Advanced Processing and Manufacturing Technologies for Nanostructured and Multifunctional Materials II
Contents

Preface ix
Introduction xi

ADVANCED PROCESSING AND MANUFACTURING

Development of High Temperature Joining and Thermomechanical Characterization Approaches for SiC/SiC Composites 3
Michael C. Halbig, Mrityunjay Singh, and Jerry Lang

Microstructural Observation of Interfaces in Diffusion Bonded Silicon Carbide Ceramics by TEM 13
Hiroshi Tsuda, Shigeo Mori, Michael C. Halbig, Mrityunjay Singh, and Rajiv Asthana

Preparation and Characterization of Rb-SiC Ceramics Fabricated from Phenolic Resin/SiC 21
Akihiro Shimamura, Mkinori Hotta, Tatsuki Ohji, and Naoki Kondo

New Combined Method of MPS and FEM for Simulating Friction Stir Processing 27
Hisashi Serizawa and Fumikazu Miyasaka

Novel Visualizing Technique of the Tips of the Cracks for Indentation Fracture Resistance Method 37
H. Miyazaki and Y. Yoshizawa

Slip-Casting by Water-Absorbing Resin Mold Enables Crack-Free Ceramic Molding System and Products with Partially Different Thicknesses 45
Akio Matsumoto
Influence of Lanthanoid Dopant and N/O Substitution on the Electronic Structure and Luminescent Properties of Lanthanum Silicon Oxynitride Phosphors
I.A.M. Ibrahim, Z. Lenčesš, L. Benco, and P. Šajgalík

Effect of Ti$_3$SiC$_2$ Particulates on the Mechanical and Tribological Behavior of Sn Matrix Composites
T. Hammann, R. Johnson, M. F. Riyad, and S. Gupta

Field Assisted Sintering of Silicate Glass-Containing Alumina
Mattia Biesuz and Vincenzo M. Sglavo

Modeling the First Activation Stages of the Fe(hfa)$_2$TMEDA CVD Precursor on a Heated Growth Surface
Gloria Tabacchi, Ettore Fois, Davide Barreca, Giorgio Carraro, Alberto Gasparotto, and Chiara Maccato

Development of High Aspect Ratio Hexagonal Boron Nitride Filler by Mechanical Exfoliation
Yuichi Tominaga, Kimiyasu Sato, Daisuke Shimamoto, Yusuke Imai, and Yuji Hotta

Preparation and Characterization of Nanostructured Films: Study of Hydrophobicity and Antibacterial Properties for Surface Protection
M. Barberio, S. Veltri, E. Sokullu, F. Xu, M.A. Gauthier, and P. Antici

ADDITIVE MANUFACTURING AND 3D PRINTING

3-D Printing and Characterization of Polymer Composites with Different Reinforcements
Anton Salem, Mrityunjay Singh, and Michael C. Halbig

Additive Manufacturing of Drainage Segments for Cooling System of Crucible Melting Furnaces
Miranda Fateri, Andreas Gebhardt, and Georg Renftle

Additive Manufacturing of Silicon Carbide-Based Ceramics by 3-D Printing Technologies
Shirley X. Zhu, Michael C. Halbig, and Mrityunjay Singh

Additive Manufacturing of Light Weight Ceramic Matrix Composites for Gas Turbine Engine Applications
Mrityunjay Singh, Michael C. Halbig, and Joseph E. Grady

Application of Selective Separation Sintering in Ceramics 3D Printing
J. Zhang and B. Khoshnevis
This CESP issue contains papers that were presented during three symposia held during the 39th International Conference and Exposition on Advanced Ceramics and Composites, Daytona Beach, Florida, January 25–30, 2015:

- Symposium 8: 9th International Symposium on Advanced Processing and Manufacturing Technologies for Structural and Multifunctional Materials and Systems (APMT)
- Focused Session 4: Additive Manufacturing and 3D Printing Technologies
- Symposium 7: 9th International Symposium on Nanostructured Materials and Nanocomposites

Over 170 contributions (invited talks, oral presentations, and posters) were presented by participants from universities, research institutions, and industry, which offered interdisciplinary discussions indicating strong scientific and technological interest in the field of nanostructured systems. This issue contains 18 peer-reviewed papers that cover various aspects and the latest developments related to nano-scaled materials and functional ceramics.

The editors wish to extend their gratitude and appreciation to all the authors for their cooperation and contributions, to all the participants and session chairs for their time and efforts, and to all the reviewers for their valuable comments and suggestions. Financial support from the Engineering Ceramics Division of The American Ceramic Society (ACerS) and industry sponsors is gratefully acknowledged. The invaluable assistance of the ACerS staff of the meetings and publication departments, instrumental in the success of the symposium, is gratefully acknowledged.

We believe that this issue will serve as a useful reference for the researchers and technologists interested in science and technology of multifunctional or nanostructured materials and devices.

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Introduction

This CESP issue consists of papers that were submitted and approved for the proceedings of the 39th International Conference on Advanced Ceramics and Composites (ICACC), held January 25–30, 2015 in Daytona Beach, Florida. ICACC is the most prominent international meeting in the area of advanced structural, functional, and nanoscopic ceramics, composites, and other emerging ceramic materials and technologies. This prestigious conference has been organized by the Engineering Ceramics Division (ECD) of The American Ceramic Society (ACerS) since 1977.

The 39th ICACC hosted more than 1,000 attendees from 40 countries and over 800 presentations. The topics ranged from ceramic nanomaterials to structural reliability of ceramic components which demonstrated the linkage between materials science developments at the atomic level and macro level structural applications. Papers addressed material, model, and component development and investigated the interrelations between the processing, properties, and microstructure of ceramic materials.

The 2015 conference was organized into the following 21 symposia and sessions:

Symposium 1  Mechanical Behavior and Performance of Ceramics and Composites
Symposium 2  Advanced Ceramic Coatings for Structural, Environmental, and Functional Applications
Symposium 3  12th International Symposium on Solid Oxide Fuel Cells (SOFC): Materials, Science, and Technology
Symposium 4  Armor Ceramics: Challenges and New Developments
Symposium 5  Next Generation Bioceramics and Biocomposites
Symposium 6  Advanced Materials and Technologies for Energy Generation and Rechargeable Energy Storage
Symposium 7  9th International Symposium on Nanostructured Materials and Nanocomposites
Symposium 8  9th International Symposium on Advanced Processing & Manufacturing Technologies for Structural & Multifunctional Materials and Systems (APMT), In Honor of Prof. Stuart Hampshire
Symposium 9 Porous Ceramics: Novel Developments and Applications
Symposium 10 Virtual Materials (Computational) Design and Ceramic Genome
Symposium 11 Advanced Materials and Innovative Processing ideas for the Industrial Root Technology
Symposium 12 Materials for Extreme Environments: Ultrahigh Temperature Ceramics (UHTCs) and Nanolaminated Ternary Carbides and Nitrides (MAX Phases)
Symposium 13 Advanced Ceramics and Composites for Sustainable Nuclear Energy and Fusion Energy
Focused Session 1 Geopolymers, Chemically Bonded Ceramics, Eco-friendly and Sustainable Materials
Focused Session 2 Advanced Ceramic Materials and Processing for Photonics and Energy
Focused Session 3 Materials Diagnostics and Structural Health Monitoring of Ceramic Components and Systems
Focused Session 4 Additive Manufacturing and 3D Printing Technologies
Focused Session 5 Single Crystalline Materials for Electrical, Optical and Medical Applications
Focused Session 6 Field Assisted Sintering and Related Phenomena at High Temperatures
Special Session 2nd European Union-USA Engineering Ceramics Summit
Special Session 4th Global Young Investigators Forum

The proceedings papers from this conference are published in the below seven issues of the 2015 CESP; Volume 36, Issues 2-8, as listed below.

- Mechanical Properties and Performance of Engineering Ceramics and Composites X, CESP Volume 36, Issue 2 (includes papers from Symposium 1)
- Advances in Solid Oxide Fuel Cells and Electronic Ceramics, CESP Volume 36, Issue 3 (includes papers from Symposium 3 and Focused Session 5)
- Advances in Ceramic Armor XI, CESP Volume 36, Issue 4 (includes papers from Symposium 4)
- Advances in Bioceramics and Porous Ceramics VIII, CESP Volume 36, Issue 5 (includes papers from Symposia 5 and 9)
- Advanced Processing and Manufacturing Technologies for Nanostructured and Multifunctional Materials II, CESP Volume 36, Issue 6 (includes papers from Symposia 7 and 8 and Focused Sessions 4 and 6)
- Ceramic Materials for Energy Applications V, CESP Volume 36, Issue 7 (includes papers from Symposia 6 and 13 and Focused Session 2)
- Developments in Strategic Ceramic Materials, CESP Volume 36, Issue 8 (includes papers from Symposia 2, 10, 11, and 12; from Focused Sessions 1 and 3); the European-USA Engineering Ceramics Summit; and the 4th Annual Global Young Investigator Forum

The organization of the Daytona Beach meeting and the publication of these proceedings were possible thanks to the professional staff of ACerS and the tireless
dedication of many ECD members. We would especially like to express our sincere thanks to the symposia organizers, session chairs, presenters and conference attendees, for their efforts and enthusiastic participation in the vibrant and cutting-edge conference.

ACerS and the ECD invite you to attend the Jubilee Celebration of the 40th International Conference on Advanced Ceramics and Composites (http://www.ceramics.org/daytona2016) January 24-29, 2016 in Daytona Beach, Florida.

To purchase additional CESP issues as well as other ceramic publications, visit the ACerS-Wiley Publications home page at www.wiley.com/go/ceramics.

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Advanced Processing and Manufacturing
DEVELOPMENT OF HIGH TEMPERATURE JOINING AND THERMOMECHANICAL CHARACTERIZATION APPROACHES FOR SiC/SiC COMPOSITES

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ABSTRACT
Advanced joining technologies are enabling for the fabrication of large and complex shaped silicon carbide-based ceramic and ceramic matrix composite components to be utilized in high temperature extreme environment applications. Many joining approaches are being proposed and developed. New standardized tests are needed to fully characterize joint properties and capabilities. One such test ISO-13124, was used for mechanical testing in this work. This test configuration allows for testing of joined crossbars in either a tensile or a shear stress state. The REABond joining approach using Si-8.5%Hf eutectic phase alloy was used to join ceramic matrix composite and monolithic silicon carbide materials. In mechanical testing, low strengths were obtained with failures occurring in the joined substrates. Finite element analysis of the stress states revealed stresses concentrations at the edges of up to 30 times higher than the 2 MPa nominal stress for the tensile state. For the shear state, out of plane displacements occurred.

INTRODUCTION
Silicon carbide fiber reinforced / silicon carbide matrix composites (SiC/SiC) are a class of ceramic matrix composite (CMC) materials being developed for turbine engine applications for such components as combustor liners, shrouds, vanes, and blades¹-⁴. These CMC components can operate at higher temperatures, require less cooling, and are lighter weight than metal components. The use of CMCs in such applications contributes to increased turbine engine fuel efficiencies, reduced emissions, and long term durability. As interest in fiber reinforced SiC-based composite materials continues to grow due to advancements in their properties, new integration technologies and testing capabilities will be critically needed.

In order to evaluate the mechanical properties of joints, standardized tests and testing capabilities are needed. One such standardized test⁵, BS-ISO-13124:2011, “Fine ceramics (advanced ceramics, advanced technical ceramics): Test method for interfacial bond strength of ceramic materials,” was applied for evaluation of mechanical properties of monolithic SiC and SiC/SiC materials joined to themselves. In this test, two long rectangular substrates are bonded across one another at their midsection to form an “X” shaped crossbar to provide samples for testing either in a tensile stress state or a shear stress state. Due to the need for multiple crossbars for testing and because of the unique shape, a simple joining approach was needed for processing the joints. The authors had previously reported a diffusion bonding approach for joining SiC based materials using titanium interlayers⁶⁷. However, such an approach needs relatively smooth surfaces and requires high applied loads from a hot press to aid in bond formation. Another joining approach, Refractory Eutectic Assisted BONDing (REABOND) was used for evaluating joints according to ISO-13124. REABond uses Si-8.5Hf eutectic phase alloy powder in a green tape for the joining interlayer. During joint processing, no load is needed and the eutectic phase melts to flow over the substrate surface and solidifies during cooling. REBOND has been demonstrated on the joining of SiC/SiC composites resulting dense, crack free joints that filled the contour of the rough CMC surface⁸.

Joining of SiC/SiC substrates and monolithic SiC was conducted to support the mechanical test method development. Microstructural analysis was conducted using optical microscopy and scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS) to