SPIE Reports

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Book Reviews

Joseph L. Horner and Paul R. Yoder, Jr.,
Book Reviews Editors

Send books for review to the Managing Editor, Optical Engineering, P.O. Box 10, Bellingham, WA 98227-0010. Since there is not space to review all books received, the Book Reviews Editor will use his discretion in selecting those of most interest to the readership of this journal.

Laser Surface Treatment of Metals

Clifton W. Draper and Paolo Mazzoldi, eds., xix + 680 pp., illus., index, references. ISBN 90-247-3405-3. Nijhoff Publishers, P.O. Box 163, 3300 AD Dordrect, The Netherlands; U.S. distributor, Kluwer Academic Publishers, 101 Philip Drive, Assinippi Park, Norwell, MA 02061 (1986) $134 clothbound.

Reviewed by David M. Roessler, General Motors Research Laboratories, Physics Department, Warren, MI 48090-9055.

"This book contains the papers presented at a NATO Advanced Study Institute held at San Miniato, Italy, from September 2 to 13, 1985, on the latest developments in the science and technology of modifications, in particular, of metallurgical surfaces due to laser treatment." These opening words from the introduction to the book give only a bare-bones summary of its contents and can convey neither its flavor nor the atmosphere of the meeting itself. As one who was able to participate in the Institute, I am tempted to write about the latter: of the splendid isolation and freedom from distraction at the meeting, held in a former monastery on the outskirts of a small city high on a hill between Pisa and Florence; of the keen enthusiasm of the 69 attendees and their camaraderie despite their diverse nationalities; of the sheer stimulation of this meeting whose 10 days passed so quickly. An appendix to the book captures a little of this flavor, but the book itself can be fully recommended in its own right.

Many different topics are covered under the umbrella title of "laser surface treatment of metals" ranging from tutorials on laser/metal interactions to previously unpublished research and from reviews of industrial applications of materials processing to research on not only metals but also semiconductors and biological tissue. The meeting attracted leading authorities in several areas of laser/surface interactions, and this is reflected in the quality of the papers. Names such as H. W. Bergmann (melting), C. W. Draper (surface melting and alloying), W. W. Duley (surface coupling), J. Mazumder (modeling, alloying, cladding), B. L. Mordike (alloying), P. S. Peercy (solidification dynamics), J. M. Poate (annealing of silicon), F. Spaepen (picosecond pulses), and W. M. Steen (cladding) are just a few of those that indicate the significance of the meeting.

The eight chapters are used to collate the 43 written papers into the following broad topics: interaction at metal surfaces, fundamentals of phase formation in laser annealing of metals, modeling of heat and mass transfer, properties of laser-processed metallic surfaces, recent developments in laser surface techniques for engineering applications, application to industry, laser surface chemistry, and laser annealing of silicon. An interesting feature is several pages of introduction to each chapter summarizing the chapter's contents and primary findings. Each chapter concludes with questions and answers presented at the meeting and edited by the graduate students who attended.

Several papers address the problem of laser coupling to a surface, an area requiring considerably more research even at CO_2 laser wavelengths, let alone at shorter wavelengths. Methods of increasing the coupling range from deposition of absorbing layers to cunning optical techniques that reflect back scattered radiation. An intriguing paper by F. Keilman discusses laser-induced periodic structures on surfaces and comments on the potential for increased coupling.

Chapter 2 includes several studies of laser-induced phase transformations in metals for systems such as Al-Sb and Al-Ni as well as in single-element metals such as Al, Mn, Au, Cu, Mo, and Bi. Picosecond pulses have been used to produce quench rates as high as 10^{13} K•s^{-1}, leading to many novel materials.

Modeling of heat and mass transfer is treated in both continuous and pulsed irradiation systems and includes not only metals but also living tissue. While the heat diffusion equation is the primary tool for both heat flow and mass transport, the latter also relies heavily on the particle diffusion equation or hydrodynamic momentum equations. Modeling of convective motion has become quite complex. Mechanical (wear), electrochemical (corrosion), electrical, and optical properties of laser-processed metal surfaces are discussed in Chap. 4, which also includes a paper by Stritzker on the production of superconducting alloys. Chapters 4 through 6 include a number of papers with very obvious industrial applications already to hand or likely in the near term. Improved surface mechanical properties are some of the benefits accruing from laser alloying, cladding, and surface melting, and materials of interest range from ferrous materials to titanium and aluminum. Papers by A. V. LaRocca and R. M. Macintyre describe applications within the automotive and aircraft industries, respectively, in Chap. 6.

The three papers composing Chap. 7 deal with laser decomposition of a gas phase prior to its condensation as a deposit, with deposition of Ni and Mo by dielectric breakdown of gas mixtures, and with the combined use of laser irradiation of a substrate with electroplating.

The last chapter is devoted to the laser annealing of silicon. The topic is reviewed by Poate, followed by papers on melt and solidification dynamics, impurity segregation, and solute trapping.

The volume itself is of high quality: the print and figures are clear, equations are less prone to be misread than is often the case in conference proceedings, and the general readability of the script testifies to the diligence of those recruited to edit it, despite the fact that English is not the

native language of many of the authors.

The book is an excellent survey of the whole field of laser surface treatment. Its disadvantage in being a compilation of conference papers is that it is the product of diverse authors and inevitably lacks some of the cohesion that would be found in a textbook. However, the diversity is such that any worker in the field will find some papers of direct significance and many others of considerable interest. The biggest barrier to personal acquisition, particularly in these days of U.S. tax reform, may be the price — more than $130. That is a great pity, for it is an excellent book and a worthy successor to others in the NATO ASI Series.

Videodisc Systems: Theory & Applications

Jordan Isailović, iii + 451 pp., illus., index, references, 10 appendixes. ISBN 0-13-941865-2. Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632 (1987) $42.95 hardbound.

Reviewed by Dennis G. Howe, Diversified Technologies Group Research Labs., Kodak Research Laboratories, Rochester, NY 14650.

This book, and its companion work *Videodisc and Optical Memory Systems* by the same author, are meant to "contain the basis of videodisc systems." *Videodisc Systems: Theory & Applications* is mainly a treatment of video signal processing, especially the various forms of narrowband frequency modulation (FM) encoding of television signals that are employed in the European, North American, and Japanese versions of laser-optical and capacitive-stylus videodisc playback systems. There is little about the optics and optical detection systems employed in laser videodisc players in this volume; these topics are covered in the companion book.

These two books are the first technical texts devoted entirely to the subject of optical disc and capacitive disc technology. Up to now, expositions on the subject could be found only in the technical literature, with some very useful compilations of such information contained in special issues dedicated to videodisc and optical recording of journals such as *RCA Review, Philips Technical Review, Applied Optics,* and a number of SPIE Proceedings volumes.

I was disappointed to find that this book is not easy to read; too often there seemed to be no sequential, logical development of the concept under discussion. Most aggravating, however, are the many typographical errors in the text, equations, and figures (one referenced figure, viz., Fig. 2.15, is even missing).

A more specific description of the book's contents follows. Chapter 1 treats the details of the optical and/or capacitive detection of the signal-bearing features embossed in the surface of the disc in the manner of an overview; no formal development or analysis of the readout mechanisms is given. The description of videodisc mastering, replication, and quality testing (Chap. 2) is good, but the treatment of the evaluation of writeable (newly made, but as yet unrecorded) digital optical discs is too brief and quite confusing. Chapter 3 is a nice discussion of modulation techniques, the effects of noise, and the signal processing (i.e., filtering, equalization, etc.) required by different modulation schemes. A weak point here is the treatment of transversal filters as equalizers, which in my opinion is intelligible only to those familiar with such filters. It is too bad that the many typos, especially in the equations, make Chap. 3 so difficult to read. Moreover, the fact that symbols used in the text often do not correspond to those in the figures is especially annoying.

Chapter 4 contains a nice tutorial of FM signals and their characteristics, except that the derivation of the S/N of an FM detector was obscure to me. The treatment of pulse FM is unique and useful (it is done by considering the spectrum of a pulse wave train, whereas other treatments familiar to me start with a sinusoidal FM signal that is subsequently hard-limited). Unfortunately, the many typos and the usage of undefined symbols again make the reading tedious.

Chapter 5 begins with a long (35 pages) general discussion of image scanning, scanned (TV) images and their baseband spectra, the spectra of broadcast (single-sideband AM) television signals, and gamma correction. Such a lengthy treatment is not especially relevant to the book since dedicated, complete expositions on these subjects exist. The remainder of Chap. 5 gives detailed descriptions of the North American (NTSC), European (PAL), and French (SECAM) TV signals and the coding and decoding circuits used to generate/demodulate them. This latter discussion is useful, not only as a reference to the signals and circuitry used but also because it gives the reader a sense of the (playback signal) tolerances that must be maintained by a video recording machine.

Chapter 6 starts by justifying the use of narrowband FM as the coding of choice for videodisc systems. The justification is based principally on bandwidth and distortion (intermodulation) considerations. One aspect of the discussion that is not clear to me is why the author does not point out the importance of the stationary baseband color subcarrier component that is demodulated out when composite NTSC or PAL video signals are recorded via pulse FM. Other comprehensive treatments of this topic [e.g., G. C. Kenney and A. H. Hoogendijk, "Signal processing for a videodisc system," Trans. BTR (August 1974) and M. R. DeHaan and C. H. F. Velzel, "Intermodulation and moire effects in optical video recording," Philips Res. Rep. 32, (1977)] suggest that interference between this demodulated stationary component and the lower first-order sideband of the FM-encoded luminance signal is the reason why PAL video signals (with 6.5 MHz bandwidth and a 4.43 MHz color subcarrier) had to be recorded using color-under processing, while NTSC video (with 4.5 MHz bandwidth and a 3.58 MHz color subcarrier) could be recorded in its composite form. Furthermore, the intellectual value of this chapter could be substantially enhanced if it were shown that one is just able to obtain a demodulated playback video signal with adequate wideband S/N from a pulse FM recording that exhibits a carrier-to-noise ratio equal to (or greater than) that which is practically achievable with the videodisc system and if the chapter incorporated a discussion of the player's optical transfer function and its compensation (such as the one in Sec. 3.4 of the companion text). Again, elimination of typos and correction of mislabeled variables and parameters in the figures would help.

Chapter 7 discusses methods for increasing the system's playing time (storage capacity). It starts by describing some arcane methods of enhancing the optical resolution of the player's detection subsystem and goes on to treat more realizable technology such as constant linear velocity (CLV) recording and playback, video bandwidth compression, and video frame rate reduction. The best part of this chapter is the description of the TV signal bandwidth reduction scheme used in the capacitive (RCA SelectaVision) videodisc system.

Chapter 8 is an exposition on audio signal recording. It begins with a technical description of speech, hearing, and noise reduction techniques. Digital audio recording is then introduced via overviews of pulse code modulation of audio signals and of the signal processing (i.e., the format, modulation coding, and error correction coding) employed in the digital audio compact disc (DAD). The chapter concludes with a review of the use of digital audio in the LaserVision videodisc system. The entire treatment of audio is well done, except for some inconsistencies in the definition of the run-length constraints of the eight-to-fourteen modulation (EFM) code used in the DAD.

The main thrust of the final chapter (Chap. 9) is applications of videodisc systems beyond the conveyance of entertainment TV programming. It begins with a rambling discussion of interactive (programmed) applications, e.g., catalogs, training, etc., as well as some speculative uses such as storage of 3-D TV images.

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ERIM REPORT #3

The Science of Radar Image Processing

ERIM researchers are investigating numerous topics in the field of radar image processing, including speckle reduction and synthetic image generation.

Speckle Reduction

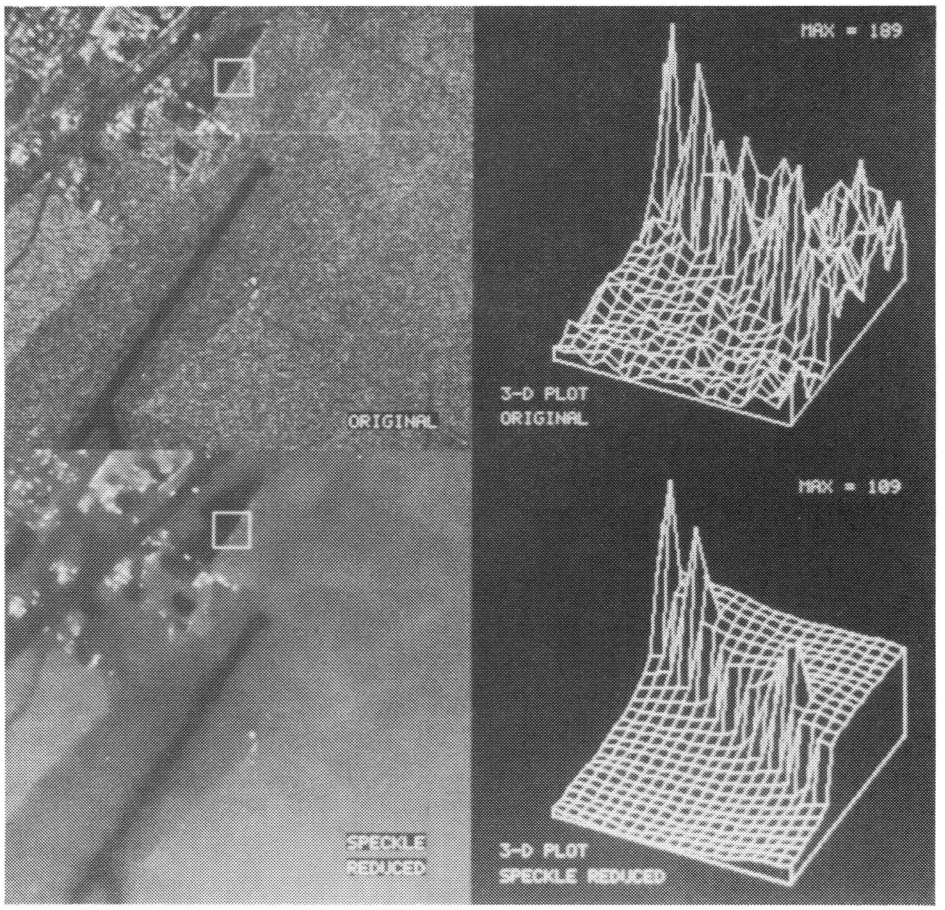
Due to the coherent nature of the synthetic aperture radar imaging process, radar images suffer from a disturbing speckle noise. This "salt-and-pepper" appearance of the imagery is a hindrance to the performance of radar image interpreters as well as automatic recognition algorithms. Conventional speckle reduction techniques, such as noncoherent integration of multiple looks and median filtering, degrade image resolution and thereby blur key image features such as edges and point returns.

To overcome this difficulty, ERIM researchers developed a nonlinear speckle reduction algorithm based on geometric concepts. The method iteratively applies a sequence of neighboring processing operations based on the "digital convex hull". As shown below, this algorithm preserves edges and strong returns in the image without resolution degradation while smoothing speckle.

Speckle Image Generation

The ability to synthetically generate radar images of modelled objects has many important advantages. These include imaging of objects which do not physically exist, interactive object design via changing of object material properties or shape, and avoidance of costly sensor collections.

ERIM's staff have developed a hardware/software system capable of producing realistic radar images of modelled objects. A combinatorial solid geometry model of the object is first generated from available plans and photos. This model is then input to a module which emulates the electromagnetic interaction between radar and object. Important features such as multiple reflections, shadows, range layover and added noise are faithfully portrayed in the resulting imagery. Extension of this capability to include IR and optical wavelengths is now underway.



ERIM is a scientific research institute that performs contract research services for a variety of sponsors. Our sponsors include government organizations, industry, and universities. Research at ERIM focuses upon remote sensing systems, devices, and techniques that span the electromagnetic spectrum. Within this broad research area, staff members employ their knowledge of modern electronics, optics, computer science, and infrared and microwave physics.

Career Opportunities

ERIM's Radar and Infrared & Optics divisions have research and management positions available at several levels in the following areas:

- **Radar System Design**
- **E-O/IR System Design and Analysis**
- **RF Circuit Design**
- **Optical Computer System**
- **Phase Retrieval/Signal Reconstruction**
- **Radar System Engineering and Analysis**
- **Signal and Image Processing**
- **Microwave Scattering and Measurement Engineering**
- **Diffractive Optics**

All positions require a BS, MS, or Ph.D. in engineering, physics, mathematics, or statistics, along with appropriate work experience. Salary and benefits are highly competitive.

If qualified, send your resume to ERIM, Personnel Administration, Dept. OE, P.O. Box 8618, Ann Arbor, MI 48107-8618. Ask about positions available in Ann Arbor, MI; Los Angeles, CA; Fort Walton Beach, FL; Washington, DC and Dayton, OH.

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Next, the usage of the conventional video signal as a means of carrying digital data is considered; this is relevant since it allows one to directly employ the videodisc system for digital data storage/retrieval without making any substantial system modifications. The last part of this chapter (20 pages) discusses the run-length-limited (RLL) codes used to carry digital information in conventional digital data storage machines. This, together with the text supporting Fig. 6.14 and Table 6.1, the DAD treatment in Chap. 8, and the few remarks (3 pages) on digital signaling equalization (i.e., pulse shaping) at the end of Chap. 3, constitutes all the information given in the book on the subject of digital signal coding/processing as it is normally practiced in the data storage industry. The discussion is limited mainly to the description of the RLL codes; the topic of how one selects among the coding options (e.g., by considering channel margin and error rates) is not broached.

Strength of Inorganic Glass

Charles R. Kurkjian, ed., xiv + 643 pp., illus., index, references. ISBN 0-306-42096-1. Plenum Press, 233 Spring St., New York, NY 10013 (1985) $97.50 hardbound.

Reviewed by Michael J. Suscavage, Rome Air Development Center, Solid State Sciences Directorate (RADC/ESMO), Hanscom Air Force Base, MA 01731.

Strength of Inorganic Glass is a publication of the proceedings of a NATO workshop. This book contains 12 sections with 45 papers by a total of 61 well-respected authors writing in their areas of expertise. As the editor states, the basis for the meeting and this publication was to at least partially document the state of understanding of the strength of inorganic glass. The publication has succeeded nicely in this regard, and the result is an excellent reference for professionals just entering the field or those currently working in it.

The introductory section covers the history of glass strength, reviewing the early developments relating flaw size to the reduction of strength. The theory of fracture is discussed in the second section. One of the two papers in this section is a brief abstract on the atomistic theory of fracture with references to more extensive literature. The parameters that determine the fracture toughness of a material are dealt with in the other paper.

The third section treats surface chemistry and its effects on the strength of glass. Various kinds of glass surfaces are examined using instruments that are sensitive to the first few monolayers of a surface. Section four addresses flaws produced by different loading techniques under a number of conditions. Environmental effects relating to crack growth and fatigue are discussed in the following section. The sixth section covers fibers and the behavior of flaws, environment, testing parameters, and other factors controlling the strength.

Practical considerations are examined in the seventh section. This includes the "real world" strength of glass objects, windshields, protective coatings for glass, a new cutting method, and the statistics of fracture. A good review of thermal and chemical strengthening is presented in the next section. Additional papers on strengthening address the practical aspects, prestressing methods, and the prediction of results of strengthening. Results of fracture toughness measurements on chalcogenide glasses and glass ceramics are also included in this section.

Section nine discusses the high-temperature behavior of fracture. The bending strength of flat glass from room temperature to Littleton temperature and the high-temperature fracture (above T_g) of non-Newtonian flow behavior are examined. The third paper in this section, addressing high-temperature failure, is essentially an abstract with references for additional reading.

The tenth section deals with optical examination as a means of fracture analysis and stress measurement. The last section contains a tabulation of fracture mechanics parameters and mechanical property data. This is a very useful addition in that glass composition, test type, surface condition, and test environment are presented in tables along with references. The editor concludes the book with a summary and some conclusions.

Books Received

Chemical Processing with Lasers, Dieter Bäuerle, Vol. 1, Springer Series in Materials Science, Aaram Mooradian and Morton B. Panish, series editors. ix + 245 pp., illus., index, references, list of abbreviations and symbols. ISBN 0-387-17147-9 (1986). Springer-Verlag, 175 Fifth Ave., New York, NY 10010. Gives a comprehensive survey of the fundamental mechanisms and diverse applications of this new field of research and technology.

The Elements of Artificial Intelligence: An Introduction Using LISP. Steven L. Tanimoto, xxii + 529 pp., illus., index, references, appendix, chapter problems. ISBN 0-88175-113-8. Computer Science Press, Inc., 1803 Research Blvd., Rockville, MD 20850. $35.95 hardbound (1987). Contents include programming in LISP, productions and matching, knowledge representation, search, logical reasoning, probabilistic reasoning, learning, natural-language understanding, vision, and expert systems.

Gas Flow and Chemical Lasers, S. Rosenwaks, ed., xiii + 579 pages, illus., index, references. Vol. 15 of Springer Proceedings in Physics, Proceedings of the 6th International Symposium, Jerusalem, Israel, Sept. 8–12, 1986. ISBN 0-387-17481-8. Springer-Verlag, 175 Fifth Ave., New York, NY 10010 (1987). Chapters on fluid dynamics, optics, short-wavelength lasers and short-wavelength chemical lasers, chemical oxygen-iodine lasers, chemical vibrational-transition lasers, CO lasers, CO_2 lasers, beam diagnostics, laser propagation and interaction, applications, and recent developments.

Infrared Optoelectronics: Devices and Applications, William Nunley and J. Scott Bechtel, Optical Engineering Series, Vol. 12, Brian J. Thompson, series editor. x + 276 pp., illus., index, references, glossary. ISBN 0-8247-7586-4 (1987). Marcel Dekker, Inc., 270 Madison Ave., New York, NY 10016. Introduction and on-the-job reference to the manufacture, selection, characterization, operation, and application of components.

Laser Handbook, Volume 5. M. Bass and M. L. Stitch, eds., ix + 692 pp., illus., subject and author indexes, references. ISBN 0-444-86934-4. North-Holland division of Elsevier Science Publishing, P.O. Box 1663, Grand Central Station, NY 10163. $122.25 hardbound (1985). Presents detailed overview of coherent UV and vacuum UV sources; the class of tunable lasers provided by optically pumped paramagnetic ions; frequency tunability and control resulting from recent advances in laser technology, the use of spatially localized laser-driven chemistry to process materials at the micrometer level; and the use of lasers in the diagnostics required to study and operate magnetically confined thermonuclear plasmas.

Laser Spectroscopy and Its Applications. Leon J. Radziemski, Richard W. Solarz, and Jeffrey A. Paisner, eds. (Optical Engineering Series Volume 11, Brian J. Thompson, series editor), xvi + 685 pp., illus., index, references. ISBN 0-8247-7525-2 (1987), hardbound, $99.75 U.S. and Canada, $119.50 all other countries. Marcel Dekker, Inc., 270 Madison Ave., New York, NY 10016. Includes chapters on the most important laser isotope separation techniques; numerous tables summarize important features of lasers, experiments, and parameters for quick reference.

Mass Spectrometry. F. A. White and G. M. Wood. ISBN 0-471-09236-3. John Wiley & Sons, 605 Third Ave., New York, NY 10158. $72.50 hardbound.