

# MRS SYMPOSIUM PROCEEDINGS

Volume 1621 • 2013 MRS Fall Meeting

## Advances in Structures, Properties and Applications of Biological and Bioinspired Materials

### EDITORS

Syam P. Nukavarapu

Huinan Liu

Tao Deng

Michelle Oyen

Candan Tamerler

# **Advances in Structures, Properties and Applications of Biological and Bioinspired Materials**

**MATERIALS RESEARCH SOCIETY**  
**SYMPOSIUM PROCEEDINGS VOLUME 1621**

**Advances in Structures, Properties  
and Applications of Biological  
and Bioinspired Materials**

Symposia held December 1–6, 2013 Boston, Massachusetts. U.S.A.

**EDITORS**

**Syam P. Nukavarapu**

University of Connecticut  
Farmington, Connecticut, U.S.A.

**Huinan Liu**

University of California, Riverside  
Riverside, California, U.S.A.

**Tao Deng**

Shanghai Jiao Tong University  
Shanghai, China

**Michelle Oyen**

Cambridge University  
Cambridge, United Kingdom

**Candan Tamerler**

University of Kansas  
Lawrence, Kansas, U.S.A.



Materials Research Society  
Warrendale, Pennsylvania



CAMBRIDGE UNIVERSITY PRESS  
Cambridge, New York, Melbourne, Madrid, Cape Town,  
Singapore, São Paulo, Delhi, Mexico City

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

[www.cambridge.org](http://www.cambridge.org)  
Information on this title: [www.cambridge.org/9781605115986](http://www.cambridge.org/9781605115986)

Materials Research Society  
506 Keystone Drive, Warrendale, PA 15086  
<http://www.mrs.org>

© Materials Research Society 2014

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

This book has been registered with Copyright Clearance Center, Inc. For further information please contact the Copyright Clearance Center, Salem, Massachusetts.

First published 2014

CODEN: MRSPDH

ISBN: 978-1-60511-598-6 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party Internet Web sites referred to in this publication and does not guarantee that any content on such Web sites is, or will remain, accurate or appropriate.

# CONTENTS

Preface . . . . . xi

Materials Research Society Symposium Proceedings . . . . . xiii

## *ADVANCED COMPOSITES AND STRUCTURES FOR TISSUE ENGINEERING*

\* **Composites and Structures for Regenerative Engineering** . . . . . 3  
Cato T. Laurencin and Roshan James

**Novel and Unique Matrix Design for Osteochondral  
Tissue Engineering** . . . . . 17  
Deborah L. Dorcemus and Syam P. Nukavarapu

\* **Reducing Infections Using Nanotechnology** . . . . . 25  
Thomas J. Webster

**Identifying Iron Oxide Based Materials that Can Either Pass  
or Not Pass through the *in vitro* Blood-brain Barrier** . . . . . 33  
Di Shi, Linlin Sun, Gujie Mi, Soumya Bhattacharya,  
Suprabha Nayar, and Thomas J. Webster

**Nanostructured Ceramic and Ceramic-polymer Composites as Dual  
Functional Interface for Bioresorbable Metallic Implants** . . . . . 39  
Ian Johnson, Qiaomu Tian, and Huinan Liu

**Novel Silicone-epoxy Composites for Dental Restorations** . . . . . 47  
Liyun Ren, Vaibhav Pandit, Amanda Mixon,  
Crivello James, and Shiva P. Kotha

**Development of Hydroxyapatite-mediated Synthesis  
of Collagen-based Copolymers for Application as  
Bio Scaffolds in Bone Regeneration** . . . . . 53  
Didarul Bhuiyan, John Middleton, and Rina Tannenbaum

\* **Size Also Matters in Biodegradable Composite Microfiber  
Reinforced by Chitosan Nanofibers** . . . . . 59  
Elisabete D. Pinho, Albino Martins, José V. Araújo,  
Rui L. Reis, and Nuno M. Neves

\*Invited Paper

<b>Proliferation and Osteogenic Differentiation of Mesenchymal Stem Cells on Biodegradable Calcium-deficient Hydroxyapatite Tubular Bacterial Cellulose Composites. . . . .</b>	<b>71</b>
Pelagie Favi, Madhu Dhar, Nancy Neilsen, and Roberto Benson	
<b>Dielectrophoretical Fabrication of Hybrid Carbon Nanotubes-hydrogel Biomaterial for Muscle Tissue Engineering Applications. . . . .</b>	<b>81</b>
Javier Ramón-Azcón, Samad Ahadian, Raquel Obregon, Hitoshi Shiku, Ali Khademhosseini, and Tomokazu Matsue	
<b><i>In Vitro</i> Examination of Poly(glycerol sebacate) Degradation Kinetics: Effects of Porosity and Cure Temperature. . . . .</b>	<b>87</b>
Nadia M. Krook, Courtney LeBlon, and Sabrina S. Jedlicka	
<b>Novel Absorbable Polyurethane Biomaterials and Scaffolds for Tissue Engineering . . . . .</b>	<b>93</b>
Syam P. Nukavarapu, Rao S. Bezwada, Deborah L. Dorcemus, Neeti Srivasthava, and Robert J. Armentano	
<b>Control of Cell Adhesion and Detachment on Temperature-responsive Block Copolymer Langmuir Films. . . . .</b>	<b>101</b>
Morito Sakuma, Yoshikazu Kumashiro, Masamichi Nakayama, Nobuyuki Tanaka, Umemura Kazuo, Masayuki Yamato, and Teruo Okano	
<b>Biofunctional Thermo-responsive Polymeric Surface with Micropatterns for Label Free Cell Separation. . . . .</b>	<b>107</b>
Yoshikazu Kumashiro, Jun Ishihara, Terumasa Umemoto, Kazuyoshi Itoga, Jun Kobayashi, Masayuki Yamato, and Teruo Okano	
<b>Preliminary Investigation of a Sacrificial Process for Fabrication of Polymer Membranes with Sub-micron Thickness . . . . .</b>	<b>113</b>
Luke A. Beardslee, Dimitrius A. Khaladj, and Magnus Bergkvist	
<b>Fabrication and Morphological Investigation of Multi-walled Electrospun Polymeric Nanofibers . . . . .</b>	<b>119</b>
Jamal Seyyed Monfared Zanjani, Burcu Saner Okan, Mehmet Yildiz, and Yusuf Menciloglu	

**A Novel Injectable Chitosan Sponge Containing Brain Derived Neurotrophic Factor (BDNF) to Enhance Human Oligodendrocyte Progenitor Cells' (OPC) Differentiation. . . . .127**  
 Mina Mekhail, Qiao-Ling Cui, Guillermina Almazan, Jack Antel, and Maryam Tabrizian

*ADVANCES IN MECHANICS OF BIOLOGICAL AND BIOINSPIRED MATERIALS*

**DNA i-motif Provides Steel-like Tough Ends to Chromosomes . . . . .135**  
 Raghvendra P. Singh, Ralf Blossey, and Fabrizio Cleri

**Scanning Acoustic Microscopy of Biological Cryosections: The Effect of Local Thickness on Apparent Acoustic Wave Speed . . . . .143**  
 Craig J. Williams, Helen. K. Graham, Xuegen Zhao, Riaz Akhtar, Christopher E.M. Griffiths, Rachel E.B. Watson, Michael J. Sherratt, and Brian Derby

**The Structure and the Mechanical Properties of a Newly Fabricated Cellulose-nanofiber/Polyvinyl-alcohol Composite . . . . .149**  
 Yukako Oishi and Atsushi Hotta

**Modular Peptide-based Hybrid Nanoprobes for Bio-imaging and Bio-sensing. . . . .155**  
 Banu Taktak Karaca, James Meyer, Sarah VanOosten, Mark Richter, and Candan Tamerler

**Microstructure, Spectroscopic Studies and Nanomechanical Properties of Human Cortical Bone with Osteogenesis Imperfecta. . . . .163**  
 Chunju Gu, Dinesh R. Katti, and Kalpana S. Katti

*ENGINEERING AND APPLICATION OF BIOINSPIRED STRUCTURED MATERIALS*

**Mechanosensitive Channels Activity in a Droplet Interface Bilayer System . . . . .171**  
 Joseph Najem, Myles Dunlap, Sergei Sukharev, and Donald J. Leo

<b>Cellulose Nanofibril (CNF) Reinforced Starch Insulating Foams. . . . .</b>	<b>177</b>
N. Yildirim, S.M. Shaler, D.J. Gardner, R. Rice, and D.W. Bousfield	
<b>Degradation Control of Cellulose Scaffold by Malaprade Oxidation. . .</b>	<b>191</b>
Wichchulada Konkumnerd, Suong-Hyu Hyon, and Kazuaki Matsumura	
<b>* Toward Bioinspired Nanostructures for Selective Vapor Sensing: Diverse Vapor-induced Spectral Responses within Iridescent Scales of <i>Morpho</i> Butterflies. . . . .</b>	<b>197</b>
Timothy A. Starkey, Peter Vukusic, and Radislav A. Potyrailo	
<b>Integrative Chemistry toward Biosourced SiC Macrocellular Foams Bearing Unprecedented Heat Transport Properties. . . . .</b>	<b>209</b>
Simona Ungureanu, Marc Birot, Gérard Vignoles, Christophe Lorette, Gilles Sigaud, Hervé Deleuze, and Rénal Backov	
<b>Preparation of Porous B-type Carbonate Apatite with Different Carbonate Contents for an Artificial Bone Substitute . . . . .</b>	<b>215</b>
Toshimitsu Tanaka, Tomohiko Yoshioka, Toshiyuki Ikoma, and Junzo Tanaka	
<b>* Science of Swimming and the Swimming of the Soft Shelled Turtle. . . . .</b>	<b>221</b>
Shinichiro Ito	
<b>Effect of Microtubules Hierarchy on Photoinduced Hydrogen Generation and Application to Artificial Photosynthesis . . . . .</b>	<b>229</b>
Kosuke Okeyoshi, Kawamura Ryuzo, Ryo Yoshida, and Yoshihito Osada	

**MATERIALS FOR NEURAL INTERFACES**

<b>Investigating the Surface Changes of Silicon <i>in vitro</i> within Physiological Environments for Neurological Application . . . . .</b>	<b>237</b>
Maysam Nezafati, Stephen E. Sadow, and Christopher L. Frewin	

\*Invited Paper



**Quantification of Axonal Outgrowth on a Surface with Asymmetric Topography** .....243  
 Elise Spedden and Cristian Staii

**Improved Biphasic Pulsing Power Efficiency with Pt-Ir Coated Microelectrodes** .....249  
 Artin Petrossians, Navya Davuluri, John J. Whalen, Florian Mansfeld, and James D. Weiland

**Atomic Layer Deposited Al<sub>2</sub>O<sub>3</sub> and Parylene C Bi-layer Encapsulation for Utah Electrode Array Based Neural Interfaces** .....259  
 Xianzong Xie, Loren W. Rieth, Rohit Sharma, Sandeep Negi, Rajmohan Bhandari, Ryan Caldwell, Prashant Tathireddy, and Florian Solzbacher

**Author Index** .....267

**Subject Index** .....269

## PREFACE

There were eleven symposia conducted with a focus on biomaterials under the sub-class of “Biomaterials and Soft Matter” in the MRS 2013 fall meeting. Symposia, H, C, D and J, with a considerable overlap in the content and focus have been combined into single proceedings entitled “Advances in Structures, Properties and Applications of Biological and Bioinspired Materials”. This volume contains both invited as well as regular submissions to the symposia listed below:

Symposium H, “Advanced Composites and Structures for Tissue Engineering”  
Symposium C, “Advances in Mechanics of Biological and Bioinspired Materials”  
Symposium D, “Engineering and Application of Bioinspired Structured Materials”  
Symposium J, “Materials for Neural Interfaces”

The aim of this volume is to provide state-of-the-art research in biomaterials and bio-inspired materials—their structures, properties, and applications. Biological materials provide the critical support for the proper function of the living systems. The wide range and complexity exhibited by biological materials is unmatched in current bio-inspired as well as biomaterials. Understanding the underlying operation principles of these materials will provide promising approaches to not only improve biomaterials and bio-inspired materials’ performances in the living systems, but also provide creative new materials and systems that enable the applications of those materials for bio-sensing to tissue engineering. This symposia Proceedings volume presents some of the most recent advancements in the following areas: (1) Tissue Engineering, (2) Bio-inspired Materials, (3) Bio-inspired structures, and (4) Neural Interfaces. We hope the papers in the volume will provide the readers some insight of the current methodologies and approaches used in studying fundamental problems associated with biological materials, biomaterials, and bio-inspired materials. Some stimulating discussions of potential applications of these materials are also offered in the volume, which represents the trend of research in this exciting area of materials science and engineering.

Syam Nukavarapu  
Huinan Liu  
Tao Deng  
Michelle Oyen  
Candan Tamerler

May 2014

## MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS

- Volume 1607E – Nanotechnology-Enhanced Coatings, 2014, A. Taylor, N. Ludford, C. Avila-Orta, C. Becker-Willinger, ISBN 978-1-60511-584-9
- Volume 1608 – Nanostructured Materials and Nanotechnology, 2014, J.L. Rodríguez-López, O. Graeve, A.G. Palestino-Escobedo, M. Muñoz-Navia, ISBN 978-1-60511-585-6
- Volume 1609E – Biomaterials for Medical Applications, 2014, S.E. Rodil, A. Almaguer-Flores, K. Anselme, J. Castro, ISBN 978-1-60511-586-3
- Volume 1610E – Advanced Materials and Technologies for Energy Storage Devices, 2014, I. Belharouak, J. Xiao, P. Balaya, D. Carlier, A. Cuentas-Gallegos, ISBN 978-1-60511-587-0
- Volume 1611 – Advanced Structural Materials, 2014, H. Calderon, H. Balmori Ramirez, A. Salinas Rodriguez, ISBN 978-1-60511-588-7
- Volume 1612E – Concrete and Durability of Concrete Structures, 2013, L.E. Rendon Diaz Miron, B. Martínez Sánchez, N. Ramirez Salinas, ISBN 978-1-60511-589-4
- Volume 1613 – New Trends in Polymer Chemistry and Characterization, 2014, L. Fomina, G. Cedillo Valverde, M. del Pilar Carreón Castro, ISBN 978-1-60511-590-0
- Volume 1614E – Advances in Computational Materials Science, 2014, E. Martínez Guerra, J.U. Reveles, O. de la Peña Seaman, ISBN 978-1-60511-591-7
- Volume 1615E – Advanced Microscopy of Materials, 2014, H. Calderon, C. Kisielowski, L. Francis, P. Ferreira, A. Mayoral, ISBN 978-1-60511-592-4
- Volume 1616 – Structural and Chemical Characterization of Metals, Alloys and Compounds, 2014, A. Contreras Cuevas, R. Pérez Campos, R. Esparza Muñoz, ISBN 978-1-60511-593-1
- Volume 1617 – Low-Dimensional Semiconductor Structures, 2013, T.V. Torchynska, L. Khomenkova, G. Polupan, G. Burlak, ISBN 978-1-60511-594-8
- Volume 1618 – Cultural Heritage and Archaeological Issues in Materials Science II, 2014, J.L. Ruvalcaba Sil, J. Reyes Trujeque, A. Velázquez Castro, M. Espinosa Pesqueira, ISBN 978-1-60511-595-5
- Volume 1619E – Modeling and Theory-Driven Design of Soft Materials, 2014, M. Rodger, M. Dutt, Y. Yingling, V. Ginzburg, ISBN 978-1-60511-596-2
- Volume 1621 – Advances in Structures, Properties and Applications of Biological and Bioinspired Materials, 2014, S.P. Nukavarapu, H. Liu, T. Deng, M. Oyen, C. Tamerler, ISBN 978-1-60511-598-6
- Volume 1622 – Fundamentals of Gels and Self-Assembled Polymer Systems, 2014, F. Horkay, N. Langrana, M. Shibayama, S. Basu, ISBN 978-1-60511-599-3
- Volume 1623E – Synthetic Tools for Understanding Biological Phenomena, 2014, D. Benoit, A. Kloxin, C-C. Lin, V. Sée, ISBN 978-1-60511-600-6
- Volume 1624E – Integration of Biomaterials with Organic Electronics, 2014, M.R. Abidian, M. Irimia-Vladu, R. Owens, M. Rolandi, ISBN 978-1-60511-601-3
- Volume 1625E – Multiscale Materials in the Study and Treatment of Cancer, 2014, N. Moore, S. Peyton, J. Snedeker, C. Williams, ISBN 978-1-60511-602-0
- Volume 1626 – Micro- and Nanoscale Processing of Materials for Biomedical Devices, 2014, R. Narayan, V. Davé, S. Jayasinghe, M. Reiterer, ISBN 978-1-60511-603-7
- Volume 1627E – Photonic and Plasmonic Materials for Enhanced Optoelectronic Performance, 2014, C. Battaglia, ISBN 978-1-60511-604-4
- Volume 1628E – Large-Area Processing and Patterning for Active Optical and Electronic Devices, 2014, T.D. Anthopoulos, I. Kymissis, B. O'Connor, M. Panzer, ISBN 978-1-60511-605-1
- Volume 1629E – Functional Aspects of Luminescent and Photoactive Organic and Soft Materials, 2014, M.C. Gather, S. Reineke, ISBN 978-1-60511-606-8
- Volume 1630E – Solution Processing of Inorganic and Hybrid Materials for Electronics and Photonics, 2014, P. Smith, M. van Hest, H. Hillhouse, ISBN 978-1-60511-607-5
- Volume 1631E – Emergent Electron Transport Properties at Complex Oxide Interfaces, 2014, K.H. Bevan, S. Ismail-Beigi, T.Z. Ward, Z. Zhang, ISBN 978-1-60511-608-2
- Volume 1632E – Organic Microlasers—From Fundamentals to Device Application, 2014, R. Brückner, ISBN 978-1-60511-609-9
- Volume 1633 – Oxide Semiconductors, 2014, S. Durbin, M. Grundmann, A. Janotti, T. Veal, ISBN 978-1-60511-610-5

## MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS

- Volume 1634E – Diamond Electronics and Biotechnology—Fundamentals to Applications VII, 2014, J. C. Arnault, C.L. Cheng, M. Nesladek, G.M. Swain, O.A. Williams, ISBN 978-1-60511-611-2
- Volume 1635 – Compound Semiconductor Materials and Devices, 2014, F. Shahedipour-Sandvik, L.D. Bell, K.A. Jones, A. Clark, K. Ohmori, ISBN 978-1-60511-612-9
- Volume 1636E – Magnetic Nanostructures and Spin-Electron-Lattice Phenomena in Functional Materials, 2014, A. Petford-Long, ISBN 978-1-60511-613-6
- Volume 1638E – Next-Generation Inorganic Thin-Film Photovoltaics, 2014, C. Kim, C. Giebink, B. Rand, A. Boukai, ISBN 978-1-60511-615-0
- Volume 1639E – Physics of Organic and Hybrid Organic-Inorganic Solar Cells, 2014, P. Ho, M. Niggemann, G. Rumbles, L. Schmidt-Mende, C. Silva, ISBN 978-1-60511-616-7
- Volume 1640E – Sustainable Solar-Energy Conversion Using Earth-Abundant Materials, 2014, S. Jin, K. Sivula, J. Stevens, G. Zheng, ISBN 978-1-60511-617-4
- Volume 1641E – Catalytic Nanomaterials for Energy and Environment, 2014, J. Erlebacher, D. Jiang, V. Stamenkovic, S. Sun, J. Waldecker, ISBN 978-1-60511-618-1
- Volume 1642E – Thermoelectric Materials—From Basic Science to Applications, 2014, Q. Li, W. Zhang, I. Terasaki, A. Maignan, ISBN 978-1-60511-619-8
- Volume 1643E – Advanced Materials for Rechargeable Batteries, 2014, T. Aselage, J. Cho, B. Deveney, K.S. Jones, A. Manthiram, C. Wang, ISBN 978-1-60511-620-4
- Volume 1644E – Materials and Technologies for Grid-Scale Energy Storage, 2014, B. Chalamala, J. Lemmon, V. Subramanian, Z. Wen, ISBN 978-1-60511-621-1
- Volume 1645 – Advanced Materials in Extreme Environments, 2014, M. Bertolus, H.M. Chichester, P. Edmondson, F. Gao, M. Posselt, C. Stanek, P. Trocellier, X. Zhang, ISBN 978-1-60511-622-8
- Volume 1646E – Characterization of Energy Materials *In-Situ* and *Operando*, 2014, I. Arslan, Y. Gogotsi, L. Mai, E. Stach, ISBN 978-1-60511-623-5
- Volume 1647E – Surface/Interface Characterization and Renewable Energy, 2014, R. Opila, P. Sheldon, ISBN 978-1-60511-624-2
- Volume 1648E – Functional Surfaces/Interfaces for Controlling Wetting and Adhesion, 2014, D. Beysens, ISBN 978-1-60511-625-9
- Volume 1649E – Bulk Metallic Glasses, 2014, S. Mukherjee, ISBN 978-1-60511-626-6
- Volume 1650E – Materials Fundamentals of Fatigue and Fracture, 2014, A.A. Benzerga, E.P. Busso, D.L. McDowell, T. Pardoën, ISBN 978-1-60511-627-3
- Volume 1651E – Dislocation Plasticity, 2014, J. El-Awady, T. Hochrainer, G. Po, S. Sandfeld, ISBN 978-1-60511-628-0
- Volume 1652E – Advances in Scanning Probe Microscopy, 2014, T. Mueller, ISBN 978-1-60511-629-7
- Volume 1653E – Neutron Scattering Studies of Advanced Materials, 2014, J. Lynn, ISBN 978-1-60511-630-3
- Volume 1654E – Strategies and Techniques to Accelerate Inorganic Materials Innovation, 2014, S. Curtarolo, J. Hattrick-Simpers, J. Perkins, I. Tanaka, ISBN 978-1-60511-631-0
- Volume 1655E – Solid-State Chemistry of Inorganic Materials, 2014, S. Banerjee, M.C. Beard, C. Felser, A. Prieto, ISBN 978-1-60511-632-7
- Volume 1656 – Materials Issues in Art and Archaeology X, 2014, P. Vandiver, W. Li, C. Maines, P. Sciau, ISBN 978-1-60511-633-4
- Volume 1657E – Advances in Materials Science and Engineering Education and Outreach, 2014, P. Dickrell, K. Dilley, N. Rutter, C. Stone, ISBN 978-1-60511-634-1
- Volume 1658E – Large-Area Graphene and Other 2D-Layered Materials—Synthesis, Properties and Applications, 2014, editor TBD, ISBN 978-1-60511-635-8
- Volume 1659 – Micro- and Nanoscale Systems – Novel Materials, Structures and Devices, 2014, J.J. Boeckl, R.N. Candler, F.W. DelRio, A. Fontcuberta i Morral, C. Jagadish, C. Keimel, H. Silva, T. Voss, Q.H. Xiong, ISBN 978-1-60511-636-5
- Volume 1660E – Transport Properties in Nanocomposites, 2014, H. Garmestani, H. Ardebili, ISBN 978-1-60511-637-2
- Volume 1661E – Phonon-Interaction-Based Materials Design—Theory, Experiments and Applications, 2014, D.H. Hurley, S.L. Shinde, G.P. Srivastava, M. Yamaguchi, ISBN 978-1-60511-638-9
- Volume 1662E – Designed Cellular Materials—Synthesis, Modeling, Analysis and Applications, 2014, K. Bertoldi, ISBN 978-1-60511-639-6

## **MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS**

- Volume 1663E – Self-Organization and Nanoscale Pattern Formation, 2014, M.P. Brenner, P. Bellon, F. Frost, S. Glotzer, ISBN 978-1-60511-640-2
- Volume 1664E – Elastic Strain Engineering for Unprecedented Materials Properties, 2014, J. Li, E. Ma, Z.W. Shan, O.L. Warren, ISBN 978-1-60511-641-9

**Prior Materials Research Symposium Proceedings available by contacting Materials Research Society**