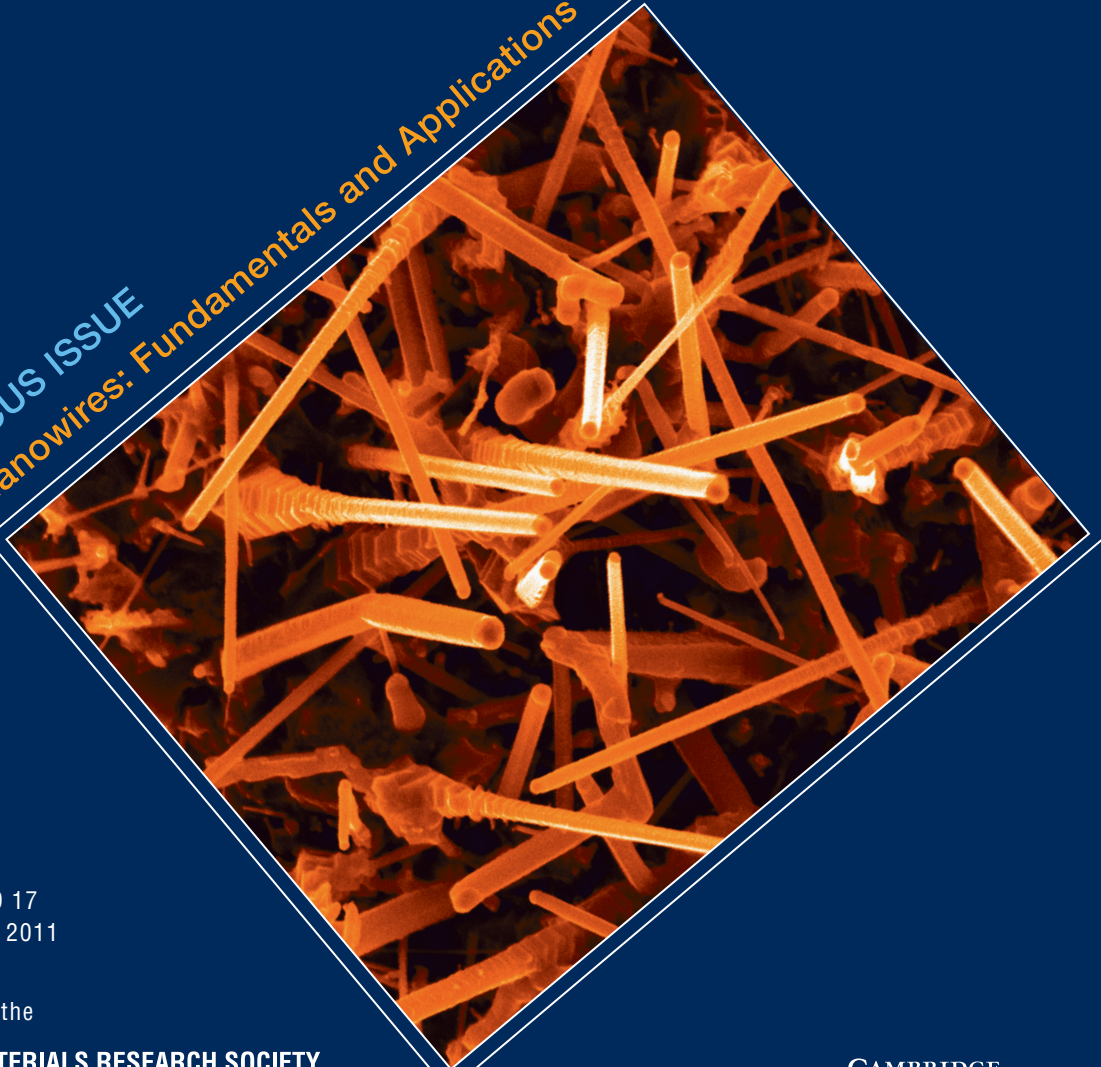




**Journal of
MATERIALS RESEARCH**

FOCUS ISSUE
Nanowires: Fundamentals and Applications



VOLUME 26 • NO 17
SEPTEMBER 14, 2011

A publication of the

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

CAMBRIDGE
UNIVERSITY PRESS

complete characterization

Science continues to challenge the limits of material properties and capabilities. Whether improving conventional materials, such as tungsten alloys, or probing the potential of carbon fiber nanotechnology, our instruments and expertise help scientists characterize and confirm complex chemistries and unique structures. Our comprehensive offering includes innovative imaging and spectroscopy, industry-leading data management and proven method development. All designed to help provide deeper insights and more confident decisions as you drive bold progress in the materials of tomorrow.

speeds discovery in materials science

• www.thermoscientific.com/materialsscience

Nanotechnology

Polymers

Metallurgy

Microelectronics

Bio-Materials

Cement

Energy

Ceramics and Glass

Polymers

Carbon

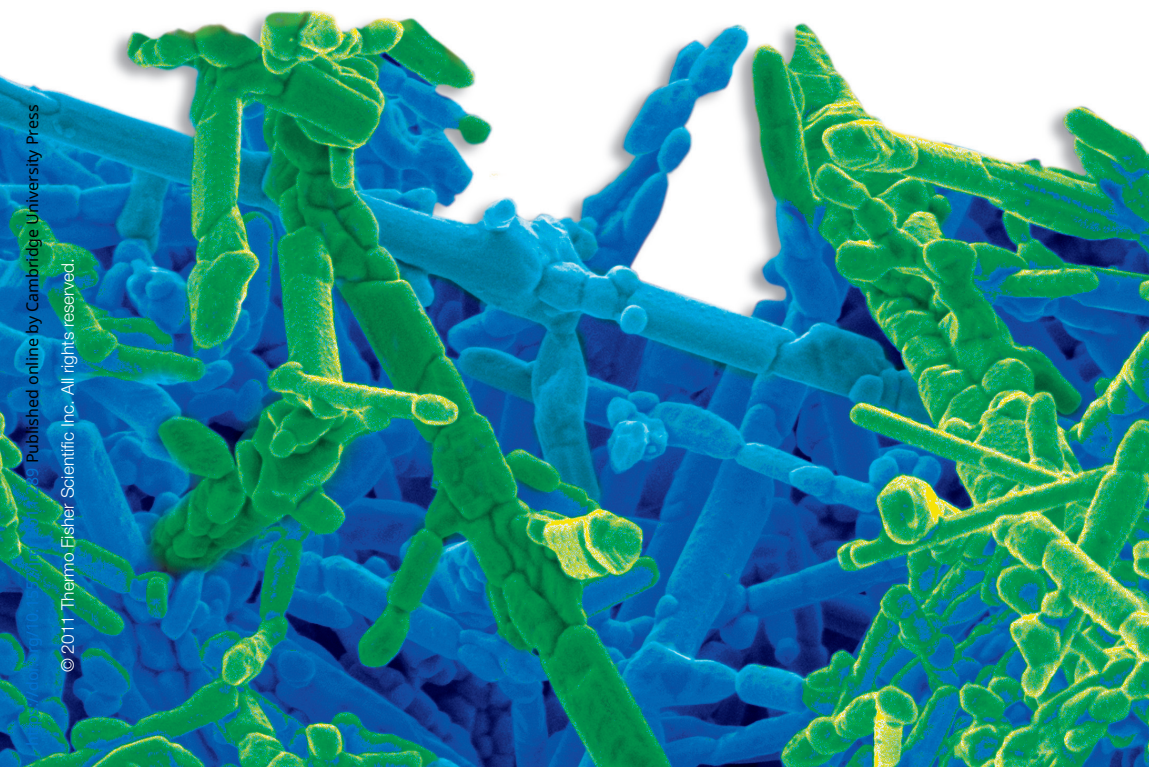
Paints and Coatings

Chemicals

Paper and Printing

Medical Implants

Art Restoration



Journal of MATERIALS RESEARCH

Editor-in-Chief: Gary L. Messing, *The Pennsylvania State University*

Associate Editor, Biomaterials: Adrian Mann, *Rutgers University*

Associate Editor, Metallic Materials: Jürgen Eckert, *IFW Dresden, Germany*

Associate Editor, Polymers and Organic Materials: Howard E. Katz, *Johns Hopkins University*

Guest Editors for Focus Issue: Nanowires: Fundamentals and Applications

Paul C. McIntyre, *Stanford University*

Volker Schmidt, *Max Planck Institute, Halle, Germany*

Principal Editors for Focus Issue: Tom Picraux, *Los Alamos National Laboratory*

Nathaniel Quitarano, *McGill University, Canada*

Heike Riel, *IBM Research, Switzerland*

Claes Thelander, *Lund University, Sweden*

Carl Thompson, *Massachusetts Institute of Technology*

Editorial Office: Eileen Kiley Novak, *Director of Publications and Marketing, Materials Research Society, Warrendale, PA*

Linda A. Baker, *JMR Editorial Assistant, Materials Research Society, Warrendale, PA*

Lorraine K. Wolf, *JMR Publishing Assistant, Materials Research Society, Warrendale, PA*

2011 Principal Editors:

Robert C. Cammarata, *Johns Hopkins University*

Edwin A. Chandross, *MaterialsChemistry LLC*

Ping Chen, *Dalian Institute of Chemical Physics, China*

Yang-T. Cheng, *University of Kentucky*

Franz Faupel, *Universität Kiel, Germany*

David S. Ginley, *National Renewable Energy Laboratory*

Amit Goyal, *UT-Battelle/Oak Ridge National Laboratory*

Mikko P. Haataja, *Princeton University*

Himanshu Jain, *Lehigh University*

Suk-Joong L. Kang, *Korean Advanced Institute of Science and Technology, Republic of Korea*

C. Robert Kao, *National Taiwan University, Taiwan*

Koichi Kugimiya, *Osaka University, Japan*

Sharvan Kumar, *Brown University*

Yadong Li, *Tsinghua University, China*

Scott T. Misture, *Alfred University*

Paul Murali, *Ecole Polytechnique Federale de Lausanne, Switzerland*

Michelle Oyen, *Cambridge University, United Kingdom*

Nitin P. Padture, *The Ohio State University*

Ian M. Reaney, *The University of Sheffield, United Kingdom*

Joan M. Redwing, *The Pennsylvania State University*

Clifford L. Renschler, *Sandia National Laboratories*

Mototsugu Sakai, *Toyohashi University of Science and Technology, Japan*

Dale Schaefer, *University of Cincinnati*

Winston Schoenfeld, *University of Central Florida*

Christopher A. Schuh, *Massachusetts Institute of Technology*

Don W. Shaw, *The University of Texas at Dallas*

Robert L. Snyder, *Georgia Institute of Technology*

Jay A. Switzer, *Missouri University of Science and Technology*

Mauricio Terrones, *The Pennsylvania State University; and Shinshu University, Japan*

Terry M. Tritt, *Clemson University*

Yoshihisa Watanabe, *National Defense Academy, Japan*

William J. Weber, *University of Tennessee/Oak Ridge National Laboratory*

Sam Zhang, *Nanyang Technological University, Singapore*

Yanchun Zhou, *Aerospace Research Institute of Materials and Processing Technology, China*

Cover: Non-catalyzed germanium deposition produces nanowires with a wide base which turn into uniform diameter nanowires as nanowires extend away from the microbridge's surface. [C.J. Redcay and O. Englander: Germanium nanowire synthesis using a localized heat source and a comparison to synthesis in a uniform temperature environment. p. 2215.]

Journal of MATERIALS RESEARCH

Volume 26, Number 17, September 14, 2011

NANOWIRES: FUNDAMENTALS AND APPLICATIONS

2125–2126 **Introduction**

Paul C. McIntyre, Volker Schmidt,
Tom Picraux, Nathaniel Quitarano,
Heike Riel, Claes Thelander,
Carl Thompson

REVIEWS

2127–2141 **Selective-area growth of III-V nanowires and their applications**

Katsuhiko Tomioka, Keitaro Ikejiri,
Tomotaka Tanaka,
Junichi Motohisa, Shinjiroh Hara,
Kenji Hiruma, Takashi Fukui

2142–2156 **Doping of semiconductor nanowires**

Jesper Wallentin,
Magnus T. Borgström

2157–2168 **Surface-induced effects in GaN nanowires**

Raffaella Calarco, Toma Stoica,
Oliver Brandt, Lutz Geelhaar

2169–2174 **Ferromagnetic resonance on Ni nanowire arrays**

Mircea Chipara, Ralph Skomski,
Roger Kirby, David J. Sellmyer

2175–2185 **Vanadium oxide nanowires for Li-ion batteries**

Liqiang Mai, Xu Xu, Lin Xu,
Chunhua Han, Yanzhu Luo

ARTICLES

2186–2198 **Liquid droplet dynamics and complex morphologies in vapor–liquid–solid nanowire growth**

E.J. Schwalbach, S.H. Davis,
P.W. Voorhees, D. Wheeler,
J.A. Warren

2199–2206 **Molecular dynamics simulations of gold-catalyzed growth of silicon bulk crystals and nanowires**

Seunghwa Ryu, Wei Cai

2207–2214 **Gas phase equilibrium limitations on the vapor–liquid–solid growth of epitaxial silicon nanowires using SiCl₄**

Sarah M. Eichfeld, Haoting Shen,
Chad M. Eichfeld,
Suzanne E. Mohny,
Elizabeth C. Dickey,
Joan M. Redwing

2215–2223 **Germanium nanowire synthesis using a localized heat source and a comparison to synthesis in a uniform temperature environment**

Christopher J. Redcay,
Onge Englander

2224–2231 **Selective lateral ZnO nanowire growth by surface diffusion on nanometer scale–patterned alumina on silicon**

Bing Hu, Nitin Chopra,
Pawan Tyagi, Bruce Hinds

2232–2239 **Novel growth mode of solid–liquid–solid (SLS) silica nanowires**

Jae Ho Lee, Michael A. Carpenter,
Robert E. Geer

2240–2246 **GeO_x and SiO_x nanowires grown via the active oxidation of Ge and Si substrates**

Avi Shalav, Gabriel H. Collin,
Yi Yang, Taehyun Kim,
Robert G. Elliman

2247–2253 **Importance of line and interfacial energies during VLS growth of finely stranded silica nanowires**

Martin Bettge, Scott MacLaren,
Steve Burdin, Daniel Abraham,
Ivan Petrov, Min-Feng Yu,
Ernie Sammann

(Continued)

- 2254–2260 **Solution heteroepitaxial growth of dendritic SnO₂/TiO₂ hybrid nanowires** Chuanwei Cheng, Yee Yan Tay, Huey Hoon Hng, Hong Jin Fan
- 2261–2267 **Microstructure development in zinc oxide nanowires and iron oxohydroxide nanotubes by cathodic electrodeposition in nanopores** Michiel G. Maas, Eddy J.B. Rodijk, A. Wouter Maijenburg, Dave H.A. Blank, Johan E. ten Elshof
- 2268–2275 **Mild hydrothermal synthesis of γ -MnO₂ nanostructures and their phase transformation to α -MnO₂ nanowires** Yaqoob Khan, Shahid Khan Durrani, Mazhar Mehmood, Muhammad Riaz Khan
- 2276–2281 **Phase transformation in self-assembled Gd silicide nanostructures on Si(001)** Gangfeng Ye, Martin A. Crimp, Jun Nogami
- 2282–2285 **Kinetics of reactions of Ni contact pads with Si nanowires** Nicholas S. Dellas, Michael Abraham, Sharis Minassian, Chito Kendrick, Suzanne E. Mohney
- 2286–2292 **Continuum modeling of large-strain deformation modes in gold nanowires** Omid Rezvanian, Mohammed A. Zikry
- 2293–2298 **Threading defect elimination in GaN nanowires** Stephen D. Hersee, Ashwin K. Rishinaramangalam, Michael N. Fairchild, Lei Zhang, Petros Varangis
- 2299–2304 **Texture analysis of manganese-germanide/germanium nanowire heterostructures by high resolution electron microscopy and diffraction** E.R. Hemesath, J.L. Lensch-Falk, L.J. Lauhon
- 2305–2310 **Electrostatic charging and manipulation of semiconductor nanowires** Vincent C. Holmberg, Reken N. Patel, Brian A. Korgel
- 2311–2315 **SrAl₂O₄:Eu²⁺,Dy³⁺ nanobelts: Synthesis by combustion and properties of long-persistent phosphorescence** Baochang Cheng, Zhaodong Zhang, Zhihui Han, Yanhe Xiao, Shuijin Lei
- 2316–2321 **Electrospun TiO₂ nanowires for hybrid photovoltaic cells** Surawut Chuangchote, Takashi Sagawa, Susumu Yoshikawa
- 2322–2327 **Fabrication of Ga₂O₃/SnO₂ core–shell nanowires and their ethanol gas sensing properties** Yun-Guk Jang, Won-Sik Kim, Dai-Hong Kim, Seong-Hyeon Hong
- 2328–2333 **Biomolecular sensing using gold nanoparticle–coated ZnO nanotetrapods** Ramakrishna Podila, Pengyu Chen, Jason Reppert, Apparao M. Rao, Pu Chun Ke

Journal of MATERIALS RESEARCH

JOURNAL OF MATERIALS RESEARCH (JMR) is an interdisciplinary journal serving the materials research community through publication of original research articles and invited reviews encompassing the synthesis, processing, characterization, properties, and theoretical description of materials.

JMR publishes new research that demonstrates a significant impact or advance of scientific understanding of interest to the materials research community. Engineering studies and applications to commercial products are beyond the scope of *JMR* and should be submitted elsewhere. Manuscripts that report data without giving an analysis, interpretation, or discussion are only acceptable if the data are sufficiently important that publication is expected to lead to significant new studies or advancements in science or technology.

Manuscripts must be submitted to the *Journal of Materials Research* electronically via ScholarOne manuscripts, at the following website address: <http://mc.manuscriptcentral.com/jmr>. Electronic submission expedites the review process and also allows authors to track the status of their manuscripts at any time. Complete instructions are available on the ScholarOne site and authors will be prompted to provide all necessary information.

Manuscripts must be prepared in English, using a word processing program, formatted to fit 8½ x 11 in. paper, and saved as .doc, .pdf, .rtf, or .ps files. Separate graphics files (.eps and .tif) must be uploaded for each figure. Authors may also upload .xls or .ppt supplemental files as part of the manuscript submission process. All of these files will be converted to .pdf format. Detailed instructions are available on the submission web site. During submission, authors must enter all coauthor names and e-mail addresses. Manuscripts will not be considered for peer review until this information is provided. Authors must also enter manuscript keywords using the *JMR* keyword list (located on the submission web site). Authors who are not fluent in English must have their manuscript edited for correct English grammar and sentence structure before submission.

Authors are expected to follow the conventional writing, notation, and illustration style prescribed in *Scientific Style and Format: the CSE Manual for Authors, Editors and Publishers, 7th edition, 2006*. Authors should also study the form and style of printed material in this journal. SI units should be used. Authors should use an identical format for their names in all publications to facilitate use of citations and author indexes.

Manuscripts are accepted with the understanding that they represent original research, except for review articles, and that they have not been copyrighted, published, or submitted for publication elsewhere. Authors submitting manuscripts to *JMR* who have related material under consideration or in press elsewhere should send a copy of the related material to *JMR* at the time of submission. While their manuscripts are under consideration at *JMR*, authors must disclose any such related material. To expedite the review process, authors may provide names and contact information for up to four possible reviewers.

Articles are original research reports that include complete, detailed, self-contained descriptions of research efforts. All articles must contain an abstract and section headings.

Commentaries and Reviews: *Journal of Materials Research* occasionally publishes commentaries on topics of current interest or reviews of the literature in a given area. If an author proposes a review, the title, abstract, and a brief outline should be submitted to the Editorial Office via e-mail for prior consultation on the appropriateness of the topic.

Color policy: It is not necessary for authors to indicate that a figure should be displayed in color online. *JMR* will assume that any author who submits figures in color wants and agrees to their being produced in color online. Figures may be printed in color at the author's request for an additional charge. Color figures must be submitted before the paper is accepted for publication, and cannot be received later in the process. Authors cannot submit two versions of the same figure, one for color and one for black and white; only one version can be submitted. Authors need to carefully consider the following when submitting figures in color that will

be published in color online only: 1) The colors chosen must reproduce effectively and the colors should be distinguishable when printed in black and white; 2) The descriptions of figures in text and captions must be sufficiently clear for both online and print copy. When submitting figures to be in color online only, authors should include the phrase <<color online>> in the figure captions. This is the author's responsibility. Authors will see these color figures when viewing their author page proofs on screen. Authors should always print their page proofs in black and white to see how they will appear in print. Authors will NOT be allowed to submit color figures to replace black and white figures in the page proof stage. To maximize the probability that figures will be published in color online and also print as good quality black and white or grayscale graphics, authors are encouraged to follow these figure submission guidelines: 1) Submit a color graphic in Tagged Image File Format (.tif); 2) Submit color graphics with a resolution of at least 300 dpi (600 dpi if there is text or line art in the figure); 3) Submit color graphics in CMYK format; 4) Submit figures sized to fit the actual column or page width of the journal so that reduction or enlargement is not necessary; 5) Submit multipart figures in one single electronic file.

Copyright © 2011, Materials Research Society. All rights reserved. No part of this publication may be reproduced, in any form or by any means, electronic, photocopying, or otherwise, without permission in writing from Cambridge University Press. Policies, request forms and contacts are available at: <http://www.cambridge.org/rights/permissions/permission.htm>. Permission to copy (for users in the USA) is available from Copyright Clearance Center <http://www.copyright.com>, email: info@copyright.com.

Journal of Materials Research Subscription Prices (2011)

[includes on-line web access]

	USA and Poss.	Non-US	Online Only
MRS Regular and Student Members	\$225.00	\$275.00	\$100.00
Institutions	\$1326.00	\$1423.00	\$1260.00

Journal of Materials Research (ISSN: 0884-2914) is published twenty-four times a year by Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013 – 2473 for the Materials Research Society. Periodical Postage Paid in New York, NY and additional mailing offices. **POSTMASTER:** Send address changes to *Journal of Materials Research*, c/o Journals Dept., Cambridge University Press, 100 Brook Hill Drive, West Nyack, NY 10994-2113, USA.

Subscriptions, renewals, address changes, and single-copy orders should be addressed to Subscription Fulfillment, *Journal of Materials Research*, Cambridge University Press, 100 Brook Hill Drive, West Nyack, NY 10994-2133, USA (for USA, Canada, and Mexico); or Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 8RU, England (for UK and elsewhere). Allow at least six weeks advance notice. For address changes, please send both old and new addresses and, if possible, include a mailing label from a recent issue. 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; otherwise, the issue may be purchased at the single-copy price.

Reprints of individual articles in *Journal of Materials Research* may be ordered. For information on reprints, please contact Cambridge University Press.

Individual member subscriptions are for personal use only.