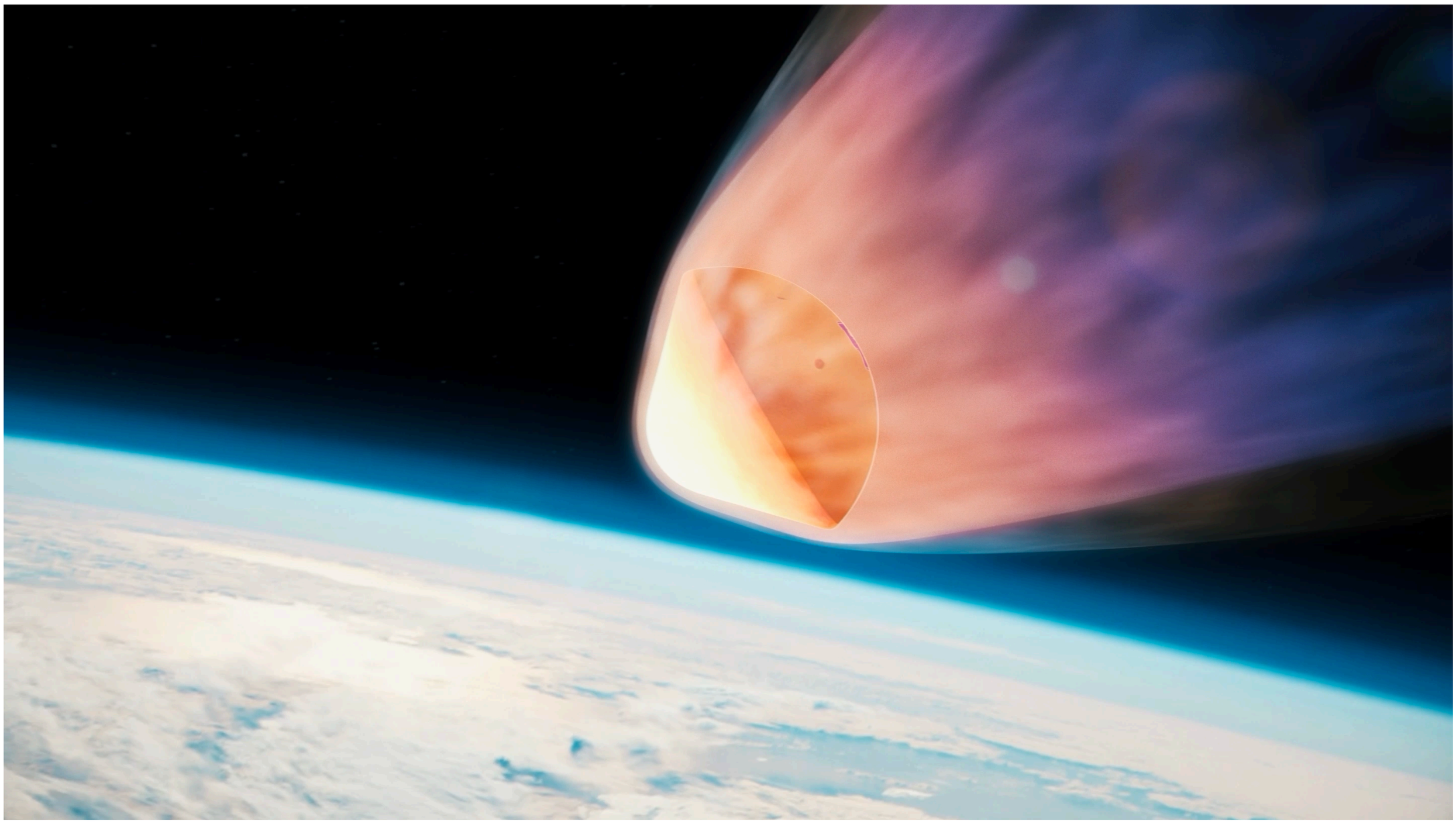
12th Ablation Workshop

November 9-10, 2022
Worsham Cinema, Gatton Student Center, University of Kentucky
404 S Limestone St, Lexington, KY 40508
http://ablation.engr.uky.edu

Hosted and organized by

University of Kentucky



Steering organizations

Sandia National Laboratories

NASA

Agenda

Sponsored by

Sandia National Laboratories

60 YEARS 1962-2022 ANALYTICAL MECHANICS ASSOCIATES

University of Kentucky

NASA Kentucky
Space Grant Consortium and EPSCoR Programs

Agenda

Wednesday November 9, 2022

7:00 **Registration, Breakfast and Coffee** (Great Hall/Harris Ballroom)

Introduction/Overview
Chair: Savio Poovathingal, University of Kentucky, USA

8:00 Overview and welcome
Savio Poovathingal, University of Kentucky, USA
8:20 Overview of ablation modeling at NASA
Justin Haskins, NASA Ames Research Center, USA
8:40 Overview of AFOSR ablation activities
Sarah Popkin, Air Force Office of Scientific Research, USA
9:00 Overview of ArianeGroup and the European Space Agency ablation activities
Gregory Pinaud, ArianeGroup SAS, France
9:20 Overview of ablation research at Sandia National Laboratories
Scott Roberts, Sandia National Laboratories, USA
9:40 An overview of VKI activities related to ablation research
Bernd Helber, Von Karman Institute for Fluid Dynamics, Belgium
10:00 A perspective on ablative TPS needs by emerging commercial space and NASA's role
Ethiraj Venkatapathy, NASA Ames Research Center, USA

10:20 **Coffee Break** (Worsham Cinema)

Technical Session #1: Microscale modeling and experiments
Chair: Timothy Deschenes, Spectral Sciences Inc., USA

10:40 Mesoscale ablation modeling
Lincoln Collins, Sandia National Laboratories, USA
11:00 Supervised learning model for permeability of TPS materials
Savio Poovathingal, University of Kentucky, USA
11:20 Characterizing char rate and extent in fiber-reinforced plastics using x-ray computed tomography
Benton Greene, Jacobs Engineering, USA
11:40 High temperature morphology of phenolic resin pyrolysis
Collin Foster, University of Illinois Urbana-Champaign, USA

12:00 **Lunch** (Harris Ballroom)

Technical Session #2: Material response modeling
Chair: Giovanni Salazar, Corvid Technologies, USA

13:00 Overview and recent developments of Icarus
Eric Stern, NASA Ames Research Center, USA
13:20 Comparison of material response models
Samantha Bernstein, University of Texas at Austin, USA
13:40 Numerical reconstruction of spalled particle trajectories in an arc-jet environment
Raghava Davuluri, University of Kentucky, USA
14:00 Material response simulations of the Dragonfly capsule using Icarus
Joseph Schulz, NASA Ames Research Center, USA

Technical Session #3: Flight experiments
Chair: Thierry Magin, Von Karman Institute for Fluid Dynamics, Belgium

14:20 Overview of post-flight analyses and airborne observation of Hayabusa2 SRC
Tetsuya Yamada, Japan Space Exploration Agency, Japan
14:40 KREPE: The first orbital entry mission of the KRUPS capsule
Alexandre Martin, University of Kentucky, USA

Poster Session (see page 4)

15:00 Poster session and reception (Harris Ballroom)

16:15 **Buses 1 and 2 depart for Banquet** (Castle & Keys Distillery)

16:45 **Bus 3 departs for Banquet** (Castle & Keys Distillery)

18:00 **Dinner** (Castle & Keys Distillery)

23:00 **Return to campus**

Agenda

Thursday November 10, 2022

7:00 **Registration, Breakfast and Coffee** (Great Hall/Harris Ballroom)

Invited talk
Chair: Alexandre Martin, University of Kentucky, USA

8:00 NASA's envisioned future and where we fit
Michael Wright, NASA Ames Research Center, USA

Technical Session #4: Validation, coupling, and surface phenomenon
Chair: Christian Zuber, German Aerospace Center (DLR), Germany

8:20 Ares: A multi-physics modeling framework for entry systems
Olivia Schroder, University of Minnesota, USA
8:40 Numerical modeling of ceramics leading edge oxidation in inductively coupled plasma facility
Vincent Le Maout, University of Illinois Urbana-Champaign, USA
9:00 Key aspects of a finite-rate air-carbon surface chemistry model
Tom Schwartzentruber, University of Minnesota, USA
9:20 Detailed characterization and plasma-testing of carbon-phenolic ablators: towards an open-source database for code validation
Alessandro Turchi, Von Karman Institute for Fluid Dynamics, Belgium
9:40 Identification and study of validation level test cases for computational modeling of non-Charring ablators
Aleksander Zibitsker, University of Kentucky, USA

10:00 **Coffee Break** (Worsham Cinema)

Technical Session #5: Multi-scale modeling
Chair: Samuel Chen, Johns Hopkins University Applied Physics Laboratory, USA

10:20 Implementation of active sites to capture pitting of oxidizing carbon materials in DSMC
Krishnan Swaminathan Gopalan, NASA Ames Research Center, USA
10:40 Chemical kinetics and thermal properties of ablator pyrolysis products during atmospheric entry
Mitchell Gosma, University of Illinois Urbana-Champaign, USA
11:00 Ablation response of high enthalpy instrumented test article assembly
Sreevishnu Oruganti, University of Illinois Urbana-Champaign, USA
11:20 Radiative transport through TPS materials
Savio Poovathingal, University of Kentucky, USA
11:40 TPS certification by analysis: model-driven characterization of properties and failure in woven TPS
Lauren Abbott, NASA Ames Research Center, USA

12:00 **Lunch** (Harris Ballroom)

Technical Session #6: Ablation experiments
Chair: Mark Ewing, Northrup Grumman Corp., USA

13:00 A table-top shock tunnel for investigations of hypersonic ablation
Timothy Minton, University of Colorado Boulder, USA
13:20 Solar-thermal testing for ablator thermal-model validation
Jeffrey Engerer, Sandia National Laboratories, USA
13:40 Assessment of density grading for the carbon-phenolic ablator ZURAM
Christian Zuber, German Aerospace Center (DLR), Germany
14:00 Towards the measurement of ablation products in hypersonic boundary layers
Joshua Hargis, Sandia National Laboratories, USA
14:20 An orthotropic thermal conductivity measurement in fibrous insulation materials
Alex Senig, University of Kentucky - Paducah Campus, USA
14:40 Experimental characterization of ablation and spallation in the plasma wind tunnel PWK1
Felix Grigat, University of Stuttgart, Germany

15:00 **Coffee Break** (Worsham Cinema)

Technical Session #7: Uncertainty quantification/Innovative methods
Chair: Charles Bersbach, Raytheon Technologies Corp., USA

15:20 Thermomechanical response of infrastructure protective materials to direct impingement by rocket exhaust
Jason Foley, Air Force Research Laboratory, USA
15:40 Simulating meteor ablation at the hypersonic materials environmental test system
Brody Bessire, NASA Ames Research Center, USA
16:00 Characterization of the oxyacetylene free stream and UHTC and graphite oxidation material response
Erica Corral, University of Arizona, USA
16:20 Calibration of nitridation reaction efficiencies from plasma wind tunnel data and beyond
Anabel del Val, Von Karman Institute for Fluid Dynamics, Belgium
16:40 Assessment of surrogate modeling techniques for use in 2D uncertainty quantification of ablation heat transfer
Bradley Heath, Northrup Grumman Corp., USA

17:00 **Conclusion/Adjourn**

Posters

- Samantha Bernstein, Colin Yee, Steven Kim, Wei Li, Joseph H. Koo, and Dilworth Y. *Parkinson Micro-Tomography Based Analysis of Thermal Protection System Materials*
- Alessio Gardi, Vincent Twin, Ellen K. Longmire, and Demoz Gebre-Egziabher *HyCUBE: An Emission Spectrometer Payload on a Hypersonic Reentry CubeSat*
- Sam Chen, Victoria Arias, Kelly A. Stephani, Brody K. Bessire, and Francesco Panerai *Microstructure and Oxidation Behavior of Fibers and Binders in Charring Ablator Preforms*
- Tyler D. Stoffel, Manuel Viqueira-Moreira, Christoph Brehm, and Savio J. Poovathingal *Development of a Computational Framework to Investigate Thermochemistry of Molten Flows in Aerothermal Entry Physics*
- Luis Chacon, Ben Deaton, and Savio J. Poovathingal *Decomposition and permeability of room temperature vulcanizing (RTV) silicone rubber used in thermal protection systems for re-entry capsules*
- Sergio Fraile-Izquierdo, Jeremie B. E. Meurisse, Georgios Bellas Chatzigeorgis, and Nagi N. Mansour *Mechanical Erosion Modeling of TPS Materials*
- Bibin Joseph, Raghava S. C. Davuluri, Aleksander L. Zibitsker, and Alexandre Martin *Preliminary analysis of multi-dimensional material response of DragonFly heat shield*
- Victoria A. DuPlessis, Kate B. Rhoads, and Alexandre Martin *Trajectory Modelling of Re-entry Vehicles*
- Grant E. Palmer and Olivia M. Schroeder *A combined CFD/material response analysis of 3MDCP arcjet experiments*
- Jakob Trammell, Max Honebrink, David Pham, and Erica L. Corral *Ablation and Oxidation Behavior of Aerospace Materials Using an Oxyacetylene Torch Facility*
- Simon Schmitt, Krishnan Swaminathan Gopalan, and Joseph C. Ferguson *Investigation of the effect of etch pits on the material properties of carbon fiber structures*
- Joel Douglas, Krishna Sandeep Prata, and Thomas E. Schwartzentruber *Finite Rate Ablation Model Applicability: Diffusion versus reaction limited regimes*
- Rui Fu and Alexandre Martin *Crack modeling in ablative materials*
- Sahadeo Ramjatan, Michael Kroells, and Thomas E. Schwartzentruber *Boundary layer flow over resolved material microstructure using air-carbon ablation model*
- Brendan Soto and Savio J. Poovathingal *A Combined Convolutional Neural Network (CNN) and Multi-Layer Perceptron (MLP) to Predict Effective Permeability*
- Jino George, Rui Fu, and Alexandre Martin *Incorporating Ablation Physics in Fluid Ablation Interaction Model*
- Jeremie B.E. Meurisse, Grant E. Palmer, Magnus Haw and Nagi N. Mansour *Arc jet CFD/ablation simulations using a plasma flow model in the arc heater*
- Federico Semeraro, Sergio Fraile Izquierdo, and Marcos Acin *Modeling the effective elasticity of anisotropic porous materials*
- Victoria Arias, Sam Chen, Brody K. Bessire, Justin B. Haskins, Francesco Panerai, Harley Johnson, and Kelly A. Stephani *The effect of pitting on the tensile behavior of amorphous carbon and carbon fiber*
- Samuel Chen and John Reinert *Hypersonic and Ablation Capabilities at JHU/APL*
- Bruce Crawford and Valerio Viti *Multi-physics simulation workflow for ablating Thermal Protection Systems (TPS)*
- Kirsten F. Ford, John D. Schmidt, Matthew P. Ruffner, William T. Smith, and Alexandre Martin *KREPE-2: The Second Orbital Entry Mission for the KRUPS Capsule*
- Diana Martins, Francisco Torres-Herrador, Bernd Helber, Alessandro Turchi, P. Gamboa, and Thierry E. Magin *Simulation of heat transfer of carbon fibers felts and microstructure effects on thermal conductivity of carbon/phenolic ablators*
- Benjamin Ringel, Bernd Helber, Andrea Fagnani, Alessandro Turchi, and Francesco Panerai *In-depth analysis of ablated carbon fiber preform in high-enthalpy plasma air*
- John M. Thornton, Dinesh K. Prabhu, Jeremie B.E. Meurisse, Arnaud Borner, Joshua D. Monk, and Brett A. Cruden *Coupling CFD and Material Response for Analysis of Mars Entry*
- Andrea Fagnani, Bernd Helber, and Olivier Chazot *Infrared ablation metrology in the VKI Plasmatron Facility*
- Lorenzo Capponi, Matthew T. Konnik, Trey Oldham, Kelly A. Stephani, Marco Panesi, Gregory S. Elliott, and Francesco Panerai *Plasmatron X: a New Ground Testing Platform for Hypersonic Ablation Research*
- Brian E. Riggs, Eric C. Geistfeld, Irina Gouzman, Chenbiao Xu, Thomas E. Schwartzentruber, and Timothy K. Minton *Table-Top Shock Tunnel for Studies of Shock Layer Chemistry and Rapid and Low-Cost Testing of Materials for Hypersonics*
- Kaan Kirmanoglu, Nicholas A. Anderson, Lorenzo Capponi, Francesco Panerai, and Kelly Stephani *Particle based simulations of the high temperature oxidation of carbon fibers*
- Joseph C. Ferguson, and Sigrid Elschot *Development of an immersed boundary heterogeneous isotropic heat equation solver in the Porous Microstruc- ture Analysis (PuMA) software*
- Cameron Brewer, Vijay Mohan, Luis Chacon, and Savio J. Poovathingal *Utilizing x-ray computed tomography to validate microstructures generated through fiber-generation algorithm*
- Massimo Franco, and Francesco Panerai *Ablation of Rocket Nozzles in PATO*
- Andrea Fagnani, Bernd Helber, and Olivier Chazot *Experimental and numerical study of graphite ablation in air plasma*
- Bruno Tacchi, Alexandre Martin, and Savio J. Poovathingal *Modeling material response for the orbital Flight of the Kentucky Re-Entry Universal Payload System (KRUPS)*
- Michele Capriati, Alessandro Turchi, Pietro M. Congedo, and Thierry Magin *Multi-Fidelity characterization of an under-expanded/supersonic high-enthalpy jet under uncertainty*
- Henry X. Varona, Seth Westfall, Massimo Franco, Gregory S. Elliott, and Francesco Panerai *Manufacturing HARLEM Lightweight Carbon Phenolic Ablator with Domestic Constituents*
- Kristen J. Price, Alexandre Martin, and Sean C. C. Bailey *Characterizing and modeling the spallation phenomenon utilizing arc-jet experiments*
- Jordan Burgess, John Craddock, Dali Qian, Vidyarani Sangal Matt Durandhara Murthy, Cody Fox, and Matthew Weisenberger *Tensile properties, density, diameter, and coefficient of thermal expansion of commercial carbon fibers as a function of heat treatment temperature*
- Craig Meade and Alexandre Martin *The Old Two-step: oxyacetylene combustion using a a two-step reaction mechanism and the effects on ablation*
- Ayan Banerjee and Savio J. Poovathingal *Estimating radiative coefficients and their influence on in-depth heating in porous ablators*
- Vijay B. Mohan Ramu and Savio J. Poovathingal *Development of a custom supervised learning network to model ablation of TPS materials*
- Celeste H. Guiles, Yanice Benitez, Jeffrey D. Engerer, Bernadette A. Hernandez-Sanchez, and Timothy K. Minton *Pyrolysis of Ablative Heat Shields: Phenolic Resin*
- Francisco Torres-Herrador, Samuel Tovey, Fabian Zills, Christoph Lohrmann, Thierry E. Magin, and Christian Holm *MDSuite: comprehensive post-processing tool for molecular dynamics simulations*
- Alessio Gardi, Vincent Twin, Ellen K. Longmire, and Demoz Gebre-Egziabher *HyCUBE: An Emission Spectrometer Payload on a Hypersonic Reentry CubeSat*
- Sean M. McDaniel, Rui Fu, Mujan N. Seif, Matthew J. Beck, and Alexandre Martin *Mesoscale structural analysis of inhomogeneities in ablative materials using statistical distribution of properties derived at the microscale*
- H. Berk Gur, Rui Fu, and Alexandre Martin *Porous Flow Analysis in the Presents of Thin Layers for Material Response*
- Christopher T. Barrow and John F. Maddox *Strain-Dependent Measurement of Conductivity in Fibrous Insulation Materials*
- Matthew T. Konnik, Vincent Le Maout, Kelly A. Stephani, and Francesco Panerai *Flow-tube furnace evaluation of the high temperature oxidation response of zirconium carbide*
- Ahmed H. Yassin and Savio J. Poovathingal *Solving radiative transfer equation inside porous ablators using reverse Monte Carlo ray-tracing method*
- Ares Barrios-Lobelle, Rui Fu, Savio J. Poovathingal, and Alexandre Martin *Modeling carbon fiber oxidation utilizing the hinge method*
- Bernd Helber, Loic Sombaert, Alan Viladegut, Olivier Chazot, and Louis Walpot *Commissioning and characterization of semi-elliptical and conical supersonic nozzles for material characterization in the VKI Plasmatron*
- Jaden Kim and Savio J. Poovathingal *Micro-structural feature analysis of American white oak in different conditions*
- Yejajul Hakim, John R. O'Nan, and Michael W. Renfro *Measurements of permeability of different virgin and charred materials (FiberForm, NORCOAT-LIEGE, ASTERM) used for TPS inside a vacuum system*
- John R. O'Nan, Yejajul Hakim, and Michael W. Renfro *The Determination of Geometric Tortuosity via Spectral Analysis of Gaseous Diffusion in Porous Thermal Pro- tection System Materials*
- Vijay B. Mohan Ramu, Luis Chacon, and Savio J. Poovathingal *Supervised learning model to predict the permeability of porous carbon composites used as TPS materials*
- Nicholas A. Anderson, Lindsay Lawless, Lam Banh, Kimberly D. Wakefield, Ricky Tang, Brian Z. Bentz, Francesco Panerai, and Jeffrey D. Engerer *Solar-Thermal Testing of Ablative Materials in Atomic Oxygen Plasma*
- R. Nicholaus Quammen, Mujan N. Seif, Matthew J. Beck, and Paul F. Rottmann *Directionally dependent mesoscale mechanics and strain localization in FiberForm under compression*
- Collin W. Foster and Francesco Panerai *Microstructure and Pyrolysis of Superlight Ablators for Entry Systems Backshell*
- Mujan N. Seif, Alexandre Martin, and Matthew J. Beck *Stochastic mechanical modeling of fibrous ablators: the influence of defects on directional behavior*

Local Organizing Committee

Dr. Savio J. Poovathingal, Chair
Assistant Professor
University of Kentucky
Lexington, KY 40506
saviopoovathingal@uky.edu

Dr. Alexandre Martin
Professor
University of Kentucky
Lexington, KY 40506
Alexandre.Martin@uky.edu