Microscopy AND Microanalysis

THE OFFICIAL JOURNAL OF

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MICROBEAM ANALYSIS SOCIETY
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Aims and Scope

Microscopy and Microanalysis publishes original research papers dealing with a broad range of topics in microscopy and microanalysis. These include articles describing new techniques or instrumentation and their applications, as well as papers in which established methods of microscopy or microanalysis are applied to important problems in the fields of biology or materials science. Microscopy and microanalysis are defined here in a broad sense, and include all current and developing approaches to the imaging and analysis of microstructure. The criteria for acceptance of manuscripts are the originality and significance of the research, the quality of the microscopy or microanalysis involved, and the interest for our readership.

Four types of communications are published in the Journal. **Regular Articles** are of substantial length, and describe the findings of an original research project that satisfies the aims and scope of the Journal, described above. **Communications** are brief technical or scientific articles. **Reviews** summarize the current status of an important area within the aims and scope of the Journal. **Letters to the Editor** usually contain comments on recent articles that have appeared in the Journal.

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57th Annual Meeting

Microbeam Analysis Society
33nd Annual Meeting

PORTLAND, OREGON

August 1–5, 1999

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JOHN H. L. WATSON

This Proceedings volume is dedicated to John H. L. Watson, a pioneer in electron microscopy and a long time active member of the Microscopy Society of America. John has served the Society in many capacities, as President, Program Chair, Certification Board Chair, Placement Officer, and numerous other positions. John is responsible for initiating the Proceedings in 1967 for the 25th Annual Meeting of EMSA (MSA). John is retiring this year as MSA Placement Officer. Thanks John, for your years of service and dedication to MSA, your wise counsel and guidance, and your sincere friendship with all of us. We treasure you!

Graduating from McMaster University in 1939, John joined the pioneer electron microscopy team at the Physics Department of the University of Toronto, where he earned a Masters degree in 1940 and a Doctorate in 1943 in the then new field of electron optics. He served 36 years on the professional staff of the Henry Ford Hospital in Detroit. In 1990 the Medical Association of that hospital awarded him its Distinguished Career Award for, "outstanding contributions to patient care, medical teaching and scientific advancement." For 40 years he was the director and a performer with the Windsor Light Opera Association, which he founded in 1948 and which awarded him, on his retirement, the title of Founding Director Emeritus. In 1992 Dr. Watson received the degree, Doctor of Humanities, honoris causa, from the University of Windsor, in recognition of his outstanding contributions to the cultural life of Windsor and to the science of microscopy. In that same year he was made an Honorary Charter Member of the Microscopy Society of America and received its Distinguished Service Award. In 1993 he became an Honorary Member of the Canadian Microscopical Society, and in 1996 an Honorary Member of the North Carolina Society for Microscopy and Microbeam Analysis. He is particularly proud of the Special Award, presented to him in 1981 by the Electron Microscopy Society of America, during its 39th meeting in Atlanta for, "Contributions to early development of electron microscopy in North America and in appreciation for twenty-five years of dedicated service to the Society as President (1957), Placement Officer (1954–1999), Certification Board Chairman and Troubadour." As a "troubadour" he composed and sang the poem, "The EMSAN Rhapsody," set to the music of the Wiffenpoof Song, which begins: "From the latices of Robley to the Hall where Cecil dwells."

1999 AWARDS

MICROSCOPY SOCIETY OF AMERICA

1999 DISTINGUISHED SCIENTIST AWARDS

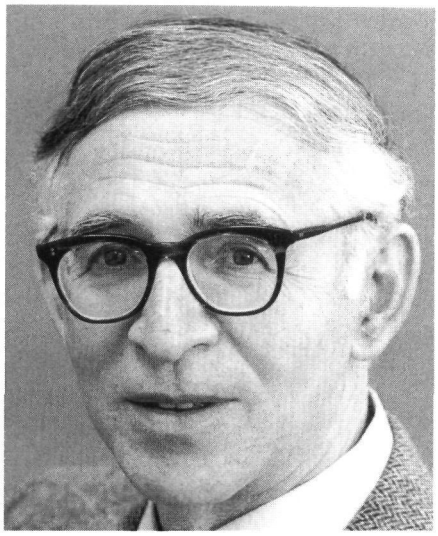
TAKEO ICHINOKAWA
Physical Sciences

He graduated in a graduate course of Science and Engineering in Waseda University in 1954 and has held posts of associate professor and full professor in Waseda University between 1958 and 1997. He is now a professor emeritus of Waseda University.

(1) He developed the first scanning electron probe X-ray microanalyzer in Japan in 1958 and developed several new techniques for surface microanalysis by using backscattering and secondary electron spectroscopy between 1958 and 1970.
(2) He developed a new electron energy analyzer of a magnetic lens type (Ichinokawa type) and analyzed microscopic structures by electron loss spectroscopy using transmission electron microscopy between 1970 and 1985.
(3) He constructed a low voltage ultrahigh vacuum scanning electron microscope equipped with a LEED detector to take dark field images in SEM, and investigated dynamic changes of domain structures, phase transitions, reconstructed structures of metal on Si surfaces, and small metal islands on Si or SiO_2 by varying temperature. Furthermore, he determined the atomic arrangements of several reconstructed structures for metals on Si(100) by using a scanning tunneling microscope developed by his laboratory.

The main subjects of his studies were instrumentation of electron optical systems and microanalyses of surface structures and defects by using UHV scanning electron microscopy.

He is an advisory committee member of the Journal of Ultramicroscopy and the International Conference of X-ray Optics and Microanalysis.



SIR AARON KLUG
Biological Sciences

Aaron Klug was educated at the Universities of Witwatersrand, Cape Town and Cambridge. He began as a medical student, transferred to science, and his PhD at the Cavendish Laboratory was in Physics. He joined the MRC Laboratory of Molecular Biology in Cambridge in 1962, was the Director of the Laboratory from 1986 to 1996, and now continues as a member of staff, leading a research group on gene expression.

His work has been on the interactions of proteins and nucleic acids and on the elucidation of the structures of large biological molecules and assemblies, including simple viruses and chromatin, by X-ray diffraction and electron microscopy and the development of new methods for their study. In particular, he invented the technique of 3-D image reconstruction from a series of tilted electron micrographs, and later the phase contrast defocusing method for "transparent" specimens. This work led to the creation of a new field, now termed electron crystallography.

In 1982 he was awarded the Nobel Prize in Chemistry, for "his development of crystallographic electron microscopy and his elucidation of the structure of protein-nucleic acid complexes of biological importance". His current research is on the structure of DNA and RNA binding proteins which regulate gene expression and in particular on the interaction with DNA of the zinc finger family of transcription factors which he discovered.

He is President of the Royal Society, a member of the Order of Merit, a Foreign Associate of the US National Academy of Sciences, and of the French Academy of Sciences, and has received many honorary degrees.

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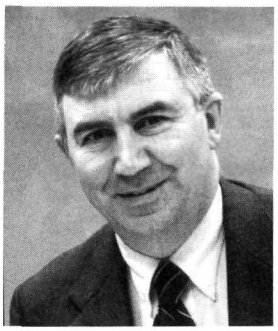
ZHONG LIN WANG

Zhong Lin (ZL) Wang received his Ph.D. in Physics from Arizona State University in 1987 under the guidance of Professors J.M. Cowley and C. Colliex. After a year as a Visiting Lecturer at SUNY Stony Brook with Professor R.F. Egerton, Dr. Wang was awarded a Research Fellowship by the University of Cambridge to work with Professor A. Howie. He was then appointed as a Research Associate Professor by the University of Tennessee to work with Dr. J. Bentley. In 1993, he moved to the National Institute of Standards and Technology. He is currently a full Professor of Materials Science and Engineering and the Director of the Electron Microscopy facility at Georgia Tech. Dr. Wang is the author and co-author of three books entitled "Elastic and Inelastic Scattering in Electron Diffraction and Imaging" (Plenum Press, 1995), "Reflection Electron Microscopy and Spectroscopy for Surface Analysis" (Cambridge University Press, 1996), "Functional and Smart Materials—Structural Evolution and Structure Analysis" (Plenum Press, 1998). Dr. Wang's research covered electron inelastic and diffuse scattering, reflection electron microscopy, and electron energy-loss spectroscopy. His current research focuses on novel TEM techniques, nanophase materials, characterization of smart materials, physical properties of carbon nanotubes, and in-situ TEM. He won the US NSF CAREER award and the 1998 China NSF Outstanding Oversea Young Scientist Award.

THE MORTON D MASER
MSA DISTINGUISHED SERVICE AWARD

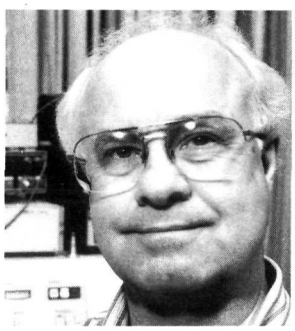
CHARLES E. LYMAN

Charles E. Lyman, Professor of Materials Science and Engineering at Lehigh University, received his B.S. from Cornell in 1968 and his Ph.D. from the Massachusetts Institute of Technology in 1974. Lyman was the 1991 president of the Microscopy Society of America. Prior to that he was program chair for the 1984 MSA annual meeting in Detroit and served on MSA Council as a physical science director, 1985–87. Since 1982 he has organized many MSA symposia concerning analytical electron microscopy and the characterization of catalysts. In 1991 Lyman explored the possibility of an MSA scientific journal by organizing a demonstration issue of the EMSA Bulletin called "Microscopy: the Key Research Tool." Currently, Dr. Lyman is Microanalysis Editor of the society's journal, Microscopy and Microanalysis, and is also president-elect of the Microbeam Analysis Society. Professor Lyman has over 30 years experience in the application of electron microscopy and microanalysis to materials problems and over 100 technical publications.



JOHN M. BASGEN
Biological Sciences

John M. Basgen received his bachelor's degree in biology from the University of Minnesota. He has spent twenty-five years working in the Department of Pediatrics at the University of Minnesota Medical School. For the past 11 years, he has been Senior Scientist in that department's Diabetes Morphometry Laboratory where he has worked on quantifying morpholobical changes in kidneys from diabetics. He is a past president of the Minnesota Electron Microscopy Society and one of the founding members and past chairs of the Technologists' Forum of the Microscopy Society of America. In addition to publishing numerous papers related to the structure and function of the kidney, John has lectured and taught many workshops on the use of morphometric techniques both in this country and as part of the MSA exchange program with the Peoples Republic of China. He continues to explore new methods for efficiently measuring structural changes within the diseased kidney.



JOHN C. WHEATLEY
Physical Sciences

John received his formal education in Arizona, graduating from Arizona State University in 1967. In the summer of 1967, he began working for the Phoenix Laboratory of the Atlanta-based Center for Disease Control and Prevention. The work there consisted of studies of viral hepatitis replication in various cell lines. In 1968 he returned to ASU to pursue graduate studies in microbiology.

John started work for the Department of Physics and Astronomy in 1970 as an electron microscope engineer. In 1981, he became the Laboratory Manager in the Center for High Resolution Electron Microscopy under the administrative umbrella of the Center for Solid State Science.

John is currently a Senior Research Professional in the Department of Physics and Astronomy and continues to manage the Center for High Resolution Electron Microscopy. His primary interest is in training students in high resolution electron microscope techniques and administering the daily activities of the laboratory.

John wishes to dedicate the award to the many students, past and present, who have utilized the microscopes in the Center for High Resolution Electron Microscopy.

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1999 MICROBEAM ANALYSIS SOCIETY AWARDS
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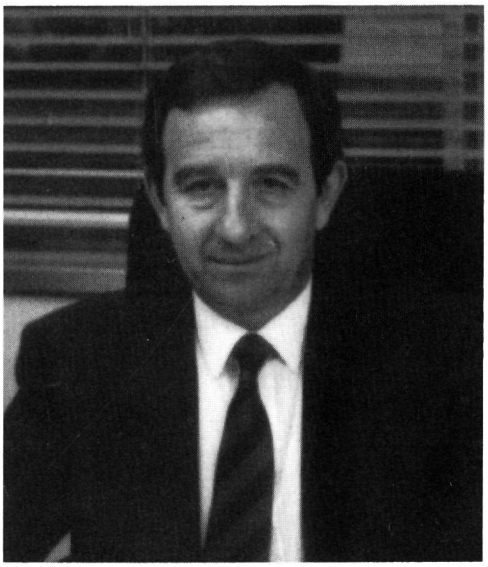


ROBERT A. SAREEN

Rob Sareen received a B.Sc and M.Sc from the University of Liverpool where his thesis involved a range of proton and alpha-particle detectors, silicon detectors for low energy x-rays and germanium detectors for gamma-ray measurements. In 1970, he joined Ortec Inc. in Tennessee working on position-sensitive and x-ray detectors.

In 1974, Rob returned to England establishing the detector group at Link Systems Ltd. and becoming Managing Director in 1980 responsible for the acquisitions of Laser Applications, Tennelec and X-Tech. During this period, Link became a leading supplier of x-ray analytical systems; part of this success was attributed to the pioneering of new and improved x-ray detectors.

In 1992, Rob completed a Ph.D. at the University of Manchester on polarisation measurements on gamma rays. In 1994, Rob returned to industry establishing Gresham Scientific Instruments Ltd.

Rob believes his one talent is motivating like-minded people to design, manufacture and sell state of the art detectors and is fortunate to have worked with a number of outstanding contributors to both the understanding and commercialisation of a range of interesting and challenging products.

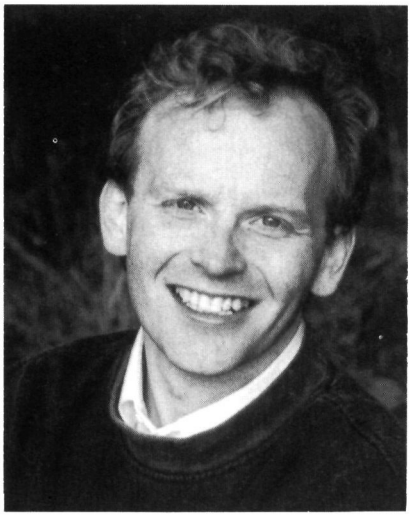
PRESIDENTIAL SERVICE AWARD

THOMAS G. HUBER

Tom Huber has a long history of service to the Microbeam Analysis Society, serving as MAS Director (1986–1988) and as MAS President in 1993. He has served as the MAS Corporate Liaison for eight years, a position he continues to enjoy. Tom was an advisor to the organizing committee for the 12th IFSEM Meeting in Seattle and was a member of the Local Arrangements Committee for the 1992 MSA/MAS meeting in Boston. In addition to his dedicated service to MAS, Tom has also served in various advisory capacities for MSA.

Tom is currently Vice Chairman Emeritus of JEOL where "his hat has hung for 33 years working on the company's Corporate Culture."

K.F.J. HEINRICH AWARD



JOHN BRULEY

Dr. John Bruley currently works at IBM's Microelectronics division where his research activities include the study of local composition, structure and bonding and how these affect properties. He has recently been active in developing methods of analytical microscopy including applications of spectrum imaging to access the nano-scale information at interfaces. Dr. Bruley obtained his Ph.D. from the University of Cambridge for his work on the analytical microscopy of diamond. He was then a post-doc at IBM's T.J. Watson Research Center, where he made use of high energy-resolution EELS to study diamond-like carbon and silicon-enriched oxide films. Since that time he has held positions in the Max-Planck Institute for Metals Research in Stuttgart and the Materials Science Department at Lehigh University. His key publications have involved the use of EELS to study interfaces and grain boundaries in metal and ceramic systems.

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1999 MAS DISTINGUISHED SCHOLAR AWARDS

F.M. Alamgir
Lehigh University

T.C. Baroni
University of Western Australia

C.F. Blanford
University of Minnesota

J.D. Holbery
University of Washington

P. Horny
Université de Sherbrooke

D.A. Kossakovski
California Institute of Technology

K.W. Kwon
Stanford University

A. Porter
Oxford University

S.T. Taylor
University of California-Berkeley

M. Toth
University of Technology-Sydney

MAS PRESIDENTIAL AWARDS

	Science		Service
1977	R. Castaing	1977	P. Lublin
1978	K.F.J. Heinrich	1978	D.R. Beaman
1979	P. Duncumb	1979	M.A. Giles
1980	D.B. Wittry	1980	A.A. Chodos
1981	S.J. Reed	1981	R. Myklebust
1982	R. Shimizu	1982	J. Doyle
1983	J. Philibert	1983	D. Newbury
1984	L.S. Birks	1984	J.I. Goldstein
1985	E. Lifshin	1985	M.C. Finn
1986	R. Myklebust	1986	V. Shull
1987	O.C. Wells	1987	D.C. Joy
1988	J.D. Brown	1988	C.G. Cleaver
1989	J. Hillier	1989	W.F. Chambers
1990	T.E. Everhart	1990	C.E. Fiori
1991	J.I. Goldstein	1991	T.G. Huber
1992	G. Lorimer	1992	E. Etz
	G. Cliff	1993	H.A. Freeman
1993	D.E. Newbury	1994	J.L. Worrall
1994	D.C. Joy	1995	R.W. Linton
1995	G. Bastin	1996	P.F. Hlava
1996	A.V. Somlyo	1997	J.A. Small
	A.P. Somlyo	1998	J.J. McCarthy
1997	D.B. Williams		
1998	F.H. Schamber		

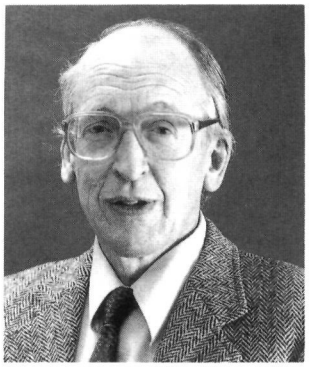
MAS K.F.J. HEINRICH AWARDS

1986	P. Statham	1992	S. Pennycook
1987	J.T. Armstrong	1993	P.E. Russell
1988	D.B. Williams	1994	J.R. Michael
1989	R. Leapman	1995	N. Lewis
1990	R.W. Linton	1997	R. Gauvin
1991	A.D. Romig, Jr.	1998	V.P. Dravid

MAS PAST PRESIDENTS

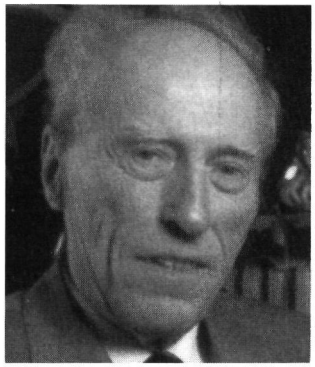
1968	L.S. Birks	1984	D.C. Joy
1969	K.F.J. Heinrich	1985	D.E. Newbury
1970	R.E. Ogilvie	1986	C.G. Cleaver
1971	A.A. Chodos	1987	C. Fiori
1972	K. Keil	1988	W.F. Chambers
1973	D.R. Beaman	1989	D.B. Wittry
1974	P. Lublin	1990	A.D. Romig, Jr.
1975	J.W. Colby	1991	J.T. Armstrong
1976	E. Lifshin	1992	D.B. Williams
1977	J.I. Goldstein	1993	T.G. Huber
1978	J.D. Brown	1994	J. Small
1979	D.F. Kyser	1995	J. McCarthy
1980	O.C. Wells	1996	D.E. Johnson
1981	J.R. Coleman	1997	Joseph R. Michael
1982	R. Myklebust	1998	Ryna B. Marineko
1983	R. Bolon		

SPECIAL SYMPOSIA HONOREES



ARCHIE HOWIE

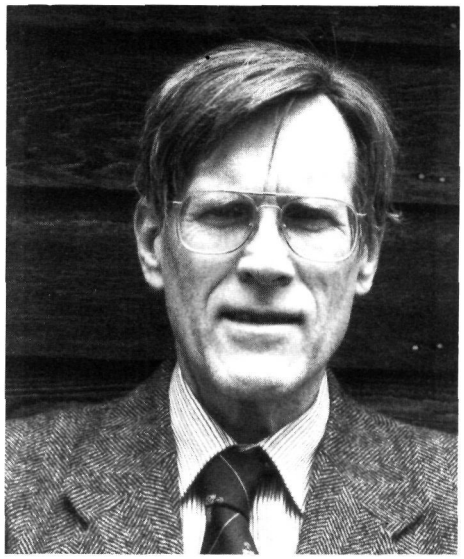
Professor Archie Howie CBE FRS is Professor of Physics, University of Cambridge and a Professorial Fellow of Churchill College, Cambridge. His early education was in Scotland at Kirkcaldy High School and then a first class B.Sc. degree in Physics from the University of Edinburgh. This was followed by an MS (summa cum laude) from the California Institute of Technology and a Ph.D. from the University of Cambridge on the subject of Electron Microscopy of Defects in Deformed Crystals. The development of the Dynamical Theory of Electron Diffraction comes from this period. From 1967 to 1989 Archie lead the Metal Physics Research Group at the Cavendish Laboratory, and from 1989 to 1997 he was Head of the Cavendish Laboratory. In 1978 he became a Fellow of the Royal Society and in 1991 he was an EMSA Distinguished Scientist Awardee. In 1998 he was honored with a CBE and in January 1999 Archie became the President of the International Federation of Societies for Electron Microscopy (IFSEM).



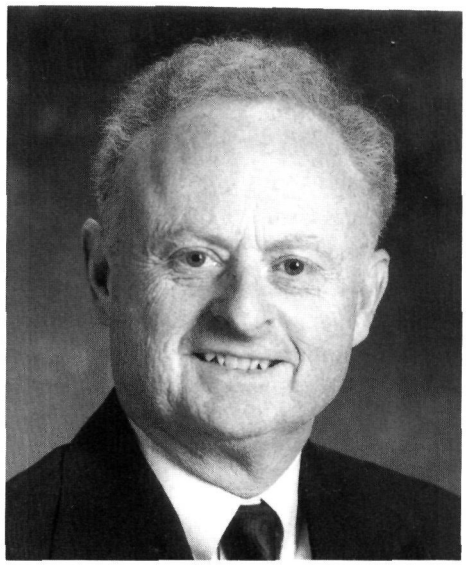
RAIMOND CASTAING

Raimond Castaing (Dec. 28, 1921–Apr. 10, 1998) was born in Monaco, entered the Ecole Normale Superieure in 1940, joined the French resistance during the War, and graduated in 1946 with the highest diploma for teaching the physical sciences. He then became a research engineer at Onera, working for his doctoral thesis under A. Guinier. At a meeting in 1949, they described the first microprobe, built by modifying a transmission electron microscope with electronic lenses. Castaing presented his doctoral thesis at the U. of Paris, *Application des Sondes Electroniques a une Methode d'Analyse Ponctuelle Chimique et Crystallographique*, in 1951. By 1958 two prototype instruments and the first commercial Cameca instrument had been built.

Prof. Castaing held many prestigious posts during his long career including lecturer at the U. of Toulouse (1952–6) and the U. of Paris (1956–9). With Gunier he founded the U. of Paris, Orsay where he became a professor and Director of the Laboratory of Physics of Solids up to his retirement. During this time, he developed the Secondary Ion Mass Spectrometer (SIMS) with Slodzian (1962). Concurrently, he was scientific director and then General Director of Onera (1968–73). He was elected to the French Academy of Sciences (1977) and to the Council of Nuclear Security (1982). He was also a member of the Atomic Energy Committee (1982–7), Administrator of the French Civil Research Organization, the CNRS (1983–9), a member of the Administration Committee of Usinor Steel Company (1984–7), and in 1996 he became President of the Commission on the fast breeder reactor Superphenix.



DAVID JOY
MSA PRESIDENT



JOHN J. FRIEL
MAS PRESIDENT

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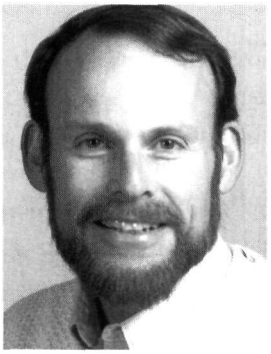
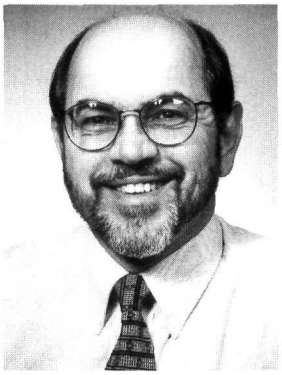
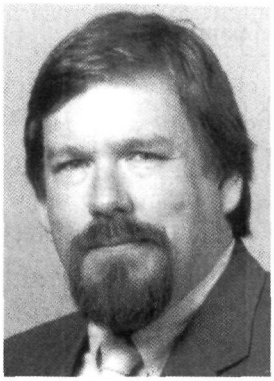


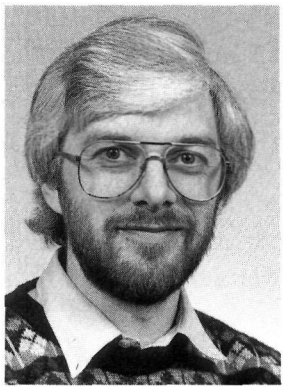
Charles Meshul
Local Arrangements Chair



Dennis Trune
Local Arrangements Treasurer

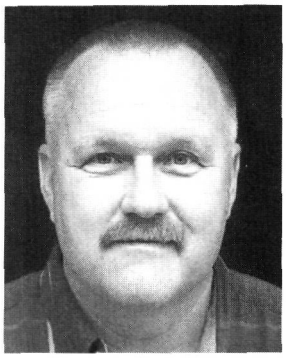


Jay Jerome
MSA Program Chair



Stuart McKernan
MSA Program Vice Chair

John Mansfield
MAS Program Co Chair



Robert L. Price
MSA Program Vice Chair Elect

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MICROSCOPY AND MICROANALYSIS 1999

PROGRAM COMMITTEE

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Stuart McKernan, MSA Program Vice Chair
John Mansfield, MAS Program Co Chair
Robert L. Price, MSA Program Vice Chair Elect

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Bryan Tracy
Christina Trivett
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David Wokosin
Yimei Zhu

FOREWORD

David Joy and John Friel
President MSA and President MAS

This is the third year that the Proceedings of our joint annual meetings have been published as a supplement to our Journal "Microscopy and Microanalysis." The handsome volume that you now hold in your hand contains the full scientific content of Microscopy and Microanalysis '99, which serves both as a reference during the meeting and as a permanent archive.

Because the meeting and the Proceedings are a joint MSA/MAS effort under the direction of a single Program Committee, and a single Local Arrangements Committee, and are published as a single Proceedings, the strengths of our two societies have been combined to maximize the benefits to all our members and guests.

We wish to congratulate the Program Committee chaired by Jay Jerome and the Local Arrangements Committee chaired by Charles Meshul for their hard work in making this an outstanding meeting. Jay and co-chairs Stuart McKernan (MSA), and John Mansfield (MAS), have worked extremely hard during the past two years arranging sessions, speakers, pre-meeting workshops, and tutorials. The result is a comprehensive and wide-ranging program of platform and poster symposia complemented by a number of special offerings. Some of these include a special pre-meeting symposium on "Optical Microscopy in the Next Millenium" organized by Brian Herman, and a comprehensive series of pre-meeting short courses organized by Brian Herman and Louis Kerr. A special MAS Symposium organized by Ryna Marinenko and Jim McGee entitled "50 Years of Electron Probe Microanalysis" will be held in memory of Prof. Raimond Casting. Other highlights include a Symposium in honor of Dr. Archie Howie, the computer workshop presented by Nestor Zaluzec and John Mansfield, and the programs of the Tech Forum arranged by Bev Maleef.

The LAC under Charles Meshul has been equally effective and instrumental to the success of the meeting in arranging for a world class meeting site, some exciting social events, hotels, and even a post-conference cruise. The Microscopy and Microanalysis Meeting has been managed by the Rebedeau Group headed by Mary Beth Rebedeau in close conjunction with both the LAC and the Program Committee to ensure a streamlined production process and an outstanding exhibit and trade show.

Our thanks are due to Bill Bailey, the MSA Proceedings Editor, who over the years has been responsible for these first class Proceedings and whose tireless attention to detail keeps everything and everybody on schedule. We also wish to express our appreciation to Herb Niemirow and the extremely competent and professional staff at Springer-Verlag for their attentive efforts in publishing our journal and these Proceedings.

These 1999 Proceedings are respectfully dedicated to Dr. John Watson who was not only a Charter member of (E)MSA but who also conceived the first Proceedings for our 25th Anniversary Meeting. John is a past president of (E)MSA, and he has also been the MSA Placement Officer for many years. We are proud to take this opportunity to honor his lifetime of service and commitment to our field.

We also extend our hearty congratulations to the MSA and MAS award winners. Sir Aaron Klug and Takeo Ichinokawa have been selected as recipients for the MSA Distinguished Scientist Awards in the Biological and Physical Sciences, respectively. Z.L. Wang is the MSA Burton Medalist, and Charles Lyman is the recipient of the MSA Morton D Maser Distinguished Service Award. The MSA Outstanding Technologist Awards go to John Wheatley and John Basgen for the Physical and Life Sciences respectively. The MAS Presidential Science Award winner is Rob Sareen and the recipient of the MAS Service Award is Tom Huber. This year the Heinrich Award will be given to John Bruley.

Portland is a beautiful and vibrant city with great natural beauty, outstanding restaurants and shops, and some unique attractions. We thank the City of Portland for their warm hospitality and all of the organizers and participants for making M & M 99 the premier event in the world of microscopy. We now look forward to Philadelphia, the site of Microscopy and Microanalysis 2000.

PRESIDENTIAL HAPPENINGS

SHARED RESOURCES AND USER FACILITIES: ACCESS TO INSTRUMENTATION

MAGNETIC IMAGING AND ITS APPLICATION TO MATERIALS

OPTICAL MICROANALYSIS VIA MOLECULAR SPECTROSCOPY

QUANTITATIVE X-RAY MICROANALYSIS

ATOMIC STRUCTURE AND MICROCHEMISTRY OF INTERFACES

HIGH RESOLUTION ELECTRON MICROSCOPY

ELECTRON DIFFRACTION IN THE TEM

ELECTRON DIFFRACTION IN THE SEM: AUTOMATED EBSP AND ITS APPLICATION

ENVIRONMENTAL SCANNING ELECTRON MICROSCOPY AND OTHER WET WORK

LOW VOLTAGE (1–5 KV) X-RAY MICROANALYSIS

SCANNING ELECTRON MICROSCOPY

IN-SITU MICROSCOPY TECHNIQUES

ADVANCES IN INSTRUMENTATION

ADVANCES IN DIGITAL IMAGING

BIOMATERIALS

CRYOTECHNIQUES, IMMUNOCYTOCHEMISTRY, AND ELECTRON MICROSCOPY I. MOLECULAR APPROACH

CRYOTECHNIQUES, IMMUNOCYTOCHEMISTRY, AND ELECTRON MICROSCOPY II. CELLS AND TISSUES

CRYOTECHNIQUES, IMMUNOCYTOCHEMISTRY, AND ELECTRON MICROSCOPY

RECENT ADVANCES IN CONFOCAL MICROSCOPY

BIOLOGICAL LABELING AND CORRELATIVE MICROSCOPY

MOLECULAR OPTICAL SPECTROSCOPY IN BIOLOGY

EDUCATION OUTREACH TOOLS

FOCUSSED ION BEAM

EDS MAPPING, THE RIGHT WAY AND THE WRONG WAY

ELECTRONIC DOCUMENT SUBMISSION

FROM 3-D LIGHT MICROSCOPIC IMAGES TO QUANTITATIVE INSIGHT

SCANNING ELECTRON MICROSCOPY AT A DISTANCE: A NUTS-AND-BOLTS DISCUSSION

GEOLOGY/MINERALOGY

MAS CELEBRATES: FIFTY YEARS OF ELECTRON PROBE MICROANALYSIS

COMPOSITIONAL IMAGING AND SPECTROSCOPY

A. HOWIE SYMPOSIUM: CELEBRATION OF PIONEERING ELECTRON MICROSCOPY

DEFECTS IN SEMICONDUCTORS

IRRADIATION AND IMPLANTATION EFFECTS IN MATERIALS

FUTURE OF MICROSCOPY: CERAMICS, COMPOSITES, AND CEMENT

THIN FILMS/COATINGS

OXIDATION/CORROSION

METALS AND ALLOYS

PRECISION SPECIMEN PREPARATION

SPECIMEN PREPARATION POSTER SESSION

COMPUTATIONAL METHODS FOR MICROSCOPY AND MICROANALYSIS

ELECTRON HOLOGRAPHY

SCANNED PROBE MICROSCOPY: MUCH MORE THAN JUST BEAUTIFUL IMAGES

DEVELOPMENTS IN SCANNED PROBE MICROSCOPY OF POLYMERS

BIOLOGICAL APPLICATIONS Of SCANNING PROBE MICROSCOPIES

STRUCTURAL APPROACHES TO THE STUDY OF CELL CELL INTERACTIONS IN THREE DIMENSIONS

NOVEL APPROACHES TO MICROSCOPY OF LIVING CELLS

MULTI PHOTON EXCITATION MICROSCOPY: THE NEXT GENERATION

APPLICATIONS OF IMAGING TECHNIQUES TO THE STUDY OF EMBRYOLOGICAL DEVELOPMENT

PATHOLOGY OF AIDS AND RELATED CONDITIONS

BIOMEDICAL APPLICATIONS

BLOOD/IMMUNOLOGY

MICROBIOLOGY

PATHOLOGY

SAFE MANAGEMENT OF INFECTIOUS AND BIOHAZARDOUS AGENTS

APPLICATIONS AND ADVANCES IN VASCULAR CORROSION CASTING IN MICROVASCULAR RESEARCH

BIOPOLYMERS AND BIOMEMETICS

HIGHLIGHTS OF BIOLOGICAL MICROSCOPY IN THE PACIFIC NORTHWEST USA

APPLICATION OF CORRELATIVE MICROSCOPY TO STUDIES OF PLANT CELL FUNCTION

ULTRASTRUCTURAL ANALYSIS OF PLANT CELLS

BIOLOGICAL ULTRASTRUCTURE (CELLS, TISSUES, ORGAN SYSTEMS)

BIOLOGICAL MICROANALYSIS

NEUROBIOLOGY

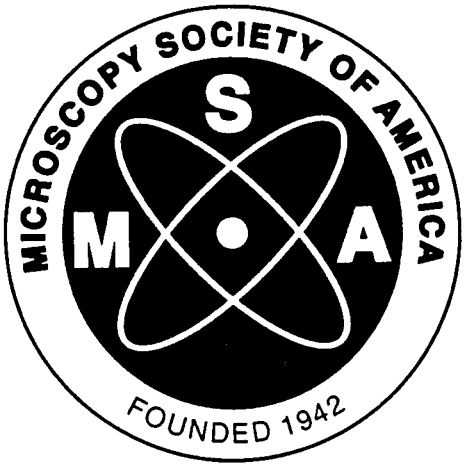
BIOLOGICAL SPECIMEN PREPARATION

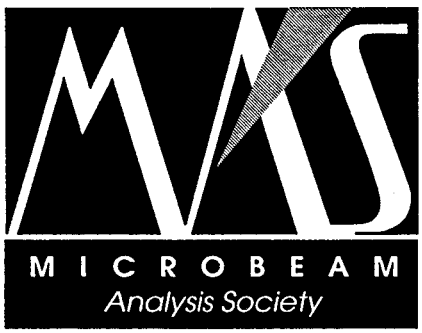
CYTOCHEMISTRY

MSA TECHNOLOGISTS' FORUM SYMPOSIUM: TECHNOLOGY FROM THE PACIFIC NORTHWEST

MSA TECHNOLOGISTS' FORUM SPECIAL TOPIC PRESENTATION

On the cover: SEM of free-swimming sperm cell of the fern ally Equisetum arvense. The cell forms a helix of about 3.5 coils, with a locomotory apparatus consisting of approximately 55 flagella and associated structures occupying the anterior end of the cell. From S.J. Schmitt and K.S. Renzaglia, Correlative SEM And TEM Of Plant Spermatozoids: Equisetum Arvense L, page 1261.





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