Appendix 1, "The Fourier Transform," is helpful for the reader to refresh the basics in Fourier transform. Appendix 2, "Solutions to Problems," gives the reader a reference to check answers to problems in real time.

The authors present the contents in a good order. They start with the history of optics in Chap. 1. In the section of past history, they discuss the major scientists and events that made big contributions to optics. In the section of the present, they discuss the popular and important fields in which coherent optics has applications. In the section of the future, they start and end with questions to challenge the reader. In Chap. 2, they classify optics into four main areas: geometrical optics, wave optics, quantum optics, and statistical optics. Only wave optics is highlighted by this book. Chapter 3 introduces the fundamentals of wave optics. It starts with Maxwell equations then goes to a wave equation via a concise mathematical derivation. Solutions to the wave equation, such as one-dimensional waves, plane waves, spherical waves, and Bessel waves, are presented. The expression for intensity of light wave is derived thereafter.

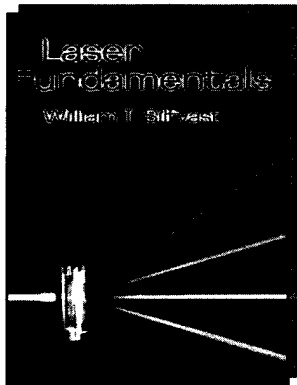
In Chaps. 4 to 9, they introduce the concepts, principles, and applications in several different aspects of light wave propagation. They start with the concept of coherence in Chap. 4. After the definition of temporal coherence, spatial coherence, and spatiotemporal coherence, the applications are naturally derived, such as stellar interferometry, Fourier transform spectroscopy, and intensity correlation. Chapter 5 has an emphasis on multiple beam interference, the principle of which is exemplified by the Fabry-Pérot interferometer. The applications to interference spectroscopy,

difference-frequency analysis, and dual-recycling interferometers are introduced and demonstrated with some experimental results. In Chap. 6, the authors gave a neat explanation about the size of speckle, which is supported by simple experimental results. Double exposure and time-average techniques are introduced. Then the experimental results are used to demonstrate the applications of speckle interferometry. Holography is highlighted in Chap. 7. The principles of optical holography and digital holography are well explained and demonstrated. A white light hologram is engraved in the cover of this book. They also introduce different holographic arrangements for in-line holograms, reflection holograms, transmission holograms, white light holograms, rainbow holograms, and holographic cinematography. Chapter 8 introduces the principle and applications of three interferometers: Mach-Zehnder, Sagnac, and holographic. In Chap. 9, Fourier optics is well explained and demonstrated. They start with scalar diffraction theory, followed by the description of Fresnel and Fraunhofer approximations. After constructing the concept of Fourier transforms by a lens, they discuss many optical Fourier spectra, e.g., point source, plane wave, infinitely long slit, two point source, cosine grating, circular aperture, and compound grating systems. Then the concept of coherent optical filtering is exemplified by several applications, such as low-pass filter or spatial frequency filter, high-pass filter or dark field method, phase filter or phase contrast method, half-plane filter or Schlieren method, raster elimination, holographic filters, and pattern recognition. Many experimental results are provided.

Chapter 10 introduces the laser principle, laser rate equations, stationary operation, stability analysis, and chaotic dynamics. In Chapter 11, the authors give brief introductions to several nonlinear optical processes, such as two-wave, three-wave, four-wave, and multiphoton interactions, and multiple optical wave interactions in crystal. The last chapter is devoted to a brief introduction to fiber optics, in which they discuss glass fiber, fiber sensors, optical solitons, and fiber optical signal processing.

In summary, this book is recommended as an introductory text book to junior undergraduates who have a little background in college physics and mathematics, and

# NEW FROM CAMBRIDGE: THE KEY TO LASERS



## Laser Fundamentals William T. Silfvast University of Central Florida

*Laser Fundamentals* provides a clear, up-to-date, and comprehensive introduction to the physical and engineering principles of laser operation and design. Simple explanations, based throughout on key underlying concepts, lead from the basics of laser action to advanced topics in laser physics and engineering. The author discusses the concepts of amplification, gain-bandwidth, and broadening in detail, as well as topics such as Q-switching, mode-locking, and waveguide lasers. The author gives descriptions of the twenty most common types of laser toward the end of the book, and he concludes with a chapter devoted to frequency multiplication. Containing worked examples and many homework problems, the book will be invaluable to undergraduate and first year graduate physics and electrical engineering students taking courses on lasers. The summaries of key types of lasers and extensive references will also make it a useful reference volume.

1996 544 pp.  
5 halftones/ 240 line diagrams/  
5 tables/ 117 exercises  
55424-1 Hardback \$95.00  
55617-1 Paperback \$39.95

Available in bookstores or from

## CAMBRIDGE UNIVERSITY PRESS

40 West 20th St., NY, NY 10011-4211.  
Call toll free 800-872-7423.  
MasterCard/VISA accepted.  
Prices subject to change.  
Web Site: <http://www.cup.org>

want to have a broad view of the fundamentals and applications of coherent optics. It is also recommended as supplementary reading material to senior undergraduates and graduates who major in the fields related to coherent optics. The problems, references, additional readings, and two appendixes can help the reader in the process of studying this book.

### Semiconductor Lasers: Past, Present, and Future

Govind P. Agrawal, Editor, 365 pages, illustrations, index, references, and contributors list. ISBN 1-56396-211-X, AIP Press, 500 Sunnyside Blvd., Woodbury, NY 11797-2999 (1995) \$75 hardbound.

Reviewed by O'Dae Kwon, Pohang University of Science and Technology, Electrical Engineering Department, Pohang, KB 790-784, Korea.

The major title of this book is identical to *Semiconductor Lasers*, by G. P. Agrawal and N. K. Dutta (1993, 2nd ed.), now abbreviated as SL/93. Whereas SL/93 has been regarded by many as an excellent graduate-level text or reference in this field, the new monograph edited by Agrawal may become a popular companion reference, giving a broad review of the state-of-the-art techniques in several different areas of importance.

The book consists of a collection of review articles contributed by different authors. Most articles are well organized within the book, with each self-contained and clear chapter supplying about 50 to 140 references. The book employs fairly coherent notations and terminology throughout and begins with the editor's introduction, which is similar to SL/93's introduction except with some modifications, additions, and deletions.

Chapter 1, written by J. J. Coleman, discusses quantum-well heterostructure lasers, including a short introduction to the quantum effects, two-dimensional density of states, transparent and threshold current densities, and gain. Issues associated with designs and materials are almost absent here, while the author gives a neat account of strained quantum-well InGaAs lasers in terms of threshold current density, polarization, and gain.

Chapter 2, by N. Chinone and M. Okai, is well organized and presents the distributed feedback (DFB) laser for lightwave communication systems, covering the theory, fabrication, performance, and recent progress. However, objective comments on primary limitations of the current DFB lasers could have been in place for next-generation systems.

The next chapter, contributed by M.

Kouroggi and M. Ohtsu, reviews the current progress on the suppression of the frequency modulation noise in semiconductor lasers. The noise originating from quantum fluctuation degrades system performances due to broadened linewidth. Principles of frequency modulation noise by optical feedback and negative electrical feedback are also given.

Chapter 4 concerns mode-locked semiconductor lasers for short pulse generation and was written by R. J. Helkey and J. E. Bowers. It starts with general mode-locking configurations and models, and then stresses the role of self-phase modulation effects leading to chirped pulse generation. This chapter also offers a special section on the colliding pulse mode-locking technique and schemes of mode-locked pulse stabilization.

C. J. Chang-Hasnain presents a review of vertical cavity surface-emitting lasers (VCSELs) in Chap. 5. This chapter begins with a rather short overview, and addresses real difficulties associated with actual multilayer growth of Bragg reflectors together with different VCSEL geometries and arrays. The author later extends the array discussion to an impressive account of multiple wavelength array design and fabrication. Also included is an analysis of the transverse mode variation of VCSELs. A broader account of low-threshold performances and oxidation behavior of air-post-type VCSELs is missing. As far as the surface-emitting prospects are concerned, recent work on the Fresnel zone laser and concentric circle grating laser would have been worth mentioning, too.

Chapter 6, by G. Hatakoshi, provides a good review of visible semiconductor lasers based on InGaAlP quaternary alloy structures. It briefly deals with various device structures such as ridge-type, hetero-barrier blocking, index-guiding, multi-quantum barrier, off-angle substrate, and tensile stress. In-depth discussions of carrier overflow and thermal problems are given for high-power and short-wavelength operations.

Although a bit less familiar to me, the II-VI wide-gap lasers discussion in Chap. 7, covered by A.V. Nurmikko and R. L. Gunshor, appears to provide a good review. It summarizes historical developments, doping problems, materials and physics, confinement conditions, recent results in blue-green emissions achieved by different laboratories, and degradation issues. A small drawback is the absence of detailed comparisons with III-V materials, e.g., GaN and AlN, and IV-IV materials, e.g., SiC, in the blue-green competition.

Chapter 8, by G. P. Agrawal, the editor, appears to be an updated version of the optical amplifier chapter in SL/93. The chapter now drops the fiber amplifier section and concerns solely the semiconductor am-

plifier. It treats some new aspects such as four-wave mixing involved with interchannel crosstalk, and master-oscillator power-amplifier (MOPA) structures for high-power applications. One may foresee a long-term application to the photonic switching based on the monolithic integration advantage of the semiconductor amplifier.

In Chapter 9, G. R. Gray gives a very broad overview for laser applications, from optical communication, optical data storage, laser printing, and atomic spectroscopy, through medical applications. The final chapter, by G.-H. Duan, addresses the use of semiconductor lasers and amplifiers for optical switching, in terms of basic properties, bistability, self-pulsation clocks, wavelength converters, and tunable filters.

The book as a collection of different articles suffers from a lack of information on high-power laser arrays, ultra-low threshold work, and quantum wire and box structures. Otherwise, it contains a very broad spectrum and up-to-date survey of the semiconductor laser with a good amount of references. Most chapters are easily readable and are not clogged with too many equations. It is a good companion to SL/93.

### Optical Methods of Engineering Analysis

Gary Cloud, 503 pages, illustrations, author and subject index, and references. ISBN 0-521-45087-X. Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211 (1995) \$69.95 hardbound.

**Reviewed by John L. Turner**, Bridge-stone/Firestone Inc., Advanced Technology, 1200 Firestone Parkway, Akron, OH 44317

During the past few decades, important advances in the development and application of optical methods for the engineering analysis of structural deformation have been realized. With the advent of the laser, interferometric methods have received much attention and now constitute a broad family of experimental measurement techniques for displacement and strain analysis. Recent developments in electro-optics and digital imaging have also contributed to the utility of these methods.

In researching and teaching these methods in senior and graduate level university courses over the past 25 years, Cloud developed extensive lecture notes and reference materials. In recognizing the need in engineering education for a single contemporary text book spanning these areas, Cloud was motivated to write this text to fill a void. The stated intent of the book is for use as a teaching tool rather than as a research monograph or handbook. The author's objectives include coverage of important older methods such as photoelasticity up through more recent techniques such as moiré interferometry. The approach taken is to present a blend of theory and practice for each technique, progressing through each class of methods, introducing new increments of theory only as necessary for the particular topic being covered. This approach was aimed at enhancing the teaching process and facilitating the integration of laboratory experiments into the course at an early stage.

The book is organized into seven sections. The first section covers some basic concepts in optics with an introduction to interferometry. The remaining six sections focus on particular classes of optical methods (photoelasticity, geometrical moiré, diffraction theory and optical processing, moiré interferometry, holographic interferometry, and speckle methods). Each section contains several chapters that typically cover a theoretical description of the method, implementation, and equipment issues, some illustrative examples of application, and experimental techniques.

The first section introduces light and interference with a brief review of Maxwell's equations, simple harmonic waves, and some mathematical approaches for representing and analyzing interfering light waves. A complex number representation is introduced and is generally used for wave analysis in subsequent chapters. No effort, however, is made to be consistent in this approach. Photoelasticity theory is developed, for example, by utilizing pure trigonometric functions and identities. A short section on matrix methods (Mueller and

Jones calculus) is included in Chap. 2 but is not utilized in any of the following chapters. The first section rounds out with an introduction to some classical interferometry (Newton's rings, Young's fringes, and Michelson's interferometer), which serves to set the stage for subsequent coverage of interferometric measurement methods.

Section II is dedicated to classical photoelasticity. This subject is covered in three chapters, which represent a concise and traditional treatment of the basic concepts of birefringence, polariscope function and usage, and model analysis methods for two dimensional applications. Several methods of stress separation are briefly discussed. For reasons of space and emphasis, several traditional topics are given little or no attention. The polariscope equations, for example, stop with the plane polariscope, leaving the analysis of the circular polariscope as an exercise. Reflection photoelasticity and three-dimensional photoelastic methods such as "stress freezing" are also mentioned but not pursued. These topics are well covered, however, in readily available published texts dedicated more exclusively to this subject. Their sacrifice in this book is regrettable but understandable.

Sections III, IV, and V cover classical (geometric) moiré and progress through contemporary (interferometric) moiré methods. This coverage necessitates treatment of diffraction and Fourier optical processing, which also facilitates the later introduction of holographic and speckle interferometry (Secs. VI and VII). Section III presents a simple treatment of geometrical moiré fringe formation and illustrative examples of basic in-plane displacement and strain analysis. Section IV introduces diffraction theory via the Kirchhoff integral solution and its reduction to a Fourier transform process in the far field. The use of a lens as a Fourier analyzer and for spatial filtering is also emphasized. Application of these techniques to superimposed gratings for more sophisticated moiré processing is discussed and illustrated in good detail. The final chapter of Sec. IV is dedicated to practical issues of implementation including moiré grating selection and fabrication techniques, attachment to specimens, photographic and optical setups, and fringe analysis. A step-by-step outline of the procedures is presented. Section V consists of three chapters dedicated to the more recent technique of high sensitivity moiré interferometry. The first chapter presents a detailed theoretical description of the method for a six beam moiré interferometer, appropriate for full surface strain characterization. A rather detailed geometric derivation of oblique incidence diffraction is presented and employed in developing the interferometric fringe equations. The second and third chapters cover the design issues of a moiré interferometer and the specialized tech-



22nd

### International Congress on High-Speed Photography and Photonics

27 October - 1 November 1996

Sweeney Convention Center  
Santa Fe, New Mexico USA

For more information contact:

Ms. Alita Roach

22nd ICHSPP Coordinator

Los Alamos National Laboratory

DX-DO, MS P915

Los Alamos, NM 87545 USA

Phone: 505/665-6277

Fax: 505/665-3407

E-mail: alita@lanl.gov

niques of specimen preparation and analysis. Several applications are shown that convincingly demonstrate the sensitivity and quality of the results that can be obtained, with adequate effort. References to recent monograph and handbook publications dedicated exclusively to this topic are included.

Holographic interferometry is the topic of Sec. VI. A traditional treatment of the basics of holography is provided using complex wave representations as the mathematical descriptor. A brief treatment of holography as a diffraction process is included. Double exposure, real-time, and time-average holographic interferometry are discussed and qualitatively illustrated with examples. Holographic recording methods, media, and viewing processes are discussed. The mathematical relation between surface displacements and fringe formation is presented but a detailed explanation of fringe analysis and data reduction is not pursued. The method is presented as more suitable for qualitative or semiquantitative investigations. The reader is referred to the literature for more details. This is perhaps the least developed section in the book in terms of application to engineering analysis.

Section VII is dedicated to laser-based speckle methods of deformation measurement. A lucid presentation and historically informative discussion of the speckle phenomena, speckle photography, and speckle interferometry is provided. Coverage of contemporary methods of electronic speckle interferometry including electronic hardware, various modes of application, practical advantages, and potential sources of error is given. White light speckle is briefly treated but the topic of digital correlation analysis of mechanically induced speckle is not discussed. The final chapter discusses improvements in the precision and practicality of speckle (and other) interferometers that can be realized via phase shifting techniques. Readily implemented phase shifting techniques, through the use of microcomputers and piezo-electric transducers, are described. Several algorithms for phase measurement are presented.

The book is clearly illustrated with diagrams and photographs with the possible exception of supporting figures in Chaps. 2 (light and interference) and 4 (photoelasticity). Good graphical depictions of the concepts of polarized light (linear, elliptical, and circular) and double refraction, for example, are lacking and would be helpful to the inexperienced student. The cited references following each chapter are generally adequate for follow-up study, but are by no means exhaustive. They primarily document the original published papers introducing the various methods as well as available published books on the pertinent subjects.

As a teaching tool, Cloud has succeeded in developing a single unified text covering the relevant topics in optical metrology for engineering analysis of displacement, deformation, and strain. The level of presentation is appropriate for upper undergraduate and graduate level courses in engineering. The separate sections are relatively independent and support selected coverage of topics to a reasonable degree. A noted limitation from a teaching perspective is the lack of inclusion of problems and laboratory exercises accompanying the chapters. Instructors will have to develop supplementary class assignments to accompany the text. Even so, the book is a welcomed and needed addition to the literature and will certainly find a place on the bookshelf of many teachers and researchers working in the area of applied optical measurements in engineering. As intended, a void has been filled.

#### BOOKS RECEIVED

**Fourier Series and Optical Transform Techniques in Contemporary Optics: An Introduction**, by Raymond G. Wilson, with contributions by Sean M. McCreary. xvii + 325 pp., illus., subject index, references, bibliography, problems following some chapters. ISBN 0-471-30357-7. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158 (1995) \$59.95 hardbound. Covers wave notation; the Fourier analysis of signals; the processing of light in diffraction phenomena and imaging; Zernicke polynomials; Fourier transforms for Fresnel diffraction; laser beacon adaptive optics; and related topics.

**Diode Lasers and Photonic Integrated Circuits**, by Larry A. Coldren and Scott W. Corzine. xxiii + 594 pp., illus., subject index, seventeen appendices. References, problems and/or reading list following each chapter. From the Wiley Series in Microwave and Optical Engineering. ISBN 0-471-11875-3. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158 (1995) \$74.95 hardbound. This book is devoted to diode lasers and their use in many applications. Chapters include: ingredients; phenomenological approach to diode lasers; mirrors and resonators for diode lasers; gain and current relations; dynamic effects; perturbation and coupled-mode theory; dielectric waveguides; photonic integrated circuits.

**Liquid Crystals: Physical Properties and Nonlinear Optical Phenomena**, by Iam-Choon Khoo. xvi + 298 pp., illus., subject index, references following each chapter.

## For Your Optics Library



Free 130-page catalog from Rolyn, world's leading supplier of "Off-The-Shelf" optics, offers 24-hour delivery of simple or compound lenses, filters, prisms, mirrors, beamsplitters, reticles plus thousands of other stock items.

**Off-the-Shelf-Optics**  
24-hour delivery

**ROLYN OPTICS**

706 Arrowgrand Circle, Covina, CA 91722-2199  
Phone (818) 915-5707 • (818) 915-5717  
Fax (818) 915-1379

ISBN 0-471-30362-3. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158 (1995) \$69.95 hardbound. Discusses physical properties and molecular and chemical structures of thermotropic liquid crystals. Examines the theoretical aspects of their isotropic and liquid crystalline phases, including order parameters, elastic constant, free energy, viscosity and flows, refractive indices, and birefringence. Covers new materials such as polymeric liquid crystals, polymer dispersed liquid crystals, dye-doped liquid crystals, and ferroelectric liquid crystals.

**Optical Communications: Second Edition**, by Robert M. Gagliardi and Sherman Karp. xv + 347 pp., illus., subject index, references and problems following each chapter. From the Wiley Series in Telecommunications and Signal Processing. ISBN 0-471-54287-3. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158 (1995) \$59.95 hardbound. Integrates both fiber and space optics, and includes new material on the key areas of digital communications, fiber optics, lightwave networks, atmospheric channels, and space links.