

DEPARTMENTS

BOOK REVIEWS

Fabrication Methods for Precision Optics

Hank H. Karow, 751 + xiv pages, illus., index, references. ISBN 0-471-51222-2. John Wiley & Sons, Inc., 605 Third Avenue, New York, 10158-0012 (1993) \$89.95 hardbound.

Reviewed by Robert E. Parks, Optical Sciences Center, University of Arizona, Tucson, AZ 85721.

As someone long interested in optical fabrication and testing, I have to say this book is great! The optical fabrication community has been waiting for a book like this for a long time. As the author says in the preface, "It is the only optics fabrication book written by opticians specifically with the practicing optician in mind"—not that this means only opticians will benefit from reading this very comprehensive and well-illustrated book on the practical aspects of making precision optics.

This 750-page book has six chapters, only one of which actually describes optical fabrication. At first this seemed odd until I realized that this is about the correct ratio in real life. The time spent in planning, material selection, setup, and testing when making prototype optics is often several times the actual time spent grinding and polishing the optic.

The first chapter deals with optical materials including optical glasses, filter glass, IR, and mirror materials. It thoroughly discusses the properties of optical glasses outlined in the front of glass catalogs and points out those items of particular interest to the fabricator. It goes on to warn of potential difficulties in working with filter glasses. There are easily as many pages spent on IR materials as on glasses and how these should be treated during fabrication. Many of the properties of all these materials are nicely tabulated in a number of tables.

Chapter 2 concerns the manufacture of these optical materials with an emphasis on

the forms in which the materials are available for optical working. There are good explanations of the relatively recent changes in glassmaking that have led to markedly improved quality over that available in the 1960s and 1970s. The various crystal-growing processes for IR materials are also thoroughly explained and illustrated. The third chapter deals with materials used in making optics such as abrasives, polishing compounds, waxes and pitches, synthetic polishing pads, optical cements, and coolants. I find marvelous the comment by the author that he reviewed 48 polishing compounds by 10 different suppliers and found 24 different quality grades in their joint product literature but little or no quantitative differentiation. Although the price difference can be significant between various compounds, one is left with the distinct impression that the price has more to do with Madison Avenue than real performance. The author makes a plea for standards in the preparation of polishing compounds such as those that exist in Europe.

The tools and fixtures of the trade are the subject of the next chapter. It begins with traditional cast-iron tooling most often associated with prototype optics and goes on to spot blocks used in most high-volume production shops. This chapter also deals with the subject of how to block-up optics and makes the point that if the blocking is not well done it is almost a hopeless exercise to produce good optical elements. The chapter includes a very useful section on diamond tooling including a comparison of the codes many of the larger suppliers of tooling use to describe their bond composition and hardness. This comparison helps take much of the guesswork out of buying diamond tooling.

Chapter 5 finally gets into the actual shaping and polishing of optical elements. While there is only one chapter devoted to this subject, it is by far the longest chapter. It describes the use of a glass cutter and goes on

to describe slicing crystal wafers and ultrasonic drilling as ways of preparing raw stock for further operations. There is an extensive section on all aspects of diamond wheel generating and shaping. Many illustrated examples are given on how to set up the generator to perform specific shaping operations.

The chapter continues with discussions of diamond pellet and loose abrasive grinding. In addition to classical methods, modern topics such as flat lapping and polishing machine design and operation are included. All aspects of polishing are treated including how to set machine strokes to achieve specific changes in surface figure. Centering is thoroughly treated from correctly positioning the part on the spindle to the actual edging operation. The chapter finishes with a treatment of cementing and cleaning with a few passing but useful words on coating.

The final chapter is "Optical Shop Testing—Methods and Instruments." In my mind it contains much more optical "shop" testing than Malacara's fine book of the same title in that this chapter is definitely written with the optician in mind. There is very little mathematics but numerous illustrations, tables, and explanations. The chapter begins with 60 pages on performing and understanding test plating. Another 30 pages are devoted to the theory and use of spherometers. Interferometry and the use of autocollimating instruments are also well treated.

Are there any negatives? Yes, a few. There are a few typos, some things are not discussed that would have been useful (such as some aspects of mechanical gauging), and no mention is made of final inspection for quantitative scratch-dig assessment. The most bothersome thing I found was that although each chapter section is thoroughly referenced, the references were not sufficiently complete. In many cases, it would be difficult or impossible to actually locate the specific referenced material.

By now I may have given the impression that only opticians would find this a useful book, which is definitely not the case. In the short time I've had the book for review, I have found it valuable for two completely different aspects of optical fabrication, work with IR materials and polishing silicon wafers. The book should be valuable to anyone involved with the fabrication, testing, and inspection of optics, from the project manager and optical designer to the government inspector who gives many optics a final blessing. For those involved with optical fabrication on a daily basis, I recommend that you buy the book out of your own pocket if your boss will not buy it for you. If you do have to buy it for yourself and you apply the wisdom in the book to your work, you will soon have your boss's job.

Polymers for Lightwave and Integrated Optics

Lawrence A. Hornak, Ed., 768 pages, Marcel Dekker, 270 Madison Avenue, New York 10016 (1992) \$150 hardbound.

Reviewed by Ray T. Chen, University of Texas at Austin, Microelectronics Research Center, Department of Electrical and Computer Engineering, Austin, TX 78758.

This book is a collection of interesting articles by a number of researchers in the field of polymer-based optoelectronics. By definition, a polymer matrix is formed by linking an array of monomers. Therefore, an infinite number of polymeric materials can be generated. The polymeric materials suitable for optoelectronic device research are those with the desired optical and electro-optic properties. Hornak has done a decent job of assembling chapters that may be useful in building polymer-based photonic systems for different applications.

Chapter 1, "Polymer Optical Fibers," discusses the materials properties of polymer optical fibers (POFs). The various loss factors associated with POFs are considered, and a method for POF fabrication is explained. Transmission, absorption, and scattering loss measurements are also discussed, as are the limits imposed by loss factors. An application overview of POFs is also included. Chapter 2, "Polymer Optical Fibers in Data Communications and Sensor Applications," highlights very important power budget considerations in the design of fiber networks. It also discusses different couplers for POF bus systems, bandwidth considerations, and some sensor applications of POFs.

Chapter 3, "Graded Index Materials and Components," concerns graded index (GRIN) optics. The fabrication of GRIN components by diffusion and monomer reactivity is given considerable attention, and low-loss and high-

bandwidth GRIN POFs are discussed. Important developments in GRIN polymer-based photonics integrated circuits are not discussed nor quoted in this chapter, which may represent its major defect. Chapter 4 is called "Patterning Poly(methyl methacrylate)." Poly-methyl methacrylate is very useful for recording volume holograms. The chapter discusses this application in great detail, which should be useful for those involved in hologram design and application. Chapter 5, "Photopolymers for Holography and Waveguide Applications," discusses in considerable detail the evaluation of transmission and reflection holograms. The use of photopolymers in holographic recording processes is explained, and applications of holography are also highlighted. Chapter 6, "Microoptical Grating Elements," discusses the importance of organic polymers in integrated optics, especially with respect to grating design. The use of grating plates and holographic zone plates in integrated optics is considered, and grating collimating lenses are discussed. The use of waveguide grating elements as reflectors, lenses, couplers, and the like is also mentioned.

Chapter 7, "Synthesis and Applications of Polysilyne Thin Film Optical Waveguide Media," is a routine chapter on thin film optical waveguides. Chapter 8, "Polyimide Light Guides," presents the materials and the patterning processes employed for these waveguides. The sensitivity of these waveguides to moisture seems to be a paramount issue that will require more research. Chapter 9, "Optical Interconnection Polymers," considers the formation of waveguides using etching, which is an interesting and useful idea. The evaluation of waveguide performance and the optical functionality of interconnection polymers is considered. Coupling to fibers, waveguides, and other components is another important aspect that is considered. The essential system requirements for a polymer-based optical interconnection system are also explained.

Chapter 10, "Polymer Optics in the Information Age," considers the use of polymer optics in computers and electronics, which is a very important avenue for the polymer optics field to investigate. Polymer optics can improve speed and real-time processing capabilities in the computing industry at the board, backplane, and multichip module levels. The importance of keeping the loss level as low as possible is highlighted in this chapter. Chapter 11, "Optical Polymers and Multifunctional Materials," is the first chapter in the nonlinear optics section. Its comparison of nonlinear polymer devices with lithium niobate devices gives good insights into the electro-optic and acousto-optic properties of polymer devices. The idea of incorporating various

functionalities in a single polymer device is also discussed.

Chapter 12, "Molecular Polymeric Materials for Nonlinear Optics," considers the relationship between the structure and the properties of a molecule as the basis for its use as a polymeric material in integrated optics. Phase matching in a nonlinear polymeric material is essential to improve performance efficiency. Chapter 13, "Guest-Host Polymer Systems for Second-Order Optical Nonlinearities," considers the creation of a second-order nonlinear optical system with a host polymer and a guest dye. The concepts of poling and aging in polymers are also discussed. Chapter 14, "Nonlinear Optical Side-Chain Polymers and Electro-Optic Test Devices," discusses the basic nonlinear electro-optic effect. It considers organic nonlinear optical materials and nonlinear optical side-chain polymers. Measurement of the nonlinear electro-optic effect in poled polymers is also given considerable attention, and nonlinear electro-optic test devices are briefly mentioned. This chapter is very specialized and suited only for those who are accomplished in this field.

Chapter 15, "Fabrication and Characterization of Polymeric Light Wave Devices," emphasizes the optical properties of lightwave devices that determine their usefulness. The poled properties of linear and nonlinear polymers are discussed with emphasis on nonlinear polymers, and the design of electro-optic devices is considered. The design of waveguides and photomasks for waveguides is explained, and material selection and wafer processing for device fabrication are also discussed. Device testing by amplitude and phase modulation, which is important for determining the performance efficiency of a lightwave device, is considered. The chapter concludes with a section on applications that may be possible in the future. Chapter 16, "Large-Scale Integration of Electro-Optic Polymer Waveguides," discusses combinations of photonics and electronics as the basis of optoelectronic integrated circuits (OEICs). A detailed presentation is provided on the discrete, monolithic, and hybrid integration of OEICs. Electronic packaging and processing are two of the most important considerations in OEICs. This chapter also sheds some light on the material requirements and thermal stability needs of large-scale integrated optoelectronic circuits that include electro-optic polymer waveguides. A brief insight into the general waveguide fabrication process is also given.

Chapter 17, "Polymer Etalons and Free Space Interconnects," includes a discussion of the theory behind Fabry-Pérot etalons, which is an important part of any presentation on etalons and is quite efficiently carried out in this chapter. Various experimental

characteristics are illustrated, and the use of etalons in free-space interconnects and in communication systems is given some attention. Chapter 18, "Third-Order Optical Processes in Linear Chains: Electron Correlation Theory and Electrical Dispersion Measurements," is a highly specialized rendering of the theoretical concepts of third-order optical processes in linear chains. The concepts involved in macroscopic susceptibility sensors are given elaborate treatment. This chapter is useful only for those with in-depth knowledge of this field.

Chapter 19, "Third-Order Nonlinear Optical Processes and Ultrafast Dynamics in Polymers," considers four-wave mixing, the interaction of four electromagnetic fields in an optical medium, which can be a consequence of a third-order optical process. This chapter also deals with the measurement of a nonlinear refractive index by interferometric methods and discusses optical nonlinearity due to the realization of excitation in polymers. This again is a complex chapter with primary uses only for experts in the area. Chapter 20, "Third-Order Materials: Processes and Characterization," is a clear presentation of third-order nonlinear processes. The types of polymers employed and their synthesis is a very important part of polymer-based nonlinear optical devices. Coherent nonlinearity and nonlinear index variation are two essential ideas involved in third-order nonlinear processes. This chapter is the best among all the chapters on third-order nonlinear optics because of the ease with which it can be assimilated, even by beginning graduate students. Chapter 21, "Third-Order Nonlinear Optical Properties of Polymeric Materials," introduces the idea of pi-conjugated polymers. Dye-doped and dye-attached polymers are guest-host systems that are becoming important building blocks in polymer-based optical systems. The use of low-molecular-weight materials as potential polymers in nonlinear optical systems is an interesting idea and must be more closely investigated.

Chapter 22, "All-Optical Modulation in Polydiacetylene Waveguides," begins with an introduction to third-order nonlinearity. Ways to make nonlinear optical measurements in single-crystal films are explained, and a demonstration of all-optical phase modulation is described that employs a polymer waveguide Mach-Zehnder interferometer. Chapter 23, "Holographic Memories Using Organic Storage Materials," discusses the main ideas in holographic storage with emphasis on gratings, Fourier transforms, and holographic multiplexers. Different organic materials used for holographic storage are given thorough treatment. (Photorefractive crystals are the inorganic counterparts that can be used for holographic storage.) System

considerations in holographic storage are also considered. Chapter 24, "Material Structures of Organic Molecules and Matrices for Persistent Spectral Hole Burning," discusses wavelength-multiplexed optical memory, which records data by means of persistent spectral hole burning. The physical and chemical aspects of spectral hole burning are interesting but too complex for most nonspecialists. This chapter will attract minimum attention in terms of readership.

This book may be used as a reference for many areas of polymer-based optoelectronics but cannot be used as the main source of information for any division of optoelectronics because it is simply not designed to serve that purpose. It is compiled well and can supplement other structured literature in the field. It is a welcome addition to any library of books on optoelectronics.

BOOKS RECEIVED

Polarized Light: Fundamentals and Applications, by Edward Collett. Edited by Brian J. Thompson. 536 pp., illus., references following each chapter, appendix at back. ISBN 0-8247-8729-3. Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016 (1992). Covers the classical optical field, wave equation in classical optics, the polarization ellipse, the Stokes polarization parameters, the Mueller matrices for polarizing components, methods for measuring the Stokes polarization parameters, the measurement of the characteristics of polarizing elements, Mueller matrices for reflection and transmission, the Mueller matrices for dielectric plates, the Jones Matrix calculus, the Poincare sphere, the classical and quantum theory of radiation by accelerating charges, interference laws of Fresnel and Arago, Maxwell's equations for the electromagnetic field, the classical Zeeman effect, further applications of the classical radiation theory, the Stokes parameters and Mueller matrices for optical and Faraday rotation, the Stokes parameters for quantum systems, crystal optics, optics of metals, and ellipsometry.

Active Vision, Edited by Andrew Blake, Alan Yuille. xviii + 372 pp., illus., subject index, references, part of the Artificial Intelligence series. ISBN 0-262-02351-2. The MIT Press, 55 Hayward Street, Cambridge, Massachusetts 02142 (1992). Covers tracking with Kalman snakes, deformable templates, dynamic contours: real-time active splines, tracking with rigid models, tracking nonrigid 3D objects, data association methods for track-

ing systems, color region tracking for vehicle guidance, control of vision heads, real-time smooth pursuit tracking, attentive visual servoing, design of stereo heads, geometric and task planning, visual exploration of free-space, motion planning using image divergence and deformation, adaptive local navigation, task-oriented vision with multiple Bayes nets, architectures and applications, a parallel 3D vision system, geometry from visual motion, medical image tracking, expectation-based dynamic scene understanding.

Fundamentals of Fibre Optics in Telecommunication and Sensor Systems, Edited by Bishnu P. Pal. xxii + 778 pp., illus., subject index, references following each chapter. ISBN 81-224-0469-3. Wiley Eastern Limited, 4835/24 Ansari Road, Daryaganj, New Delhi 110 002, India (1992). Covers fibre and integrated optical waveguides: fundamental principles, evolution of fibre optics—a brief survey, opto-electronics and the information age: a perspective, electromagnetics of electronics and the information age: a perspective, electromagnetics of integrated optical waveguides, transmission characteristics of telecommunication optical fibres, single-mode fibre designs for telecommunications, polarisation, maintaining fibres and their applications, nonlinear processes in optical fibres: phase-matching for second harmonic generation in optical waveguides, non-linear integrated optics, fabrication techniques of optical fibres, characterisation of optical fibres for telecommunication and sensors—part I: multimode fibres, characterisation of optical fibres—part II: single-mode fibres, optical fiber cables, optical sources, detectors and communication systems, optical sources, detectors and engineered systems—introductory remarks, semiconductor lasers for optical fibre communications, distributed feedback InGaAsP lasers, some fundamentals of photodetectors for fibre optics, receivers for digital fibre optic communication systems, fundamentals of digital communication, purpose designing of optical fibre systems, coherent optical fibre transmission systems, integrated optic devices, optical fibre sensors and devices, intensity modulated optical fibre sensors, interferometric optical fibre sensors, fused single-mode optical fibre couplers, single-mode all fibre components, signal processing in monomode fibre optic sensor systems, fibre optic sensor multiplexing, optical fibres for power systems.