I have often noted that the most important contributors to a journal usually go unnamed. These are the referees. They contribute their expertise free and with little thanks. Indeed, they often suffer some real abuse from the authors. There follows an honor roll of people who have helped me to referee Optical Engineering prior to 1984. If I have missed your name through clerical error, please (1) forgive me and (2) let me know.


Editorial
H. J. Caulfield, Editor

Referees

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Forum

Optics at...

THE PENNSYLVANIA STATE UNIVERSITY

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The Pennsylvania State University
Electrical Engineering Department
University Park, Pennsylvania 16802

Abstract. This paper presents an overview of the graduate program in electro-optics at The Pennsylvania State University. Emphasis is placed on the current research programs of the Electro-Optics Laboratory in the Electrical Engineering Department, with brief mentions of different optics-related activities in various other departments. The courses offered in association with these activities are discussed, as is the philosophy of education.

INTRODUCTION

The Pennsylvania State University traditionally has emphasized engineering and science education. In 1980, the Electro-Optics Laboratory was founded with its main objective to prepare students for graduate studies by providing a strong background in optical signal processing research. This objective is achieved by combining optical research with education. Accordingly, the program offers a sequence of elective and graduate courses in optical signal processing, with strong emphasis on both theoretical concepts and laboratory experience. Since its formation, the Electro-Optics Laboratory has established strong ties with other international optics institutions, which has brought several visiting scholars to the laboratory to conduct research.

Recent research activities in the Electro-Optics Laboratory include white-light optical signal processing, holography, interferometry, hybrid optical-digital computer systems, large capacity optical correlator systems, spread-spectrum communications, and statistical analysis of white-light optical correlators in the presence of noise. Also, real-time signal processing is under study using spatial light modulators, liquid-crystal light valves, acousto-optic cells, and magneto-optic devices.

This article concentrates on optical signal processing education and research, which are centered in the Electrical Engineering Department at the university. However, other optics-related research activities, such as spectroscopy, laser studies, quantum optics, nonlinear behavior of liquid crystal cells, flow visualization, interferometry, and quantum electronics, are explained briefly.

PHILOSOPHY

The key to the success of the Electro-Optics Laboratory is the integration of research and education. Its goal is to teach students the theoretical concepts, the experimental skills, and the ability to solve a given problem and, more importantly, to give them the experience of working on a team. Various projects are assigned to the students to improve their experimental techniques and encourage them to conduct research.

New students usually begin by working with a more experienced member of the laboratory, thereby learning the skills required to conduct independent research. This also can help the new student to observe through experimentation the concepts that he has learned in class. Research progress is reported to an advisor regularly to ensure that the direction of the research is correct.

Graduate students are assigned to research projects that are publishable, giving each student the opportunity to build up a substantial list of publications before graduating.

OPTICS EDUCATION

There are three optical signal processing courses presently offered in the Electrical Engineering Department. The first course, Introduction to Holography, is a senior-level course that covers the basic optics concepts needed for more advanced treatment of the field. It is intended to serve as an introduction for students who are not familiar with the basic concepts of diffraction, while also presenting a thorough treatment of holography and its applications. The course covers such important topics as partial coherence theory, linear and nonlinear holography, white-light holography, and their applications. The prerequisites for this course are intermediate-level courses in electromagnetic fields and communication systems.

The second course, Optical Information Processing, is an advanced graduate-level course that applies the concepts of linear system theory and communication theory to many problems, such as pattern recognition, complex spatial filtering, color image processing, coherent and noncoherent optics, synthetic aperture radar, polychromatic processing with noncoherent light, pseudocolor encoding, nonlinear processing, and many others. In this course the students are required to do research on advanced-level topics and to present the results in a seminar. The prerequisite for this course is Introduction to Holography, mentioned above.

The textbook used for both of these courses is Optical Information Processing by F. T. S. Yu. Mathematical analysis by means of an elementary point concept (impulse response) is used in both courses because it simplifies the calculations and because electrical engineering students are familiar with the concepts of linear system theory.

The third and final course in the sequence is a laboratory course in which students are required to conduct experiments based on the subjects studied in the first two courses. The experiments include holography, complex spatial filtering, white-light optical signal processing, photographic film processing, color image processing, and many others. Students also are given different experimental projects according to their research interests and capabilities.

The important subject of fiber optics is treated in a graduate-level course titled Optical Fiber Communications, which covers the properties of electromagnetic waves (modes) in optical fibers

OPTICAL ENGINEERING EDITORIAL SCHEDULE

July/August 1984

 Precision Surface Metrology
James C. Wyant
Optical Sciences Center
University of Arizona
Tucson, AZ 85721 602/621-2448

September/October 1984

 Particle Sizing and Spray Analysis
Gerald W. Stewart
Aerodyne Research, Inc.
45 Manning Road
Billerica, MA 01821
617/663-9500

 Robot Vision
David P. Casasent
Carnegie-Mellon University
Dept. of Electrical & Computer Engineering
Pittsburgh, PA 15213 412/578-2464

November/December 1984

 Laser Spectroscopy
Fred Milanovich
Lawrence Livermore National Laboratory
MS L-524
P.O. Box 808
Livermore, CA 94550
415/422-6838

 Pattern Recognition
Joseph L. Hornor
Rome Air Development Center/ESO
Hanscom Air Force Base, MA 01731
617/861-5563

 January 1985

 Optical Computing
John Neff
DSO/ESD
DARPA
1400 Wilson Blvd.
Arlington, VA 22209 202/694-5800

 Optical Information Processing Components
Armand R. Tanguay, Jr.
Cardinal Warde
523 Seaver Science Ctr.
Room 13-3134
Univ. of Southern California
Los Angeles, CA 90089
617/253-6858
213/743-6152

 February 1985

 Integrated Optical Circuit Engineering
S. Sriram
GTE Laboratories, Inc.
40 Sylvan Road
Waltham, MA 02254
617/446-2607
and the communication system aspects of optical fiber communication systems. Laser theory and applications are covered in Principles and Applications of Lasers and Masers. This course is an introduction to the principles of laser amplifiers and oscillators and to applications of lasers to communications and holography.

The fact that these courses cover such important topics as pattern recognition, holography, radar signal processing, fiber optics, lasers, among others, has made them quite attractive to seniors and graduate students in the Electrical Engineering Department.

**RESEARCH ACTIVITIES**
**Electro-Optics Laboratory**

Coherent optical information processors are capable of fast (speed of light), high resolution processing in complex amplitude. However, the critical processing environment, the coherent artifact noise, and the costly coherent light sources are severe limitations in many data processing systems.

We have developed a white-light optical processing technique that can alleviate these problems. Furthermore, using a white-light processing method, the information can be processed in complex amplitude rather than intensity. Using this technique, the optical processor can operate in a partially coherent mode rather than an incoherent mode; therefore, the image can be processed in complex amplitude. In other words, the main feature of a coherent processor, which is its complex amplitude processing capability, is preserved, and, at the same time, the coherent artifact noise is suppressed.

We have shown that smeared photographic image deblurring, image subtraction, and signal correlation detection can be achieved by using partially coherent processing systems. Both the temporal and spatial coherence requirements for these operations have been determined. One research objective is to find out to what degree the coherence requirements can be relaxed without sacrificing the overall performance of the processing system.

Since a broadband light source that contains all visible electromagnetic wavelengths is used, the white-light processing system is particularly suitable for color image processing applications such as pseudocolor encoding, color image deblurring, color image subtraction, and color correlation detection.

In recent years, the major research emphasis has been on the development of pattern recognition systems and their application to spread-spectrum communication needs, using a broadband source and a partially coherent optical processor. Correlator systems are synthesized to process two-dimensional color codes in real-time. Large capacity optical memories for correlation applications are generated, and their computer-controlled real-time processing capabilities are tested. Real-time color-sensitive pattern recognition correlators are being designed, and their applications to identification and inspection problems, color monitoring devices, color-sensitive robotic eyes, and biomedical testing are under study. Figure 1(a) shows a real-time color-sensitive pattern recognition system, while Fig. 1(b) shows a real-time white-light optical processor using a magneto-optic device.

Interferometric techniques are used in the study of vehicle structure, missile tracking, and nondestructive testing. Real-time color image subtraction processing is under study using an extended incoherent source and a partially coherent optical processor. The result of a color image subtraction using an incoherent source is shown in Fig. 2. Figures 2(a) and 2(b) show black-and-white reproductions of two color image transparencies of a parking lot. Figure 2(c) shows the color-subtracted image obtained by using an incoherent source.

Computer-controlled color image processing and various techniques of pseudocolor encoding are achieved by using the techniques of the white-light optical processing system described earlier. Incoherent spatial encoding techniques are used to multiplex a positive, a negative, and a product image onto black-and-white photographic film. A density color-coded image can be obtained, using the above encoded transparency in a white-light optical processor, by color filtering at the Fourier plane. Figures 3(a) and 3(b) show, in black and white, a color-coded image of a woman's pelvis. The positive image was encoded in red and the negative image in blue. The product image was encoded in green. Figure 3(c) shows a computer-controlled white-light pseudocolor encoding processor.

Color image deblurring of photographs severely blurred due to linear motion is achieved by using the partially coherent optical processor described previously. Figure 4(a) shows a black-and-white reproduction of a color picture of an automobile at a stop sign, blurred due to linear motion. Figure 4(b) shows the deblurred image of the automobile obtained with the white-light processing technique. Comparison of the two figures shows the great improvement obtained in the visibility of the picture by using the white-light technique.

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Research in the statistical theory of optics is being conducted for white-light optical processors. The performance of partially coherent systems under noisy conditions is under study. The system's signal-to-noise ratio has been determined for temporally and spatially incoherent illumination, and experimental verification is being sought.

Another area of research is the generation of complex spatial filters by using digital computers. It is intended to use these computer-generated filters for the white-light optical processors since such complex spatial filters cannot be generated by usual interferometric techniques.

Additional research programs

The theoretical activities in optics within the Physics Department at Penn State are carried out by Dr. R. M. Herman and his associates. These are classified into three categories. The first category, collisional transfer and relaxation of photobeat phenomena in quantum optics, is being investigated with Dr. K. S. Meyer. The second category is the production of a series of identical images having graded intensities for use in laser damage testing. This has been achieved by using certain types of hole gratings in metallic masks. Dr. T. A. Wiggins from the department and T. T. Saito from the U.S. Air Force Academy are involved in this work. The third category is the study of nonlinear optical responses of liquid crystal cells under the influence of optical fields, which are being examined under a variety of conditions. In earlier work (with Mr. Serinko), a cell that utilized the instabilities near Fredericzs transitions to give abnormally large optical amplifications of weak beams was proposed. Presently, optical bistability is being analyzed in a cell configuration in which the free-energy barrier between the two stable states can be adjusted with ease and in which high optical contrast between the two optical modes is predicted.

Molecular spectroscopy research in the Physics Department is conducted by Drs. J. Pliva, S. R. Polo, and T. K. McCubbin. Their laboratory has a large (4.5 m focal length) echelle grating spectrograph/spectrometer that has been used primarily to measure infrared absorption and emission spectra of small gas-phase molecules with high resolution. A dedicated PDP-15 computer is used for data acquisition, digital smoothing, resolution enhancement by deconvolution, plotting of the spectra, etc. In cooperation with several other laboratories [U.S. National Bureau of Standards, National Research Council (Canada), University of Paris (France), and University of Oulu (Finland)], high quality data for larger molecules also are obtained from Fourier transform spectrometers and laser spectrometers located at these institutions and are processed and analyzed here. Sophisticated computer programs, developed by J. Pliva, are used for the analysis of the spectra and the determination of spectroscopic and structural constants of the molecules.

Research in physical optics and laser damage is conducted by Dr. T. A. Wiggins in the Physics Department. His current work, the study of laser beam propagation, involves the measurement of beam waist and divergence. This work includes the use of hole gratings as an aid in the study of waist sizes that must be known in order to predict the intensity in a focused laser beam. Focused beams from a ruby laser system are used in the measurement of damage thresholds in metals, dielectric films, and plastics. The first two materials are useful in laser systems as reflectors and in the modification of the reflectivity of various optical elements. Plastics may be of interest due to their lower weight and cost and because of the ease of machining and forming them. They also can be impregnated to produce graded-index materials, filters, and saturable absorbers for various applications.

Related optical research in the Mechanical Engineering Department is conducted by Dr. Gary Settles. Dr. Settles uses shadowgraph, schlieren, and interferometer optics for the visualization and quantitative measurement of fluid flows. The flows under study emanate from thermal convective flow interactions. Special interest is given to the development of new optical techniques for the visualization of three-dimensional flows, high speed photography, and the use of pseudocolor encoding in schlieren optics (analogous to the use of such encoding techniques in noncoherent optical information processing). The Mechanical Engineering Optics Laboratory includes a 1 m aperture double-pass coincident schlieren instrument, a Mach-Zehnder interferometer, and sev-
eral “breadboard” optical systems used in specific fluid dynamics-related research projects.

Work involving Fraunhofer holography for dynamic particle/bubble fields, boundary layers, etc., is being carried out by Dr. C. S. Vikram (Materials Research Laboratory), Dr. M. L. Billet (Applied Research Laboratory), and students. This involves the recording of in-line holograms by a Q-switched ruby laser and reconstruction by a HeNe laser, aided by a closed-circuit TV system. The group of Dr. K. Vedam (Materials Research Laboratory and Physics Department) and Dr. Vikram carries out work on interferometry, holographic interferometry, laser speckle photography, and their numerous applications for ultrasonic thermal expansion measurements and vibration analysis.

Research in quantum electronics is conducted by Dr. G. Lachs. It originally involved an analytic study of the quantum mechanical description of waveforms at optical frequencies but eventually broadened into a general investigation of the statistics for the detection of modulated laser light in the presence of background light. Formulas have been obtained for photocount statistics for arbitrary superpositions of coherent and chaotic light. These results have been verified by experiments employing some novel modulation techniques to generate the superimposed laser beams and natural light (with arbitrary spectra).

FACILITIES

The Electro-Optics Laboratory has an extensive complex of facilities. It contains eight optical tables with a set of high power incoherent and coherent sources such as xenon, mercury, tungsten, HeNe, argon, etc. It also contains spatial light modulators, liquid crystal light valves, acousto-optic cells, magnetooptic devices, and the necessary optical accessories. Several personal computers and terminals with links to the university system provide further support for the research and education of the students in the Electro-Optics Laboratory.

SUMMARY

The philosophy of education in the Electro-Optics Laboratory is to involve the student in research projects as soon as possible. The considerable research potential of the laboratory allows students to select from many different activities, depending on their research interests. Most research projects involve white-light optical signal processing and image processing. The low cost, the superior noise performance, and the less-critical processing environment requirement have given the partially coherent optical processor a significant advantage over its coherent counterpart. Real-time white-light optical processors offer solutions for the design of low-cost, practical information processors for industrial, educational, and research needs.

Considerable research in other areas of optics, such as laser damage testing, nonlinear optical response of liquid crystal cells under the influence of optical fields, molecular spectroscopy, physical optics, flow visualization using color encoding techniques, interferometry, and quantum electronics, also is being conducted in different centers at The Pennsylvania State University. For more information on these various research programs, interested readers can contact directly the corresponding departments or professors.

OPTICAL CIRCUITRY

COOPERATIVE MAY BE ESTABLISHED AT

THE UNIVERSITY OF ARIZONA

Plans for a university-industry cooperative center for basic research in optical circuitry were presented at The University of Arizona. In a meeting that took place in Tucson on February 15-16, 1984, more than 50 representatives from 23 industries and researchers from The University of Arizona discussed a proposal for establishing the Optical Circuitry Cooperative (OCC). The cooperative, which would be headed by Hyatt M. Gibbs, Professor of Optical Sciences, could be in operation by late summer.

With the university and industry working together, the time lag between a scientific discovery and its practical application in the marketplace can be shortened.

Optical circuitry involves the use of light to conduct operations that are now being done electronically, but in a much faster time scale. The intention is not to replace but to complement electronics, exploiting the areas where optics have the advantage. Parallel aspects of light propagation and the ability of optics to pass light beams through each other, will be utilized. The research would be directed toward fundamental concepts and designing and perfecting techniques, rather than making specific devices. Findings would be shared by industrial members, who would be free to use the research to design specific devices. Although many of the companies do have fine research laboratories, research can be too costly for some individual companies. Industrial participants will influence the direction of research by stating their needs and evaluating university proposals.

Optical switching, semiconductor spatial light modulators, parallel processing, optoelectronics, optical data storage, three- and four-part optical gates, nonlinear optical waveguides, directional couplers, and optical computing are among the research proposals being considered for the first year. These proposals may be somewhat revised in response to feedback from the industrial participants, and possibly expanded to include other areas such as optical interconnects.

The cooperative will be supported by the National Science Foundation and the participating industries. The NSF grant will be about $200,000 for the first year, and each industry is being asked to contribute $50,000, to provide an annual budget of about $750,000. Industry is expected to pick up the tab as NSF funding phases out in five years.

Japanese and European companies already have adopted such a cooperative approach. Ventures of this type must be adopted for optical circuitry to be accelerated and for U.S. companies to remain competitive with the rest of the world.

A distinction between competition in the marketplace and in basic research will still exist. Companies will still be able to get together and talk about basic planning and research, yet compete in the marketplace.

For further information, contact Professor Hyatt M. Gibbs, Optical Sciences Center, The University of Arizona, Tucson, Arizona 85721. 602/621-2941.

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Optics Education

T. K. Gaylord
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Georgia Institute of Technology
Atlanta, GA 30332

ELECTRO-OPTICS PROGRAM AT THE UNIVERSITY OF HOUSTON
The University of Houston at Clear Lake (UH-CL) offers the Bachelor and Master of Science degrees in electro-optics. The B.S. program of instruction includes mathematics, physics, optics, electronics, and computer science. These general areas are further subdivided as follows: engineering math, calculus-based engineering physics, fiber optics, holography, optical systems, instruments and devices, photon sources, detectors, noise theory, radiometry and photometry, laser theory and optical electronics, software optics, and electronic and linear circuits.

The M.S. degree program consists of 30 hours of instruction plus 6 hours of thesis work. The curriculum is composed of advanced engineering math, laser theory, quantum mechanics, electromagnetic theory, image and optical signal processing, holography, diffraction and coherence theory, optical electronics, and fiber optics.

Areas of significant activity in research are industrial fiber optic sensors and data transmission, laser communication and materials processing, fiber optic medical sensors, instrumentation, seismic cable instrumentation, laser graphics, and robotics.

The program at UH-CL was developed in 1977 and is tailored to fit the growing needs of the world of electro-optics. The service courses, such as physics, math, and computer science, were developed jointly with the electro-optics department. There are three full-time and four part-time faculty members, all with Ph.D. degrees in physics and engineering.

There are co-op opportunities with local industry for undergraduate as well as graduate students. Several large corporations are presently evolving joint R&D relations with UH-CL on a long-term basis. The resulting improvement in laboratory equipment is having a dramatic effect on the present and future course of the electro-optics program.

For further information concerning any aspect of the Electro-Optics Program, contact Dr. William R. Lawrence, 2700 Bay Area Blvd., University of Houston-CL, Houston, TX 77058. 713/488-9480.

Book Reviews

Integrated Optics: Theory and Technology

Reviewed by Dennis G. Hall, The Institute of Optics, University of Rochester, Rochester, NY 14627.

The field of integrated optics continues to attract the attention of scientists and engineers with diverse backgrounds and interests. Since the existing literature on the subject is, for the most part, directed toward the specialist, there is a serious need for an introductory-level treatment that provides a unified picture of this highly multidisciplinary field. Hunsperger's book attempts to meet this need with an interesting blend of the theoretical and materials and device considerations necessary for further work in integrated optics.

The volume is organized into 16 chapters that treat the theories of waveguide modes and interactions between them, input and output couplers, electro-optic and acousto-optic modulators, semiconductor lasers, integrated detectors, and circuit applications. The author states in his preface that the book is an outgrowth of a one-semester graduate-level course taught first at the University of Southern California and later at the University of Delaware and therefore has a definite textbook style, with problems presented at the end of 15 of the chapters. The text requires very little in the way of mathematical sophistication and should be easily managed by seniors with a previous course in electromagnetic theory.

Hunsperger approaches the field of integrated optics from a device point of view. He describes an impressive array of modulators, couplers, interferometers, waveguides, laser structures, detectors, and fabrication techniques. While he acknowledges the existence of two approaches to integrated optics, the text is aimed toward monolithic integration in GaAs/As. There is no quantitative discussion, for example, of the graded-index waveguide, which is the foundation for LiNbO₃-based integrated optical devices and systems.

As is customary, the author uses coupled-mode theory to describe the quantitative aspects of devices such as directional couplers and waveguide-grating reflectors. The coupled-mode equations are introduced without derivation, and no attempt is made to instruct the reader in how to calculate the all-important coupling coefficients that determine device performance. Hunsperger provides the standard expressions for these coupling coefficients and cites references, but his treatment does not leave the reader prepared to calculate new ones when the need arises. In spite of the device orientation of the book, certain devices have been excluded: waveguide lenses, metal-clad waveguides, and ring resonators, for example, are not discussed.

While Hunsperger's book gives a much better introduction to integrated optics than does the standard reference, Integrated Optics, edited by T. Tamir (Springer-Verlag, 1979), it does not replace it. The emphasis on devices that gives Hunsperger's text both strength and unity seems to come at the expense of important fundamental material. I do not believe, for example, that one can learn an adequate amount about optical waveguides by studying Hunsperger's book alone. In short, the book is broad and descriptive; it does not delve deeply into details.

In the year that Hunsperger's book has been in print, I have personally recommended it to seniors and first-year graduate students who want to know in a general way what one does in the field of integrated optics. There is no other book available that can provide this "first look" for the initiate.

Electro-Optic and Acousto-Optic Scanning and Deflection

Reviewed by Pankaj Das, Rensselaer Polytechnic Institute, Department of Electrical, Computer and Systems Engineering, Troy, NY 12181.

The use of optics in electronics is increasing, and it appears that in the near future this trend will accelerate. This area of electronics incorporates such diverse fields as optical communications, including fiber optics; data processing, image processing, and optical signal processing; and computer applications such as information storage, A/D converters, and logic elements. In all of these applications one needs to manipulate the laser beam for the purpose of deflection, scanning, and modulation, multiplexing, etc. Excluding the direct modulation of a p-n junction laser in some cases one needs either an electro-optic or an acousto-optic device to serve these purposes. Thus, this book on scanning and deflection using acousto-optic and electro-optic effects in liquids and crystals is highly welcome.

The book is divided into two parts. Part I consists of five chapters devoted to electro-optic deflectors and includes a review of the fundamental electro-optic effect, relevant properties of the materials, and principles, design, and practical applications of these deflectors. The practical applications covered include streak cameras, real-time scanned laser displays, and picosecond optical pulse shaping. The five chapters of Part I focus on electro-optic deflectors, starting with elementary presentations on acousto-optic interaction in isotropic and anisotropic solids, materials for acousto-optic scanning, ultrasonic transducers, and design and applications of scanning acousto-optic systems, such as acousto-optic television displays, flying spot microscopes, and array scanners. The last chapter deals with the use of acousto-optic interaction in integrated optics.
Overall, the book fulfills its objective of collecting in a single volume the widely scattered information required for the design and application of optical data. It will be useful for the practicing engineer and valuable for the novice in this subject. However, I would be reluctant to use this book as a textbook since the chapters on fundamentals are somewhat sketchy. For example, in Chap. 6 most of the results are simply stated, rather than derived, although the derivations can be found in other textbooks. Other weaknesses of the book are the rather sketchy treatment of integrated optics and the fact that no mention is made of other signal processing functions, such as real-time correlation. Again, one can argue that the emerging technologies, such as optical matrix processors and convolvers, are beyond the scope of this book. But, certainly, this book will be an excellent reference for further reading.

Ultrasensitive Laser Spectroscopy


Reviewed by C. K. N. Patel, AT&T Bell Laboratories, Murray Hill, NJ 07974.

A book that is a collection of chapters written by a number of individuals who are authorities in their own fields is hard to review because it is difficult to decide whether or not the book as a whole has accomplished its goals. The task is especially difficult when there are no guidelines other than the title of the book to instruct the reviewer about what I consider to be very elementary properties of what I am convinced, will not make anyone the wiser about the potential of his technique for ultrasensitive laser spectroscopy. There is a lot of information on the latest in techniques and interpretations. For the expert, these chapters provide evaluations of ultrasensitive laser spectroscopy. There is a lot of information on the potential of his technique for ultrasensitive laser spectroscopy. However, I am distressed by some lack of precision in stating dimensions, etc., as evidenced in the sentence that begins, “By considering a two-photon...” at the bottom of p. 243 and ends, “…$10^{-25}$ cm$^2$ sec at the top of p. 244. The dimensions of a two-photon cross section are cm$^2$ sec molecule$^{-1}$ photon$^{-1}$. The same sentence also states “…the laser should produce an intensity of on the order of $10^{-25}$ cm$^2$ sec.” The units of laser intensity that I am aware of are either watts cm$^{-2}$ or photons cm$^{-2}$ sec$^{-1}$. But such details aside, here again I would like to have seen more results and critical evaluation of data and limitations rather than a few descriptive lines about a large number of experiments, with no presentation of data.

The chapter on laser intracavity techniques by Harris could have been an excellent introduction to this alternate way of measuring small absorption coefficients but missed the chance to provide the reader with data on which his arguments could be safely anchored. As for the last chapter, on analytical applications of laser spectroscopy by Harris and Lytle, my only comment is—was it necessary?

How well do the various chapters hang together? Unfortunately, I came away with a strong impression of a lack of coherence in the book. An indication of this lack of coherence can be obtained by noting the rarity with which the authors cross-reference other chapters. The chapters that deal with the theme of the book do so, although not as often as I would like in order to give one a feeling of coherence. But the remaining chapters do not cross-reference any other chapters, further confirming my statement that in this book there are three chapters that have very little to do with ultrasensitive laser spectroscopy.

Overall, am I glad that I read the book? Yes, because the parts that are good, are good enough for me to have waded through those chapters that may be and probably are alright on their own merits but have no bearing whatsoever on the stated purpose of the book.
Surface Studies with Lasers

Reviewed by S. R. J. Brueck, Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, MA 02173-0073.

Surface studies, both basic and applied, are becoming increasingly important in contemporary science and technology. Basic studies have progressed extraordinarily with the ready availability of clean, well-characterized vacuum environments and with the application of the wide range of surface spectroscopies that have recently become available. The effects of interface states and surfaces on semiconductor devices and device processing are becoming increasingly important as dimensions shrink and surface-to-volume ratios increase. Surface states have always played a dominant role in catalysis.

Laser optics are because of their unique capabilities for spectral and temporal resolution and, thus, their ability to follow state-selective excitations, are playing an even more significant role in these studies. Additionally, laser sources are being used to deliver energy to spatially well-defined sample areas as an active part of a processing step. Recently, there have been extensive investigations of both photochemical and photothermal processes with applications to semiconductor device fabrication.

This volume is the proceedings of a 1983 divisional meeting of the Quantum Electronics Division of the European Physical Society. The book is divided into four main areas: General Surface Spectroscopy, Surface Enhanced Optical Processes, Laser Surface Spectroscopy, and Laser Induced Surface Processes. In all, 40 papers are included, with international representation from 13 countries.

The first section consists of three review articles on vibrational spectroscopies of adsorbed atoms and molecules, on molecular vibrations at surfaces, and on electronically excited states of surface species. These are all very substantial subjects, and the aim of the articles is not exhaustive review but rather an overview of effects and a physically intuitive introduction to the non-specialist. In general, this goal is achieved, and in many ways these are the most valuable papers in the volume. The remaining sections of the book are devoted to current research papers. The quality of these papers, as is common in the genre of conference proceedings, is quite variable, with current contributions from many of the editors in the field, some of which are quite well written while others are little more than extended abstracts. There is no index.

The value of volumes such as this lies in the fact that it reviews new laser systems and their applications in laser spectroscopy in which many of the same subjects, and indeed these same authors, are also well represented. These include the proceedings of a laser spectroscopy conference held in the summer of 1983 and of the Materials Research Society symposium on Laser-Controlled Chemical Proces proof Surfaces held in the fall. Each of these has a different emphasis and selection of topics, aimed at different portions of the work covered in this volume, but they all share the same goal of providing a wide sampling of important research in laser interactions and laser spectroscopy at surfaces. Much of the content in this volume has also appeared in the journal literature, although usually in somewhat less detail. The book is recommended for active researchers in these areas; readers who are looking for overviews and review papers will not find them here.

Quantum Electronics and Electro-Optics

Reviewed by Elsa Garmire, Center for Laser Studies, University of Southern California, University Park, MC1112, Los Angeles, CA 90089-1112.

Quantum Electronics and Electro-Optics is the glamorous title of a book that is, in fact, the unglamorous proceedings of a British national conference held in Hull, England, in 1981. Edited by P. L. Knight, this book contains approximately 75 short papers varying in length from 2 to 10 pages, a list of participants, and an index. A suspicious reader might wonder if the "buzz" title was chosen purposefully to include two of the most glamorous phrases in the field today, quantum electronics and electro-optics, in order to sell more copies to unsuspecting libraries and individuals. Many of my students, attracted by its title, picked up the book off my desk, but put it down again when they saw that it was merely a conference proceedings. Misrepresentation is further evidenced by the fact that the book contains no papers on what is generally considered to be electro-optics, even though this term is included in the title. The volume should have been titled Proceedings of the Fifth National British Quantum Electronics Conference (1981).

Research described at this conference is limited to that under way in the United Kingdom. The book's primary value, therefore, is its overview of quantum electronics research in the United Kingdom. It reviews new laser systems and their application to quantum electronics. Other contributions included several contributions to quantum electronics, although usually in somewhat less detail. In my opinion, it was not successful as a director of research in the United Kingdom, as an overview of the field of quantum electronics, or even as an introduction to more specialized topics.

Its greatest value is its overview of research being conducted in the U.K. The alphabetical list of participants at the beginning includes many well-known scientists. However, as a directory to laser research in the U.K. it has several serious limitations. First, there is no author index, which means that it is impossible to locate an author's paper unless one already knows his or her area of interest and looks under the appropriate section in the Table of Contents. Hence, the book also does not tell who is doing what. Second, there is no index of institutions. As an American familiar with a number of scientific institutions in the U.K., I would like to know what research is being pursued at what institution. Such an index would have allowed me access to this information and would have been a simple inclusion for the editor.

Finally, there are in the U.K. a number of very well-known researchers in the fields of quantum electronics and electro-optics who are not included in the book. I know of several in the areas of semiconductor lasers, mode-locking, and integrated optics. Thus, this compendium of research being conducted there, it is the reviewer's opinion that a single well-written article on the subject would suffice.

The book also fails to be useful to those looking for an overview of the fields of quantum electronics and electro-optics. Sadly lacking is the discussing research in semiconductor lasers that has been under way in the U.K. for ten years. This volume tends to perpetuate the myth that the study of semiconductor lasers is not quantum electronics. For any book to serve as an overview of the field, it must include material on semiconductor lasers.

Regarding the absence of papers on laser electronics, perhaps the editor meant the title to include some nonlinear optics devices such as phase conjugation and optical bistability that were included.

The papers were divided into 14 sections. Some, such as those on CO2, Lasers, Rare Gas Halide Lasers, and Spectroscopy and Photochemistry, were extensive. Sections on Optically Pumped Molecular Lasers, Remote Sensing, and Quantum Optics were more abstract and paper-heavy, but were missing some very important aspects. Finally, there were sections that were too sketchy or too broad to provide an adequate overview of the field. These include Mode Control, Applications of Lasers, General Lasers, and Theory and General Quantum Electronics. Totally missing were papers on electro-optic modulators, integrated optics, and spatial light modulators.

Finally, the book fails as an introduction to the state of the art of research in specific areas of quantum electronics. In common with most conference proceedings, many of the papers are merely abstracts that do not provide sufficient information to be self-contained, references are not sufficiently extensive to provide adequate source material, and no information is given as to where the final results were published in the open literature. Readers would find it more rewarding to locate proceedings of topical conferences in the specific areas of interest or refer to the quantum electronics journals and their many excellent invited papers.

For those who are interested in pursuing the details of quantum electronics research specifically...
Semiconductor Devices for Optical Communications (Second Edition)


Reviewed by F. J. Leonberger, MIT Lincoln Laboratory, Lexington, MA 02173.

This book is a collection of review articles primarily focusing on semiconductor optoelectronic devices and circuits for fiber systems. The articles are well written by experts in fiber communications and present the material from an engineering viewpoint. The book can serve as a very useful introduction to fiber devices as well as a reference book for workers in the field.

The original edition of the book was published in 1980 and appears current through work reported in 1978. The second edition, which is reviewed here, was published in 1982 and, in addition to material in the first edition, includes updates on optical sources and photodetectors. These updates are current through most of 1981. The emphasis in the book is primarily on GaAs/GaAlAs lasers and LEDs, Si detectors, and associated communication systems. While this reflects the bulk of the commercial interest in 1980, the emphasis of much current device research and new commercial fiber component fabrication is on InP-based materials for the optimum 1.3 to 1.5 μm fiber transmission wavelength. These devices are addressed primarily in the updates.

While the overall technology emphasis of the book is slightly outdated, the presentation of the engineering aspects of optoelectronic devices is still extremely relevant. Five chapters are devoted to optical sources. Specific topics covered are the fabrication, operational principles, and characteristics of diode lasers and LEDs, the characteristics and drive circuitry for transmitters, modulation characteristics, and the effect of junction heating on laser linearity and harmonic distortion. Two chapters devoted to optical detectors present the characteristics of photodiodes, with emphasis on avalanche photodiodes, and a comprehensive review of photoreceiver design. Additional chapters cover fiber couplers and an example of an optical communication system, the Bell System's 45 Mbit/s "Chicago Lightwave Project."

The book is fairly well balanced, although a bit more detailed description of the operational principles of photodiodes would be useful. Throughout the book, the reference lists contain many review papers and textbooks that allow the reader to delve more deeply into the device physics or system design. The index and table of contents are detailed and clear so that the book can be easily used as a reference. The notation is not entirely consistent between chapters, but the variations are easy to follow.

In summary, the book should be a valuable reference for those interested in the engineering aspects of semiconductor optoelectronic devices.

The Radon Transform and Some of Its Applications


Reviewed by Anne V. Clough, University of Arizona, Tucson, Arizona 85721.

In 1917 Johann Radon, an Austrian mathematician, published a paper entitled "On the Determination of Functions from Their Integrals Along Certain Manifolds." In it, he introduced a transform that reduces an n-dimensional (nD) function to a one-dimensional (1D) function through integration over n − 1 hyperplanes. Conversely, the inverse Radon transform recovers the original nD function from its given 1D projections. Although unnoticed for many years, this paper now forms the mathematical basis of medical computed tomography (CT). In CT, one measures line integrals, or a projection, of the x-ray attenuation coefficient of an object by passing an x-ray beam through it. The complete set of these projections for all beam directions through a 2D slice of the object is the 2D Radon transform of the attenuation coefficient. Reconstruction of the object from its line integrals is an implementation of the 2D inverse Radon transform. The use of the Radon transform has attracted most attention in CT, but it has also been applied to problems in areas such as electron microscopy, radio astronomy, and geophysics.

The Radon Transform and Some of Its Applications is the first book devoted exclusively to a study of this transform. A sampling of applications of reconstruction from projections provides an introduction to the use of the Radon transform and its inverse. Medical imaging techniques, image reconstruction methods in astronomy, determination of refractive index, and computation of synthetic geophysical seismograms are a few of the topics discussed in Chap. One.

The mathematical foundation of the transform is laid in Chaps. Two and Three, which contain the definition of the general nD Radon transform on a Euclidean space as well as a more detailed presentation of the more practical 2D and 3D cases. The basic properties of the transform are given with useful examples of interesting mathematical functions and pertinent, physically motivated functions.

In Chap. Four the important relationships between the Radon transform and other well-known transforms, such as Fourier, Gegenbauer, and Hough, are derived, thus providing the necessary groundwork for a study of inversion methods. A mathematically rigorous derivation of the nD inverse transform is presented in Chap. Five. Although very detailed, the analysis is well motivated. The discussion of inversion techniques continues in Chap. Six, focusing on Fourier and other methods useful in digital implementations. Although no attempt is made to elaborate on the details of the computational schemes used in these procedures, an extensive list of references is given for those interested in practical aspects of the inverse Radon transform.

Series expansion methods introduced by Cormack in 1963 and developed thereafter are presented in Chap. Seven. As is done elsewhere in...
the text, the general nD framework is outlined in
the beginning of the chapter, while the special
cases of n = 2 and n = 3 are described throughout
the remainder. The text proper concludes with a
chapter of assorted properties, applications, and
generalizations of the Radon transform. Though
often overlooked, applications such as those used in
solving potential scatter problems and partial
differential equations are especially befitting the
applied mathematician.

Three appendices provide considerable insight
into the mathematical aspects of the Radon trans-
form. The first is an often referenced but rarely
seen translation of Radon’s original paper, for
which Deans deserves commendation. The second
appendix is a brief but succinct review of general-
ized functions for those who are more theoretici-
ally inclined. Special functions widely used in
Radon transform theory are given in the last
appendix, which provides a useful look-up table
for readers unfamiliar with standard formulas or
the author’s notation.

As the author intended, this book serves two
purposes: first, it presents a rigorous yet readable
derivation of the Radon transform and its basic
properties, and second, it discusses the applica-
tions of the transform to major problems. Any reader versed in engineering mathematics and
Fourier theory will be able to follow and use the
material discussed. The presentation flows from
general to specific, thus satisfying the needs of
theorist and experimentalist alike. For example,
the general nD Radon transform theory is derived,
but particulars and examples are confined to the
more widely used 2D and 3D cases. Similarly, by
using illustrative examples from many research
areas to present the usefulness and properties of
the material, the Radon transform is shown to be
an important practical tool, rather than just
another interesting mathematical concept. A third
important contribution of the book is the exten-
sive review of pertinent literature. Although in
places the numerous references are distracting,
those cited throughout the text afford guidance to
a wealth of literature related to all areas of the
transform.

Deans has added an important contribution to
the Radon transform literature. The book pro-
vides an excellent and much-needed overview of
the analysis of the transform and its applications
to some of the more often studied reconstruction-
from-projections problems. It can be used as a
basic introduction for those just entering the field
as well as a solid reference for those currently
researching in the field.

Thin Film Solar Cells

Reviewed by Roland Winston, The University of Chicago, Department of Physics, 5640 South Ellis Avenue, Chicago, IL 60637.

Electricity derived from direct conversion of sun-
light is perhaps the most attractive form of solar
energy. However, the persistent problem with
conventional single crystal solar cells has been
their high cost, while the earth may be
"free," one cannot afford the initial capital
investment. Thin film technology offers the prom-
ise of a much less costly solar cell. It is precisely
for this reason that a competent treatment of the sub-
ject is both timely and important for workers and
students in renewable energy and in solar energy
particularly.

The present monograph meets this need with
an admirably clear, readable, and comprehensive
account of the subject. The authors begin with an
overview chapter on solar economics and the
potential contribution of thin film solar cells to an
abundant renewable energy supply. There follow
two chapters on the basic physics of photovoltaic
device and a chapter on measurements. These
three chapters are, to my taste, probably the high
point of the book, since it is difficult to find an
accessible account of the basic physics of
photovoltaic devices. Moreover, an explanation of
the techniques of measurement is particular useful
to students. There follow more specialized chapters on topics specific to thin film technology. I found
the chapter on amorphous silicon solar cells of
special interest because of the present emphasis on
this potentially low cost option for photovoltaic
electricity. Certain peripheral topics, e.g., antire-
flection coatings, concentrators, grid design,
encapsulation, and solar cell arrays, are treated in
appendices which, while brief, are very much to
the point.

In the preface, the authors recommend the
material to graduate students and to R&D scienti-
tists and engineers. However, I would expect the
advanced undergraduate student in physics to be
able to cope with the technical content. In fact,
even the nontechnical reader desiring to form an
impression of this emerging technology would
benefit by perusing the pages. The general layout of text and figures is clear and makes a favorable impression. This and an attractive binding and good quality paper com-
bine to give this book an accessible quality that
invites examination. The reader who does so will
not be disappointed.

Books Received

Industrial Robots—A Summary and Forecast, Tech Tran Corp., 134 N. Washington St., Nap-
erville, IL, 60540 (312/369-9223). Spiral-bound, 308 pp. This report presents an overview of robot
technology, applications, models and manufac-
turers, emerging developments, and future trends,
more from a business point of view than a techni-
cal one. $50.00 from publisher. J.H.

Conference Papers in Applied Physical Sciences, a monthly publication started in July 1983, which
lists title and author(s) of papers from various
conferences. Although devoted mostly to engi-
neering (e.g., mechanical, civil, chemical, etc.)
and materials, there is a category for optics. $100.
for one-year subscription, available from Applied
Science Publishers LTD, 22 Rippleside Commer-
J.H.

The Defense Communication Study 1984-1985, Corporate Communications Studies, Inc., P.O.
Box 9538, Daytona Beach, FL 32020 (904/673-
Profiles defense associations, identifies and de-
scribes the periodicals and other publica-
tions worldwide. $23.50.

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JUNE 1984

June 3-7 Robots Conference and Exposition, Detroit, MI, Sponsored by Robotics International of SME and the Robot Institute of America. Contact Society of Manufacturing Engineers, P.O.
Box 930, Dearborn, MI 48121. TWX 810-221-1232
SME DRBN.

June 4-5 Council for Optical Radiation Mea-
surements (CORM) 1984 Conference and Annual
Meeting, Gaithersburg, MD. Contact Norbert L.
Johnson, 3M Center, Bldg. 582-1-16, St. Paul MN
55144. 612/733-5939.

June 7-8 Society for Information Display (SID), International Symposium, San Francisco,
CA. Contact Leonard H. Klein, Symposium Manager, Palisades Institute for Research Ser-
VICES, 401 783-4011.

June 4-5 Synergistic Approach to Hybrid
Automation, Workshop II, Chicago, IL. Spon-
Sored by the International Society for Hybrid
Microelectronics. Contact ISHM, P.O. Box 670,
Silver Spring MD 20901. 301/933-8777.

June 7-9 OPTICOM: Economic Development and Photonics Communications, Luxembourg,
Grand Duchy of Luxembourg, Sponsored by the European Photonics Assn. Contact EPA, 2 rue
Brulée, 67000 Strasbourg, France.

June 10-15 Fifth International Congress on
Experimental Mechanics, Montreal, Canada.
Sponsored by the Society for Experimental Stress
Analysis (SESA), the British Society for Strain
Measurement (BSSM), and the Permanent Euro-
Pean Committee for Stress Analysis. Contact
SESA, 14 Fairfield Dr., Brookfield Center CT
06805. 203/775-6373.

June 11-13 American Astronomical Society's
164th Meeting, Baltimore, MD. Hosted by Johns
Hopkins Univ. and the Space Telescope Science
Institute. Contact AAS, 1816 Jefferson Place NW,

June 11-15 UV/Visible MultiPhotons & Disso-
ciation Processes, New London, NH. Sponsored by
Gordon Research Conferences. Contact A.M. Cruickshank, Gordon Research Conferences,
Univ. of Rhode Island, Kingston RI 02881-0801.
401/783-4011.

June 11-15 Holography & Coherent Optics,
Plymouth, NH. Sponsored by Gordon Research
Conferences, Contact A.M. Cruickshank, Gordon
Research Conferences, Univ. of Rhode Island,
Kingston RI 02881-0801. 401/783-4011.