rapid communications

This section was established to reduce the lead time for the publication of Letters containing new, significant material in rapidly advancing areas of optics judged compelling in their timeliness. The author of such a Letter should have his manuscript reviewed by an OSA Fellow who has similar technical interests and is not a member of the author's institution. The Letter should then be submitted to the Editor, accompanied by a letter of endorsement from the OSA Fellow (who in effect has served as the referee and whose sponsorship will be indicated in the published Letter) and A COMMITMENT FROM THE AUTHOR'S INSTITUTION TO PAY THE PUBLICATION CHARGES. The Letter will be published without further refereeing. The latest Directory of OSA Members, including Fellows, was published in the Spring 76 issue of Optics News.

Absolute reflectance of Eastman White Reflectance Standard

F. Grum and T. E. Wightman

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The purpose of this Communication is to report the absolute reflectance values of Eastman White Reflectance Standard material based on the Kodak Research Laboratories scale. The absolute reflectance values, based on this scale, are in good agreement with the values obtained on the same material at the National Research Council of Canada, which, in turn, agrees with Physikalish-Technische Bundesanstalt of Germany.

In an article by Grum and Luckey,[1] the absolute reflectance values of pressed $BaSO_4$ were reported. Since these values have often been referred to by many authors[2–4] and since new, more recent values have been determined, it is felt that the most recent data should be published, particularly because the new values are somewhat at variance with the original data (e.g., the original reflectance value reported for λ 300 nm was 0.987 for the pressed powder, the newer absolute value for that wavelength is 0.968). Although some of the differences appear to be small, they are significant when compared with the precision of modern reflectometers.

The absolute reflectance values described in Ref. 1 were based on the absolute reflectance scale that was available at that time (the 1966 NBS scale). We subsequently established our own absolute scale; the data given here are based on the 1974 EK scale. (These values are also given in Kodak Publication JJ-31.)

The Kodak Absolute Reflectance Scale was established by making numerous readings on pressed $BaSO_4$ (Eastman White Reflectance Standard) powder by two different methods. The two methods were:

1. the Double Sphere Method,
2. a modified, Third Taylor Method.

The Double Sphere Method has been adequately described in the literature.[5,6] The modified Taylor Method is described below and uses $0/d$ geometry.

A modification of the Third Taylor Method, described by Budde,[7] was set up for measuring absolute reflectance ($0/d$). The general layout of the instrument is shown in Fig. 1. The sphere is mounted on a platform on rollers in such a way that it can pivot about the line A–A, passing through the center of the entrance aperture. An image of the source is focused by the quartz lens on the sample. By rotating the sphere about 20°, this image falls on the sphere wall. The screen shields the photocell from direct light from the sample, but not from the location of the source image on the sphere wall. These are

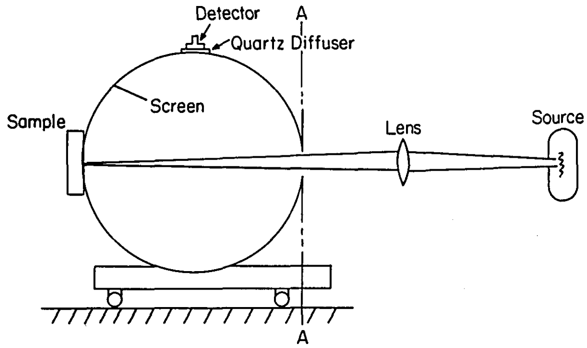

Fig. 1. Schematic for modified Third Taylor Method.

the conditions necessary for $0/d$ measurements by the Third Taylor Method.

The source was either a Bausch & Lomb high intensity monochromator with xenon lamp or the bare xenon lamp with interference filters to isolate narrow spectral bands. The output of the photocell was read with an Optronic 730 radiometer readout.

The reflectance was calculated from the formula given by Budde,[7]

$$\rho_x = \frac{B_s}{B_w} \cdot \frac{A_0}{A_1 + A_2}, \tag{1}$$

where ρ_x is the reflectance ($0/d$) of the unknown sample, B_s is the photocell output when the source image strikes the sample, B_w is the similar reading from the sphere wall, A_0 is the total sphere area, including ports, A_1 is the area of the sample port, and A_2 is the area of the remaining sphere wall.

Results obtained with this instrument agree within a few tenths of 1% with those obtained from readings made by the Double Sphere Method, using the DK-2A spectrophotometer.

The results obtained with the two methods are in good agreement with each other, and the maximum deviation between the means of the two methods is not greater than 0.005 in reflectance value in the uv and is less than 0.002 in the visible region of the spectrum.

The absolute values, based on the means from several determinations are given in Table I and Fig. 2. Table I also gives the old reflectance values, as reported in Ref. 1.

Figure 2 also gives the absolute reflectance values determined by Budde[8] and by Erb.

Table I. Absolute Reflectance Values of Eastman White Reflectance Standard

Wavelength nm	EK 1974 scale	Old values
250	0.950	0.939
280	0.962	
300	0.968	0.987
320	0.972	
340	0.977	0.983
360	0.981	
380	0.984	0.992
400	0.987	0.995
420	0.989	0.999
440	0.990	0.999
460	0.991	0.999
480	0.991	0.999
500	0.991	0.999
520	0.991	0.998
540	0.991	0.998
560	0.992	0.998
580	0.992	0.998
600	0.992	0.998
650	0.992	0.998
700	0.992	0.997
750	0.992	0.997
800	0.992	0.996
900	0.990	0.995
1000	0.986	0.991

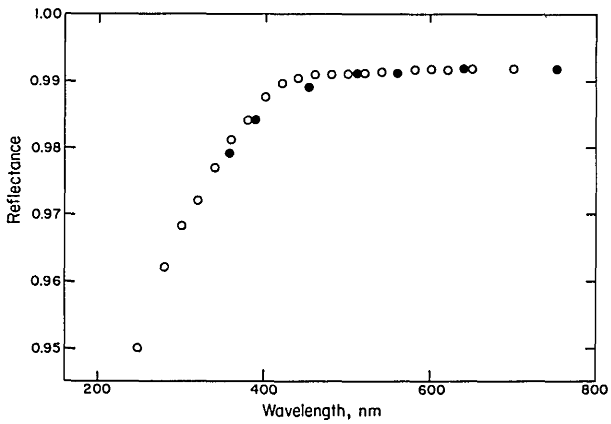

Fig. 2. Absolute reflectance values of Eastman White Reflectance Standard: ○○○ Kodak Scale; ●●● Budde, Ref. 8.

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Various Methods of Making Prisms Developed Since 1946. By FRANK COOKE. Optical Society of America, Washington D.C., 1977.

A 16-mm color film with narration by Frank Cooke, this 1-h long movie is available for rental or purchase from the Executive Office of the Optical Society of America, 2000 L Street N. W., Washington D.C. 20009. Contact Jon Hagan.

VARIOUS METHODS OF MAKING PRISMS is a unique attempt to illustrate the broadest possible approach to optical fabrication techniques. Emphasis is limited to technique by using the same prisms as subject matter for each illustration. *VARIOUS METHODS* is not only unique because it is a film but also because no other description exists in the literature of optical fabrication of so many similar yet subtly and fundamentally different methods for making optical components. Any serious student of optical fabrication should not fail to see this film at least once, preferably several times. Others who should see the film are opticians who think they know all the tricks of the trade and managerial types who cannot understand why optics cost so much and/or take so long to make.

After a musical introduction that somehow sets the wrong mood for viewing the film, the author begins with an example of making a prism entirely by hand techniques. The methods shown are those used prior to the 1940s and those still used by amateur telescope makers. Every step is demonstrated in picture and word in sufficient detail that any reasonably observant person should be able to duplicate the results of a right angle prism with faces flat to 1 fringe and angles held to 1 min of arc.

Next a semiproduction method of making a plaster block of some thirty prisms is shown. The prisms are first diamond wheel generated using suitable fixtures to the correct angular tolerances. A plaster block matrix is relied on to preserve the angular accuracy during polishing. The method illustrates that the optician must exercise a reasonable degree of skill and finesse to get a satisfactory yield.

The next method looks so similar to the last that it takes a close look to see that each face of the block of prisms is taken from diamond generating to polish individually. After rough grind, a fine diamond wheel produces a smooth and flat enough grind that the block is then put directly on the polisher without any intermediate loose abrasive grinding steps. A full polish is obtained almost as quickly, as if the prisms had been ground first. The angular accuracies are high and dictated by novel high accuracy tooling.

The second half of the film first illustrates two methods of making individual large prisms. One method is a traditional approach using a plaster block and filler material to make up a circular cross section for polishing. The other method has only been fully developed in the last several years—single face or continuous path polishing. Noncircular components may be made extremely flat by using a continuous lap that is constantly being conditioned to maintain flatness. The explanation of the method is complete down to minor variations in technique for problem situations.

Next is perhaps the most dramatic part of the film because of the imaginative technique used and the obvious costliness of the prisms and tooling. Here the author demonstrates a production technique he devised for making some thirty-six facet hollow rotating prisms. The techniques used are sufficiently forward looking that they may serve as inspiration to other opticians and methods engineers for many years.

The film ends with the latest development in optics manufacture: single point diamond milling. Here a piece of acrylic rod is mounted to a mandrel and placed in an indexing head. In 4 min an eight-facet prism is made with faces flat to one wave and angular accuracy as good as the indexing head. With this kind of potential it is no wonder the subject is of the greatest interest.

As I have said, the film is unique; it covers technique all the way from working around the barrel as the amateurs call it to the latest diamond turning techniques. Further, all the examples are real hardware in the process of being manufactured for real customers. Very few scenes were staged strictly for the purpose of making a movie. The techniques and tooling were dictated by the quantity and quality of the components being made, so they represent real choices of method—not just good movie footage.

The movie is unique, too, in that the techniques illustrated apply not only to prisms but to lenses and mirrors as well. With but a little imagination, every method shown using prisms as an example could just as easily be applied to other types of optical components. Finally, the movie is unique because it was conceived, filmed, edited, and narrated by an individual in the business of making optics for profit; not of making educational movies.

Considering the constraints and conditions under which the film was made it would be a small miracle if the movie were technically perfect; it is not. The lighting is generally too dark, and some scenes are slightly out of focus. In places the editing is not as good as it might be. Coupled with the density of the material covered in the film, it is not an easy movie to watch, in fact it is work to view this film. Yet perhaps this is the highest compliment I can pay the movie. It is a classic, and like most classics the first reading is difficult. Often all we learn are the names of the characters and an outline of the plot. It takes a second and third reading to understand all the author was trying to say. So it is with this movie; the first time through it is almost dull, yet when you try to take notes and understand all of what is being said it is obvious that a second and third viewing are necessary, even for people who are familiar with the general subject matter. It might also be asked if the narrative were necessary on movie illustrating technique. The answer is an emphatic yes. In fact, time does not permit the narrative to say all that could be said about the various examples because of the mass of detail associated with some techniques.

To the best of my knowledge there is no other movie which even begins to come close to covering the various techniques of optical fabrication that this one does. Even the better known books are either out of date or just do not go into the kind of detail and illustration that this film does. One could easily write a 200–300-page book on the subject of optical fabrication without going one step beyond the material covered in *VARIOUS METHODS OF MAKING PRISMS*.

I would highly recommend this film to anyone with an interest in how optical components are made and to those who cannot understand why they cannot be made less costly and faster. But be forewarned: it is not entertainment; it is hard work. Bring paper and pencil, some strong coffee, and see it several times. It is well worth the effort.

ROBERT E. PARKS

Nonemissive Electrooptic Displays. Edited by A. R. KMETZ and F. K. VON WILLISEN. Plenum Press, New York, 1976. 360 pp. $35.00.

This book contains a collection of papers (and brief reports of discussions) presented at a private conference in September 1975. The papers, which by and large are good, span a very wide range of disciplines brought to bear on one objective, namely, the nonemissive electrooptic display. Anyone looking for a good introduction to the physics or chemistry of one or other of the nonemissive systems discussed would be well advised to look elsewhere. Indeed, this book is so highly specialized within each discipline that it will only be of use to the technologist in the business, and then only selected portions. It does not seem to this reviewer to have been a sensible decision to publish these titles between one pair of hard covers; better that the articles should have been submitted to the professional journals, as indeed some have. At $35, this book is bound to achieve the circulation it deserves.

The volume opens with a brief but useful introduction on Requirements on Modern Displays, in which matching of existing (or almost existing) nonemissive electrooptic technology to particular uses is emphasized. Then follows the major subject of the conference, i.e., liquid crystal displays. The subjects of this section are: computational methods for obtaining Electrical and Optical Properties of Twisted Nematic Structures; more useful ways of using Cholesteric Texture and Phase Change Effects in thin layer display devices; a survey of Liquid Crystal Color Displays; a comprehensive review of liquid crystal materials relating Chemical Composition and Display Performance; and, finally, a discussion of the Anchoring Properties and Alignment of Liquid Crystals.

The rest of the book is taken up with more speculative aspects of the display field. There is a section on electrochromic displays describing the properties of various electrochemical cells exhibiting reversible color change. The first paper is a deliberately elementary, but useful, account of the Principles of Electrochromic Display, followed by a comprehensive compilation of the literature, including patents, of Electrochromic and Electrochemichromic Materials and Phenomena, and ending with Electrochromic Display Devices based on electrochemical reactions involving the viologens.

There is one further electrochemical system based on the reversible deposition of a lyophobic colloid called Electrophoretic Displays. The final display system discussed is an all solid-state device based on the electrically alterable optical anisotropy of ceramics, such as lanthanated lead-zirconate-titanate, which gives rise to Ferroelectric Displays.

The remaining technical papers are concerned with problems of addressing: Matrix Addressing of Nonemissive Displays and Integrated Electrooptic Displays, involving thin film transistors, are considered.

The book ends with some fairly pithy Concluding Remarks by Cyril Hilsum.

MINO GREEN

Molecular Electro-Optics. Part 1: Theory and Methods. Edited by C. T. O'KONSKI. Dekker, New York, 1977. 528 pp. $48.50.

This book reviews comprehensively experimental and theoretical work on two main topics:

(1) The Kerr effect and its modern extensions, e.g., elective birefringence and electric dichroism of atoms, molecules, and polymers.

(2) Nonlinear electrooptics and magnetoelectrooptics of fluids and solids. These properties are of much current interest for the generation of second- and third-harmonic laser light.

The editor has brought together at a favorable time a panel of sixteen authors. The book provides a wealth of experimental data and theoretical insight otherwise dispersed; no comparable book is available.

The classical Kerr effect and its modern variations are treated in nine chapters. The semiclassical quantum theory of electric birefringence in gases and liquids is succinctly summarized by **Buckingham;** birefringence in electric field gradients is also analyzed by him. The numerical evaluation of the electric polarizability in atoms and molecules using both nonempirical and semiempirical methods is discussed by **Ha.** Optical absorption in electric fields, commonly termed electrochromism, is examined in a chapter by **Liptay.** The major emphasis of this chapter is on the electrochromism of molecules in solution. Macromolecules, which form the subject of six chapters, are an especially fruitful subject for electrooptic studies because their large ground-state dipole moments allow extensive orientation in experimentally accessible fields. Experimental methods and data analysis for electric birefringence of rigid macromolecules in solution are presented by **O'Konski** and **Krause;** the theory of the rotational diffusion constants obtained by this method is discussed by **Ridgeway.** The dynamic properties of flexible polymers, as manifested by their birefringence in time-dependent external electric fields, are examined by **Jernigan** and **Thompson;** the use of electric dichroism to elucidate the macromolecular conformation, rotational diffusion, and the orientation of dyes adsorbed to polymers is described by **Paulson. Jennings** and **Tinoco** describe the new information accruing to light-scattering and optical activity measurements, respectively, when macromolecules are oriented by external fields.

The generation of second- and third-harmonic laser light by intense laser pulses, and by the combination of laser pulses and external dc electric or magnetic fields, is set out comprehensively in two chapters by **Kielich,** totaling eighty pages and 230 references. In particular, the consequences of local point-group symmetry to the second- and third-order nonlinear polarizability tensors will prove valuable in the exploration of new media for optical harmonic generation.

In addition to the topics above, the use of quasi-elastic light scattering to measure electrophoretic mobility of large particles is reviewed by **Flygare, Ware,** and **Hartford;** electrooptics of polymers in the ir is examined by **Charney;** and **O'Konski** provides a short historical introduction to Kerr's work and reviews briefly the major developments in molecular electrooptics in the last twenty-five years.

The book contains many excellent drawings and photographs to illustrate the text. References as recent as 1976 are cited. However, there is neither a subject nor an author index, so the reader will be obliged to use the brief outlines which commence each chapter to locate material of interest.

G. HOLZWARTH

Recent Advances in Optical Physics; Proceedings of 1975-ICO-10 Prague. Edited by BEDRICH HAVELKA and JAN BLABKA. Palacky University, Olomouc and Society of Czechoslovak Mathematicians and Physicists, Prague, 1976. 955 pp. Price not known.

The ICO-10 meeting was reviewed briefly, with a summary of the opening address and five invited papers, and the nontechnical aspects of the meeting, in *Applied Optics* **15,** 590, 595(1976). This volume gives the actual invited papers at length, as well as the contributed papers, for a total of 105 papers grouped in sections under: statistical and coherence properties of optical fields, nonlinear optics, holography, propagation of radiation in media and media properties, and new coherent sources and detectors. There is detailed coverage by international experts in the many papers under each of the five headings. Though dated 1976, this volume has just recently become available in a thick, well-bound paperback, using good paper offset-printed from original typed copy. A list of participants is included, but not an author index.

FRANKLIN S. HARRIS, JR.

Superconducting Electron-Optic Devices. By I. DIETRICH. Plenum Press, New York, 1977. 140 pp. $19.50.

This monograph is devoted almost entirely to superconducting electron-microscope lenses, a subject for which its author has an international reputation.

Development of the electron microscope toward its ultimate limit of resolution has been an exquisite technological task spanning nearly fifty years. The electron wavelength at commonly used voltages is in the order of 0.1 Å, but lens aberrations arising from various technological limits have thus far limited resolution of conventional electron microscope to 3–5 Å. Superconductors have held promise for improving resolution, and lens development has been carried out in several countries since the early 1960s.

After a decade of research, there are now perhaps a dozen SC microscopes operating in nine or ten laboratories throughout the world. The best of these superconducting microscopes have reached the stage of development where they are competitive with the best conventional devices.

Superconducting lenses can be shown to have spherical and chromatic aberration coefficients two times smaller than conventional lenses at acceleration voltages above 1 MV. Now that the resolutions are comparable at modest voltages (0.1–0.25 MV), the superconductor lenses can be expected to come into their own as higher voltage microscopes are built and equipped with SC lenses. Another factor of 2 in resolution, down to 1.5 Å, would allow the resolution of individual atom in crystals, a long-sought goal.

Dietrich traces the history of development of SC lenses over the last decade and treats both those lines of attack that did not work well and those that resulted in the best resolution. The best results to date have been obtained using superconducting coils in combination with the diamagnetic shielding of superconducting tubes to control the leakage flux and produce the very high gradient fields needed for the small half-width of the lens. The principal aberrations are directly proportional to the half-width of the lens and inversely proportional to the peak field. Thus, it does no good to have a high field unless the lens length can remain very small. The ability to make very small superconducting shielding tubes with high accuracy has allowed the high resolution to be obtained.

Superconducting lenses have certain advantages beyond their potential to reduce lens aberration. Their ability to run on persistent current removes the need for high regulation power supplies, although it complicates the ability to adjust the lens. The high current density in the winding allows much more compact over-all lens envelopes and can thus dramatically reduce the over-all size of an ultrahigh voltage microscope. Dietrich describes in detail a proposal for such a compact 3-MV microscope. He further describes a compact superconducting accelerator to achieve the 3-MV beam. The fact that the specimen stage in SC microscopes is generally cold is of benefit for obtaining high vacuum at the sample and protection of the specimen. The cold stage also allows microscopic investigation of superconducting phenomena, several applications of which are described by Dietrich.

The book is somewhat short on description of the fundamentals of lenses; the reader might be referred to P. W. Hawkes, *ELECTRON OPTICS AND ELECTRON MICROSCOPY* (Taylor and Francis, Ltd., London 1972). The book is also very slim on electron optics other than microscopy, and here the reader is referred to A. Septier, *FOCUSING OF CHARGED PARTICLES* (Academic Press, New York, 1967).

D. BRUCE MONTGOMERY

Black Holes, Quasars, and the Universe. By HARRY L. SHIPMAN. Houghton Mifflin Company, Boston, 1976. 310 pp. $5.50.

Even as the calm complacent world of optics—completely predictable by Maxwell's equations and only needing to have a few minor details filled in—was jolted by the laser just a few years ago, so also has astrophysics had its jolts within the past decade with the discovery of quasars, pulsars, and the postulating of black holes. The postwar period brought new, more sensitive detectors for telescopes, with spectral ranges from the far-infrared to x rays; and space vehicles have freed astronomers from the limitations formerly imposed by the earth's atmosphere. When pulsars were first detected, some writers speculated that perhaps they represented signal beacons for space travel by some distant supercivilization. (That was, of course, immediately dismissed as ridiculous, as any supercivilization would surely have come to call on us.) So perhaps these pulsars are only prosaic spinning neutron stars that have suddenly collapsed from old age or weariness. And are the quasars impossibly bright and impossibly far away, or are they perhaps due to laser action by nearby stars accidently in synchronous spacing? Then, add the mystery that when one adds up the total mass of all the stars that we can see or extrapolate to, that total mass is hopelessly inadequate to account for the gravitational fields that we observe. So somebody dreams up invisible black holes, where gravitational forces are so strong that light from within cannot escape. (These mysterious objects contribute that excess gravitational field.) It is rather like that Cheshire cat that has disappeared except for its grin.

A few short years ago all of these phenomena would have been dismissed out of hand as hare-brained science fiction. But now explanations of these curious effects are the subject of speculation by every science writer turned cosmologist. In this volume, Harry Shipman has made an effort to present these effects, to describe the observational evidence on which the various theories are based, and to organize these mysterious aspects of present-day astrophysics into as logical a treatment as is possible at the moment. Unfortunately, it seems to us that, even after all the phenomena are discussed and analyzed, they remain just about as mysterious as ever (at least to this poor sinner). But at least these more far-out ideas are in better context. The situation is rather like the medieval monks who discussed the imponderable mysteries and "the things we didn't understand we explained to each other." But Shipman has here attempted a noble and heroic task, a narrative of the impossible. We highly recommend to all of you who have curiosity about these mysteries of the universe to examine this calm, cool, and collected book.

JOHN N. HOWARD