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Presented at the 3rd International Conference
on Ellipsometry, Lincoln, Nebraska,
September 23 - 25, 1975

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MEETING REPORT

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MEETING REPORT

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The Third International Conference on Ellipsometry has been organized by N. M. Bashara (Univ. Nebraska), R. M. A. Azzam (Univ. Nebraska) and G. Poste (Roswell Park Mem. Inst.). The very informative program consisted of 46 papers. A third of the Conference participants, who contributed almost half of the papers, came from outside the U. S.

Previous meetings in this series have been held at the Univ. Nebraska (1968) and at Natl. Bur. Standards (1963). Many participants agreed that a gathering of the ellipsometry community at several-year intervals provides a useful mechanism to take stock of current developments. Although ellipsometry still does not occupy the position in surface science it potentially could, significant progress in theory, instrumentation and application has been made since the last meeting. This progress has been amply reflected at the meeting.

Status review papers were opened by A. B. Winterbottom (Univ. Trondheim) with a consideration of means to produce surfaces for ellipsometry that are smooth, clean and representative of bulk material. R. M. A. Azzam (Univ. Nebraska) treated the general problem of the analysis of polarized electromagnetic radiation, including partial polarization that has, so far, hardly been considered in ellipsometry. R. H. Muller (Lawrence Berkeley Lab.) reviewed operating principles and capabilities of presently-built

automatic ellipsometers. Instruments with greatly increased speed of response and resolution have been introduced in the last few years and it appears that the use of spectroscopic ellipsometry, as a powerful tool in surface science, is imminent. F. Meyer (Philips, Eindhoven) discussed the merits of different macroscopic and microscopic models for films in the monolayer region. The use of ellipsometry for the characterization of biological surfaces is a new and promising development. Unfortunately, the talk by G. Poste (Roswell Park Mem. Inst.) on this topic could not be delivered but will hopefully be included in the conference proceedings.

Analysis of ellipsometer measurements was the topic of the second session. The problem of inverting the reflection equations continues to generate new numerical approaches that were the subject of four papers by A. R. M. Zaghloul, R. M. A. Azzam and N. M. Bashara (Univ. Nebraska), M. A. Barrett Gültepe (Univ. Bristol), S. S. So (IBM, Southampton) and M. Malin and K. Vedam (Pennsylvania State Univ.). The evaluation of data obtained with the return-path ellipsometer that operates at the principal angle of incidence is a bit different and was discussed by K. Kinosita and M. Yamamato (Gakushuin Univ., Tokyo). Their paper also included several applications of their instrument.

A session on applications of ellipsometry in biology, although shortened by the cancellation of two papers, showed potential for new developments. A. Rothen (Rockefeller Univ.) talked about the observation of immunologic reactions at a liquid-solid interface. S. M. Ma, D. L. Coleman and J. D. Andrade (Univ. Utah) have

investigated the preparation of adsorbed and cross-linked albumin coatings to make medical devices more blood-tolerable. R. M. A. Azzam (Univ. Nebraska) described a scheme to probe cell surfaces by total-reflection ellipsometry.

Continued interest in instrumental development was reflected in half a day of the meeting being devoted to automation. Up to date versions of automatic ellipsometers, based on compensating and non-compensating principles of operation, some with wavelength-scanning capabilities, were shown. A. C. Lowe (IBM, Southampton) described the construction of a self-compensating wavelength-scanning (250-800 nm) ellipsometer that provides measurements with absolute accuracy of a few millidegrees in 5 sec. P. S. Hauge (IBM, Yorktown Heights) reported on a rotating-compensator ellipsometer for the determination of three normalized Stokes parameters. D. E. Aspnes (Bell Labs., Murray Hill) introduced the combined rotation of compensator and analyzer. He also concluded that partial polarization is always very small (1% or less) in ellipsometry because of the high f-numbers (approx. 30) used.

O. Hunderi and R. Ryberg (Chalmers Univ., Sweden) have replaced the analyzer by a Wollaston prism that allows them to simultaneously measure the irradiances of two orthogonal polarization states. An ellipsometer arrangement with two separated analyzer and detector trains has been described by D. N. Henty and H. G. Jerrard (Univ. Southampton). Similarly, T. Smith (Rockwell International, Thousand Oaks) has employed two analyzers of fixed azimuth to be used in a hand-held miniature ellipsometer for the routine examination of extended surfaces.

C. C. Matheson and J. G. Wright (Univ. East Anglia) with R. Gundermann and H. Norris (Bellingham and Stanley, Ltd., London) described their self-compensating ellipsometer that employs a three-reflection Fresnel rhomb as achromatic quarter-wave plate. An automatic version of the return-path ellipsometer was presented by E. G. Lluesma, C. A. Pelá and I. Wilmanns (Univ. Campinas, Brazil).

It was evident that the amount of information emanating from increasingly fast and precise ellipsometers, particularly in a wavelength-scanning mode of operation, calls for efficient data collection and evaluation schemes that have not been necessary before.

Another half-day of the conference was devoted to the topics of anisotropy, roughness and inhomogeneity. F. Abelès (Univ. Paris) discussed the use of ellipsometry for the characterization of electromagnetic surface waves. He showed that, with attenuated total reflection, the effect of an applied voltage on the electrons in a metal can be separated from the effect of ions at an electrochemical interface. Experimental aspects of surface roughness were treated by T. Smith (Rockwell International, Thousand Oaks) and K. Vedam (Pennsylvania State Univ.).

The ellipsometry of optically anistropic media is an area in which important theoretical developments have taken place recently. A paper by D. J. De Smet (Univ. Alabama) and one by M. E. Zaghloul, R. M. A. Azzam and N. M. Bashara (Univ. Nebraska) addressed further theoretical advances, while two other contributions by D. den Engelsen (Philips, Eindhoven) and S. Kawabata and K. Ichiji (Gakushuin Univ., Tokyo) were primarily concerned with experimental aspects.

Refractive-index profiles of inhomogeneous films on silicon have been determined with multiple angles of incidence by J. R. Adams (Sandia, Albuquerque) and G. A. Rakes, J. R. Adams and N. M. Bashara (Univ. Nebraska).

A session on spectroscopy and electrochemistry illustrated the great potential of spectroscopic ellipsometry. D. E. Aspnes (Bell Labs., Murray Hill) reported on the extension of ellipsometric spectra into experimentally inaccessible regions by use of oscillator models. M. J. Dignam, B. Rao and R. W. Stobie (Univ. Toronto) discussed the infrared ellipsometry of adsorbed molecules. The combination of reflectometry with ellipsometry was examined by B. D. Cahan (Case Western Reserve Univ.) and S. Gottesfeld, M. Babai and B. Reichman (Tel-Aviv Univ.).

J. Kruger and J. R. Ambrose (Natl. Bur. Standards) have used ellipsometry in a qualitative way to investigate optically very complex localized corrosion processes. By judicious choice of wavelength, they have been able to observe optical changes in passive films, caused by the addition of chloride ions, prior to the breakdown of the films that leads to pitting corrosion. J. L. Ord (Univ. Waterloo, Ontario) has identified different modifications of nickel hydroxides and their mutual conversion as they may occur in the operation of a battery electrode. The effect of mass-transport boundary layers, that are inevitably associated with electrochemical reactions, on the ellipsometry of electrode surfaces has been analyzed by R. H. Muller and C. G. Smith (Lawrence Berkeley Lab.). They have also proposed the use of ellipsometry for the determination of

interfacial concentration.

A final session was devoted to applications in a wide range of subject areas that had not been considered in other sessions. E. F. I. Roberts and D. Ross (City of London Polytechnic) talked about anomalous optical constants of very thin films caused by changes in electron population in the film. G. R. Boyer and B. F. Prade (Lab. d'Optique Appliquée, Paris) reported air-flow birefringence measurements in the atmosphere and in a wind tunnel. E. P. Honig (Philips, Eindhoven) has determined diffusion coefficients in Langmuir-Blodgett films by observing the skeletonization process that takes place when films composed of two components are exposed to a solvent for one of the components. T. H. Allen (McDonnell Douglas, St. Louis) has observed the vaporization of organic lubricant films. He has also identified phase transitions in films that had been cross-linked by electron irradiation. M. A. Hopper, R. A. Clarke and L. Young (Univ. British Columbia) found that oxide films could be removed from silicon without producing a rough surface by high-temperature flashing in vacuum. J. R. Adams and D. K. Kramer (Sandia, Albuquerque) reported on a study of the oxidation of tantalum nitride resistor films in microelectronic circuits. A short contribution by F. Meyer (Philips, Eindhoven) dealt with the spreading of a lubricant film on metals. P. C. S. Hayfield (Imperial Metals, Ltd) provided a late contribution on possible optical effects of surface roughness in corrosion studies.

At a luncheon presentation, A. B. Winterbottom (Univ. Trondheim) and A. Rothen (Rockefeller Univ.) were honored for

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their pioneering contributions to ellipsometry.

The conference proceedings will be published as a special volume of Surface Science, to appear approximately in May 1976.

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