6-5-2022

# Conference Program

Daniel Butts

Carmen Carney

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Chris Weinberger

# *Program*

# ULTRA-HIGH TEMPERATURE CERAMICS: MATERIALS FOR EXTREME ENVIRONMENT APPLICATIONS V

**June 5-8, 2022**

**The Cliff Lodge at Snowbird**
**Snowbird, Utah**


**Conference Co-Chairs**
**Daniel Butts**
MACH-20, LLC, USA

**Carmen Carney**
Air Force Research Laboratory, USA

**Carolina Tallon**
Virginia Tech, USA

**Gregory Thompson**
University of Alabama, USA

**Chris Weinberger**
Colorado State University, USA



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**9320 Cliff Lodge Dr.**
**Snowbird, UT 84092**
**+1-801-933-2222**
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Engineering Conferences International (ECI) is a not-for-profit global engineering conferences program, originally established in 1962, that provides opportunities for the exploration of problems and issues of concern to engineers and scientists from many disciplines.

## ***Organizing Committee***

Jon Binner (Birmingham University, UK)

Michael Cinibulk (Air Force Research Lab, USA)

William Fahrenholtz (Missouri University of Science & Technology, USA)

Frederic Monteverde (Institute of Science and Technology for Ceramics ISTEC, Italy)

Elizabeth Opila (University of Virginia, USA)

Diletta Sciti (Institute of Science and Technology for Ceramics ISTEC, Italy)

Eric Wuchina (Naval Surface Warfare Center, USA)

Yanchun Zhou (Aerospace Research Institute of Materials & Processing Technology, China)

## ***Previous conferences in this series***

***Ultra-High Temperature Ceramics:***
***Materials for Extreme Environment Applications***
**August 3-8, 2008**
**Lake Tahoe, California**
*Conference Chairs:*
Eric Wuchina, Naval Surface Warfare Center, USA
Alida Bellosi, Institute of Science & Technology for Ceramics, Italy

***Ultra-High Temperature Ceramics:***
***Materials for Extreme Environment Applications II***
**May 13-18, 2012**
**Hernstein, Austria**
*Conference Chairs:*
Bill Fahrenholtz, Missouri University of Science & Technology, USA
Bill Lee, Imperial College, London, UK
Eric Wuchina, Naval Surface Warfare Center, USA
Yanchun Zhou, Aerospace Research Inst. Of Materials & Processing Technology, China

***Ultra-High Temperature Ceramics:***
***Materials for Extreme Environment Applications III***
**April 12-16, 2015**
**Gold Coast, Australia**
*Conference Chairs:*
George Franks, The University of Melbourne, Australia
Carolina Tallon, The University of Melbourne, Australia

***Ultra-High Temperature Ceramics:***
***Materials for Extreme Environment Applications IV***
**September 17 – 20, 2017**
**Windsor, UK**
*Conference Chairs:*
Jon Binner, University of Birmingham, UK
Bill Lee, Imperial College, London, UK

## *Conference Sponsors*

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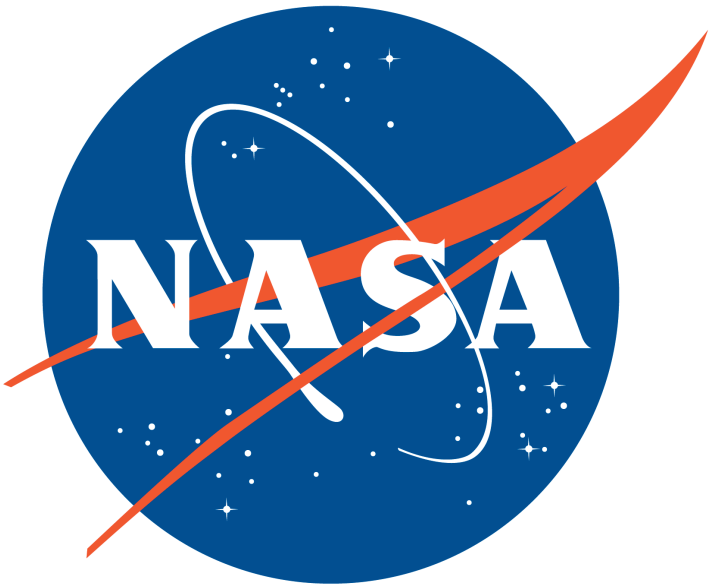
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EXOTHERMICS

**Sunday, June 5, 2022**

| | |
|---|---|
| 15:00 – 16:45 | Conference Check-in (Ballroom 3 Lobby) |
| 16:45 – 17:00 | Opening remarks – Conference Chairs<br>ECI welcome: Ram Darolia (GE Aviation, retired) |
| 17:00 – 18:00 | **Plenary – Parker Solar Probe**<br>Elizabeth Congdon, Johns Hopkins University Applied Physics Laboratory (JHU/APL), USA |
| 18:00 – 20:30 | Welcome reception followed by Dinner |

***Locations and Notes***

- *Technical sessions are in Ballroom 3.*
- *Poster sessions are in Atrium Overlook and Ballroom Mezzanine.*
- *Breakfasts are in Golden Cliff / Eagles Nest.*
- *Lunches on Monday and Wednesday are in Golden Cliff / Eagles Nest.*
- *Boxed lunches will be available Tuesday in Ballroom 3 Lobby.*
- *The reception and dinner on Sunday are in the Golden Cliff Terrace / Golden Cliff Room.*
- *The conference banquet on Tuesday is in Golden Cliff / Eagles Nest.*
- *The ECI on site office is in Coat Room A.*
- *Please wear your mask except when giving a presentation or actively eating or drinking. Please maintain physical distancing as much as possible.*
- *Audio, still photo and video recording by any device (e.g., cameras, cell phones, laptops, PDAs, watches) is strictly prohibited during the technical sessions, unless the author and ECI have granted prior permission.*
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- *Speakers – Please leave at least 3-5 minutes for questions and discussion.*
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- *After the conference, ECI will send an updated participant list to all participants. Please check your listing now and if it needs updating, you may correct it at any time by logging into your ECI account.*
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**Monday, June 6, 2022**

| | |
|---|---|
| 07:00 – 08:00 | **Breakfast** |
| | **Session: Processing & Properties**<br>Chairs: Bill Fahrenholtz, Jon Binner |
| 08:00 – 08:10 | **Conference Welcome and Expectations**<br>Carmen Carney, Air Force Research Laboratory, USA<br>Ram Darolia |
| 8:10 – 8:15 | **Session Introduction**<br>Bill Fahrenholtz, Jon Binner |
| 08:15 – 08:35 | **Investigation of the oxidation resistance of $ZrB_2$-based monoliths using polymer-derived Si(Zr,B)CN as sintering aid**<br>Nils-Christian Petry, DECHEMA-Forschungsinstitut, Germany |
| 08:35 – 08:55 | **The zeta phase in the transition metal carbides and nitrides: Structure, microstructure and properties**<br>Christopher Weinberger, Colorado State University, USA |
| 08:55 – 09:15 | **Textured UHTC borides using extremely low magnetic fields: influence of colloidal processing parameters and material selection**<br>Juan Diego Shiraishi, Virginia Tech, USA |
| 09:15 – 09:35 | **Plasticity of $ZrB_2$ grains during micropillar compression: The effect of anisotropy, temperature and dislocations**<br>Tamás Csanádi, Institute of Materials Research, Slovakia |
| 09:35 – 10:15 | **Coffee Break** |
| 10:15 – 10:35 | **Highly Stable Nanolamellar MXene-derived Carbides by Phase Transformation of $Ti_3C2T_x$ and $Mo_2TiC_2T_x$ MXenes**<br>Babak Anasori, Indiana University-Purdue University Indianapolis, USA |
| 10:35 – 10:55 | **Oxidation of high entropy ultra-high temperature ceramics**<br>Elizabeth Opila, University of Virginia, USA |
| 10:55 – 11:15 | **Tungsten diboride for high energy nuclear applications**<br>James Davidson, Imperial College London, United Kingdom |
| 11:15 – 11:35 | **Carbon influence on the fracture toughness of transition metal carbides**<br>Xingyuan Zhao, Colorado School of Mines, USA |
| 11:35 – 11:55 | **Discussion** |
| 11:55 – 13:30 | **Lunch** |
| | **Session: Fundamental Properties**<br>Chairs: Chris Weinberger, Kris Behler |
| 13:30 – 13:35 | **Session Introduction**<br>Chris Weinberger, Kris Behler |
| 13:35 – 13:55 | **Experimental techniques to study structure and thermodynamics at ultra-high temperatures**<br>Sergey V. Ushakov, Arizona State University, USA |

**Monday, June 6, 2022 (continued)**

| | |
|---|---|
| 13:55 – 14:15 | ***In-situ* high temperature spatially resolved X-ray diffraction of $TiB_2$ up to ~3250 ˚C**<br>Scott McCormack, University of California, Davis, USA |
| 14:15 – 14:35 | **Design of Ultra-High Temperature Ceramics for Oxidation Resistance**<br>Niquana Smith, University of Virginia, USA |
| 14:35 – 14:55 | **Short-range chemical environment versus long-range chemical homogeneity analyses in high-entropy transition metal $AlB_2$-type diboride solid solutions**<br>Frederic Monteverde, CNR-ISTEC, Italy |
| 14:55 – 15:25 | **Coffee Break** |
| 15:25 – 15:45 | **First-principles prediction of thermal conductivity of zirconium carbide and hafnium carbide at ultra-high temperatures**<br>Tianli Feng, University of Utah, USA |
| 15:45 – 16:05 | **From the atomic scale to the bulk: Ultra high temperature evaluation of metal diborides $MB_2$ (M = Ta, Ti, Hf, Zr, Nb)**<br>Elizabeth Sobalvarro Converse, Lawrence Livermore National Laboratory, USA |
| 16:05 – 16:25 | **Modeling environmental effects in $MeB_2$/SiC UHTCs: Oxidation by oxygen and water vapor**<br>Pavel Mogilevsky, UES Inc., USA |
| 16:25 – 16:45 | **Stress distribution analysis in zirconium diboride and silica carbide ($ZrB_2$-SiC) based thermal protection system under hypersonic flight conditions using a machine learning driven approach**<br>Carmine Zuccarini, Kingston University London, United Kingdom |
| 16:45 – 17:00 | **Break** |
| 17:00 – 20:00 | Poster Session with heavy hors d'oeuvres and wine/beer/soft drinks |

**Tuesday, June 7, 2022**

| | |
|---|---|
| 07:00 – 08:00 | **Breakfast** |
| | **Session: UHTC-CMCs & Coatings**<br>Chairs: Mike Cinibulk, Lisa Rueschhoff |
| 08:00 – 08:05 | **Session Introduction**<br>Mike Cinibulk, Lisa Rueschhoff |
| 08:05 – 08:25 | **Advances and challenges in the development of UHTCMCs - A review of the C3harme project**<br>Diletta Sciti, ISTEC-CNR, Italy |
| 08:25 – 08:45 | **The AM3aC2A Project: Multiscale approach for modeling CMC and UHTCMC materials for reusable components for aerospace**<br>Mario De Stefano Fumo, Italian Aerospace Research Centre, Italy |
| 08:45 – 09:05 | **Influence of Nb coating on the oxidation behavior of $ZrB_2$**<br>Jan Erik Förster, German Aerospace Center, Germany |
| 09:05 – 09:25 | **Novel polymer-derived carbide and boride refractory ceramics**<br>Brad Pindzola, Triton Systems Inc, USA |
| 09:25 – 09:45 | **Laser additive manufacturing of ultra high temperature ceramics**<br>Steven Storck, Johns Hopkins University-Applied Physics Laboratory, USA |
| 09:45 – 10:15 | **Coffee Break** |
| 10:15 – 10:35 | **Thermal ablation behaviour of ultra-high temperature ceramic matrix composites made by RF enhanced chemical vapour infiltration**<br>Jon Binner, University of Birmingham, United Kingdom |
| 10:35 – 10:55 | **Thermodynamic and experimental SiC-ZrC CVD process development**<br>Benjamin Lam, Oak Ridge National Laboratory, USA |
| 10:55 – 11:15 | **Oxidation behavior of Cf / MC – SiC (with M = Hf, Zr) composites in an oxyacetylene torch environment under over oxygen concentration**<br>Thomas Bourdeau, Laboratory for thermo-structural composites LCTS, France |
| 11:15 – 11:35 | **Zirconium Carbide Oxidation and Passivation for Nuclear Fuel Applications**<br>Allison Rzepka. UIUC Department of Mechanical Science and Engineering, USA |
| 11:35 – 11:55 | **UHTC coatings obtained by plasma spraying: Characterization and oxidation behavior**<br>Arthur Charrue, CEA-DAM Le Ripault, France |
| 11:55 – 15:30 | **Lunch / Free time** |
| | **Session: Near Net Shape Processing**<br>Chairs: Greg Hilmas, Carolina Tallon |
| 15:30 – 15:35 | **Session Introduction**<br>Greg Hilmas, Carolina Tallon |
| 15:35 – 15:55 | **Additive manufacturing of chopped fiber ultra-high ceramic composites**<br>Lisa Rueschhoff, Air Force Research Laboratory, USA |

**Tuesday, June 7, 2022 (continued)**

| | |
|---|---|
| 15:55 – 16:15 | **Low-toxity gelcasting to 3D shaping of UHTCs**<br>Carolina Tallon, Virginia Tech, USA |
| 16:15 – 16:35 | **Direct ink writing of ultra-high temperature ceramics**<br>Swetha Chandrasekaran, Lawrence Livermore National Laboratory, USA |
| 16:35 – 16:55 | **Additive manufacturing enabling W-SiC and W-ZrB2-SiC heterogeneous materials**<br>David Mitchell, Oak Ridge National Laboratory, USA |
| 16:55 – 17:15 | **Discussion** |
| 17:15 – 18:00 | **Break** |
| 18:00 – 20:00 | **Conference Dinner** |

**Wednesday, June 8, 2022**

| | |
|---|---|
| 07:00 – 08:00 | **Breakfast** |
| | **Session: Engineered Structures**<br>Chairs: Diletta Sciti, Daniel Butts |
| 08:00 – 08:05 | **Session Introduction**<br>Diletta Sciti, Daniel Butts |
| 08:05 – 08:25 | **Ultra-high temperature ceramics for transpiration cooling applications in hypersonic vehicles**<br>Matthew McGilvray, University of Oxford, United Kingdom |
| 08:25 – 08:45 | **Porous UHTCs for transpiration cooling of hypersonic flight**<br>Rowan Hedgecock, Imperial College London, United Kingdom |
| 08:45 – 09:05 | **Ultra-high temperature ceramics with exceptional strength at elevated temperature**<br>Laura Silvestroni, CNR-ISTEC, Italy |
| 09:05 – 09:25 | **Characterization of ultra-high temperature materials produced by rapid-laser chemical vapor deposition (R-LCVD)**<br>Jeff Vervlied, Free Form Fibers, USA |
| 09:25 – 09:45 | **Integrated self-healing thermal protection for high-speed vehicles**<br>Steven Storck, Johns Hopkins University, Applied Physics Laboratory, USA |
| 09:45 – 10:15 | **Coffee Break** |
| | **Session: Extreme Environment Testing**<br>Chairs: Frederick Monteverde, Scott McCormack |
| 10:15 – 10:20 | **Session Introduction**<br>Frederick Monteverde, Scott McCormack |
| 10:20 – 10:40 | **Diagnostics for improved understanding of test environment and material interactions to advance oxidation-degradation models of UHTCs**<br>Michael K. Cinibulk, Air Force Research Laboratory, USA |
| 10:40 – 11:00 | **Plasma wind tunnel testing of UHTC coated components for hypersonic applications**<br>Mario De Stefano Fumo, Italian Aerospace Research Centre, Italy |
| 11:00 – 11:20 | **Characterization & testing in extreme, applicable environments**<br>Bhavesh V. Patel, Southern Research Institute, USA |
| | **Session: High Entropy Materials I**<br>Chairs: Greg Thompson, Lavina Backman |
| 11:20 – 10:25 | **Session Introduction**<br>Greg Thompson, Lavina Backman |
| 11:25 – 11:45 | **Synthesis, densification, and properties of high entropy ultra-high temperature ceramics**<br>William Fahrenholtz, Missouri University of Science and Technology, USA |

**Wednesday, June 8, 2022 (continued)**

| | |
|---|---|
| 11:45 – 12:05 | **Synthesis and crystallography of high entropy metal carbides: A new class of ultrahigh temperature and irradiation resistant ceramics**<br>Olivia A. Graeve, University of California, San Diego, USA |
| 12:05 – 12:25 | **Processing of high entropy carbide based ceramics**<br>Lavina Backman, US Naval Research Laboratory, USA |
| 12:25 – 13:30 | **Lunch** |
| 13:30 – 13:50 | **Towards complex component manufacture via 3D printing and joining of parts**<br>Luc J. Vandeperre, Imperial College London, United Kingdom |
| 13:50 – 14:10 | **High Entropy Rare Earth $A_2b_2o_7$ Type Zirconates**<br>Daniel R. Lowry, Sandia National Laboratories, USA |
| 14:10 – 14:30 | **Protective complex oxide film formation in multi-component ultra-high temperature carbides during plasma jet exposure**<br>Ambreen Nisar, Florida International University, USA |
| 14:30 | **Announcement of the 2024 Conference and presentation of awards** |

## Poster Presentations

1. **Multiscale porous high-temperature heat exchanger using ceramic co-extrusion**
   Xiangyu Li, MIT, USA

2. **Strategies for printing fibers and post-processing for ceramic matrix composites (CMCs)**
   Corson Cramer, Oak Ridge National Laboratory, USA

3. **Mechanical andthermal properties of Zeta phase tantalum carbide atelevated temperatures**
   Evan Schwind, Missouri University of Science and Technology, USA

4. **Design of ultra-high temperature ceramics for oxidation resistance**
   Niquana Smith, University of Virginia, USA

5. **Environmental conical nozzle levitator equipped with dual lasers**
   Fox Thorpe, University of California, Davis, USA

6. **Investigation of anomalous hardness in sub-stoichiometric transition metal carbides using ab-initio simulations**
   Brennan Watkins, Colorado State University, USA

7. **Oxidation behavior of Cf / MC – MB2 – SiC (with M = Hf, Zr) composites in an oxyacetylene torch environment**
   Thomas Bourdeau, Laboratory for thermo-structural composites LCTS (CNRS-CEA-Safran-UB), France

8. **Finite difference simulation ofphasetransformation kinetics in transition metal carbide composites**
   John Carter Stotts, Colorado State University, USA

9. **Mixing the transition metals in transition metal carbides**
   Christopher Weinberger, Colorado State University, USA

10. **Oxidation kinetics of sub-stoichiometric ZrCX via furnace testing to 2500˚C / 1 atm air**
    Mark Opeka, Southern Research Institute, USA

11. **Oxidation of TaC-HfC blends densified by spark plasma sintering**
    Maritza Sanchez, University of California, San Diego, USA

12. **Computational study of temperature in a millimeter wave heat exchanger with an AlN:Mo Susceptor on an isothermal metal plate**
    Vadim Yakovlev, Worcester Polytechnic Institute, USA

13. **Cold spray deposition of metallic-UHTC composites**
    Michael Large, University of Alabama, USA

14. **Phase evolution in thermally annealed metallic-UHTC composites**
    Michael Large, University of Alabama, USA

15. **Materials processing and property-structure characterization capabilities at The University of Alabama**
    Gregory Thompson, The University of Alabama, USA

16. **Novel polymer-derived carbide and boride refractory ceramics**
Brad Pindzola, Triton Systems Inc., USA

17. **The development of polymer-derived Si(Al)CN CMC for high temperature applications**
Muhammed Younas, University of Birmingham, United Kingdom

18. **Diffusional and microstructural profiles in metallic-to-UHTC conversion by carbonization**
Haas Blacksher, The University of Alabama, USA

19. **CuAAC for inorganic preceramic polymer synthesis**
Matthew B. Dickerson, US Air Force (AFRL), USA