The American Ceramic Society

47th International Conference & Exposition on Advanced Ceramics and Composites

ABSTRACT BOOK

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Introduction

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How to Use the Abstract Book

Refer to the Table of Contents to determine page numbers on which specific session abstracts begin. At the beginning of each session are headings that list session title, location and session chair. Starting times for presentations and paper numbers precede each paper title. The Author Index lists each author and the page number on which their abstract can be found.

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9:30 AM

(ICACC-S17-024-2023) Design of photoactive inorganic nanosystems for energy and environmental applications (Invited)

E. Moretti*[1]; L. Liccardo[1]; M. Bordin[1]; A. Vomiero[2]

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In the broad scenario of multi-component nanosystems, oxide-based materials are of primary importance for many different applications of current interest, spanning from catalysis to photovoltaics, water remediation and energy conversion and storage. Such a wide range of applications can be tailored by means of suitable synthetic methodologies. In particular, tuning the morphological features of a material has emerged as an important strategy to improve its performance, and there has been extensive research to develop highly active oxide-based systems rationally designed with a controlled shape and an ordered porosity at the nano/microscale for energy and environmental applications. This talk will focus on the importance of tuning the morphological features of a catalyst as a strategy to improve the photocatalytic activity, focusing on how rationally designing inorganic materials at the nanoscale can lead to morphologies and structures suitable to enhance the catalytic performance of industrially and environmentally important processes. The talk will discuss some applications that can be addressed by multi-component systems, synthesized via the bottom–up approach, highlighting their structure-reactivity relationship. H_2 production and purification, and drugs photodegradation will be presented as successful cases history.

10:20 AM

(ICACC-S17-025-2023) Rare Earth Doped Nanoparticles: Design, Architecture and Applications (Invited)

F. Vetrone*[1]

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In the last decade, the field of rare earth doped nanoparticles has vastly matured, progressing from the basic understanding of the photophysical properties governing their nanoscale luminescence, to their use in the study of a number of fundamental properties and ultimately to a plethora of applications, with considerable focus in biology and medicine. This interest stems primarily from the ability to stimulate these luminescent nanoparticles with near-infrared (NIR) light as well as their diverse emission wavelengths spanning the UV to the NIR. Therefore, with a single NIR excitation wavelength, it is possible to observe anti-Stokes emission, known as upconversion, or single photon (Stokes) NIR emission. Here, we present our work on the synthesis and surface functionalization of various NIR excited (and emitting) core/shell rare earth doped nanostructures/nanoplatforms and demonstrate how their various emissions could be harnessed for applications in biology and nanomedicine. Moreover, we investigate how these functional nanoparticles could be rendered even more versatile through rational combination with other NIR excited optical nanostructures.

10:50 AM

(ICACC-S17-026-2023) Towards tunable mid-infrared detection for advanced optical imaging with epitaxial graphene on silicon carbide on silicon (Invited)

F. Iacopi*[1]

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We have pioneered a method to obtain large-scale, consistent epitaxial growth of graphene on cubic silicon carbide on silicon pseudo-substrates using a solid-source, catalytic alloy approach. This platform allows to fabricate any complex graphene-coated silicon carbide 3D nanostructures selectively at the wafer-scale with a comparable electrical conductivity to that of graphene on hexagonal SiC wafers. This epitaxial graphene on 3C-SiC platform is of particular interest for integrated optics and nanophotonics. Thanks to the hybridization of surface plasmons in the graphene with the surface phonons supported by the carbide, graphene-coated SiC nanostructures can lead to low loss MIR response with high confinement. We have recently demonstrated an enhanced MIR absorption using graphene/SiC nanowires and indicated the capability for strong field confinement within a nm-thin oxide spacer between the graphene and the core SiC of the nanowire. Based on both analytical methods and numerical simulations, we have also indicated that, correspondingly, the light-matter interaction in the MIR can also be strongly enhanced by using a 3-layer nanoparticle made of a polar core, a low refractive index spacer and a graphene shell. We will illustrate an example of metasurface as an all-optical spatial filter for phase -contrast imaging.

S18: Ultra-High Temperature Ceramics

Processing-Microstructure-Property Relationship II

Room: Coquina Salon A (North Tower)

Session Chair: Scott McCormack, University of California, Davis

8:30 AM

(ICACC-S18-024-2023) Uncertainty quantification and processing optimization for UHTC manufacturing through an ICME framework (Invited)

R. Swanson[1]; A. Hilmas[2]; H. Babaee[4]; W. Xiong[4]; W. Fahrenholtz[3]; S. J. McCormack*[1]

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2. Air Force Research Lab, USA
3. Missouri University of Science & Technology, Dept. of Materials Science and Engineering, USA
4. University of Pittsburgh, Mechanical and Materials Science, USA

Standard ultra-high temperature ceramic (UHTC) manufacturing results in components with large differences in properties due to variability in microstructural "critical flaw" distributions. Critical flaws can be any irregularity in a component, such as a secondary phase, inclusion, cracks, pores etc. This is problematic when designing reproducible UHTC components. The goal of this project is to build a probabilistic characterization for processing-structure-properties (PSP) parameters and link them at each stage of UHTC processing in a way that allows for uncertainty propagation. This methodology has not been performed in the past due to the complex interrelations of UHTC PSP parameters that need to be deconvolved. Thus, multi-fidelity PSP database development and effective integrated computational materials engineering (ICME) combined with statistical modeling is key to minimize uncertainty during UHTC manufacturing. ZrB_2 will be used as a case study, detailing the construction of a PSP database from literature data and how high-fidelity 3D microstructural data will be used to reduce uncertainty along with other types of data.

9:00 AM

(ICACC-S18-025-2023) Effect of mechanical activation on carbothermal synthesis and densification of ZrC

N. Obradovic*[1]; S. Filipovic[1]; L. Feng[2]; M. Mirkovic[3]; W. Fahrenholtz[4]

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Mixtures of ZrO_2 and C were prepared by high-energy ball milling. Powders were milled for times from 0 to 120 minutes in air atmosphere. As milling time increased, surface area of powders increased, indicating significant particle size reduction. Milled powders were

densified by spark plasma sintering at 2000 °C. Unmilled powders did not reach full density. Milled powders reached full density, but ZrO_2 impurities were found for specimens prepared from powders milled for 60 and 120 minutes. Microstructure analysis showed that grain size was less than 2 microns for powder milled for 15 minutes. Based on densification data and impurities level, milling time of 15 minutes appears to give the best balance of particle size reduction to promote densification while minimizing impurities level.

9:20 AM

(ICACC-S18-026-2023) Gel casting elaboration process for porous alumina ceramics with complex shapes

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Thanks to their excellent thermomechanical properties while moving to high porosity, porous Al_2O_3 are good candidates for transpiration cooling. This technology is used between the hypersonic flight component and the hot freestream flow to reduce the heat flux to the material in a hostile environment. Gelcasting is the elaboration process selected to manufacture porous Al_2O_3 ceramics with complex shapes and homogeneous properties. It allows obtaining materials with relative ease and high green mechanical properties, however, the drying step without damage or crack apparition remains challenging. Indeed, porous materials with low loading powder and complex shapes are particularly difficult to properly dry without internal stresses. Decreasing solid loading in the porous structure of the gel cast part induces a higher water potential and the low solid particle packing is equivalent to low resistance to internal moisture diffusing to the surface of the gel cast part. Besides, the ceramic final shape complexity may present a nonuniform and differential drying, so mechanical stress apparition is caused by non-uniform shrinkage. For this reason, the drying step is optimized to avoid cracking before sintering.

9:40 AM

(ICACC-S18-027-2023) Thermal and Electrical Properties of $(Ti,Cr)B_2$ Ceramics

S. M. Smith*[1]; L. Feng[1]; W. Fahrenholtz[1]; L. Silvestroni[2]

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2. CNR, ISTEC, Italy

Chromium additions change the densification behavior, grain size, Vickers hardness, and flexural strength of $(Ti,Cr)B_2$ ceramics. Hardness and strength of the $(Ti,Cr)B_2$ ceramics were highest for a Cr content of 10 at%. The goals of the present study were to determine if the effect of Cr solid solution extends to the thermal and electrical properties of $(Ti,Cr)B_2$ ceramics and whether Cr content affects the anisotropy in the coefficient of thermal expansion (CTE). $(Ti,Cr)B_2$ ceramics containing varying amounts of Cr solid solution were synthesized by boro/carbothermal reduction. Powders were consolidated by spark plasma sintering. The CTE was determined for the principle crystallographic directions by variable temperature X-ray diffraction. Thermal diffusivity of sintered samples was measured by the laser flash method and was used to calculate thermal conductivity. The electrical resistivity was measured using the 4-point linear probe method. The discussion will focus on identifying any systematic changes in properties that occur as the Cr content of the $(Ti,Cr)B_2$ ceramics changes.

Response in Extreme Environments II

Room: Coquina Salon A (North Tower)
Session Chair: Elizabeth Opila, University of Virginia

10:20 AM

(ICACC-S18-028-2023) Oxidation mechanisms of developmental refractory materials (Invited)

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Materials for long-term application in high temperature oxidizing environments have relied on formation of protective Cr_2O_3, Al_2O_3, and SiO_2 scales. These materials are limited to use temperatures of about 1500°C. A need exists for refractory materials for use in oxidizing environments at temperatures > 1500°C. Refractory alloys and ultra-high temperature ceramics have been proposed for these use conditions. While much effort has been expended to develop these materials, a lack of both fundamental understanding of their oxidation mechanisms and methods to improve their oxidation resistance exists. Furthermore, the advantages and disadvantages of utilizing refractory metals, alloys, or carbides have not been completely elucidated. In this study, refractory metals and their corresponding carbides were oxidized under the same conditions. Additionally, oxidation of multicomponent alloys and carbides containing, Ti, Zr, Hf, Nb, and Ta were studied. Short term oxidation studies (2 minutes to 20 hours) were conducted at temperatures from 900 to 1800°C in 1% O_2/balance argon using resistive heating or thermogravimetric analysis. Weight change, oxide thickness, and material consumption rates with microstructural characterization were used to elucidate oxidation mechanisms including oxygen dissolution in alloys, CO(g) production from carbides, and complex oxide formation from multicomponent materials.

10:50 AM

(ICACC-S18-029-2023) Study of Ceramic Composites High-Temperature Response in Aerospace High-Enthalpy Flows (Invited)

S. Mungiguerra*[1]; A. Cecere[1]; R. Savino[1]

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Interest for new-generation reusable space vehicles is spreading worldwide, calling for novel materials able to survive the extreme conditions of hypersonic atmospheric re-entry and rocket propulsion. Among the most promising candidates are the Ultra-High-Temperature Ceramics (UHTC), transition metal borides and carbides, which excel for their high-temperature properties, e.g. oxidation and ablation resistance. Research is increasingly oriented towards the introduction of secondary phases, such as silicon carbide and carbon fibers reinforcement (Ultra-High-Temperature Ceramic Matrix Composites, UHTCMC), to improve the materials performance. The European H2020 C^3HARME research project was aimed at development and characterization of new UHTCMCs for near-zero ablation TPS and near-zero erosion rocket nozzles. The University of Naples Federico II, having long-term expertise in aero-thermo-dynamics and propulsion, was in charge for requirements definition, prototypes and test condition design, and carried out extensive test campaigns to characterize the thermal response of the samples in an arc-jet plasma wind tunnel and a lab-scale hybrid rocket engine. Numerical computations of fluid-dynamic flowfields and materials thermal behavior complemented the test activities. The results supported development and testing of full-scale TPS assemblies and a large-size solid rocket nozzle.