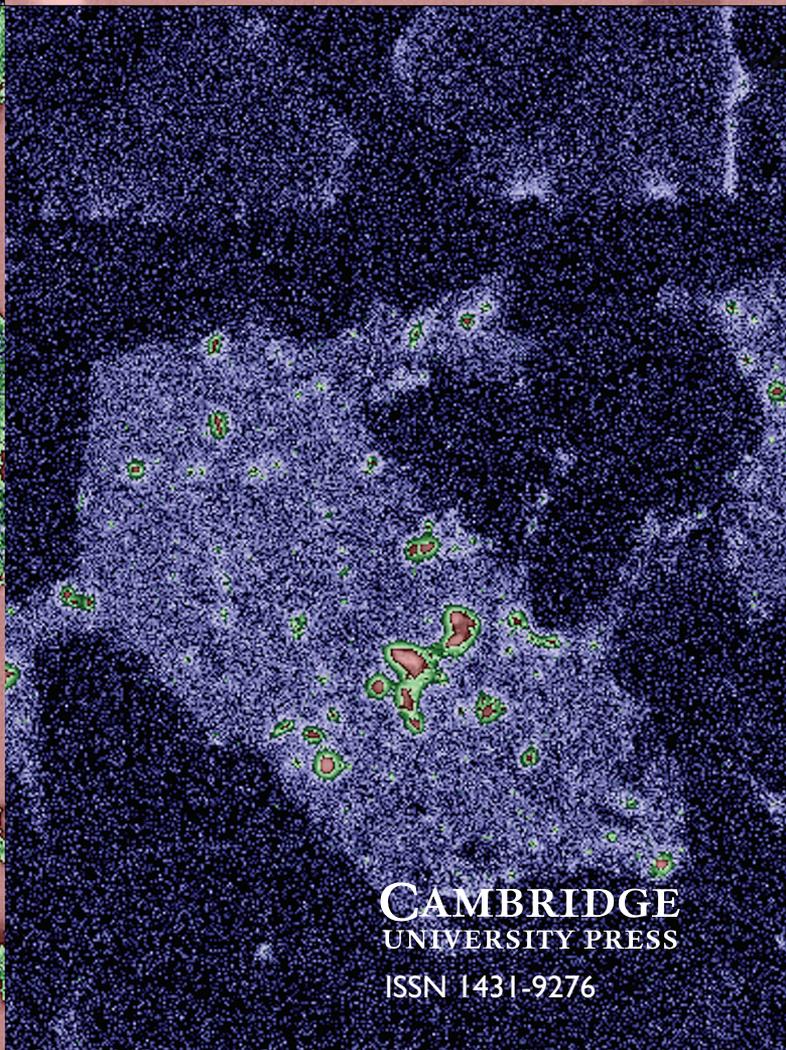
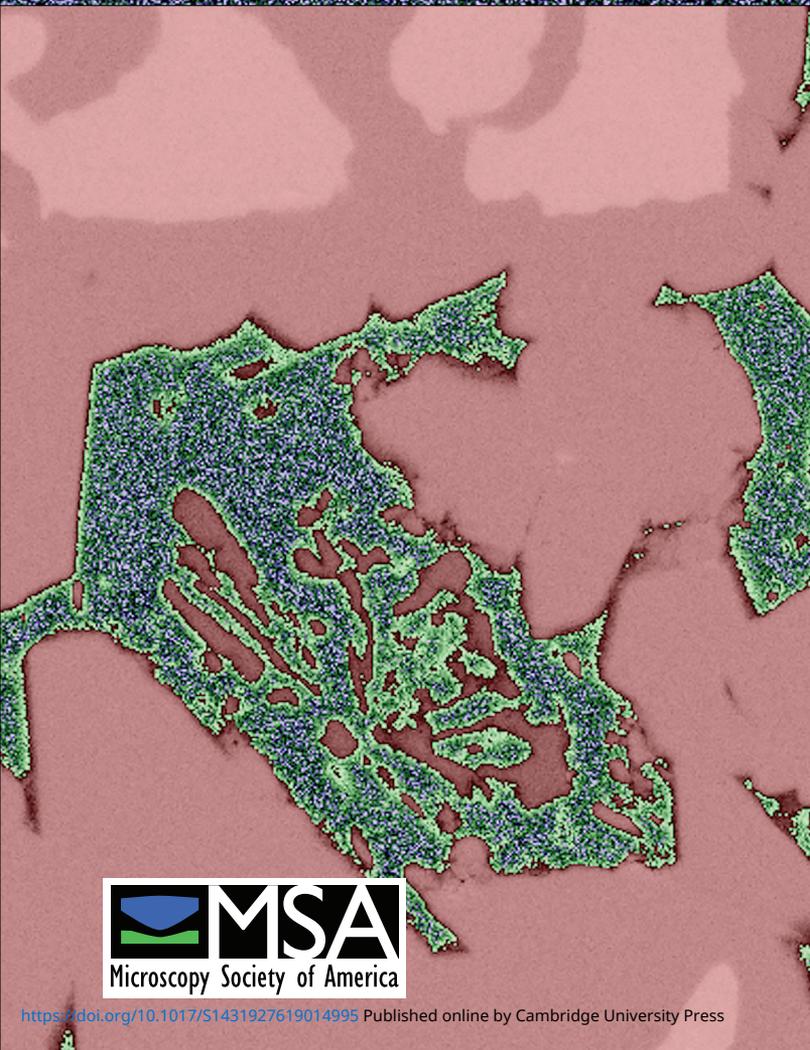


Volume 25, Number 5 October 2019

Microscopy AND Microanalysis



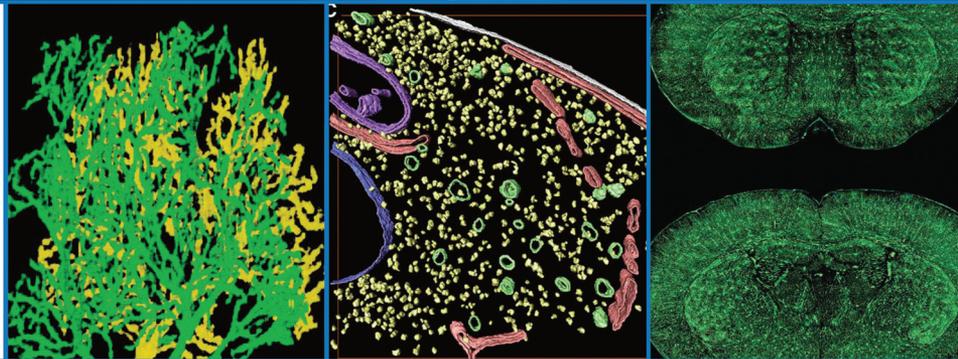
CAMBRIDGE
UNIVERSITY PRESS

ISSN 1431-9276

DiATOME Diamond Knives



at the forefront of innovation



NEW! Ultra ATS The Ultra ATS Diamond knife is perfect for placing sections on Si wafers to view under the SEM. The knife comes in 3.0mm size with 35° angle.

**ultra 45° • cryo • histo • ultra 35°
histo jumbo • STATIC LINE II • cryo immuno
ultra sonic • ultra AFM & cryo AFM
trimtool 20, 45, and 90**

www.emsdiasum.com

DiATOME U.S.
P.O. Box 550 • 1560 Industry Rd. • Hatfield, PA 19440
Tel: (215) 412-8390 • Fax: (215) 412-8450
email: info@emsdiasum.com or stacie@ems-secure.com

Microscopy AND Microanalysis

An International Journal for the Biological and Physical Sciences

THE OFFICIAL JOURNAL OF

MICROSCOPY SOCIETY OF AMERICA
MICROANALYSIS SOCIETY
MICROSCOPICAL SOCIETY OF CANADA /
SOCIÉTÉ DE MICROSCOPIE DU CANADA
MEXICAN MICROSCOPY SOCIETY
BRAZILIAN SOCIETY FOR MICROSCOPY AND MICROANALYSIS
VENEZUELAN SOCIETY OF ELECTRON MICROSCOPY
EUROPEAN MICROBEAM ANALYSIS SOCIETY
AUSTRALIAN MICROSCOPY AND MICROANALYSIS SOCIETY
PORTUGUESE SOCIETY FOR MICROSCOPY
ELECTRON MICROSCOPY SOCIETY OF INDIA

PUBLISHED IN AFFILIATION WITH

ROYAL MICROSCOPICAL SOCIETY
GERMAN SOCIETY FOR ELECTRON MICROSCOPY
BELGIAN SOCIETY FOR MICROSCOPY
MICROSCOPY SOCIETY OF SOUTHERN AFRICA

Editor-in-Chief

John Mansfield
4304 Spring Lake Blvd.
Ann Arbor, MI 48108-9657
e-mail: thejfmjfm@me.com

Administrative Editor

John Shields
University of Georgia
Athens, GA 30602
e-mail: jpsshield@uga.edu

Biological Sciences Applications Editors

W. Gray (Jay) Jerome
Department of Pathology, Microbiology and
Immunology
U-2206 MCN
Vanderbilt University
Nashville, TN 37232-2561
e-mail: jay.jerome@vanderbilt.edu

Heide Schatten

Department of Veterinary Pathobiology
University of Missouri-Columbia
Columbia, MO 65211
e-mail: SchattenH@missouri.edu

Rosemary White

CSIRO Plant Industry
Canberra, ACT 2601, Australia
e-mail: Rosemary.white@csiro.au

Elizabeth Wright

Department of Biochemistry
College of Agricultural and Life Sciences
University of Wisconsin
Madison, WI 53706-1544
e-mail: erwright2@wisc.edu

Deborah Kelly

Department of Biomedical Engineering
College of Engineering
Pennsylvania State University

University Park, PA 16802-4400
e-mail: debkelly@psu.edu

Cultural Heritage Applications Editor

Edward P. Vicenzi
Smithsonian Institution, Museum
Conservation Institute
4210 Silver Hill Rd., Suitland, MD 20746
e-mail: VicenziE@si.edu

Materials Sciences Applications Editors

Vinayak Dravid
Materials Science and Engineering
Northwestern University
Evanston, IL 60208-3105
e-mail: v-dravid@northwestern.edu

Georg E. Fantner

Interfaculty Institute for Bioengineering
École Polytechnique Fédéral de Lausanne
Lausanne 1015, Switzerland
e-mail: georg.fantner@epfl.ch

David J. Larson

CAMECA
5500 Nobel Drive
Madison, WI 53711
e-mail: david.larson@ametek.com

Ian MacLaren

Materials and Condensed Matter Physics
School of Physics and Astronomy
University of Glasgow
Glasgow G12 8QQ, UK
e-mail: Ian.MacLaren@glasgow.ac.uk

Ross Marceau

Institute for Frontier Materials
Deakin University
Geelong, VIC 3216, Australia
e-mail: r.marceau@deakin.edu.au

Joseph Michael

Sandia National Laboratories
P.O. Box 5800, Albuquerque, NM 87185
e-mail: jrmicha@sandia.gov

Yoosuf N. Picard

National Energy Technology Laboratory
P.O. Box 10940
Pittsburgh, PA 15236
e-mail: Yoosuf.Picard@netl.doe.gov

Daniel Ruscitto

GE Research
Niskayuna NY 12309
e-mail: dan.ruscitto@gmail.com

Masashi Watanabe

Dept. of Mater. Sci. & Eng.
Lehigh University, Bethlehem, PA 18015
e-mail: masashi.watanabe@lehigh.edu

Special Issues and Reviews Editor

David J. Smith
Department of Physics
Arizona State University, Tempe,
AZ 85287-1504
e-mail: david.smith@asu.edu

Book Review Editor

Cynthia Goldsmith
Centers for Disease Control, Atlanta, GA 30333
e-mail: csg1@cdc.gov

M&M Program Guide Editor

Richard L. Martens
1013 Bevell Building
Box 870164, Tuscaloosa, AL 35487-0164
e-mail: rmartens@caf.ua.edu

Proceedings Editor

Gail Celio
University of Minnesota, St. Paul, MN 55108
e-mail: celio001@umn.edu

Editorial Board

Ralph Albrecht	<i>University of Wisconsin, Madison, Wisconsin</i>
Ilke Arslan	<i>Pacific Northwest Laboratory, Richland, Washington</i>
Mary Grace Burke	<i>University of Manchester, Manchester, UK</i>
Barry Carter	<i>University of Connecticut, Storrs, Connecticut</i>
Wah Chiu	<i>Baylor College of Medicine, Houston, Texas</i>
Marc De Graef	<i>Carnegie Mellon University, Pittsburgh, Pennsylvania</i>
Niels de Jonge	<i>INM Institute for New Materials, Saarbrücken, Germany</i>
Elizabeth Dickey	<i>North Carolina State University, Raleigh</i>
Mark Ellisman	<i>University of California at San Diego, San Diego, California</i>
Pratibha Gai	<i>University of York, United Kingdom</i>
Marija Gajdardziska-Josifovska	<i>University of Wisconsin-Milwaukee, Milwaukee, Wisconsin</i>
Paul Kotula	<i>Sandia National Labs, Albuquerque, New Mexico</i>
William Landis	<i>University of Akron, Akron, Ohio</i>
Charles Lyman	<i>Lehigh University, Bethlehem, Pennsylvania</i>
Dale Newbury	<i>National Institute of Standards and Technology, Gaithersburg, Maryland</i>
Robert Price	<i>University of South Carolina, Columbia, South Carolina</i>
Jean-Paul Revel	<i>California Institute of Technology, Pasadena, California</i>
David Smith	<i>Arizona State University, Tempe, Arizona</i>
Nan Yao	<i>Princeton University, Princeton, New Jersey</i>
Nestor Zaluzec	<i>Argonne National Laboratory, Argonne, Illinois</i>

Editorial Board Representatives from Affiliated Societies

Donovan Leonard	<i>Oak Ridge National Laboratory (MAS)</i>
Gautam Kumar Dey	<i>Bhabha Atomic Research Centre (EMSI)</i>
Gema Gonzalez	<i>Venezuelan Institute for Scientific Investigation (Venezuela)</i>
Michael Robertson	<i>Acadia University, Wolfville, Nova Scotia (Canada)</i>
Brendan Griffin	<i>University of Western Australia (AMMS)</i>
Guillermo Solorzano	<i>Pontificia Universidade Catolica, Rio de Janeiro (Brazil)</i>
Mike Matthews	<i>Atomic Weapons Establishment, Reading, Great Britain (EMAS)</i>
Miguel Yacaman	<i>Mexico Institute for Nuclear Research (Mexico)</i>
Henrique Almeida	<i>Universidade do Porto (Portugal)</i>

Founding Editor

Jean-Paul Revel *California Institute of Technology, Pasadena, California*

Previous Editors-in-Chief

Dale Johnson	<i>University of South Florida, Tampa, Florida</i>
Charles Lyman	<i>Lehigh University, Bethlehem, Pennsylvania</i>
Robert L. Price	<i>University of South Carolina, Columbia, South Carolina</i>

This journal is part of the **Cambridge** Core service. Access to online tables of contents and article abstracts is available to all researchers at no cost. Access to full-text articles online is provided to those with online subscription. Online subscriptions must be activated. Once your subscription is activated, free access to past, present, and forthcoming articles is available at:

***Microscopy and Microanalysis* website: cambridge.org/MAM.**

Instructions for authors submitting manuscripts may be found at cambridge.org/MAM. Select "Further Information" then select "Instructions for Contributors."

Proven Electron Microscopy Solutions

QUANTAX EDS

- Featuring XFlash® 6 – worldwide leading SDD technology for SEM and TEM
- Delivering the fastest, most accurate EDS results
- Easiest-to-use EDS, available in configurations for every budget
- Integration of EDS, WDS, EBSD and Micro-XRF on SEM under a single user interface



www.bruker.com/quantax

Innovation with Integrity

EDS

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. **Review Articles** 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. **Book Reviews** are also published, but these are solicited only through the Book Review Editor.

Instructions for Contributors

Instructions for authors contributing manuscripts may be found at <http://mc.manuscriptcentral.com/mam> under "Resources: Instructions and Forms." Authors may also visit cambridge.org/mam, select "Information," and then select "Instructions for Contributors."

Copyright Information

Submission of a manuscript implies: that the work described has not been published before (except in the form of an abstract or as part of a published lecture, review, or thesis); that it is not under consideration for publication elsewhere; that its publication has been approved by all coauthors, if any, as well as by the responsible authorities at the institute where the work has been carried out; that, if and when the manuscript is accepted for publication, the authors agree to automatic transfer of the copyright to the Microscopy Society of America; that the manuscript will not be published elsewhere in any language without the consent of the copyright holders; and that written permission of the copyright holder is obtained by the authors for material used from other copyrighted sources.

All articles published in this journal are protected by copyright, which covers the exclusive rights to reproduce and distribute the article (e.g., as offprints), as well as all translation rights. No material published in this journal may be reproduced photographically or stored on microfilm, in electronic data bases, video disks, etc., without first obtaining written permission from the publisher.

The use of general descriptive names, trade names, trademarks, etc., in this publication, even if not specifically identified, does not imply that these names lack protection by the relevant laws and regulation.

Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by Cambridge University Press, provided that the appropriate fee is paid directly to Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, USA [Tel: (508) 750-8400], stating the ISSN (1431-9276), the volume, and the first and last page numbers of each article copied. The copyright owner's consent does not include copying for general distribution, promotion, new works, or resale. In these cases, specific written permission must first be obtained from the publisher.

Disclaimer

The Microscopy Society of America, the other societies stated, and Cambridge University Press cannot be held responsible for errors or for any consequences arising from the use of the information contained in this journal. The appearance of scientific reports and/or workshops, or any other material in *Microscopy and Microanalysis* does not constitute an endorsement or approval by The Microscopy Society of America of the findings, data, conclusions, recommendations, procedures, results, or any other aspect of the content of such articles. The appearance of advertising in *Microscopy and Microanalysis* does not constitute an endorsement or approval by The Microscopy Society of America of the quality or value of the products advertised or any of the claims, data,

conclusions, recommendations, procedures, results, or any other information included in the advertisements.

While the advice and information in this journal is believed to be true and accurate at the date of its going to press, neither the authors, the editors, nor the publisher can accept any legal responsibility for any errors or omissions that may be made.

Subscription Information

Microscopy and Microanalysis is published bimonthly in February, April, June, August, October, and December by Cambridge University Press (1 Liberty Plaza, New York, NY 10006). Three supplements (*Meeting Guide, Program Guide, and Proceedings*) are published in June and August.

Society Rates: Members of the Microscopy Society of America should contact the MSA Business Office for all subscription inquiries: Microscopy Society of America, 11130 Sunrise Valley Dr, Suite 350, Reston, VA 20191, Tel.: (703) 234-4115, Email: associationmanagement@microscopy.org, URL: www.microscopy.org. Members of other affiliated societies should contact their respective society business offices for all subscription inquiries.

Subscription Rates: Institutions print and electronic: US \$2364.00 in the USA, Canada, and Mexico; UK £1422.00+VAT elsewhere. Institutions online only: US \$1533.00 in the USA, Canada, and Mexico; UK £928.00 + VAT elsewhere. Individuals print plus online: US \$691.00 in the USA, Canada, and Mexico; UK £420.00+VAT elsewhere. Prices include postage and insurance.

USA, Canada, and Mexico: Subscribers in the USA, Canada, and Mexico should send their orders, with payment in US dollars or the equivalent value in Canadian dollars, to: Cambridge University Press, Customer Services Department (Journals), 1 Liberty Plaza, New York, NY 10006, USA. Tel: (845) 353-7500. Fax: (845) 353-4141. Orders may be phoned direct (toll free): (800) 872-7423. E-mail: journals_subscriptions@cup.org.

Outside North America: Subscribers elsewhere should send their orders, with payment in sterling, to: Customer Services Department (Journals), Cambridge University Press, University Printing House, Shaftesbury Road, Cambridge CB2 8BS, UK. Tel: +44 (0)1223 326070. Fax: 44 (0) 1223 325150. E-mail: journals@cambridge.org

Change of address: POSTMASTER: Send address changes in the USA, Canada, and Mexico to: *Microscopy & Microanalysis*, Cambridge University Press, Journals Fulfillment Department, One Liberty Plaza, 20th Floor, New York, NY 10006. Send address changes elsewhere to *Microscopy & Microanalysis*, Cambridge University Press, Journals Fulfillment Department, One Liberty Plaza, 20th Floor, New York, NY 10006. Society members should contact their respective society business offices to inform them of address changes.

Editorial Office

John Mansfield, Editor in Chief, 4304 Spring Lake Blvd., Ann Arbor, MI 48108-9657, USA; Tel: (734) 994-3096; Fax: (734) 763-2282; E-mail: thefmjfm@me.com.

Office of Publication

Cambridge University Press, 1 Liberty Plaza, New York, NY 10006, USA; Tel: (212) 337-5000; Fax: (212) 337-5959.

Advertising Sales & Production

Kelly Miller, M.J. Mrvica Associates, Inc., 2 West Taunton Avenue, Berlin, NJ 08009, USA; Tel: (856) 768-9360; Fax: (856) 753-0064.

© 2019 by Microscopy Society of America. Printed in the United States on acid-free paper. Periodicals postage paid at New York, NY, and additional mailing offices. Return postage guaranteed. Postmaster: Send address changes in the U.S.A. and Canada to *Microscopy and Microanalysis*, Subscription Department, Cambridge University Press, 1 Liberty Plaza, New York, NY 10006.

The best way to get better results



The APEX™ platform is the powerful and user-friendly software that drives the collection and analysis of Energy Dispersive Spectroscopy (EDS) and Electron Backscatter Diffraction (EBSD) data for the compositional and microstructural characterization of materials.

Please visit edax.com/apex for more information.

Faster results from an intuitive user interface

Customizable color schemes and layouts

Best analytical performance for both EDS and EBSD

Easy reporting for the flexible presentation of data

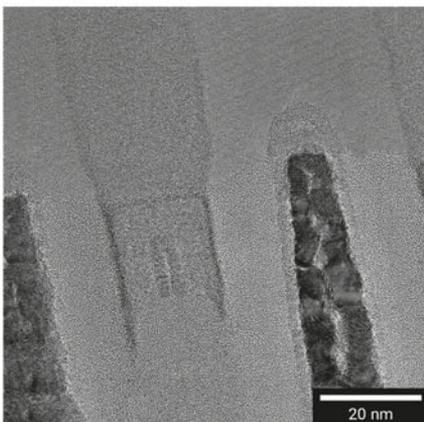
AMETEK
MATERIALS ANALYSIS DIVISION

edax.com

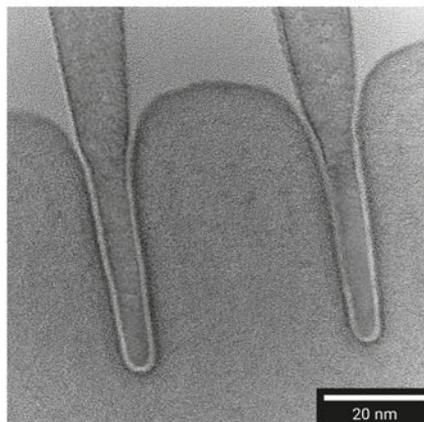
EDAX
Smart Insight

Advanced preparation of ultra-thin TEM specimens from sub-20 nm node technologies

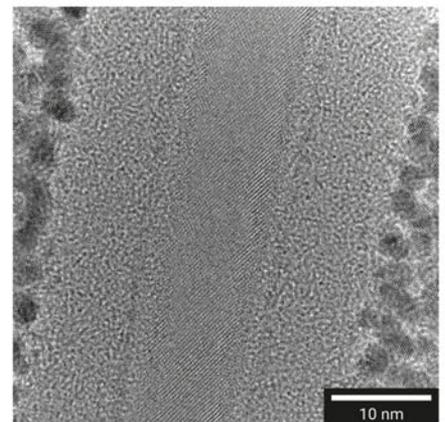
- ✓ Optimized dynamic CT for in-situ research and imaging of delicate samples
- ✓ Unique gantry-based design
- ✓ Continuous scanning under 10 seconds per rotation
- ✓ Software tools for 4D acquisition and reconstruction
- ✓ Dynamic screening for synchrotron beamtime



Gate-cut - TEM image of thin specimen from a 10 nm node technology-based IC



Fin-cut - TEM image of thin specimen from a 10 nm node technology-based IC



Cross TEM lamella, showing a thickness of < 10 nm. TEM image of thin specimen from a 10 nm node technology-based IC

Microscopy AND Microanalysis

An International Journal for the Biological and Physical Sciences

Volume 25, Number 5

October 2019

MATERIALS APPLICATIONS

Electron-Excited X-ray Microanalysis by Energy Dispersive Spectrometry at 50: Analytical Accuracy, Precision, Trace Sensitivity, and Quantitative Compositional Mapping

Dale E. Newbury and Nicholas W.M. Ritchie

1075

Atomic Force Microscopy (AFM) Analysis of an Object Larger and Sharper than the AFM Tip

Zhe Chen, Jiawei Luo, Ivo Doudevski, Sema Erten and Seong H. Kim

1106

Electron Probe Microanalysis Through Coated Oxidized Surfaces

Mike B. Matthews, Ben Buse and Stuart L. Kearns

1112

Determining the Volume Expansion at Grain Boundaries Using Extended Energy-Loss Fine Structure Analysis

Proloy Nandi and James M. Howe

1130

Image Segmentation for FIB-SEM Serial Sectioning of a Si/C-Graphite Composite Anode Microstructure Based on Preprocessing and Global Thresholding

Dongjae Kim, Sihyung Lee, Wooram Hong, Hyosug Lee, Seongho Jeon, Sungsoo Han and Jaewook Nam

1139

Investigation of Electron Momentum Density in Carbon Nanotubes Using Transmission Electron Microscopy

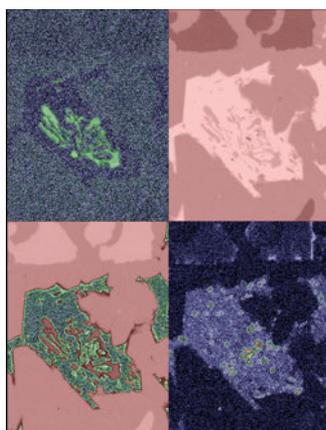
Zhenbao Feng, Hefu Li, Zongliang Wang, Xiaoyan Zhang, Hengshuai Li, Haiquan Hu and Dangsheng Su

1155

Carrier-Transport Study of Gallium Arsenide Hillock Defects

Chuanxiao Xiao, Chun-Sheng Jiang, Jun Liu, Andrew Norman, John Moseley, Kevin Schulte, Aaron J. Ptak, Brian Gorman, Mowafak Al-Jassim, Nancy M. Haegel and Helio Moutinho

1160



On the Cover: Raney nickel alloy X-ray spectrum images obtained via standards-based quantitative processing through NIST DTSA-II and color display using the logarithmic three-band encoding of concentration. Clockwise from top left, iron, aluminum, silicon and nickel. See Newbury and Ritchie, page 1075.

SOFTWARE AND INSTRUMENTATION

Exploring the Parameter Space of Point Spread Function Determination for the Scanning Electron Microscope—Part I: Effect on the Point Spread Function

Mandy C. Nevins, Kathryn Quoi, Richard K. Hailstone and Eric Lifshin

1167

Exploring the Parameter Space of Point Spread Function Determination for the Scanning Electron Microscope—Part II: Effect on Image Restoration Quality

Mandy C. Nevins, Richard K. Hailstone and Eric Lifshin

1183

BIOLOGICAL APPLICATIONS

Adipocytes Migration is Altered Through Differentiation

Maayan Lustig, Yuliya Zadka, Irena Levitsky, Amit Gefen and Dafna Benayahu

1195

Investigation on the Dependency of Phase Retrieval Accuracy Versus Edge Enhancement to the Noise Ratio of X-ray Propagation-Based Phase-Contrast Imaging

Lin Zhang, Huijuan Zhao, Jingying Jiang, Limin Zhang, Jiao Li, Feng Gao and Zhongxing Zhou

1201

- Anatomical, Phytochemical, and Histochemical Study of *Juniperus rigida* Needles at Different Altitudes
Shun Kuang, Linfang Liu, Mingliang Qing, Yujia Zhang, Xueping Feng, Dongmei Wang, Yun Jiang, Xin Zhang and Dengwu Li 1213
- Elucidation of Differential Nano-Textural Attributes for Normal Oral Mucosa and Pre-Cancer
Debaleena Nawn, Saunak Chatterjee, Anji Anura, Swarnendu Bag, Debjani Chakraborty, Mousumi Pal, Ranjan Rashmi Paul and Jyotirmoy Chatterjee 1224
- Bee Venom Stimulates Hormone Secretion in Rat Somatotroph and Corticotroph Cells: Digital Image Analysis of Secretory Granules
Adrian Florea, Fares Abu El Hof, Georgeta Maria Hazi and Marius Cristian Oprea 1234
- Onset of Appearance and Potential Significance of Telocytes in the Developing Fetal Lung
Mahmoud Awad, Wafaa Gaber and Dalia Ibrahim 1246

MICROGRAPHIA

- Microscopic Assessment of Dead Cell Ratio in Cryopreserved Chicken Primordial Germ Cells
Andrea Svoradová, Alexander Makarevich, Jaromír Vašíček, Lucia Olexiková, Sasa Dragin and Peter Chrenek 1257
- Functional Validation of DownRegulated MicroRNAs in HeLa Cells Treated with *Polyalthia longifolia* Leaf Extract Using Different Microscopic Approaches: A Morphological Alteration-Based Validation
Shanmugapriya, Soundararajan Vijayarathna and Sreenivasan Sasidharan 1263
- Immunohistochemical and Ultrastructural Features of the Seasonal Changes in the Epididymal Epithelium of Camel (*Camelus dromedarius*)
Dalia Ibrahim and Fatma M. Abdel-Maksoud 1273
- Cellular Invasion and Matrix Degradation, a Different Type of Matrix- Degrading Cells in the Cartilage of Catfish (*Clarias gariepinus*) and Japanese Quail Embryos (*Coturnix coturnix japonica*)
Soha A. Soliman, Basma Mohamed Kamal and Hanan H. Abd-Elhafeez 1283

BOOK REVIEW

- Confocal Raman Microscopy, Second Edition
Samir F. El-Mashtoly 1293

CORRIGENDUM

- Hydrotalcite Can Prevent the Damaging Effects of *Helicobacter Pylori* on Gastric Epithelial Cells—CORRIGENDUM
Yanyan Shi, Yanlei Guo, Ting Zhang and Shigang Ding 1295

Connected productivity in the materials lab



ZEISS ZEN core

ZEN core is the most comprehensive suite of imaging, analysis, and data connectivity tools for multi-modal microscopy in connected material laboratories. ZEN core helps to improve your lab's efficiency through automated image segmentation, contextual data analysis, and centralized data management.

zeiss.com/zen-core



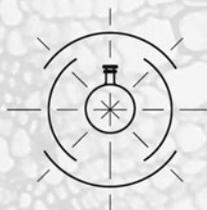
Seeing beyond

Hempstead Halide®

Products for your slide mounting needs

- Euparal Mounting Medium
- Hoyer's Mounting Medium
- KRYSTALIS™ Sealant
- SUBERCLEAR™ Clearing Solution
- ZOOCLEAR™ Clearing Solution
- DELICLEAR™ Clearing Solution

www.hempsteadhalide.com
for complete product information and
to place your order.



Hempstead Halide®

Hempstead Halide Inc.
P.O. Box 2630
Galveston, TX 77550
P: (409)572-2505



Euparal Mounting Medium Family
Available in sizes ranging from 10ml to 10L

*Hoyer's Mounting Medium is manufactured
in Great Britain and shipped from the US.
All other products are manufactured and
shipped by Hempstead Halide Inc. in the US.*