March
18-19,
2024

Raleigh, NC

Thermal Management Symposium and Workshop

Sponsored by the American Carbon Society and North Carolina State University

Welcome to a pivotal gathering that marks a new frontier in thermal management technologies. This workshop brings together the brightest minds from government, industry and academia to delve into the latest advancements and explore the future of high-temperature materials science. Through keynote speeches, panel discussions, poster sessions and hands-on lab tours, we will enhance the understanding of the challenges and opportunities within thermal management and foster collaborations that bridge the gap between theory and application. Join us to be at the forefront of shaping a future where thermal management technologies elevate safety, efficiency and performance across diverse sectors, contributing to the advancement of industries such as defense, energy, electronics and beyond.

Conference Chair and Co-Chair

Dr. Weiming Lu, Company Senior Technical Fellow, Collins Aerospace

Weiming Lu is the company senior technical fellow of Collins Aerospace, an RTX Business, and has been working for the company since 2003. Prior to joining Goodrich/Collins Aerospace, he worked for the Carbon Technical Center at ConocoPhillips as a project leader from 2000 to 2003. Lu has over 30 years of experience in advanced composite development and processing, including fibers, carbon/carbon and ceramic matrix composites (CMC). He earned a bachelor's degree in chemistry, a master's degree in chemical engineering and a Ph.D. in material sciences and engineering. He is a Fellow of the American Carbon Society. Lu is also an adjunct professor at the University of Connecticut, teaching a graduate course on carbon science and technology.

Dr. Cheryl Xu, Professor, NC State University

Dr. Cheryl Xu is a professor of mechanical and aerospace engineering at NC State University. Xu serves as editor-in-chief in Nature portfolio: npj Advanced Manufacturing. She is a Fellow of the American Society of Mechanical Engineers (ASME). Xu has served on the Fellows Committee of the IEEE Education Society since 2014. She is an expert with more than 20 years of experience in multifunctional ceramic materials, high-temperature wireless sensing, and artificial intelligence (AI) for process modeling and real-time control. Her research work has been supported by both government agencies and large defense companies that include and are not limited to the ONR, ARO, AFOSR, NSF, DOE, NASA, General Dynamics, etc. She has graduated eight Ph.D. and seven M.S. students. Most of her students work in major manufacturing industries, such as Google, Apple, SpaceX, GE, Lockheed Martin, Siemens, etc. She has co-authored one textbook and has written seven book chapters. She has 15 U.S. and international patents and patent applications.

This two-day event will promote high-temperature materials science and technology in the field of thermal management.

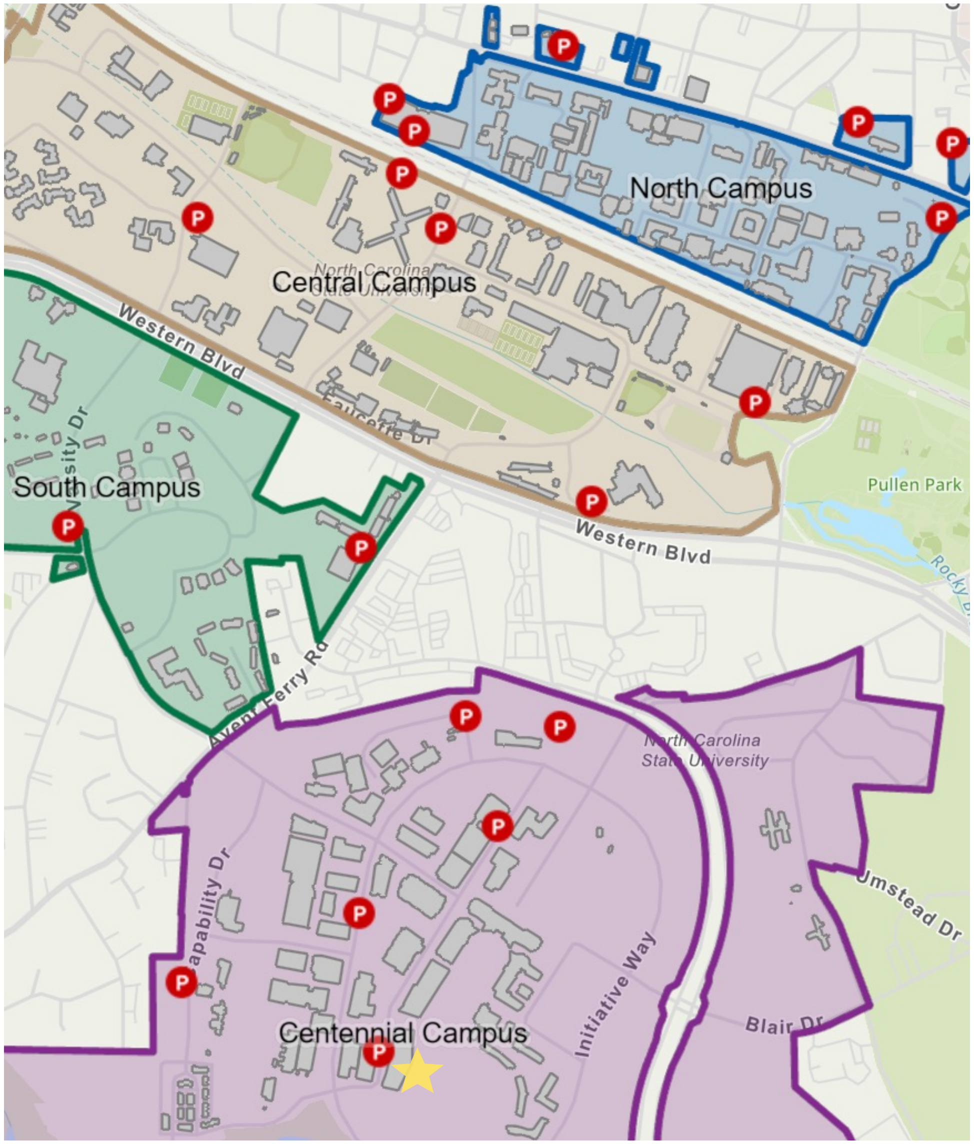
Four areas of potential opportunity have been identified for consideration:

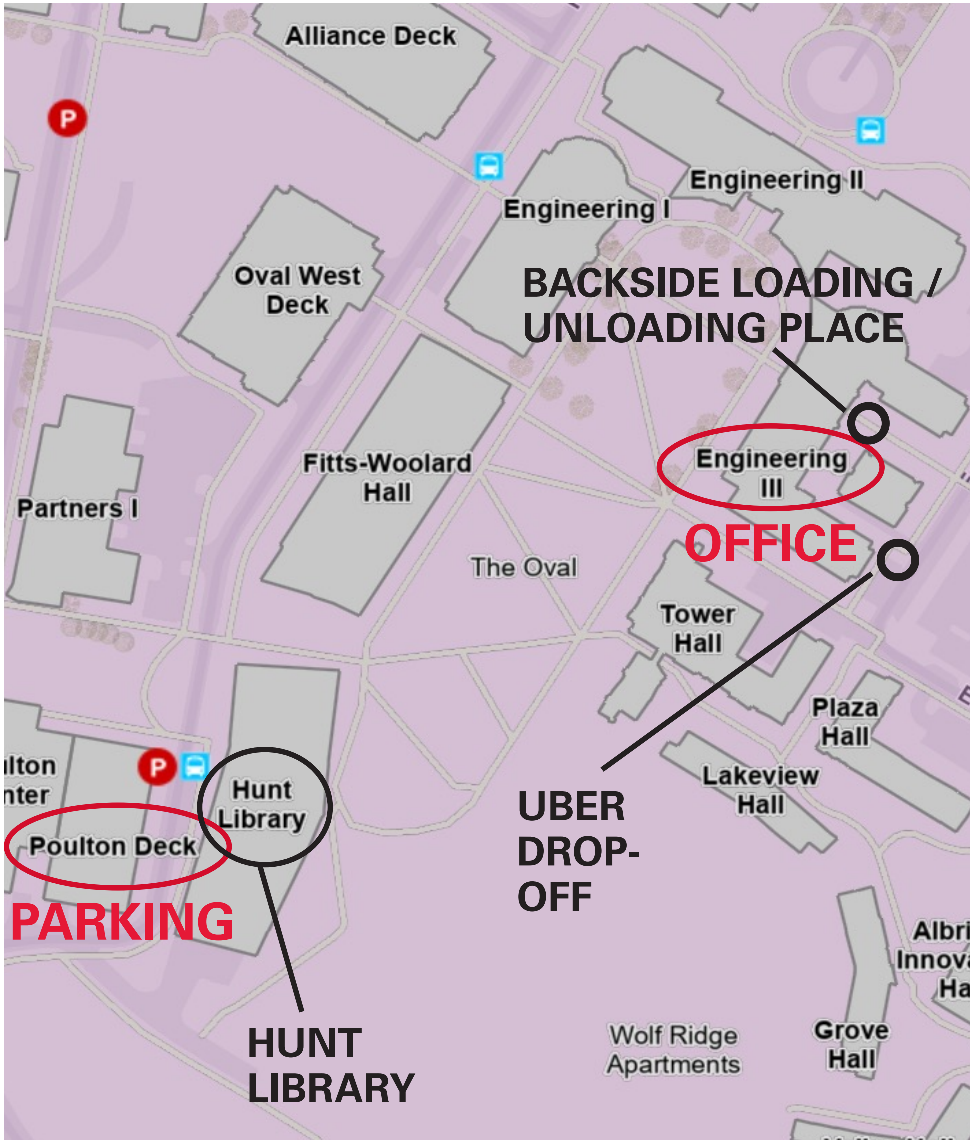
- Materials for Thermal Insulation
- Materials for High Thermal Conductivity
- Materials for Constructing Fire / Heat Barriers & Seals
- Thermal Analysis

CONFERENCE REGISTRATION AND FEE

The **conference fee is $350** (USD). The fee covers conference attendance, tours, handouts, refreshments, the reception and meals. There is also an online option for virtual conference attendance at a cost of $200. Attendees will receive a Zoom link to participate after completing registration.

Learn more and register at **go.ncsu.edu/thermal-conference-2024**.





EVENT LOCATION AND ACCOMMODATIONS

The conference will be held at the James B. Hunt Jr. Library on NC State's Centennial Campus. Participants are encouraged to stay at The StateView Hotel, located nearby. A daily shuttle service will run between the conference location and the hotel.

Program

MONDAY, MARCH 18

7:00 a.m. - 5:00 p.m.	**Registration**
7:00 a.m. - 8:00 a.m.	Breakfast
8:00 a.m. - 8:30 a.m.	Welcome / Introductions
8:30 a.m. - 12:00 p.m.	**Sessions I and II**
8:30 a.m. - 8:55 a.m.	I-1 and Q&A *with Anand Kulkarni*
8:55 a.m. - 9:20 a.m.	I-2 and Q&A *with Karen Thole*
9:20 a.m. - 9:45 a.m.	I-3 and Q&A *with Don King*
9:45 a.m. - 10:10 a.m.	I-4 and Q&A *with Matt Weisenberger*
BREAK	
10:40 a.m. - 11:05 a.m.	II-1 and Q&A *with Ryan Paul*
11:05 a.m. - 11:30 a.m.	II-2 and Q&A *with Andy Reynolds*
11:30 p.m. - 11:55 p.m.	II-3 and Q&A *with Afsaneh Rabiei*
12:00 p.m. - 1:30 p.m.	**Lunch**
1:30 p.m. - 4:30 p.m.	**Lab Tour**

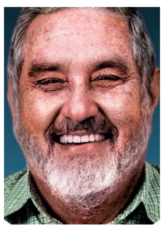
TUESDAY, MARCH 19

7:00 a.m. - 6:00 p.m.	**Registration**
7:00 a.m. - 8:30 a.m.	Breakfast
8:30 a.m. - 12:00 p.m.	**Sessions III and IV**
8:30 a.m. - 8:55 a.m.	III-1 and Q&A *with Gary Johnson*
8:55 a.m. - 9:20 a.m.	III-2 and Q&A *with Alex Morgan*
9:20 a.m. - 9:45 a.m.	III-3 and Q&A *with Wylie Simpson*
9:45 a.m. - 10:10 a.m.	III-4 and Q&A *with Hooman Tafreshi*
BREAK	
10:40 a.m. - 11:05 a.m.	IV-1 and Q&A *with Bhavesh Patel*
11:05 a.m. - 11:30 a.m.	IV-2 and Q&A *with Patrick Hopkins*
11:30 p.m. - 11:55 p.m.	IV-3 and Q&A *with Emiel DenHartog*
12:00 p.m. - 1:30 p.m.	**Lunch**
1:30 p.m. - 3:00 p.m.	**Panel Discussion**
1:30 p.m. - 2:10 p.m.	Thermal Management: Challenges *with Suraj Rawal, Carolyn Grimley, Rob Riegle, Andy Reynolds, Marc Simpson*
2:15 p.m. - 2:55 p.m.	Future Visions *with Dave Shifler, Bob Burton, Michael Mullins, Julian Norley, Emiel DenHartog*
BREAK	
3:00 p.m. - 4:30 p.m.	**Poster Session**

TOPIC 1: MATERIALS FOR THERMAL INSULATION

Early Ballpark Analysis: Entry

ABSTRACT: New product development often starts with the brainstorming of several candidate concepts and ideas. Full modern engineering design analyses mainly use finite element computer software. These are expensive in terms of effort and schedule time because the computer models require very large data sets, which in turn must be verified before use. There is rarely enough budget and scheduled time to do this for all the concepts and ideas. Guessing the "winner" among them is a low probability, as is getting a larger budget and longer schedule in order to enable doing all of them "right." What is needed are simple, quick analyses that are "ballpark correct", for screening the candidates down to the winner. The old by-hand, pencil-and-paper analyses used long ago but updated and automated with modern spreadsheet software, provide the necessary screening tools. The examples presented deal with entry analysis as it is used to design heat shields.



Dr. Gary W. Johnson, PE (ret.)

Dr. Johnson had a 20-year career in aerospace defense doing new product development design, analysis, test, and evaluation, first entering the workforce in the slide rule days with a master's degree in aerospace engineering from the University of Texas. As a graduate student, he did hypersonic wind tunnel testing of Space Shuttle nose shapes and spent one summer at LTV Aerospace working in the "Scout" launch vehicle program doing advanced configuration feasibility and customer launch support. In the workplace, the transition to the then-expensive pocket calculators was underway, but desktop computers were still years in the future. Mainframe computers were still "card batch input" in those days. He did rocket and ramjet missile propulsion development at Hercules / Rocketdyne in McGregor, Texas, and aircraft and missile decoy development at Tracor Aerospace in Austin, Texas. Those jobs included design analysis, prototype testing (including flight tests), test facilities design, test protocol development, and more. The author then had a second 20-year career that was mostly in teaching (math, physics, and engineering) at all levels from high school to university, plus some civil engineering and some aviation work. The aviation work included tests of alternate aircraft fuels, including supplemental type certificates from the FAA. He earned a doctorate in general engineering late in life, to support that second career. He is now retired.

TOPIC 1: MATERIALS FOR THERMAL INSULATION FOR HUMAN SAFETY AND COMFORT

Challenges in Developing Materials for Thermal Management of the Human Body

ABSTRACT: Humans are homeotherm, which means they need to be in thermal balance with their environment. When not in thermal balance people can at best not optimally perform, at worst will not be able to survive. A major part of the textiles and clothing industry is searching for materials to expand the range of conditions in which people are comfortable and/or safe. As the human body has a significant range of heat production, the challenges to providing materials in this domain are often underestimated. In this lecture, we will start from the principles of human heat exchange and focus on the limitations and opportunities that exist in a wide variety of conditions -on earth- to explore what opportunities for new materials and thermal technologies might exist for which thermal engineering could provide significant contributions. This will be explored with the human limitations in mind, i.e. when developing clothing systems people must be able to work, play or move in it. These human factors requirements provide exciting challenges, and some recent new fiber technologies may help open up more opportunities to enhance human safety and comfort in wider ranges of conditions.

Dr. Emiel DenHartog, Professor, NC State University

Dr. Emiel DenHartog is a Professor of the Department of Textile Engineering, Chemistry and Science (TECS) in the Wilson College of Textiles. He is the Director of Graduate Programs and Interim Department Head of TECS. He has a Masters' degree in Experimental Physics from the University of Utrecht in the Netherlands and Ph.D. in Biophysics from the Erasmus University, Rotterdam, The Netherlands. After his PhD he went to work for more than 15 years in the Defense research on military and first responder personal protective clothing and thermal physiology. He has worked at the Wilson College of Textiles at North Carolina State University since 2013. He actively collaborates with a wide range of scientists, conducting research on the evaluation of the interaction of humans and textiles, focusing on human health, performance, and comfort. In 2019, he received the NC State Award as a University Faculty Scholar (UFS) for his contributions to research and education in this field. In summer 2020 he was hired part-time by the CDC/NIOSH/NPPTL lab to provide support in testing, standards, and conformity assessment on issues of protective clothing for health care and first responders.

TOPIC 2: MATERIALS FOR HIGH THERMAL CONDUCTIVITY

Tensile properties, density, diameter, and coefficient of thermal expansion of commercial carbon fibers as a function of heat treatment temperature

ABSTRACT: Ample evidence in the literature suggests that typical, standard and intermediate modulus PAN-based carbon fibers are carbonized to temperatures between 1000 and 2000 °C during production. Yet, in some cases, these carbon fibers are subsequently heat treated to temperatures beyond 2000 °C. For example, carbon fiber – carbon matrix composites, such as aircraft brake discs utilizing PAN-based carbon fibers, are often graphitized to such temperatures. These graphitization heat treatments, above the original carbon fiber's carbonization temperature, irreversibly alters several fiber properties such as density, diameter, tensile modulus, strength, strain to failure, and coefficient of thermal expansion (CTE). This processing essentially renders the original carbon fiber data sheets irrelevant. Here we report on the effect of post-production graphitization heat treatment from 1500 to 2700 °C, on a set of three commercial carbon fibers: T300, AS4, and IM7. A novel measurement method for the axial CTE of collimated carbon fiber bundles, without matrix, was achieved and is described.

Dr. Matthew C. Weisenberger, Associate Director, University of Kentucky

Weisenberger has been at the University of Kentucky Center for Applied Research (UK CAER) since 2000, and since 2015 has served as associate director and leader of the Carbon Materials Group. Since the early 2000s, a large part of his research has focused on carbon fiber processing, structure and performance, including solution-spun PAN-based carbon fiber, melt-spun (mesophase) pitch-based carbon fiber, and carbon nanotubes. In 2006, UK CAER commissioned a fiber development facility that today operates as the largest solution-spinning facility outside of industry in North America. Recent and current work is focused on low-cost, high-strength carbon fiber — including multifilament tow, hollow PAN-based carbon fiber. Additionally, the Carbon Group is very active in the conversion of coal to graphitic products, including general-purpose and high-performance carbon fiber and anode-grade graphite. Weisenberger has served on the executive committee of the American Carbon Society (2010 – 2019) and is currently a member of the advisory committee. At the University of Kentucky, in addition to being associate director of CAER, he serves as an adjunct assistant professor in materials science and engineering and is a member of the graduate faculty.

Bios of the Invited Speakers

TOPIC 2: MATERIALS FOR HIGH THERMAL CONDUCTIVITY

Assessing the performance of graphite materials under extreme thermal conditions

ABSTRACT: As a class of engineered materials, manufactured graphite materials are composites that broadly can include both polygranular and fiber reinforcements. For over 100 years, advanced graphite materials have been put to the test in demanding applications ranging from energy generation, energy storage, aerospace, and metal processing. A commonality is that the unique thermal and mechanical properties of manufactured graphite have enabled high performance even under extreme conditions, whether that be, for example, the intense thermal radiation from an electric arc in a steel furnace or irradiation from neutron flux in a nuclear reactor core.

The goal of this talk is to present various performance assessments of advanced graphite materials under intense thermal conditions. This will not only illustrate their incredible performance but also highlight the important areas where future research and collaboration are needed to continue to push the limits. While there exist a robust set of international standards regarding graphite testing, these are not all inclusive and further work is needed to better clarify their structure-properties-performance.

Dr. Ryan Paul, Associate Director of Research & Development, GrafTech International

Dr. Paul is a native of Youngstown, Ohio, and has a Ph.D. in materials science and engineering from Ohio State University. He has been working in the field of carbon and composite materials for 20 years, including academic, national lab and industrial roles. At GrafTech, he has led the commercialization of several new products and processes and is a co-inventor on two patent applications. Ryan is passionate about mentoring in science and engineering for both industry and academic roles and promoting scientific literacy. He serves on the advisory board for the American Carbon Society and is an active executive committee member for the Cleveland Chapter of ASM International. He was named a STEM Exemplar by the Believe in Ohio Program, part of the Ohio Academy of Science. His awards include the Technical Achievement Award and Technical Educator Award by the Cleveland Technical Societies Council, the Young Members Award by ASM Cleveland and the Chairperson's Award by ASM Cleveland. In recognition of his achievements in carbon materials science, the American Carbon Society selected him as the prestigious Graffin Lecturer for 2021.

TOPIC 3: MATERIALS FOR HEAT BARRIERS

Exploring Additive Manufacturing for Advancing Cooling

ABSTRACT: Recent advances in the field of additive manufacturing (AM) have widened the possibilities of new features in designs aimed at convective cooling applications. Using additive manufacturing allows for increasingly small and complex geometries to be fabricated with little increase in time or cost while rapidly decreasing the time to do development. The opportunity is to exploit the use of additive manufacturing in re-thinking cooling schemes for components while considering the inherent effects of the metal additive process. This talk will also provide insights into various challenges associated with additive manufacturing components.

Dr. Karen A. Thole, Distinguished Professor, Pennsylvania State University

Dr. Thole is a Distinguished Professor in the Department of Mechanical Engineering at The Pennsylvania State University. She is a Fellow of ASME, AIAA, and the Royal Aeronautical Society. Dr. Thole's expertise is heat transfer and cooling of gas turbine airfoils through detailed experimental and computational studies. She directs the Steady Thermal Aero Research (START) Lab, which focuses on heat transfer, additive manufacturing, and instrumentation development. Dr. Thole's most recent awards include ASME's R. Tom Sawyer Award and the Heat Transfer Memorial Award. In 2019, she was recognized by AIAA's Air Breathing Propulsion Award and in 2022 by AIAA's Thermophysics Award for her work in additive manufacturing. She holds two degrees in Mechanical Engineering from the University of Illinois, and a Ph.D. from the University of Texas at Austin.

Bios of the Invited Speakers

TOPIC 3: THERMAL BARRIER COATING

Materials and Manufacturing solutions for high-temperature gas turbine environments

ABSTRACT: Electrical power generation is becoming increasingly reliant on gas turbines, with research advances focused on increased efficiency/power output, multiple fuel capability, and reduced emissions. Gas turbines are utilized in highly efficient, cost-effective, and environmentally acceptable industrial and power generation plants. Most gas turbine plants have been developed to operate with natural gas and oil-derived fuels that contain extremely low levels of ash and impurities. Gas turbine components see a variety of localized damages in service operations that result in increased scrap rates or reduced performance. This can be attributed to demanding component conditions (temperatures) and engine conditions, needing materials and design upgrades. The talk discusses material developments coupled with innovative manufacturing approaches to be married with advanced design strategies to realize the needed improvements at a reasonable cost. This hybrid manufacturing approach takes advantage of conventional processes like casting and brazing, together with AM, for new as well as service-run repair components. The case studies for combustion and turbine components will be presented to demonstrate the structure-property relationships, accelerated testing, and improved component performance for future needs related to decarbonization via the hydrogen economy.

Dr. Anand Kulkarni, Siemens Corporation; Dr. Ahmed Kamel, Siemens Energy Inc.

Dr. Kulkarni is a Sr. Principal Key Expert in the Advanced Manufacturing and Circularity group within Siemens Corporation, Technology US in Charlotte, NC. He joined Siemens Energy in the Materials and Technology group in 2004 and then transitioned to Siemens Corporation in 2012. He has over 25 years of experience in R&D in materials/ coatings / sensors for power systems, 12 years in materials needs for environmental and operational flexibility, and 10 years in data-driven intelligent manufacturing for additive manufacturing (AM). While at Siemens, Dr. Kulkarni led and supported over 50 programs in the area of materials, coatings, additive manufacturing (AM), and sensors. Overall, Dr. Kulkarni has fostered multidisciplinary research programs with several external partners, universities, and national laboratories to successfully transfer technology to internal programs / products for implementation into power systems.

TOPIC 4: THERMAL ANALYSIS

Materials Characterization for Extreme Environments

ABSTRACT: There is a continuing need to develop materials capable of maintaining structural integrity and strength at high temperatures for use in extreme environments. Such environments are defined by stressing thermal and structural loads and often include degrading chemical reactions (such as oxidation). This presentation will discuss applications, environmental factors, and testing options for materials used in high-temperature and oxidizing environments with an emphasis on high-speed flight conditions. The challenges associated with fabricating and protecting ceramic and metallic materials in these environments will be highlighted. High-temperature testing options for characterizing the mechanical and thermal performance of the material will also be reviewed. Unique test facilities capable of reaching ultra-high temperatures will be discussed.

Mr. Don E. King, Principal Professional Staff, Johns Hopkins Applied Physics Laboratory (APL)

Mr. King's career at APL has focused on the development and application of high-temperature materials and protective coating systems for both terrestrial flight vehicles and spacecraft. He was a key member in the development of the heat shield technology used on NASA's Parker Solar Probe. He has been involved in planning and directing high-temperature tests of new material systems as well as the development and use of lower-cost high-temperature test methods. Over the past decade, he has led research teams focused on applying protective coating and additive manufacturing technologies to develop integrated multi-functional structures and systems for use in high-temperature oxidizing environments.

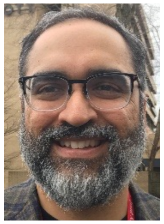
His thermal background also includes the design and analysis of thermal management techniques for electronic systems and components ranging from commercial to military applications. Prior to joining APL in 2002, Mr. King's experience included the telecommunications industry, military projectiles, and sensors, and building and aircraft insulation systems. Mr. King is a graduate of North Carolina State University (BSME 1979 and MSME 1981).

Bios of the Invited Speakers

TOPIC 4: THERMAL ANALYSIS

Best Practices for Measuring Thermal Properties of Composites

ABSTRACT: In the past 65 years, Kratos SRE (KSRE) has worked with NASA and DoD to push the boundaries of space and propulsion system materials' performance in extreme environments via testing and analysis at a wide range of temperatures and conditions. KSRE takes great care in working with our partners/customers to ensure material properties are adequately used in analytical models and to develop test techniques to aid analysts in obtaining the data required for specific models. This is critical in the future as breakthrough material technology expands, given the fruits of conducting research in extreme environments. This discussion will start with a brief introduction to the unique thermo-mechanical facilities for evaluating breakthrough materials (i.e., TPS, C/C, CMCs, and refractory metals) in applicable environments within a laboratory setting. Then, the main focus of the presentation will be best practices for thermal property measurement of carbon-based systems, including PMC and CMCs, with a discussion on how anisotropy can lead to a high level of uncertainty.



Mr. Bhavesh Patel, Director, Space and Propulsion Systems Department, Kratos SRE

Mr. Patel has 20 years of experience at Kratos SRE (KSRE) in testing advanced materials for high-temperature and cryogenic applications. Mr. Patel is currently the director of a team of 15 engineers responsible for managing and executing materials evaluation efforts for NASA, DOD, gov't subcontractors, and industry. Mr. Patel has served as KSRE's technical advisor to our thermal laboratories, where many material evaluation efforts have been undertaken from -450 to 5000 °F. In addition, Mr. Patel has been a project leader on many DOD and NASA-sponsored programs to characterize materials for use in extreme thermo-structural environments, including Sierra Space's Dream Chaser. His and his team's responsibilities include proposing and managing projects for various internal and external efforts that entail designing and constructing new test facilities which will facilitate additional external efforts and supervising the testing and analysis of various exotic high-temperature composites, carbon phenolics, refractory metals, and ceramic foams and tiles. He and his team have been involved in the characterization of materials for NASA orbiter repair, re-entry bodies, hypersonic vehicles, solid rocket motors, and next-generation vehicles. His group has also been leading and facilitating the development of a new facility that will perform mechanical tests in various temperature / pressure combinations and vacuum up to 5000 °F (4000 °F in air). He has expertise in physical, mechanical, and thermal property testing at temperatures ranging from cryogenic to over 5000 °F in inert or oxidizing environments (oxidizing up to 4000 °F) at a wide range of heating rates.

Dr. David A. Shifler, Program Officer, Office of Naval Research

Dr. Shifler is a Program Officer at the Office of Naval Research (ONR) and manages the Propulsion Materials portfolio. He has longstanding contributions to corrosion engineering as a researcher, mentor, and program manager, for materials research and development across government laboratories, academia and industry. At ONR, the research concentration areas focus on how to reduce and manage material instabilities and degradation:

- Computational approaches to creating new materials, evolving new and enhanced understanding of degradation mechanisms, developing optimal material processes, or improving the performance of current materials are encouraged.
- Current materials include Ni-base single-crystal superalloys, ceramic matrix composites, multiple principal element alloys, complex concentrated alloys, ceramics, Mo-based superalloys, polymer matrix composites, bond coats, thermal barrier coatings, environmental barrier coatings, and overlay and diffusion coatings resistant to oxidation and corrosion environments.
- Investigate mechanisms that lead to materials degradation, which should also explore how these mechanisms fundamentally relate to and/or depend on mechanics, diffusion, interdiffusion, interstitials, coatings, and materials chemistry, as well as the marine environmental effects by temperature, salt ingestion, pressure, and humidity.
- Understand multivariable diffusion, portioning, and precipitation kinetics in single and multiphase complex alloys at high temperatures to predict surface passivation structure and kinetics.

Mr. Bob Burton, Director, North Carolina Defense Technology Transition Office (NC DEFTECH)

Bob Burton is the Director of the North Carolina Defense Technology Transition Office (NC DEFTECH), where he strategically connects the state's innovation ecosystem with the urgent technology needs of the Departments of Defense and Homeland Security. His mission is technology transition to accelerate optimal solutions for the nation's most critical defense and homeland security requirements.

Bob, a retired Special Forces CSM, brings over 25 years of distinguished special operations leadership experience to his current role. His career trajectory encompasses early operational assignments and over a decade of executive-level leadership advising at the highest echelons within the U.S. Army Special Operations Command (USASOC). Bob's extensive deployments in CENTCOM, EUCOM, and PACOM areas of responsibility honed his ability to influence and drive strategic results supporting U.S. security objectives.

His combat leadership spans local and national engagements, advising diplomatic and military operations in complex security environments.

Bob holds a Master's degree in Executive Leadership from Liberty University, and his post-military experience includes work as an Executive in Residence for Hacking for Defense at North Carolina State University. In this role, he mentored the development of innovative solutions for USSOCOM's most pressing capability needs.

Conference Panelists

Dr. Suraj Rawal, Technical Fellow, Lockheed Martin

Dr. Rawal is a Technical Fellow in the Advanced Technology Center, Lockheed Martin Space Systems Company. Dr. Rawal received his B.Tech. at Indian Institute of Technology, Kanpur, India; and Ph. D. in Materials Science and Engineering at Brown Univ., RI, USA. He has over 30 years of experience in advanced materials and structures technologies. He has been a program manager and principal investigator of several contracts research and development programs in the areas of advanced composites, multifunctional materials and structures, ablators, thermal management, additive manufacturing, and sharp leading edges for hypersonic vehicles.

Dr. Rawal has successfully transitioned several components related to thermal management, advanced composites, nanocomposites, additive manufacturing, and multifunctional structures technologies into DoD/NASA spacecraft. He represents LMS in the advisory panels of the mechanical engineering department of Colorado State University, University of Denver, and University of Colorado. He is Deputy Chair at Rocky Mountains SAMPE chapter. Dr. Rawal has received several Lockheed Martin awards, including inventor, author, and technical excellence, and has authored over 80 articles. He holds nine patents and five trade secrets in the areas of thermal management, lightweight ablators, hypersonic, and multifunctional structures technology.

Dr. Julian Norley, Norley Carbon & Graphite Consultants, LLC

Dr. Norley is a consultant in the field of Carbon & Graphite materials with 39 years of experience. Former Vice President of Research & Development at NeoGraf Solutions & GrafTech International. He specializes in flexible graphite materials for electronics thermal management applications, also fuel cells, fire retardants, graphite electrodes, carbon/carbon composites, graphene and lithium-ion anode materials. Dr. Norley received five R&D 100 awards and has won and executed over $25 million in federal and state grants related to fuel cells, electronic thermal management, li ion batteries and carbon fibers. In his consulting capacity, Dr. Norley currently has 25+ clients in the government, university and private sectors, providing a range of technical, marketing and business services over a broad spectrum of carbon and graphite materials.

Mr. Michael Mullins, Director of Defense Industry Initiatives, NC State University

Michael Mullins is the Director of Defense Industry Initiatives at Industry Expansion Solutions (IES), NC State University. Michael is a former Marine Infantryman and retired Army Officer. He has extensive experience executing and managing Department of Defense training contracts in Sub-Saharan Africa, Eastern Europe, the Caucasus, and Southeast Asia. Michael has worked closely with the Department of State, various foreign ministries, non-governmental organizations, the United Nations and the Organization for Security and Cooperation in Europe. Additionally, he served as an Assistant Professor of Military Science at the University of North Carolina at Chapel Hill and Vanderbilt University. Michael has a comprehensive understanding of the processes and procedures North Carolina businesses face in the acquisition and execution of U.S. government contracts. In Fayetteville, he served as an International Operations Program Manager with General Dynamics, Project Manager for foreign military training programs with American Systems Corporation and Operations Manager with a Service Disabled Veteran Owned Small Business (SDVOSB). Michael has a B.S. in Political Science and an M.S. in International Relations.

Dr. Andy Reynolds, CTO and Sr. VP of M&A, Neograf Solutions

Dr. Reynolds joined GrafTech in 2000 as a Staff Scientist supporting the specialty graphite businesses. From there he advanced through various technical and business leadership roles eventually leading the spinout of NeoGraf Solutions from GrafTech in 2017. Currently Dr. Reynolds is the CTO and Sr. VP of M&A for Neograf Solutions. He holds a BSc. in Chemistry from Bowling Green State University, a Ph.D. in Inorganic Chemistry from The University of Michigan and was a recipient of a National Institute of Health postdoctoral fellowship to Northwestern University for research in the emerging field of Nanotechnology. Dr. Reynolds is the author or co-author of more than 20 peer-reviewed publications, has over 20 issued US patents (as well as the foreign equivalents) and has given invited lectures at numerous conferences globally.

Conference Panelists

Dr. Carolyn Grimley, Commercial Scientist, Lucideon

Dr. Carolyn Grimley leads the US Advanced Materials and Processes team at Lucideon, which focuses on a wide variety of challenges behind designing, manufacturing, and testing materials for harsh and high temperature environments. Her research background is based on the processing of advanced ceramics, with a particular focus on novel sintering techniques. During her four years at Lucideon she has further expanded her work into projects which integrate both first-principles and machine learning techniques with real-world synthesis, fabrication, and characterization methods.

Dr. Robert Riegle, Director of Government Affairs and Chief Counsel, Sub Rosa Venture

Dr. Robert Riegle previously has performed work in North America, South America, Central America, the Middle East, North Africa, and Southeast Asia. Dr. Riegle has developed security solutions for National Security Agencies, US Dept. of Homeland Security and Law Enforcement organizations worldwide. He is a nationally recognized leader in Strategic Communications with over 50 public engagements relating to formulating communications strategies for threat mitigation.

As a Government leader, Dr. Riegle served as the Director of the State and Local Government Program Office within the Office of Intelligence & Analysis in The U.S. Department of Homeland Security. Dr. Riegle entered the Senior Executive Service in 2007 after nearly fifteen years of Government employment. He served as the DHS representative to the Department of Justice's Global Justice Initiative, the Co-chair of the National Fusion Center Coordination Group and as an advisory member of the Criminal Intelligence Coordinating Council. Prior to working at DHS, Dr. Riegle worked at Booz Allen Hamilton in the Strategic Communications Area; the Defense Intelligence Agency as a National Intelligence Support Team (NIST) Intelligence Specialist, serving in Operations Iraqi Freedom.

Dr. Riegle holds a Bachelor of Science degree in Government from the University of Maryland and a Juris Doctor degree from The Catholic University of America – Columbus School of Law. He has numerous military awards and decorations including two Combat Action Ribbons, The Joint Commendation Medal, The Joint Achievement Medal, and four Navy Achievement Medals. He is a member of the UDT/Seal Association, the Association of Former Intelligence Officers, the American Bar Association, and Iraq and Afghanistan Veterans Association. He serves as a member of the NDIA Advisory Board to Wright-Patterson AFB, and as an Advisory Board member to the National Small Business Association (NSBA).

Mr. Marc Simpson, Senior Sales Account Executive, 3M

Mr. Simpson is a Senior Sales Account Executive for the 3M Company Advanced Materials Division. He has been working for 3M since 1991 and in the field of ceramic composites since 1985. Prior to joining 3M he worked for BFGoodrich and Refractory Composites Inc. Marc has experience in CVI and CVD processing of fiber reinforced composites, composite design, fabrication, testing and analysis. More recently he has focused on oxide ceramic fiber reinforced composite materials (Ox/Ox CMC's.) He earned a Bachelor's degree in Chemical Engineer at UC San Diego and a Master's degree in Materials Science from UC Los Angeles.

Dr. Emiel DenHartog, Professor, NC State University

Dr. Emiel DenHartog is a Professor of the Department of Textile Engineering, Chemistry and Science (TECS) in the Wilson College of Textiles. He is the Director of Graduate Programs and Interim Department Head of TECS. He has a Masters' degree in Experimental Physics from the University of Utrecht in the Netherlands and PhD in Biophysics from the Erasmus University, Rotterdam, The Netherlands. After his PhD he went to work for more than 15 years in the Defense research on military and first responder personal protective clothing and thermal physiology. He has worked at the Wilson College of Textiles at North Carolina State University since 2013. He actively collaborates with a wide range of scientists, conducting research on the evaluation of the interaction of humans and textiles, focusing on human health, performance, and comfort. In 2019, he received the NC State Award as a University Faculty Scholar (UFS) for his contributions to research and education in this field. In summer 2020 he was hired part-time by the CDC/NIOSH/NPPTL lab to provide support in testing, standards, and conformity assessment on issues of protective clothing for health care and first responders.

Ho-Suk Choi, Chungnam National University, Korea
Graphene-Coated Copper Nanowires with Strong Oxidation Resistance

Gary Johnson, Retired
Insulating liner for an airbreathing combustor made of ceramic pipe insulation paste reinforced with fire curtain cloth

Gary Johnson, Retired
Ablative liners for a fuel-rich solid-propellant gas generator-fed ramjet

Sajjad Bigham, Behzad Ahmadi, NC State University
High-Density SSiC 3D-Printed Lattices for Compact HTHP Aero-Engine Recuperators

Veeraraghava Raju Hasti, NC State University
Conjugate heat transfer analysis of realistic gas turbine combustor liners

Veeraraghava Raju Hasti, NC State University
Simulation of bidirectional boiling flow with phase change in microchannels for electronics cooling applications

James Braun, Jack Grunenwald, NC State University
Thermal Management in Rotating Detonation Engines with Bladeless Turbines

Arun Kota, Mohammad Javad Zarei, NC State University
Stretchable superomniphobic surfaces and simulation for stress analysis

Arun Kota, Young Jae Kim, NC State University
Understanding the Influence of Molecular Ordering on Wetting Resistance

Cheryl Xu, Luke Joyce, NC State University
Additive Manufacturing of High Temperature Ceramics using an Electron Beam Melting (EBM) Process

Cheryl Xu, Nick Maier, NC State University
Exploration of Toroidal Propeller Performance for Unmanned Aerial Vehicles (UAVs)

Cheryl Xu, Michael Reid, Wes Tucker, NC State University
High temperature wireless radiofrequency (RF) sensor array for extreme environment applications

Cheryl Xu, Jason Solomon, NC State University
High temperature electromagentic (EM) absorbing or shielding coating materials made of ceramics

Cheryl Xu, Stephen Kimball, NC State University
Enhancing Electromagnetic and Thermal Performance of Ceramics through Advanced Additive Manufacturing Techniques

Jun Liu, Cong Yang, NC State University
Toward thermal insulation coating: anomalous correlation between thermal conductivity and elastic modulus in two-dimensional hybrid metal halide perovskites

Jun Liu, Ziqi Wang, NC State University
Thermal conductivity design guideline for coatings: phonon mean free path distribution in inorganic perovskite Barium Titanate

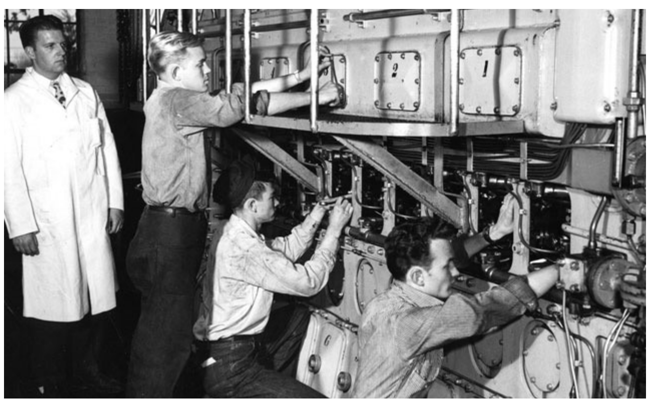
Department of Mechanical and Aerospace Engineering

MECHANICAL AND AEROSPACE ENGINEERING (MAE)

The Department of Mechanical and Aerospace Engineering (MAE) at North Carolina State University (Raleigh, NC) is the largest in the state and among the largest and most prominent in the nation. The department offers Bachelor of Science (B.S.), Master of Science (MS) and Doctor of Philosophy (Ph.D.) degrees in both Mechanical Engineering (ME) and Aerospace Engineering (AE). The department also offers accelerated B.S. / M.S. degrees in both mechanical engineering and aerospace engineering. The Department of Mechanical and Aerospace Engineering has a highly recognized faculty and an enrollment of over 1200 undergraduates and more than 400 graduate students.

The strengths of the department include the thermal sciences, particularly thermal fluids, fluid mechanics, and combustion; mechanical sciences, including manufacturing mechanics, structural dynamics, materials, and controls; and the aerospace sciences, particularly aerodynamics, aircraft design, hypersonics, propulsion, flight research using UAVs, and computational fluid dynamics.

Our vision is for mechanical and aerospace engineering at NC State to be at the forefront of education, research, and outreach. Our mission is to be a flagship engineering department that benefits all people of North Carolina and the global society by making a profound impact on current and emerging science and technologies, fostering exemplary, synergistic, multidisciplinary research and education programs in close partnership with industry and government, providing the environment for innovative professional and scholarly development, and graduating highly skilled, ethical engineers who will thrive in a rapidly changing world and be future leaders in technology and society.



Department History

… from its beginnings in 1889 at the North Carolina College of Agriculture and Mechanic Arts…

About the Department

The anechoic chamber

The anechoic chamber mimics an infinite space by absorbing acoustic and electromagnetic waves, providing a perfect environment to test those waves without reflectivity affecting the measurements being taken.

Students success

Research Experiences for undergraduate and graduate students

THE NONWOVENS INSTITUTE

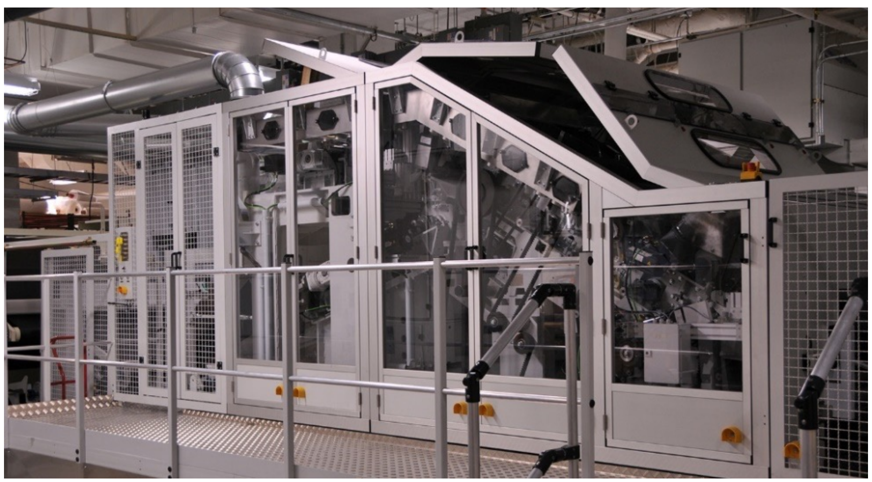
ABOUT THE NONWOVENS INSTITUTE

The Nonwovens Institute (NWI), as part of the Office of Research and Innovation (ORI) at North Carolina State University, is the world's first accredited academic program for the interdisciplinary field of engineered fabrics. A partnership among stakeholders spanning the breadth of the nonwoven value chain, NWI operates across the full stage-gate research range from basic to translational to commercialization, engaging government, industry, and academia to enable next-generation nonwoven solutions to mission-critical challenges.

NWI's pillar focus areas include Knowledge Creation, Workforce Development, Fabrication and Testing, Product Development, and Product Incubation. NWI houses extensive state-of-the-art facilities from fiber and fabric formation to a full range of analytical and physical testing operated with strict adherence to standard test methods. These capabilities are available for running trials, product development, and commercialization, as well as for training purposes.

Nonwovens are engineered fabrics that serve applications in thermal management, as well as many others, from baby diapers to feminine care and incontinence hygiene, medical surgical drapes, gowns, HVAC filtration, respirators and facemasks, cleaning and personal care wipes, automotive and transportation, geosynthetics for road stabilizing, construction insulation, composites, and apparel.

High-Speed Nonowoven Card



About the Nonwovens Institute

Meltblown Nonwoven Pilot Line

Spunbond Nonwoven Pilot Line

CAMAL
Center for Additive Manufacturing and Logistics

ABOUT THE CAMAL CENTER

The Center for Additive Manufacturing and Logistics (CAMAL) at North Carolina State University is a leading US domestic manufacturing education and research institute located in a new state-of-the-art facility. The three major research components of the center are a) Additive Manufacturing, b) Advanced Manufacturing & Machining, and c) Materials Characterization. Below are highlights of the CAMAL capabilities and infrastructure available for performing research:

Additive manufacturing:

CAMAL currently has metal additive manufacturing systems dedicated to new materials development, geometry design, alloy development, and in-situ process monitoring & control. Our powder bed fusion (PBF) systems range across multiple beam powers, wavelengths and energy sources. These include Laser-based systems: 1) EOS M290 (400W) & 2) M280 (200W), 3) Concept Laser M100R (100W), and 4) Xact Metals XM200C (100W), installed Fall 2023 with build areas ranging from 8"x10" to 4"x4". Additional AM capabilities include Arcam 5kW electron beam (EB) PBF machines (S12, A2, A2X, and Q10 models) and a Freemelt ONE EB-PBF w/ 6kW source. The Center also has over 20 polymer printing machines ranging from filament FDM, polymer powder bed, selective laser sintering (SLS), UV cured jetting, and stereolithography utilizing printers from Stratus, Bambu, Objet, FUSE, HP, Mark Forge, Rapid Shape, among others. This flexibility allows us to quickly optimize designs for testable structures over a wide range of materials.

Advanced Manufacturing & Machining:

Metal Powder Atomizer: New alloy development is performed on an Arcast pilot-scale gas atomizer with four melt modes: utilizing plasma & induction with a batch size typically 1-3 Kg per run, which is well matched for R&D size requirements.

Advanced Manufacturing & Machining: CAMAL also has an advanced machine shop with 1) HAAS VF 2 Vertical Machining Center, 2) HAAS VF 3ssyt Vertical Machining Center, 3) Mazak Integrex i- 100ST, 4) HAAS Multigrind CA 5-Axis Grinding Center, 5) Citizen Machinery Cincom L20, 6) AME C1000 Friction Stir Welder, 7) Mitsubishi FA10S CNC Wire EDM, 8) Amatek Creaform Laser Scanner, 9) Zeiss Coordinate Measuring Machine(CMM), and 10) Mitutoyo Quick Scope QS-L2010Z/AFC.

About the CAMAL Center

Materials Experience:

CAMAL has extensive experience in a number of materials related to Additive Manufacturing and Advanced Manufacturing. The table below includes a selected list of materials used in research at CAMAL:

Ti-6Al-4V	cp-Ti	IN718	IN625
MAR 247	Co-28Cr6Mo	SS316	SS304
SS 17-4 PH	MS-1	AL-Si-10Mg	Molybdenum
Tungsten	C-103	Copper	GR-Cop alloys

Fitts-Woolard Hall: The passage of Connect NC in March 2016, brought us closer to putting our faculty, staff, and students together with top businesses and government agencies on Centennial Campus which serves as a model for the ideal 21st-century research campus.

CAMAL Center:

EOSINT M280: a standard DMLS machine with a build envelope of 250 x 250 x 325 mm and a 200W fiber laser

As our workshop concludes, we stand on the point of a new era in thermal management —an era where the synergy of innovative materials and forward-thinking solutions promises to redefine our approach to managing thermal challenges. The discussions held, connections made and knowledge shared here underscore the vital role of interdisciplinary collaboration in pushing the boundaries of what is possible. We are not just addressing the immediate needs of various industries but are laying the groundwork for a sustainable future. The contributions of this workshop extend far beyond technical advancements; they are pivotal in shaping a world where technology enhances the quality of life for all mankind. Together, we are not only engineering solutions for today but are also igniting the sparks of innovation that will illuminate the path for generations to come.