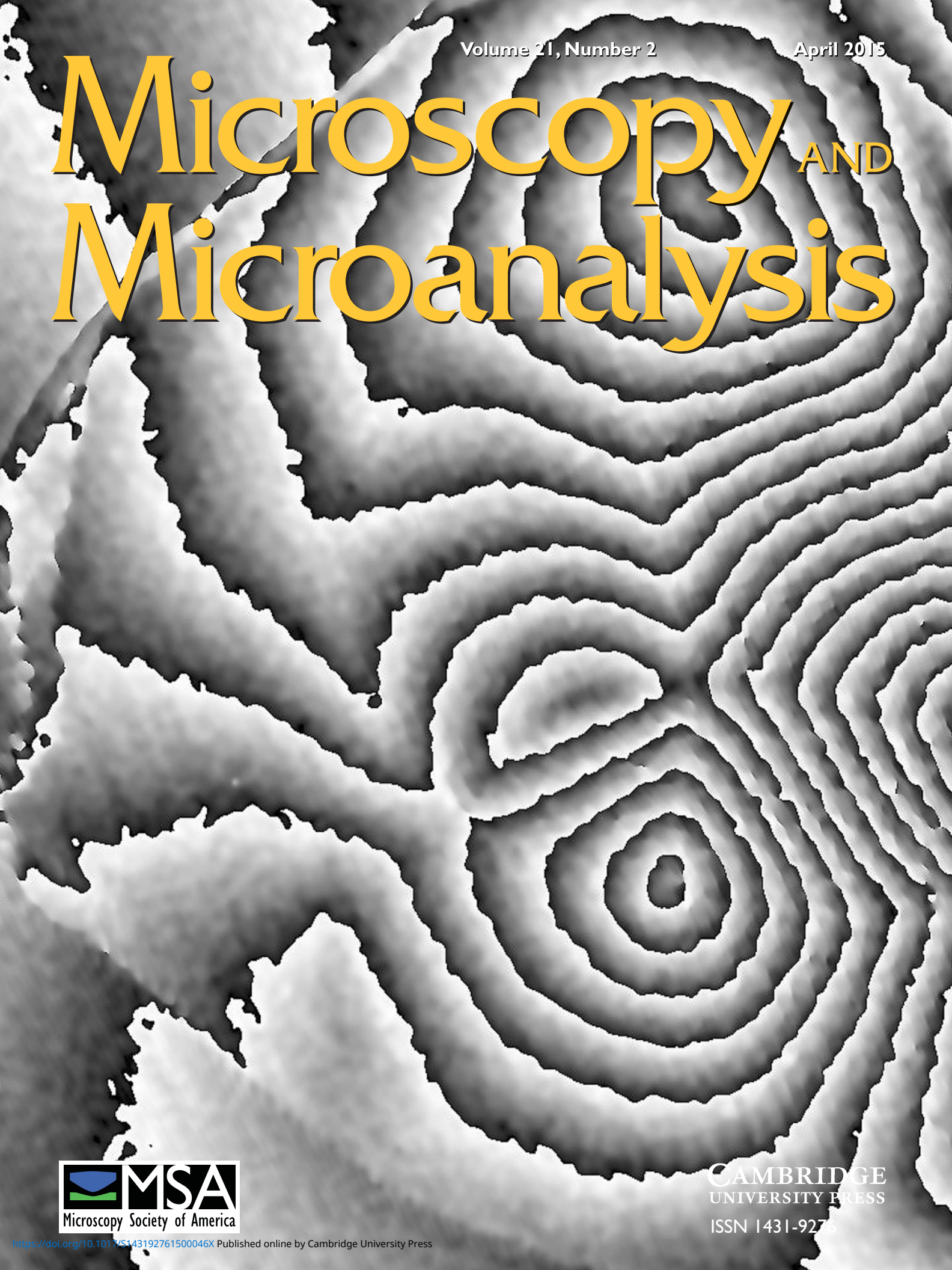
Volume 21, Number 2 April 2015

Microscopy AND Microanalysis



MSA Microscopy Society of America

CAMBRIDGE UNIVERSITY PRESS

ISSN 1431-927

https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

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

PUBLISHED IN AFFILIATION WITH

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

https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

Microscopy AND Microanalysis

Editorial Board

Editorial Board Representatives from Affiliated Societies

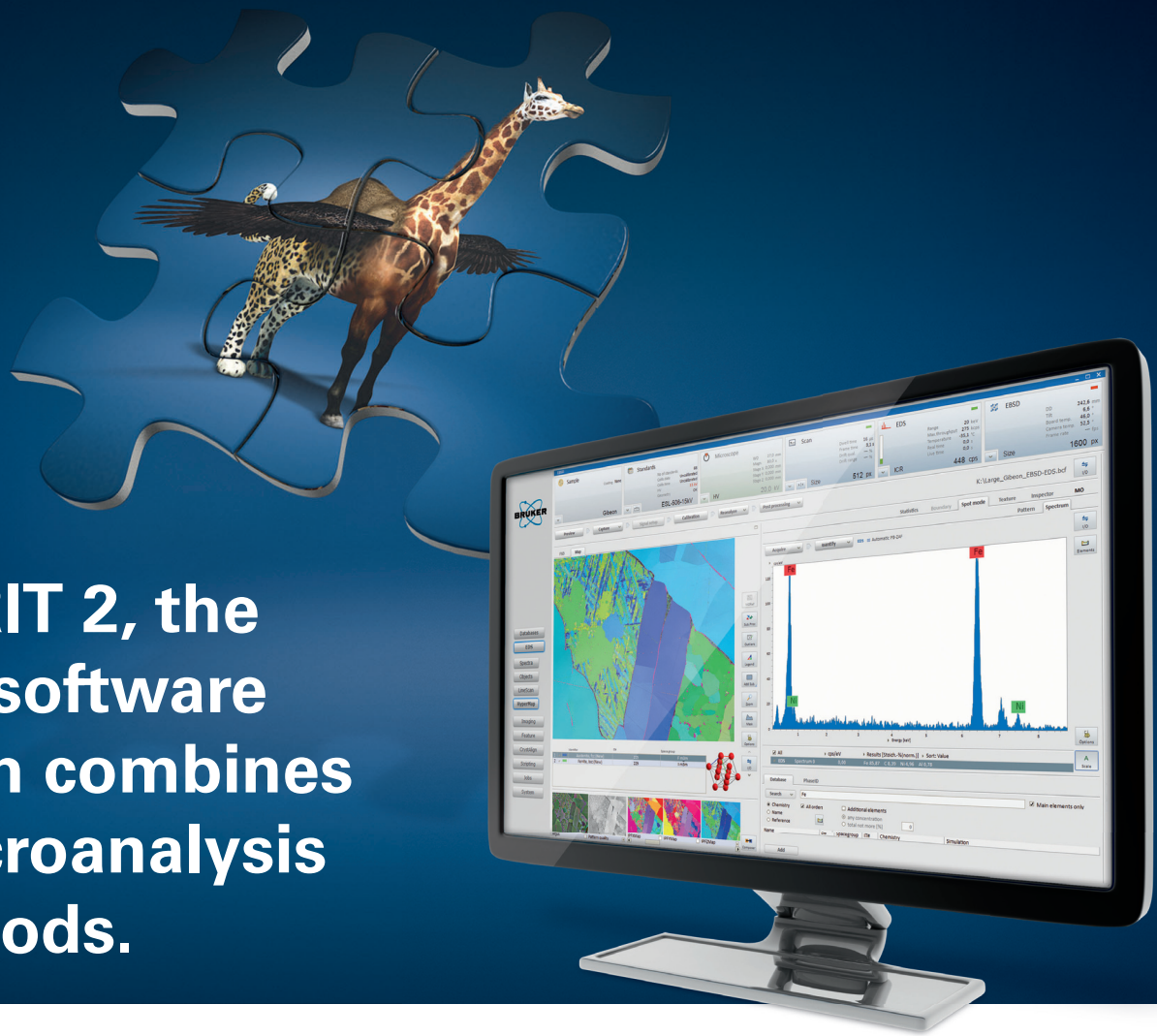
Founding Editor

Previous Editors-in-Chief

https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

BRUKER

4 Techniques – 1 Workflow.



ESPRIT 2, the only software which combines 4 microanalysis methods.

- Comprehensive management of analysis and results from EDS, WDS, EBSD and Micro-XRF with one software
- Complementary techniques provide you the most accurate and reliable results
- Zeta factor quantification for characterization of thin layers

Someone has to be first.

www.bruker.com/esprit2

Software

Innovation with Integrity

https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

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 http://www.journals.cambridge.org/jid_MAM, select "Further Information," and then select "Instructions for Contributors." An abbreviated version of these instructions will be published in the first issue (February) of each volume.

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. 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, Hachero Hill, Inc., 11260 Roger Bacon Drive, Suite 402, Reston, VA 20190, Tel.: (703) 964-1240, Ext. 14, E-mail: nicoleguy@mindspring.com, URL: www.msa.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 $1705.00 in the USA, Canada, and Mexico; UK £1025.00 + VAT elsewhere. Institutions online only: US $1264.00 in the USA, Canada, and Mexico; UK £765.00 + VAT elsewhere. Individuals print plus online: US $522.00 in the USA, Canada, and Mexico; UK £317.00 + 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), 100 Brook Hill Drive, West Nyack, NY 10994-2133, 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, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 8RU, UK. Tel: +44 (0)1223 326070. Fax: +44 (0)1223 325150. E-mail: journals@cambridge.org

Change of address: Allow six weeks for all changes to become effective. All communications should include both old and new addresses (with postal codes) and should be accompanied by a mailing label from a recent issue. Society members should contact their respective society business offices to inform them of address changes.

Editorial Office

Robert L. Price, Editor in Chief, Department of Cell and Developmental Biology and Anatomy, School of Medicine, University of South Carolina, 6439 Garner's Ferry Road, Bldg. 1 B-60, Columbia, SC 29209, USA; Tel: (803) 216-3824; Fax: (803) 733-3212; E-mail: Bob.Price@uscmed.sc.edu.

Office of Publication

Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473, 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.

// PERFORMANCE
MADE BY ZEISS

Your FIB-SEM for High Throughput Nanotomography and Nanofabrication

ZEISS Crossbeam 340 and 540

Highest 3D Resolution

Enjoy High Productivity with an Open 3D Nano-Workstation

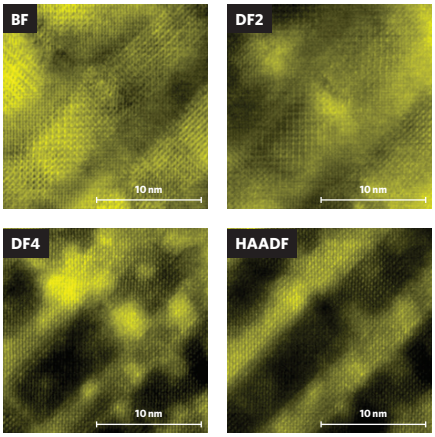
With ZEISS Crossbeam 340/540 you experience an outstanding combination of imaging performance and analytical power. Process and prepare any sample on a nanoscopic scale with the next-generation FIB. Observe your process in parallel with the superb optics of the GEMINI column. Enjoy demanding experiments with your Crossbeam especially designed for long-term stability. Find out more and book a hands-on demonstration in one of our ZEISS Microscopy Labs now.

www.zeiss.com/crossbeam

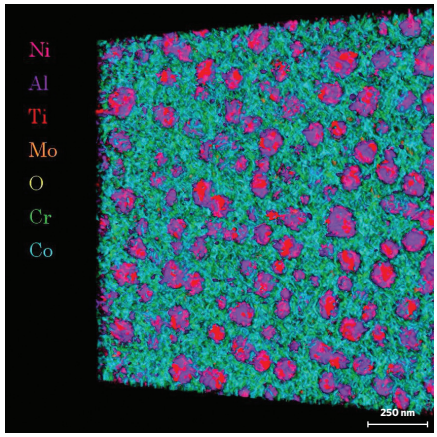
ZEISS

We make it visible.

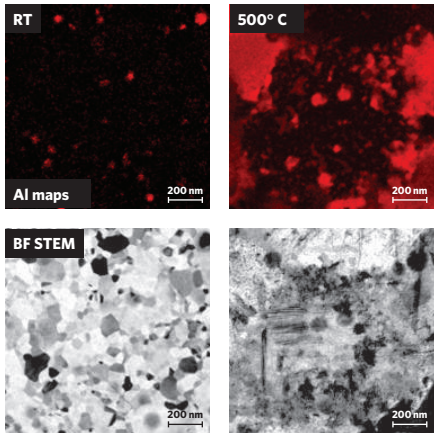
https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press



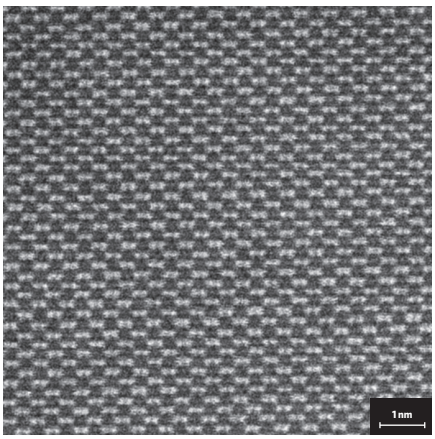
4 channel simultaneous HRSTEM imaging of $SrTiO_3$ using 4 STEM detectors.



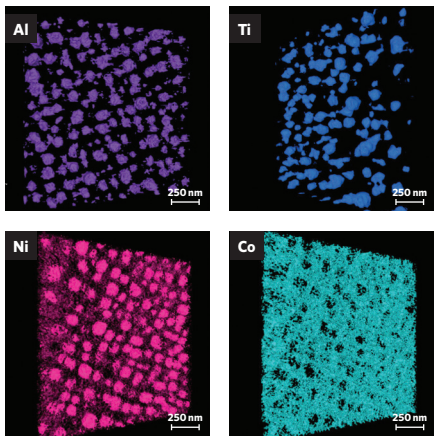
Combined 3D EDS map: Ni, Al, Ti, Mo, Cr, and Co.



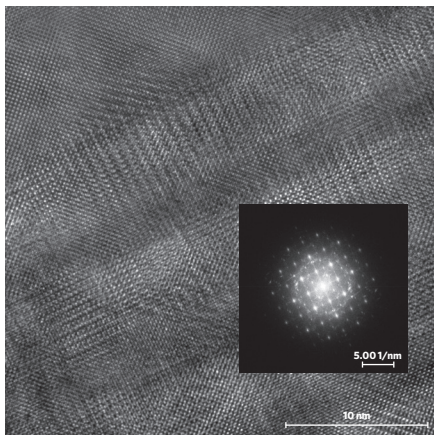
Temperature driven Al aggregation in solar cell. Sample courtesy of Dr. S. Kraschewski, U. Erlangen.



HRSTEM of Si (110) at 200kV.



3D EDS maps at different angles.



HRTEM image of $SrTiO_3$ with Ceta 16M camera.

Fast 2D & 3D Imaging and Chemical Analysis with Talos TEM

Whether you work with metals, light elements, or nanoparticles—from macro to atomic scales—Talos gives you insight into structure and composition for a complete understanding of material properties.

High speed 2D and 3D EDS analysis: Fast, multichannel, automated EDS acquisition and precise quantification to obtain multidimensional compositional maps.

Fast navigation and imaging: Highest throughput, highest resolution uncorrected S/TEM images—even for beam sensitive and challenging materials.

Space to do more: FEI TEMs have the space to accommodate additional *in situ* holders for dynamic imaging, diffraction, and tomography applications.

Watch the movie at FEI.com/DiscoverTalos

Explore. Discover. Resolve.

FEI™

https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

Microscopy AND Microanalysis

An International Journal for the Biological and Physical Sciences

Volume 21, Number 2

April 2015

On the Cover: Phase image of off-axis hologram. For further information please see Zheng et al., pp. 498–509.

Microscopy and Microanalysis **website: http://www.journals.cambridge.org/MAM**

Indexed in Chemical Abstracts, Current Contents, BIOSIS, and MEDLINE (PubMed)

https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

Materials Applications

Book Review

https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

Seamless integration for smart results.

- EDS, EBSD and WDS seamlessly integrated with a single user interface
- Built-in Smart Features facilitate set-up, guide analysis and automate reporting
- Proven algorithms guarantee quality results
- Streamlined workflows drive productivity with industry-best results in three mouse clicks

Power your next insight with EDAX.

edax.com/smart

TEAM™ TRIDENT

TEAM™ EDS

TEAM™ EBSD

TEAM™ WDS

AMETEK®
MATERIALS ANALYSIS DIVISION

EDAX®
Smart Insight

https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

FOCUS ON ESSENTIAL RESEARCH TOOLS

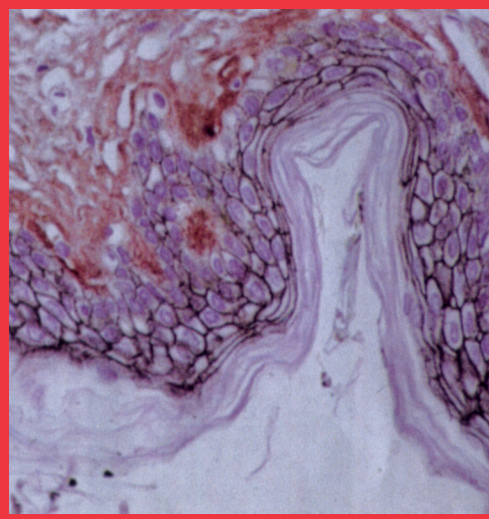
Electron Microscopy Sciences

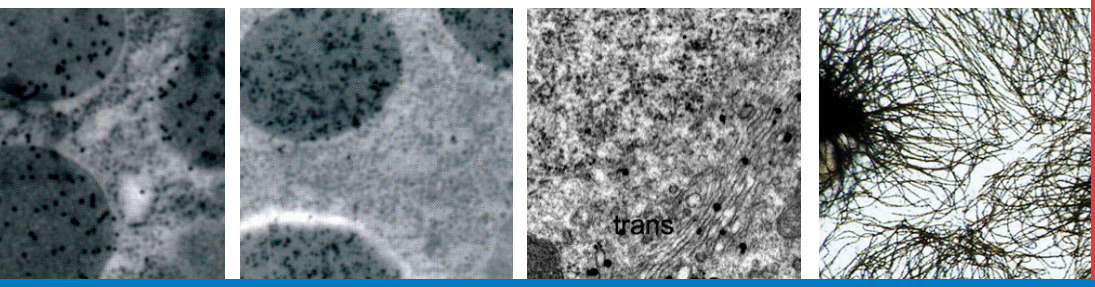
P.O. Box 550 • 1560 Industry Rd. • Hatfield, Pa 19440
Tel: (215) 412-8400 • Fax: (215) 412-8450
email: sgkcck@aol.com *or* stacie@ems-secure.com
www.emsdiasum.com

look for us... YouTube

Aurion ImmunoGold Reagents

Over the years the Aurion line has grown and has been further enhanced to include many unique and exclusive products not available elsewhere. Today their line includes not only the more commonly known reagents for EM and LM but, as well, a newly introduced line of products such as Silver Enhancement specifically for EM, Ultra-Small Fab fragments, Blocking Solutions, and even a line of donkey gold conjugates. With all of the new additions to the line up Aurion and EMS have something for everyone in the ImmunoGold Field.





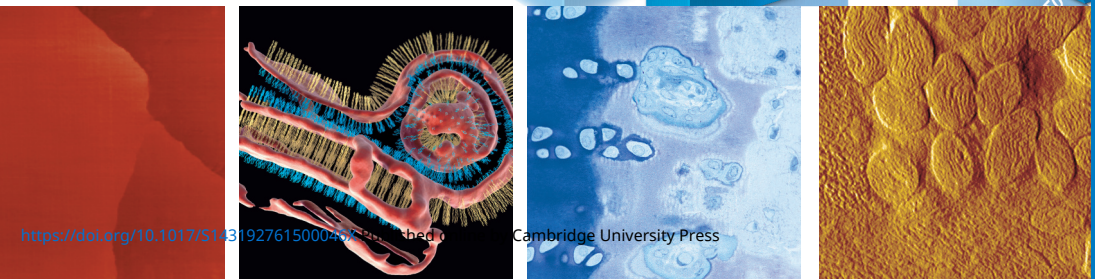
If you are interested in attending or sponsoring a workshop...

please give us a call and ask for Stacie Kirsch.

DiATOME Diamond Knives

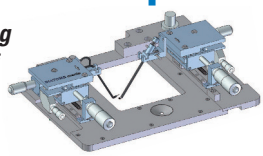
ultra 45° • cryo • histo • ultra 35°
histo jumbo • STATIC LINE II
cryo immuno • ultra sonic
ultra AFM & cryo AFM
and now the NEW!...

trimtool 20 and trimtool 45
Finally, one trimming tool for all of your trimming needs, be it at room or cryo temperatures.



NEW!...
DiATOME manip

For easy handling and mounting of section ribbons



Applications

- Frozen hydrated biological samples (CEMOVIS)
- Room temperature sectioning of water sensitive samples

Dry resin sectioning of biological samples for chemical analysis
Dry sectioning of industrial samples such as polymers

For more information, see our new Full Line Catalog or visit us on the web at www.emsdiasum.com

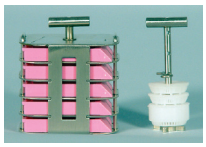
FOCUS ON ESSENTIAL RESEARCH TOOLS

Electron Microscopy Sciences

Lynx II

Automated Tissue Processor for Histology and Microscopy

The most unique state-of-the-art tissue processor which not only is compatible with all plastic resins but paraffin waxes as well



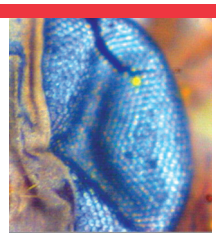
The LYNX II holds 24 reagent vials for EM processing. Optional HP (Histology processing) may be done with 12 larger size reagent vials for HP processing. In both EM and HP modes, LYNX II has two independently controlled heating/cooling stations.

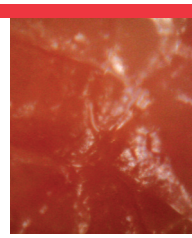
ProScope Micro Mobile, the world's first handheld digital microscope is now adaptable to mobile devices.

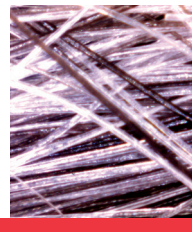
ProScope Digital Handheld Microscopes

There is always a yet undiscovered use for any of the ProScope models as the microscopic world is now in your hands. Popular uses include: ***Science Education, Law Enforcement, Medical Fields, Quality Inspections***

Our offering includes the Wireless ProScope Mobile, ProScope HR and ProScope HR2, and Proscope Micro Mobile Digital Handheld Microscopes, as well as software and accessories.







Adapt your existing lab stereo microscopes for fluorescence

NIGHTSEA™ Stereo Microscope Fluorescence Adapter

The NIGHTSEA™ Stereo Microscope Fluorescence Adapter adapts just about any stereo microscope (dissecting microscope) for fluorescence with no modification to the microscope itself. The modular design lets you easily switch between several different excitation/emission combinations to work with a variety of fluorescent proteins and other fluorophores. There are now six different excitation/emission combinations available, plus white light.

This simple system is excellent for:

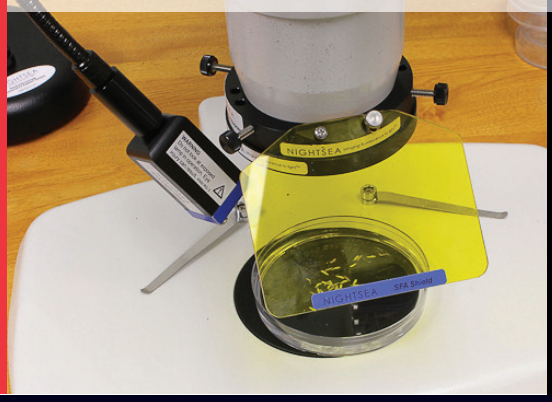
- Quick screening of your fluorescent genotypes - *Drosophila*, zebrafish, *C. elegans*,...
- Fluorescence-aided dissection, injection, or micromanipulation
- Freeing up your research-grade fluorescence microscopes for more demanding work
- New faculty start-up budgets
- Bringing fluorescence into the teaching laboratory

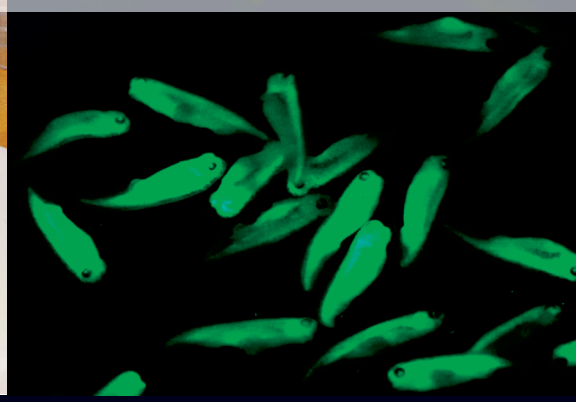
See how it works...
Learn how to do it...

We've added video content to our website to help you get to know our latest products even better!

Stop by and see what it's all about.

Stereo microscope configured for green fluorescence, viewing *Xenopus* through shield filter for sorting.





Electron Microscopy Sciences P.O. Box 550 • 1560 Industry Rd. • Hatfield, Pa 19440
Tel: (215) 412-8400 • Fax: (215) 412-8450 • email: sgkcck@aol.com *or* stacie@ems-secure.com
www.emsdiasum.com

https://doi.org/10.1017/S143192761500046X

FOCUS ON ESSENTIAL RESEARCH TOOLS

C-Flat™ Holey Carbon Grids for Cryo-TEM

C-flat™ is an ultra-flat, holey carbon-coated TEM support grid for transmission electron microscopy (TEM). Unlike competing holey carbon films, C-flat™ is manufactured without plastics, so it is clean upon arrival and the user has no residue to contend with.

C-flat™ leads to better data sets.

Made with patent pending technology, C-flat™ provides an ultra-flat surface that results in better particle dispersion and more uniform ice thickness. Patterning is done using deep-UV projection lithography, ensuring the most accurate and consistent hole shapes and sizes down to submicron features. The precise methods by which C-flat™ is manufactured eliminate artifacts such as excess carbon and edges around holes.

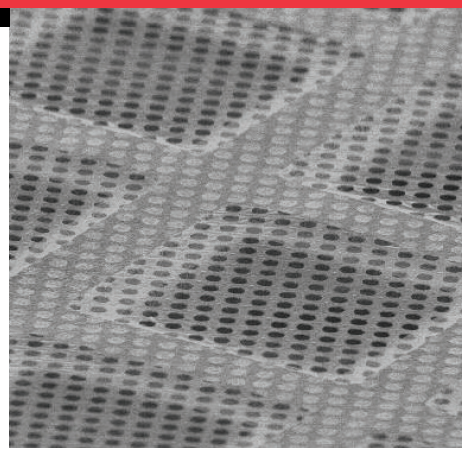
C-flat™ is affordable

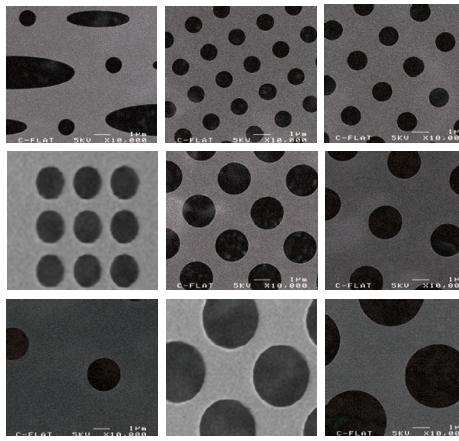
C-flat™ is available in 25, 50, and 100 packs at a per-grid price less than competing products.

C-flat™ Customization

We realize that each customer has unique needs since specimens vary greatly in composition and size. To meet the diverse and demanding needs of the cryoTEM community, C-flat™ can be customized to meet a user's specific requirements.

Please contact EMS with any custom C-flat™ requests. We will be glad to provide you with a quote for specialized C-flat™ grids. Requests for customized parts can be made directly to EMS via e-mail to sgkcck@aol.com



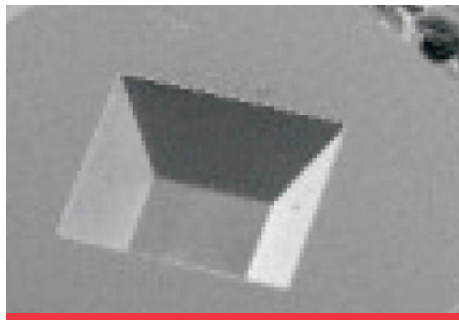


C-Flat™ is now available in the standard version and a new thick version that doubles the carbon thickness from approximately 20nm to 40nm.

DuraSiN™ Film and Mesh for TEM

DuraSiN™ Film and Mesh products are affordably-priced, durable, nonorganic, low scatter support grids for quantitative TEM and X-ray analysis. DuraSiN™ products are made of a thin, high quality, low-stress silicon nitride membrane supported around its perimeter by a rigid silicon substrate.

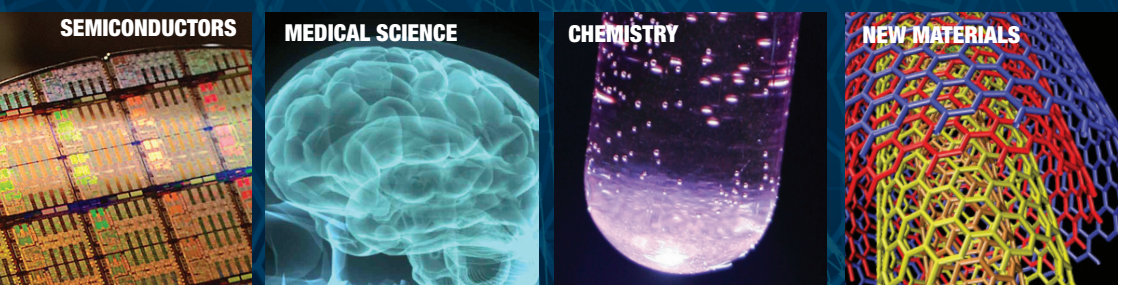
Unlike other support films and grids, DuraSiN™ Film and Mesh products can withstand harsh chemical and temperature environments. For example, DuraSiN™ Film or Mesh products could be used as a substrate onto which nanowires could be directly grown from a strong acidic solution. Once the nanowires are grown, the specimen is immediately ready for imaging and analysis in the TEM. With direct deposition, no longer will you have to prepare a sample on one substrate only to then have to transfer it to a support grid for imaging.



SEM image of a DuraSiN™ Film (taken from the back side)

SEM image of a DuraSiN™ Mesh (taken from the back side)

Applications:



Electron Microscopy Sciences

Electron Microscopy Sciences
P.O. Box 550 • 1560 Industry Rd. • Hatfield, Pa 19440
Tel: (215) 412-8400 • Fax: (215) 412-8450
email: sgkcck@aol.com *or* stacie@ems-secure.com
www.emsdiasum.com

look for us...

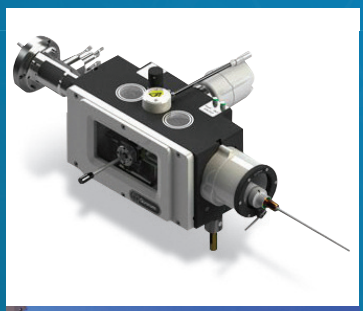
YouTube

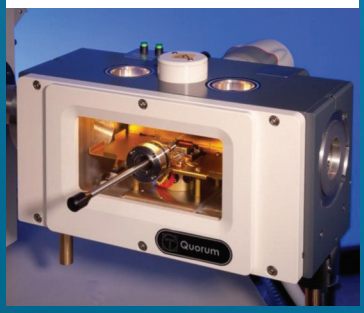
https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

FOCUS ON ESSENTIAL RESEARCH TOOLS

PP3010T Cryo-SEM Preparation System

The PP3010T is a highly automated, easy-to-use, column-mounted, gas-cooled cryo preparation system suitable for most makes and models of SEM, FE-SEM and FIB/SEM. The PP3010T has all the facilities needed to rapidly freeze, process and transfer specimens. The cryo preparation chamber is turbomolecular pumped and includes tools for cold fracturing, controlled sublimation and specimen coating. The specimen can then be transferred onto a highly stable SEM cold stage for observation. Cold trapping in the cryo preparation chamber and SEM chamber ensures the whole process is frost-free. Specimen process times are typically between five and ten minutes.

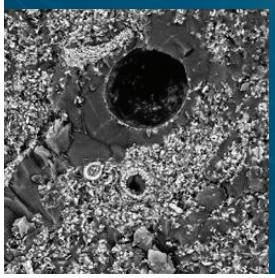


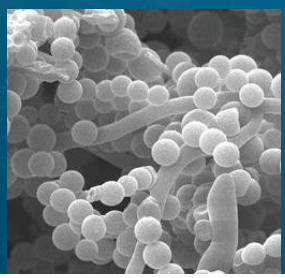


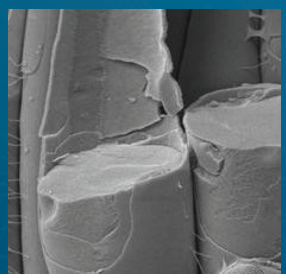
See how it works...
Learn how to do it...

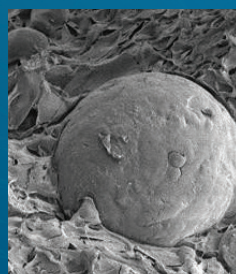
We've added video content to our website to help you get to know our latest products even better!

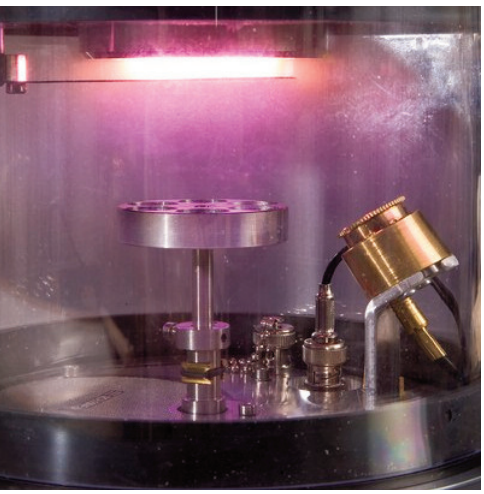
Stop by and see what it's all about.











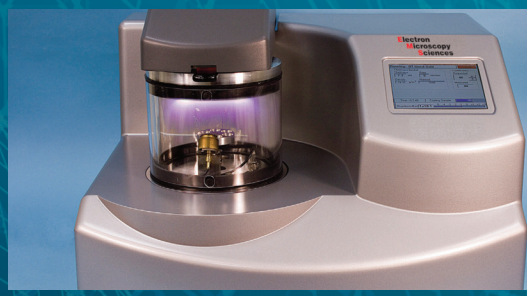
Innovative and versatile

Sputter Coaters and Carbon Evaporators

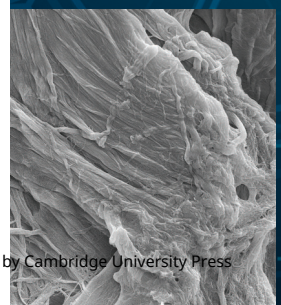
for all Microscopy Applications

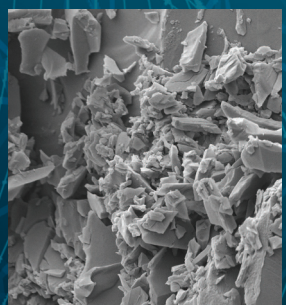
SEM, high resolution FESEM and TEM etc. The EMS-150R/T and the EMS 300 Series offers a complete range of stand alone carbon coaters, sputter coaters, Sputter/Carbon coater in one. We offer low-cost, rotary-pumped systems for depositing non-oxidizing metals - such as gold (Au) and platinum (Pt) - and also turbomolecular-pumped models, suitable for oxidizing and non-oxidizing metals - such as chromium (Cr). Large chamber models are available for specimens up to 8"/200mm diameter, and all sputter coaters can be fitted with carbon evaporation attachments.

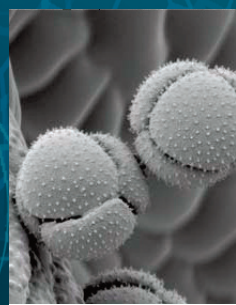
EMS300TD Dual Target, Large Chamber, Turbo-Pumped Sputter Coater



EMS150R Rotary Pumped Carbon and Sputter Coating System







Electron Microscopy Sciences

P.O. Box 550 • 1560 Industry Rd.
Hatfield, Pa 19440
Tel: (215) 412-8400
Fax: (215) 412-8450
email: sgkcck@aol.com
or stacie@ems-secure.com
www.emsdiasum.com

https://doi.org/10.1017/S143192761500046X Published online by Cambridge University Press

https://doi.org/10.1017/S1431927615000458 Published online by Cambridge University Press