DEPARTMENTS

BOOK REVIEWS

International Trends in Optics

Edited by Joseph W. Goodman, 535 pages, illus., subject index, references. ISBN 0-12-289690-4, Academic Press, Inc., 1250 Sixth Avenue, San Diego, CA 92102 (1991) $64.95 hardbound.

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This is a collection of 34 chapters by major optics researchers around the world. The chapters vary from 9 to 22 pages and address a very diverse set of topics in optics. (The book truly achieves one of its stated purposes "to provide a broad view of work underway in the field of optics throughout the world.") The list of authors reads like a who's who of optics. In reading the chapters, I felt I had just attended 34 invited keynote talks.

After much deliberation, I decided that I had to tell you what each of the 34 chapters included and the author and country of each, despite the fact that a rather lengthy review will result. The groupings noted for chapters are mine.

Chapters 1 through 3 by AT&T Bell Laboratories and Bellcore authors concern optoelectronic ICs (OEICs), optical switching nets using fiber optics, SEEDs (self electro-optic devices), and laser diode arrays. H. Kogelnik (Chap. 1) clearly tells us the present difference between integrated optics, OEICs, and photonic integrated circuits (PICs). He notes two uses of integrated optics in commercial systems, gives examples of OEICS and PICS, and addresses future commercial uses and why those uses take so long to occur. D. A. B. Miller (Chap. 2) coins the new term "quantum optoelectronics," which combines the quantum mechanics of thin films and the integration of optics and electronics. Layered semiconductor growth is described together with quantum wells, excitors, and future directions using organic materials. Peter Smith (Chap. 3) discusses switching networks and their applications. He discusses the trend toward more control and functionality and more complex processing in switching arrays using OEICs, fiber optics, SEEDs, and laser diode arrays.

Chapters 4 through 6 concern optical fabrication techniques and signal processing uses of fiber optics. Kenichi Iga from Japan (Chap. 4) describes micro-optics. (This involves the integration of small micrometer to millimeter optical devices.) Fiber optic communications and optical disk uses are emphasized. The purpose of micro-optics is not to replace components such as guided wave elements and fiber optic circuits but rather to allow these elements to be more efficiently used. Iga's discussion of stacked planar optics using microlens arrays is an excellent example of this. H. Herzig and R. Dändiker (Switzerland) describe holographic optical elements (HOEs) for use with laser diodes (Chap. 5). Emphasis is given to HOEs formed by the interference of two optical beams rather than to computer-generated holograms. The use addressed is laser diode focusing with attention to efficiency, aberrations, astigmatism, and the Bragg condition. B. Culshaw and I. Andonovic from Scotland (Chap. 6) discuss various fiber optic signal processing elements that can be fabricated (such as transversal and recursive filters) and future trends such as fiber optic gyros using a fiber optic Sagnac interferometer.

Chapter 7 on optical disk memories (Y. Tsunoda, Japan) was very good. The chapter includes good descriptions of the recording/reading mechanisms and materials plus specifications (present and future) for write once and rewriteable optical disks. Future trends are discussed that may increase storage density (short-wave laser diodes and pit-edge recording), achieve higher speed (by direct rewriting using a floating magnetic head), and reduce access times (presently three to five times longer than for magnetic disks).

Photorefractive crystal (PRC) applications are the topic of Chaps. 8 and 9. H. Rajbenbach and M. P. Huignard (France) describe PRC nonlinear operations, two-wave mixing systems (to efficiently couple energy between two optical beams), and four-wave mixing systems (to produce phase conjugate wavefronts). Applications described include optical interconnections, phase locking of several laser diode arrays, and novelty filters. S. I. Stepanov (USSR) describes other PRC applications (Chap. 9). These include an adaptive interferometer (using a PRC in place of the beamsplitter) that maintains nearly constant phase shifts, allows compensation for the transverse structure of the recording beam, and hence allows use of multimode fibers in the arms of the interferometer. A new use of the PRC as a nonsteady photo-EMF detector for phase-modulated signals is described.

Chapters 10 through 14 provide an enjoyable diversion and tour of unique optics work. Jakob Stamnes of Norway (Chap. 10) discusses water wave optics. If you have never seen the basin facility that produces water waves and uses huge underwater Fresnel lenses, I urge you to read this chapter. Stamnes presents nice discussions of the Helmholtz equation, Huygen's principle, geometrical optics, and diffraction. Applications presented include ocean wave studies of large oil depressions on the ocean bottom. Chapter 11 is vintage Adolf Lohmann (Germany). He discusses the diffraction philosophies of Kirchhoff, Huygen, Young, Abbe, and others (as only Lohmann can do). He provides insight into computer-generated holograms and Damann gratings in a "quasi-oral" style that is a pleasure to read. In Chap. 2, John Howard uses the Science Citation Index to analyze the 27 optics journals and how often the 3200 major journals reference each optics journal. You will be glad to know that you only need to read 10 to 15 optics journals per month. (Now I know where my time goes and what the cause of that 4-ft pile in the corner is.) *Optical Engineering* emerged as 10th or 11th in terms of citations. (If the *SPIE* proceedings had been included, I think the amount of references would have ranked *Optical Engineering* close to number one.) Zhi-Ming Zhang (China) then reviews optics in China (Chap. 13). He notes modern Chinese work in astronomical optics, nonlinear crystals, soft x-rays, and laser physics. I found the ancient history sections truly fascinating. Did you know that the pinhole camera concept originated 2500 years ago, concave and convex mirrors date to the eleventh century, and that a Chinese light penetrating mirror (circa 200 BC) exists that produces a projected image in sunlight at the decorative pattern on its *opaque back*? Only recently have the Chinese been able to duplicate this 2100-year-old device. Pal Greguss (Hungary) provides an enjoyable Chap. 14. After discussing the vision systems of many animals, he describes his panoramic annular lens, its 360-deg viewing feature, and its use in optical interconnections. If you've never seen this lens, you must read this chapter.

If you think you know optics, read Chaps. 15 through 18 for a collection of phenomena your child (or student) may ask you about and assumptions you have probably always made about light (which aren't always true and may lead the way to future optical systems and applications). Chris Dainty (United Kingdom) describes the opposition effect or enhanced backscattering (Chap. 15). This effect refers to the enhanced intensity observed when certain volume or surface scatterers are illuminated with parallel light. [For example, paper, white paint, and the surface of the moon exhibit this effect. (The moon really is brighter when full.)] Multiple scattering is used to explain these phenomena. You probably think that as light propagates through free space its normalized spectrum is unchanged. Wrong again, as Emil Wolf (Chap. 16) notes. This has been known since 1986 and was recently proven. The explanations for this offer the potential for new Doppler, lidar, and other uses. Jan Perina (Czechoslovakia) in Chap. 17 introduced me to a new type of nonclassical (quiet) light that has been available since 1977. The light exhibits antibunching of photons (laser photons are bunched), sub-Poisson photon statistics (laser photons obey Poisson statistics), and squeezed light. These properties can yield new interferometers with performance beyond the quantum limit, increased communication channel capacity, etc. A. Aspect and P. Grangier (France) discuss single photon light pulses (Chap. 18). They note that attenuated classical light pulses (having an average energy per pulse below one photon) are not the same as single photon light pulses. Did you know that such experiments were done in 1909 and involved a 6-month exposure of a photographic plate? Tests on single photon pulses provide data for more study of the need for quantum optics versus semiclassical theories of light.

Atmosphere imaging issues are the subject of Chaps. 19, 26, 27, and 28. Anna Consortini (Italy) addresses coherent light transmission through a turbulent atmosphere (Chap. 19). Models of a turbulent atmosphere are presented. She then describes various solved problems, problems under study, and unsolved practical problems in this area. In Chap. 26, Fritz Merkle (Germany) reviews adaptive optics and its use in removing degradations due to atmospheric turbulence. This employs real-time phase compensation methods. I found his future trend most interesting. Neural net optical computers may be the future processors for this, and tomographic principles appear to be solutions to the problems of isoplanicity because they allow aberration corrections in various height layers of the atmosphere. G. Weigelt (Germany) employs triple correlation and bispectra processing techniques (using speckle masking methods and various interferometric speckle techniques) to overcome refractive index atmospheric fluctuations to produce high-resolution astronomical imagery (Chap. 27). These solutions are detailed and noted as useful for single-disk telescopes and long-baseline optical interferometers for astronomical imaging. Jim Fienup (Chap. 28) describes phase retrieval research in which an image (or the phase of its Fourier transform) is retrieved from detected data that are the modulus of its Fourier transform. This has wide application in passive (incoherent) and active (coherent) imaging systems. Iterative, simulated annealing, maximum entropy, and other methods are critically assessed. For real-valued nonnegative objects, the algorithms are fairly well established. Topics requiring further research are algorithms for complex-valued objects with poor convex support (where the statistics of the noise in the Fourier transform should be used) and the uniqueness of the solutions.

Chapters 20 through 22 concern holography and moiré techniques. Yury Denisyuk (USSR) provides new perspectives on holography (Chap. 20). These include the selectivity of holograms (a hologram that records the radiation from two points, interacts only with the radiation of these very points, and ignores all other points), their associative property (a part of the recorded object can reconstruct the full object), and dynamic holography using nonlinear real-time recording and phase conjugation. Denisyuk notes that these types of holography have use in neural networks. Recent holographic achievements (possibly less well known) are reviewed. These achievements include holographic reconstructions that provide the Doppler velocity of a moving object, the polarization properties of the object, and echo hologram reconstructions that change with time (providing space and time object data). Advanced thoughts on 3-D cinematography are then presented. Chapter 21 by Jumpei Tsujiuchi (Japan) concerns medical 3-D display applications. Ten years of work by the Japanese group of four institutes, universities, and companies is described. The chapter describes systems and techniques of multiple exposure holograms (for CAT scanners, NMR, and ultrasound imaging) and stereograms (from a sequence of x-ray images taken from different directions). Olaf Bryngdahl (Germany) then discusses, in a clear and vivid style, moiré fringes and their applications (Chap. 22). The basic uses are made quite clear by the examples provided. Polarization and color are two added parameters that facilitate presentation of results. He notes information processing, metrology, and art uses. These techniques provide data on moving objects, are used in patterns on revolving glass doors for both decorative and warning purposes, and are also used in dressmaking, etc. (Moiré is a designation for watered silk whose appearance changes as it moves.)

Chapters 23 through 25 concern optical component testing. C. Velzel (Netherlands) describes imaging optical system design and construction (Chap. 23). His concerns are geometrical and physical optics basic limitations, aberration correction, the design optimization limitations of standard computer design programs for multielement lenses, and future trends in optimization. P. Hariharan (Australia) provides an excellent and clear discussion of recent interferometry advances (Chap. 24). The narrow spectral lines of lasers now provide accurate distance measurements by interferometry. Shearing interferometers, heterodyne techniques, and varying the phase difference between the interfering beams with time provide improvements over prior methods for testing optical components. Fiber interferometers, laser-Doppler interferometers, stellar interferometers, and phase conjugate and other nonlinear interferometers are examples of significant new advances noted. Squeezed light is expected to result in future advances. D. Malacara (Mexico) provides an excellent tutorial on currently used optical lenses, etc., and testing methods (Chap. 25). Classic test methods that will never be obsolete are described (Foucault knife-edge test, Ronchi and Star test). The chapter first reviews standard interferometer null tests of spherical and conical surfaces and then covers compensation methods (refractive and holographic compensators) that remove spherical aberrations in the elements tested to allow use of null test methods. The Hartmann test and other interferometer methods for testing of high-quality optical systems are described. The role of automation and computers in future trends is noted, and very good critical remarks (disadvantages to overcome) on various methods are advanced.

Chapters 29 through 31 address optical image processing techniques. Chapter 29 by R. H. T. Bates and Hong Jiang (New Zealand) addresses blind deconvolution (restoration of an input from a distorted received pattern, without *a priori* knowledge of the degrading function). Generally, demarcations, in which the degradations are too severe, are clearly acknowledged, and thus this discussion is most practical. The authors also relate it to phase retrieval (Chap. 28). Chapter 30 by Henri Arsenault and Yunlong Sheng (Canada) discusses optical pattern recognition. The basic concepts of feature spaces (and the need for invariant features and normalization) and similarly measures (including handling nonnumeric features) and matched spatial filter correlations are briefly noted. The distortion invariant filter and neural net sections are not complete (since the chapter is only 11 pages long). Nonlinear optical image processing is the topic of Chap. 31 by T. Szoplik and K. Chalasinska-Macuhow (Poland). They briefly introduce the reader to nonlinear correlators (using phase-only filters and nonlinearities in the joint transform plane) and morphological processors (with thresholded output nonlinearities). Nonlinear processing clearly extends the use of optical image and pattern recognition processors.

The final chapters (32 through 34) concern optical computing. V. Morozov (USSR) first addresses practical issues (size, power, consumption, and switching energy requirements of digital/optical computers) and then notes how to improve holographic information storage capacity. He then reviews his impressive waveguide hologram optical processing work. A very nice chapter (32) results. S. D. Smith (Scotland) and E. W. Martin (United States) provide (Chap. 33) a very excellent discussion of classic objections to digital/optical processing and how recent optical processing work has provided proof of concept demonstrations to overcome most objections. Their optical cellular image logic processor (O-CLIP) architecture and the use of SEED and BEAT (bistable etalons with absorbed transmission) devices are then detailed as future optical general purpose processors. Pierre Chavel (France) concludes this book (Chap. 34) with a brief review of possible optical computing functions (Fourier transforms, matrix vector processing, interconnections, digital optics, pattern recognition, and optical memory), optical computing components, and a summary of their role in future computers.

Some chapters suffer from too many figures that are only casually referenced and not discussed. Several chapters are not as critical as I would have hoped. But, in general, all the chapters are very good. Lest you worry, the English in all chapters is excellent. The book is ideal and was enjoyable to read. (The style is more informal and speculative than in formal reviews.) The text is suitable for nonspecialists and is strongly recommended for all researchers in optics (since we often tend to overspecialize). There are plans to make this book the start of a series with a new book every three years; this is the natural cycle of ICO (International Commission for Optics), which receives all profits from this text. This book clearly shows how large our world of optics is and how broad optics research is throughout the world.

Acousto-Optic Signal Processing: Fundamentals & Applications

Pankaj F. Das, Casimer DeCusatis, and Sergey V. Kulakov (contributor), 473 pages, illus., index, references, and one appendix. ISBN 0-89006-464-4, Artech House, Inc., 685 Canton Street, Norwood, MA 02062 (1991) $95 hardbound.

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This book describes the fundamentals of acousto optics and its applications in optical signal processing. The authors have done extensive research and teaching in this area, and their vast knowledge of the subject is aptly shown in this book.

As researchers they are familiar with past and present work as indicated by the large number of subjects discussed in the seven chapters as well as by the extensive references presented at the end of each chapter. The Russian references are interesting; however, English translations are often not available. There are some regrettable omissions, such as Mason's equivalent circuit for piezoelectric transducers by E. Sittig and A. Meitzler, work by R. Krimholtz, D. Leedom, and G. Matthaei, and work on high-frequency anisotropic devices by I. C. Chang. The references on acousto-optical signal processing are excellent.

Looking a the individual chapters, Chap. 1, is generally background material. Figure 1.4 describes key parameters of various signal processing technologies. This figure serves as a very useful reference when considering applications. Chapter 2 is a summary of acousto-optic interactions for two distinct regimes: the Raman Nath and the Bragg regimes. The authors also briefly describe coupled mode theory [Eq. (2.64)]. Ample references are given to more detailed treatments.

Chapter 3 describes acousto-optic interactions in isotropic and anisotropic media. A variety of subjects are covered. It would have been appropriate to add the work by Yano and Chang on interactions in anisotropic media and tunable filters and move the discussion of tunable filters from Chap. 5 to this chapter. Chapter 4 describes surface acoustic wave devices for acousto-optic interactions. Tables 4.1 and 4.2 are fairly informative. A table of material parameters for both Chaps. 3 and 4 would have been useful. Chapter 5 describes acousto-optic devices, device configurations, and applications. Of particular interest are spectrum analyzers, convolvers, and correlators. The concepts and applications of time and space integrators are discussed in great detail. The last part of the chapter is on matrix processors. The many illustrations in this chapter are extremely helpful. Chapter 6 is devoted entirely to applications. (Chapter 5 also contains a significant number of device applications.) The topics discussed include classical signal processing applications of matched filters, for which Table 6.1 on matched filter comparisons is very informative. Optical excision, spread spectrum processing, adaptive signal processors, ambiguity processors, and interceptors are also covered. Chapter 7 surveys a variety of recent topics, including integrated optics, bistable devices, neural networks, and acousto-electro effects (AEO). These topics are of current interest for R&D work. The second author's Ph.D. dissertation was on AEO interactions and applications. This reviewer contributed to the work on acousto-optic applications in moiré topography.

In conclusion, Chaps. 5 and 6 comprise the bulk of this book on acousto-optic signal processing applications and provide excellent and extensive references for a survey of the subject. The book is highly recommended as a reference for graduate students and researchers.