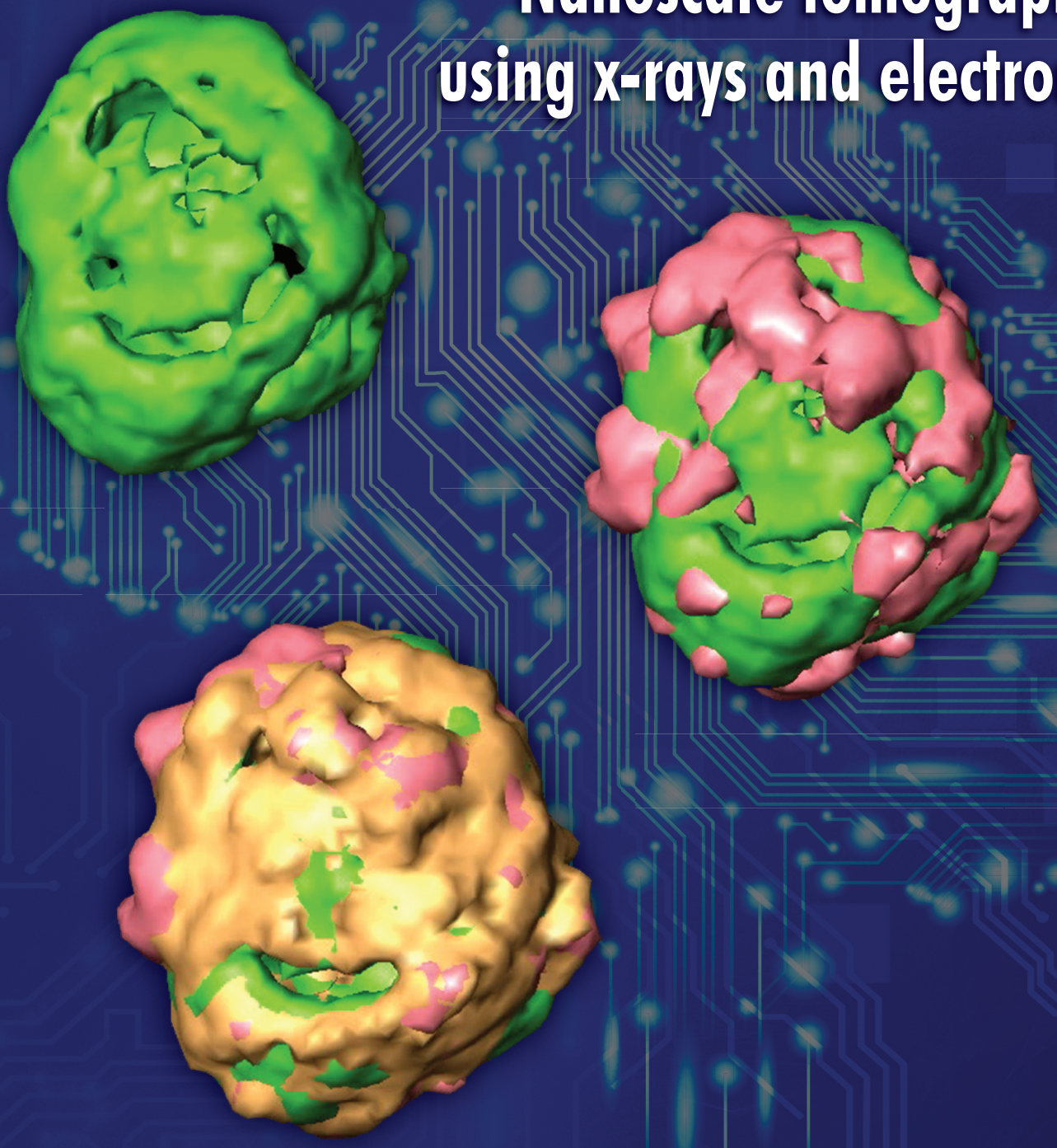
MRS Bulletin

CELEBRATING 45 YEARS

MRS MATERIALS RESEARCH SOCIETY®
Advancing materials. Improving the quality of life.

April 2020 Vol. 45 No. 4
mrs.org/bulletin

Nanoscale tomography using x-rays and electrons



CAMBRIDGE UNIVERSITY PRESS

https://doi.org/10.1557/mrs.2020.114 Published online by Cambridge University Press

https://doi.org/10.1557/mrs.2020.114 Published online by Cambridge University Press

2020 MRS® FALL MEETING & EXHIBIT

November 29–December 4, 2020 | Boston, Massachusetts

CALL FOR PAPERS

Abstract Submission Opens
May 11, 2020

Abstract Submission Deadline
June 11, 2020

Fall Meeting registrations include MRS Membership January – December 2021

BROADER IMPACT

BI01 Early-Career Development—Insights from Academia and Industry

ELECTRONICS AND OPTICS

EL01 Diamond and Diamond Heterojunctions—From Growth to Applications

EL02 Emerging Light-Emitting Materials and Devices—Halide Perovskites, Quantum Dots and Other Nanoscale Emitters

EL03 Emerging Low-Dimensional Chalcogenides for Electronics and Photonics

EL04 Beyond Graphene 2D Materials—Synthesis, Properties and Device Applications

EL05 Putting Photons to Work—Progress in Photomechanical Materials and Applications

EL06 Contacting Materials and Interfaces for Optoelectronic Devices

EL07 Coulomb Interactions in Functional Organic Materials and Devices—A Curse or a Blessing?

EL08 Frontiers of Halide Perovskites—Linking Fundamental Properties to Devices

ENERGY

EN01 Emerging Dielectric Materials—Applications in Energy Transmission, Storage and Conversion

EN02 Silicon for Photovoltaics

EN03 Overcoming the Challenges with Metal Anodes for High-Energy Batteries

EN04 Beyond Lithium-Ion Batteries—Materials, Architectures and Techniques

EN05 Redox Flow Batteries—Materials, Methods and Devices

EN06 Advancement of Lithium-Based High-Energy Density Batteries at Multiple Scales, Factoring in Safety

EN07 Innovative Materials and Cell Design, Processing and Manufacturing Strategies for Solid-State Batteries

EN08 Scientific Basis for Nuclear Waste Management

EN09 Developing *In Situ* and *Operando* Methodology for Observation of Energy Conversion, Storage and Transport Processes in Materials and Devices

FLEXIBLE, WEARABLE ELECTRONICS, TEXTILES AND SENSORS

FL01 Bioelectronic Materials for Neural Interfaces—Stimulation, Sensing, Power and Packaging

FL02 Advanced Neural Interfacing Materials, Devices and Microsystems

FL03 Flexible, Wearable Electronics and Textiles

MATERIALS THEORY, CHARACTERIZATION AND DATA SCIENCE

MT01 Advanced *In Situ* Characterization of Materials Kinetics

MT02 Multimodal, Functional and Smart Scanning Probe Microscopies for Characterization and Fabrication

MT03 Frontiers of Imaging and Spectroscopy in Electron Microscopy

MT04 Using Machine Learning and Multiscale Modeling to Study Soft Materials and Interfaces

MT05 Advancing Materials Characterization Through Atom Probe Tomography

MT06 Strain and Defect-Driven Transport Properties in van der Waals Solids

MT07 Data Science and Automation to Accelerate Materials Development and Discovery

NANOMATERIALS AND QUANTUM MATERIALS

NM01 Nanophotonics—Emerging Hybrid Platforms, Materials and Functions

NM02 Advanced Linear/Nonlinear, Tunable and Quantum Materials for Metasurfaces, Metamaterials and Plasmonics

NM03 Nanotubes, Graphene and Related Nanostructures

NM04 Material Systems for Manipulating and Controlling Magnetic Skyrmions

NM05 Emerging Materials for Quantum Information Technologies

NM06 Spin Dynamics in Materials for Quantum Sensing, Optoelectronics and Spintronics

NM07 Progress in Neuromorphic Computing Materials, Devices and Systems

SOFT MATERIALS AND BIOMATERIALS

SM01 Lessons from Nature—From Biology to Bioinspired Materials

SM02 Hydrogel Technology for Humans and Machines

SM03 Materials and Mechanics Challenges in Haptics for Human–Machine Interfaces

SM04 Degradable and Self-Healing Electronic Materials for Biological Interfaces

SM05 Brain-Inspired Information Processing—From Novel Material Concepts for Neuromorphic Computing to Sensing, Manipulation and Local Processing of Biological Signals

SM06 Biofabrication for Emulating Biological Tissues

SM07 Biomaterials for Studying and Controlling the Immune System

SM08 Regenerative Engineering and Synthetic Biology

STRUCTURAL AND FUNCTIONAL MATERIALS

SF01 Materials for Extreme Conditions (MEC)

SF02 Bulk Metallic Glasses

SF03 New Frontiers in the Design, Fabrication and Application of Metamaterials

SF04 Solution-Processed Semiconductors and Devices for Form-Free Displays, Logic and Sensors

SF05 Advanced Materials for Additive Manufacturing

SF06 High-Entropy and Compositionally Complex Alloys

SF07 Processing Structure–Property Relationship of Advanced Intermetallic-Based Alloys for Structural and Functional Applications

SF08 Defect-Dominated Plasticity and Chemistry in Metals and Alloys

Meeting Chairs

Michael E. Flatté The University of Iowa
Michael P. Rowe Toyota Research Institute of North America
Sabrina Sartori University of Oslo
Prasad Shastri University of Freiburg
Chongmin Wang Pacific Northwest National Laboratory

Don't Miss These Future MRS Meetings!

2021 MRS Spring Meeting & Exhibit
April 18–23, 2021, Seattle, Washington

2021 MRS Fall Meeting & Exhibit
November 28–December 3, 2021, Boston, Massachusetts

FOLLOW THE MEETING!

#F20MRS

MRS MATERIALS RESEARCH SOCIETY®
Advancing materials. Improving the quality of life.

mrs.org/fall2020

https://doi.org/10.1557/mrs.2020.114 Published online by Cambridge University Press

2/5/20

MRS Bulletin
APRIL 2020 VOLUME 45 Number 4 ISSN: 0883-7694 CODEN: MRSBEA

CONTENTS

NANOSCALE TOMOGRAPHY USING X-RAYS AND ELECTRONS

DEPARTMENTS

NEWS & ANALYSIS

https://doi.org/10.1557/mrs.2020.114 Published online by Cambridge University Press

SOCIETY NEWS

FEATURES

319 CAREER CENTRAL

ON THE COVER

Nanoscale tomography using x-rays and electrons. Three-dimensional (3D) tomographic imaging, using x-rays or electrons, of the structural, chemical, and physical properties of a material links the structure of a material to its processing that is central to studies across a broad spectrum of materials. In recent years, advances in technology have enabled new imaging capabilities at the nanometer or atomic scale for 3D reconstruction. This issue of *MRS Bulletin* discusses the development of these new techniques for nanoscale x-ray and electron tomography as well as future directions. The cover shows a 3D reconstruction of an iron (green)-cobalt (pink) oxide (gold) nanoparticle obtained using electron energy-loss spectroscopic scanning transmission electron microscopy (STEM-EELS) tomography. It reveals chemical segregation and nanoscale pinholes formed in the hollow structured oxide shell induced by the Kirkendall effect during oxidation of the iron-cobalt alloy particle. (Credit: Huolin L. Xin.) See the technical theme that begins on p. **264**.

COMING IN MAY 2020
Emergent quantum materials

connect
mrs.org/bulletin
mrs.org/energy-quarterly
mrs.org/mymrs
journals.cambridge.org
mrs.org/bulletin-podcast
@mrsbulletin

https://doi.org/10.1557/mrs.2020.114 Published online by Cambridge University Press

MRS MATERIALS RESEARCH SOCIETY®
Advancing materials. Improving the quality of life.

MRS Bulletin

EDITORIAL OFFICE 506 Keystone Drive, Warrendale, PA 15086-7573 USA
Bulletin@mrs.org tel 724.779.2747 fax 724.779.8313 mrs.org

About the Materials Research Society

The Materials Research Society (MRS), a not-for-profit scientific association founded in 1973 and headquartered in Warrendale, Pennsylvania, USA, promotes interdisciplinary materials research. Today, MRS is a growing, vibrant, member-driven organization of over 16,000 materials researchers spanning over 80 countries, from academia, industry, and government, and a recognized leader in the advancement of interdisciplinary materials research.

The Society's interdisciplinary approach differs from that of single-discipline professional societies because it promotes information exchange across many scientific and technical fields touching materials development. MRS conducts three major international annual meetings and also sponsors numerous single-topic scientific meetings. The Society recognizes professional and technical excellence and fosters technical interaction through University Chapters. In the international arena, MRS implements bilateral projects with partner organizations to benefit the worldwide materials community. The Materials Research Society Foundation helps the Society advance its mission by supporting various projects and initiatives.

MRS Bulletin (ISSN: 0883-7694, print; ISSN 1938-1425, online) is published monthly by the Materials Research Society, 506 Keystone Drive, Warrendale, PA 15086-7573. Permission required to reproduce content. Periodical postage paid at New York, NY, and at additional mailing offices. POSTMASTER: Send address changes to *MRS Bulletin* in care of the Journals Department, Cambridge University Press, 100 Brook Hill Drive, West Nyack, NY 10994-2113, USA. Printed in the U.S.A.

Membership in MRS is $135 annually for regular members, $35 for students, and includes an electronic subscription to *MRS Bulletin.* Print subscriptions are available to MRS members for an additional $25. Individual member subscriptions are for personal use only. Nonmember subscription rates are $618 (USD) for one calendar year (12 issues). Requests from subscribers for missing journal issues will be honored without charge only if received within six months of the issue's actual date of publication.

MRS Bulletin is included in Current Contents®/Engineering, Computing, and Technology; Current Contents®/Physical, Chemical, and Earth Sciences, the SciSearch® online database, Research Alert®, Science Citation Index®, Materials Science Citation Index™, and Scopus.

Send Letters to the Editor to **Bulletin@mrs.org**. Include your name, affiliation, and full contact information.

https://doi.org/10.1557/mrs.2020.114 Published online by Cambridge University Press