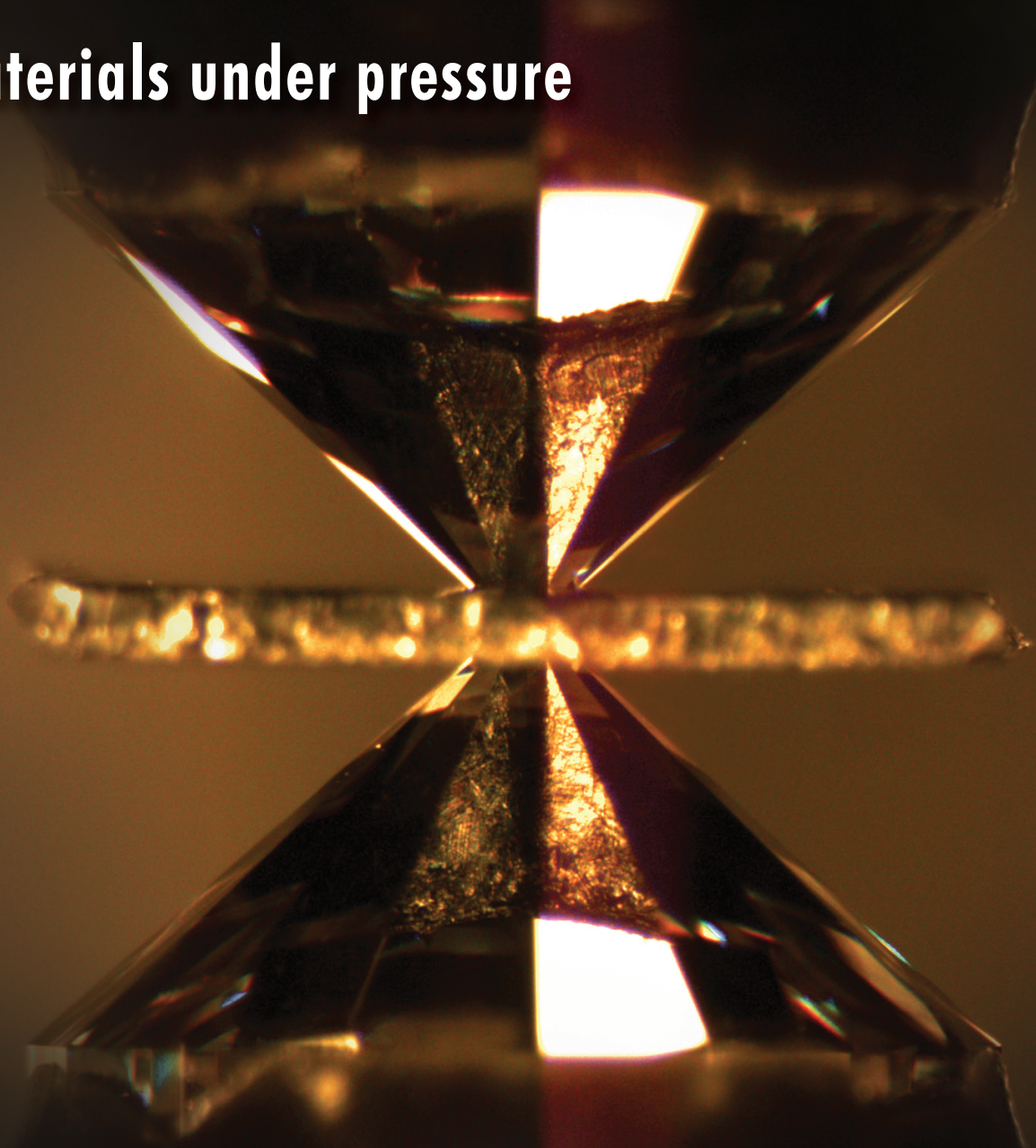


MRS Bulletin

October 2017 Vol. 42 No. 10
www.mrs.org/bulletin

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

Materials under pressure



ALSO IN THIS ISSUE

Visualizing dynamic chemical transformations *in situ* with nanometer-scale resolution

CAMBRIDGE
UNIVERSITY PRESS

CUSTOMIZED PRODUCTION ION IMPLANTERS



- Beam energies from 10 keV up to several 10s of MeV
- Beam currents from 100 micro-amps up to several milliamps
- Ion species, including H, He, B, P, As and others
- Single wafer or batch processing of wafers up to and including 300 mm
- In-air or in-vacuum cassette-to-cassette wafer handling
- Electrostatic and/or mechanical wafer clamping



High Voltage Engineering

High Voltage Engineering Europa B.V.

P.O. Box 99, 3800 AB Amersfoort, The Netherlands

Tel: 31 33 4619741 • info@highvolteng.com

www.highvolteng.com

The Norwegian Academy of Science and Letters
announces the

CALL FOR NOMINATIONS 2018

THE  KAVLI PRIZE

For outstanding scientific research in

ASTROPHYSICS • NANOSCIENCE • NEUROSCIENCE

Nomination deadline: December 1, 2017

Nominations will be reviewed by committees of
leading international scientists appointed by

The Norwegian Academy of Science and Letters
based on recommendations by

The Chinese Academy of Sciences
The French Academy of Sciences
The Max Planck Society (Germany)
The National Academy of Sciences (US)
The Royal Society (UK)

The Kavli Prize will be awarded in Oslo in September 2018
and will consist of

A gold medal • US \$ 1,000,000 • A scroll

For details about the nomination process see

www.kavliprize.org

A partnership of



THE NORWEGIAN MINISTRY
OF EDUCATION AND RESEARCH

THE  KAVLI FOUNDATION



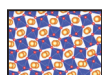
THE NORWEGIAN ACADEMY OF SCIENCE AND LETTERS

CONTENTS

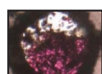
MATERIALS UNDER PRESSURE



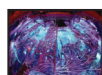
- 710 **Materials under pressure**
Anita Zeidler and Wilson A. Crichton, Guest Editors



- 714 **Plastic deformation of materials under pressure**
Philippe Carrez and Patrick Cordier



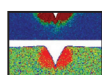
- 718 **Chemistry at high pressure: Tuning functional materials properties**
Paolo Postorino and Lorenzo Malavasi



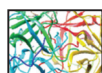
- 724 **New states of matter and chemistry at extreme pressures: Low-Z extended solid**
Choong-Shik Yoo



- 729 **Novel superhard nanopolycrystalline materials synthesized by direct conversion sintering under high pressure and high temperature**
Hitoshi Sumiya



- 734 **Impact of pressure on the structure of glass and its material properties**
Philip S. Salmon and Liping Huang



- 738 **Enzymatic activity under pressure**
Claus Czeslik, Trung Quan Luong, and Roland Winter

TECHNICAL FEATURE



- 743 **Inside out—Visualizing dynamic chemical transformations *in situ* with nanometer-scale resolution**
MRS Outstanding Young Investigator Award Lecture
2017 MRS Spring Meeting
Jennifer A. Dionne



ON THE COVER

Materials under pressure. This issue of *MRS Bulletin* focuses on several of the many and diverse domains of advanced materials research where applied pressure or stress is used to alter or garner information on material properties. The application of high pressure—often combined with high temperatures and advanced analysis—has led to important technological progress. The cover shows a diamond anvil cell used to apply high pressures to materials. The

diamond is 2.5 mm in height. A sample chamber is formed between the anvils inside a gasket made of rhenium metal. The diamond windows are transparent to a wide region of the electromagnetic spectrum for probing chemical reactions at high pressures and temperatures with UV–VIS–IR, lasers, neutrons, ultrasound, and x-rays or other forms of radiation. Image courtesy of Steven D. Jacobsen, Northwestern University. See the technical theme that appears on page 710.

DEPARTMENTS

693 OPINION

Material Matters

**Grabbing pebbles out of my shoes:
Thoughts of a grumpy old researcher on funding**
Enrico Traversa

NEWS & ANALYSIS

694 Materials News

- **Research Highlights: Perovskites**
Prachi Patel
FEATURE EDITOR: Pabitra K. Nayak
- **Small tissue reprogramming device designed to heal damaged tissues**
Joseph Bennington-Castro
- **Shattering the myth of fast-flowing medieval glass**
Lauren Borja
- **Quantum materials: Where many paths meet**
Philip Ball

706 Science Policy

- **ARPA-E sees some success from basic energy research to societal impact**
Jennifer A. Nekuda Malik
- **South Africa needs research plan for shale gas exploitation**

SOCIETY NEWS

752 Preview: 2017 Materials Research Society Fall Meeting & Exhibit

757 Profiles

Babak Anasori: Research assistant professor and microscopic photographer
Rahul Rao

728 Upcoming Conference News

- 9th International Conference of the African Materials Research Society to be held December 11–14
- Primer Encuentro de Jóvenes Investigadores en Ciencia de Materiales to be held April 13–14



FEATURES

708 Beyond the Lab

CuSTEMized: Inspiring girls in STEM through themselves
Humaira Taz

758 Historical Note

A physicist remembers 30 years after the “Woodstock of Physics”
Tim Palucka

765 Books

- **Materials Design Using Computational Intelligence Techniques**
Shubhabrata Datta
Reviewed by Jeffery Aguiar
- **Printed Electronics: Materials, Technologies and Applications**
Zheng Cui
Reviewed by Jianguo Lu
- **Stimuli-Responsive Materials: From Molecules to Nature Mimicking Materials Design**
Marek W. Urban
Reviewed by Aurelia Meghea

768 Image Gallery

Look Again



767 CAREER CENTRAL

ADVERTISERS IN THIS ISSUE

Page No.

American Elements.....	Outside back cover
High Voltage Engineering.....	Inside front cover
Kavli Foundation.....	689
Rigaku Corporation.....	713



www.mrs.org/bulletin

www.mrs.org/energy-quarterly

www.mrs.org/mymrs

<http://journals.cambridge.org>

mrsbulletin-rss

[@mrsbulletin](https://twitter.com/mrsbulletin)

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.

2017 MRS BOARD OF DIRECTORS

President Susan Trolier-McKinstry, The Pennsylvania State University, USA
Immediate Past President Kristi S. Anseth, University of Colorado Boulder, USA
Vice President and President-Elect Sean J. Hearne, Sandia National Laboratories, USA
Secretary Eric A. Stach, University of Pennsylvania, USA
Treasurer David J. Parrillo, The Dow Chemical Company, USA
Executive Director Todd M. Osman, Materials Research Society, USA

Charles T. Black, Brookhaven National Laboratory, USA
Li-Chyong Chen, National Taiwan University, Taiwan
Matt Copel, IBM Research Division, USA
Paul S. Drzaic, Apple, Inc., USA
Dawnielle Farrar-Gaines, Johns Hopkins University, USA
Yury Gogotsi, Drexel University, USA
Claudia Gutiérrez-Wing, Instituto Nacional de Investigaciones Nucleares, Mexico
Young-Chang Joo, Seoul National University, South Korea
Karen L. Kavanagh, Simon Fraser University, Canada
Lincoln J. Lauhon, Northwestern University, USA
Christine Ortiz, Massachusetts Institute of Technology, USA
Sabrina Sartori, University of Oslo, Norway
Magaly Spector, The University of Texas at Dallas, USA
Molly M. Stevens, Imperial College London, UK
Anke Weidenkaff, University of Stuttgart, Germany

MRS OPERATING COMMITTEE CHAIRS

Academic Affairs Bruce M. Clemens, Stanford University, USA
Awards Albert Polman, FOM Institute AMOLF, The Netherlands
Government Affairs Kevin J. Whittlesey, 4D Molecular Therapeutics, USA
Meetings Terry Aselage, Sandia National Laboratories, USA
Member Engagement Sossina M. Hale, Northwestern University, USA
Public Outreach Elizabeth Kupp, The Pennsylvania State University, USA
Publications Shefford Baker, Cornell University, USA

MRS HEADQUARTERS

Todd M. Osman, Executive Director
J. Ardie Dillen, Director of Finance and Administration
Damon Dozier, Director of Government Affairs
Patricia Hastings, Director of Meetings Activities
Eileen M. Kiley, Director of Communications

Editor

Gopal R. Rao, rao@mrs.org

Managing Editor

Lori A. Wilson, lwilson@mrs.org

News Editor

Judy Meiksin, meiksin@mrs.org

Technical Editor

Lisa C. Oldham, oldham@mrs.org

Editorial Assistants

Michelle S. Raley, raley@mrs.org
Mary Wilmoth

Associate Technical Editor

Tim Palucka

Production/Design

Andrea Pekelnicky-Frye, Rebecca Tokarczyk, Felicia Turano, and TNQ

Associate Production Editor

Katie Wurtzel

Principal Development Editor

Elizabeth L. Fleischer

Director of Communications

Eileen M. Kiley

Guest Editors

Anita Zeidler and Wilson A. Crichton

Special Consultant

Angelika Veziridis

Energy Quarterly

George Crabtree (Co-chair), Elizabeth A. Kócs (Co-chair), Andrea Ambrosini, Monika Backhaus, David Cahen, Russell R. Chianelli, Shirley Meng, Sabrina Sartori, Anke Weidenkaff, M. Stanley Whittingham, and Steve M. Yalisove

Advertising/Sponsorship

Mary E. Kaufold, kaufold@mrs.org
Donna L. Watterson, watterson@mrs.org

Member Subscriptions

Michelle Judt, judt@mrs.org

Non-Member Subscriptions

subscriptions_newyork@cambridge.org

EDITORIAL BOARD

Fiona C. Meldrum (Chair), University of Leeds, UK
V.S. Arunachalam, Center for Study of Science, Technology & Policy, India
Christopher J. Bettinger, Carnegie Mellon University, USA
Igor Lubomirsky, Weizmann Institute, Israel
Amit Misra, University of Michigan, USA
Steven C. Moss, The Aerospace Corporation, USA
Julie A. Nucci, Cornell University, USA
Linda J. Olafsen, Baylor University, USA
James W. Stasiak, HP Inc., USA
Carol Trager-Cowan, University of Strathclyde, UK
Eric Werwa, Washington, DC, USA
M. Stanley Whittingham, Binghamton University, The State University of New York, USA
Steve M. Yalisove, University of Michigan, USA

VOLUME ORGANIZERS

2017 Ken Haenen, Hasselt University & IMEC vzw, Belgium
John C. Mauro, The Pennsylvania State University, USA
Michael S. Strano, Massachusetts Institute of Technology, USA
Joyce Y. Wong, Boston University, USA

2018 Karsten Albe, Technische Universität Darmstadt, Germany
Hiroshi Funakubo, Tokyo Institute of Technology, Japan
Michael Hickner, The Pennsylvania State University, USA
Bethanie Stadler, University of Minnesota, USA

2019 Craig B. Arnold, Princeton University, USA
Claus Daniel, Oak Ridge National Laboratory, USA
Seung Min Han, KAIST, South Korea
Gabe Montano, Los Alamos National Laboratory/Northern Arizona University, USA

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. © 2017 Materials Research Society. 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 \$130 annually for regular members, \$32 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. Non-member subscription rates are \$533 (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®, and the Materials Science Citation Index™. Back volumes of *MRS Bulletin* are available on microfiche through University Microfilms Inc., 300 North Zeeb Road, Ann Arbor, MI 48106, USA.

Authors of each technical article appearing in *MRS Bulletin* are solely responsible for all content in their article(s), including accuracy of the facts, statements, and citing resources. Facts and opinions are solely the personal statements of the respective authors and do not necessarily represent the views of the editors, the Materials Research Society, or Cambridge University Press.

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