



Workshop Session on Transformative S&T for Defense: Materials and Manufacturing for Contested Environments

Keck 100, 500 5th St NW, Washington, DC
SEPTEMBER 15, 2025

Purpose

The National Academies' [Standing Committee on Transformative Science and Technology for the Department of Defense](#), sponsored by OUSW(R&E), is organizing a series of workshop sessions each of which explores potentially transformative science and technology topics of relevance to the national defense.

This workshop will explore the forefront of advanced materials innovation and adaptive technologies designed for performance in extreme and unpredictable environments. From polar regions and space to fusion reactors, the sessions will examine how emerging materials and design strategies can meet the challenges of harsh conditions while minimizing logistical constraints.

The workshop will also explore how sustainable manufacturing methods, including 3D printing and biomanufacturing, are enabling “build-on-demand” approaches to infrastructure, with implications for disaster response, remote research stations, and future space missions. This includes advanced manufacturing and the issues related to development and deployment of advanced composites, metamaterials, 2D materials, and self-healing systems—each engineered for resilience, and adaptability—and computational design as a critical tool in accelerating the manufacturing and optimization of structures and devices.

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About the Workshop

This public, on-the-record workshop session is part of an ongoing series highlighting emerging trends in science and technology that could transform approaches research and engineering for national defense, and is aimed at a non-expert audience. An online proceedings-in-brief will feature video highlights and summarize insights from the discussions.

AGENDA

MONDAY, SEPTEMBER 15, 2025

OPEN SESSION

8:30 AM BREAKFAST

8:50 AM **Workshop Session Introduction**

- Bob Latiff, Cecilia Bitz, Sam Achilefu, *session organizers*

9:00 AM **Materials and Manufacturing Frame Setting Talks**

(20 minute presentations followed by speaker Q&A)

These frame setting talks focus on the defense applications and extreme environments that require unique considerations for effective materials and manufacturing—in some instances the conditions set limitations on what process can be used, such as the arctic, and in other cases the restrictions are the limited number of raw materials available in the environment, such as in space or at sea.

- Brent Carey, MACH-20
- Yutai Kato, Oak Ridge National Lab, Fusion Materials
- Ryan Watkins, NASA Jet Propulsion Laboratory (virtual)
- Ted Maksym, Woods Hole Oceanographic Institute

11:00 AM BREAK

11:15 AM **Advanced Manufacturing in Extreme Environments**

(15 minute remarks followed by panel discussion)

This panel will emphasize the specific innovations in manufacturing techniques needed for rapid, adaptable construction approaches for extreme environments as wide ranging as the polar regions, at sea, and on the surface of the moon. Of specific interest is manufacturing using sustainable materials processes, 3D-printed structures, smart infrastructure, and biomanufacturing.

- Chris Spadaccini, Lawrence Livermore National Lab
- Chang-Hwan Choi, Stevens Institute of Technology
- Shirley Dyke, Purdue RETH Institute
- Slade Gardner, Big Metal Additive

12:30 PM LUNCH

1:30 PM

Advanced Materials for Extreme Environments

(15 minute remarks followed by panel discussion)

This panel will discuss materials innovation, examining advanced composites, metamaterials, 2D materials, and self-healing materials. AI-driven design. All in the light of usage in extreme environments.

- James Tour, Rice University
- Xiaoyu Rayne Zheng, Berkeley
- Kyle Matthews, MXene, Inc.
- Stefano Curtarolo, Duke University

2:45 PM

Wrap-up Session

3:30 PM

ADJOURN MEETING

SPEAKER BIOGRAPHIES

Dr. Brent Carey is a Senior Program Leader at MACH-20, LLC, previously he was a senior materials scientist at Battelle. His efforts are focused on carbon-carbon composites and other ultra high-temperature materials for hypersonic applications including the setup of a high temperature materials R&D lab at Battelle, and leading the Manufacturing of Carbon-Carbon Composites for Hypersonic Applications (MOC3HA) program through AFRL in his previous role at Battelle. Prior to Battelle he worked at Owens Corning as a program leader for advanced manufacturing. At Corning the activities comprised of individual projects spanning investment in automation technologies, material sourcing initiatives, product form innovation, and production efficiency gains enabled by advanced manufacturing analytics. He was also a global portfolio leader for the composites business with accountability spanning new products, processes, and business development opportunities globally and regionally. He also coordinated, led, and served as gatekeeper in project gate reviews with senior leadership and participated in long range planning. He was also a fellow of the NASA graduate student researchers program and a recipient of the "Sallyport Award", the highest commencement award given by the Association of Rice Alumni as well as a NASEM Christine Mirzayan Fellow.

Dr. Ted Maksym is an Associate Scientist with Tenure at the Woods Hole Oceanographic Institution. He studies sea ice properties and variability, and its interactions with the climate, ocean, ice-shelves and ecosystems. His work involves a combination of field measurements, satellite remote sensing, and modeling to understand the changing ice cover. He has been at the forefront of the use and development of novel technology to address these problems, including autonomous vehicles and drifting platforms. Dr. Maksym has participated in over a dozen research icebreaker expeditions to both the Arctic and Antarctic, including on seven different icebreakers from four countries, and several Arctic ice camps. His current research interests include the development and implementation of autonomous tools that can explore the Antarctic without the need for expensive logistics. He received a Bachelor's of Science and Engineering from Queen's University in Canada in 1992, and a PhD in Geophysics from the University of Alaska, Fairbanks, in 2001. He was a participant in the National Academies' workshop on Antarctic Sea Ice Variability in the Southern Climate-Ocean System. Dr. Maksym coauthored the article Delivering Sustained, Coordinated and Integrated Observations of the Southern Ocean for Global Impact in *Frontiers of Marine Science* in 2019 related to priorities for future observational technologies. Dr. Maksym was a co-signatory for the article Solve Antarctica's Sea-Ice Puzzle as a comment in *Nature* in 2017 that is related to the capabilities necessary to explain the recent variability in Antarctic sea ice.

Dr. Ryan Watkins is a technologist at NASA Jet Propulsion Laboratory. Ryan's research focuses on the integration of advanced materials with computational design (such as topology optimization) to enable future JPL flight missions. His background is in the experimental characterization and theoretical modeling of shape memory alloys, having

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received his Ph.D. in Aerospace Engineering from the University of Michigan in 2015. While at JPL, he has worked on flight projects as a Structural Analyst and a Cognizant Engineer, leading the design, build, test, and integration of launch restraint hardware for the SWOT and NISAR missions. His current role as a Technologist focuses on generalizing topology optimization to complex material systems (such as gradient alloys and shape memory alloys), additively manufacturing and modeling lattice structures, and 3D printing shape memory alloy systems. He is the lead developer of UnitcellHub, a first-of-its-kind lattice simulation and design tool that won JPL's Software of the Year competition in 2024. Additionally, he works to develop and foster JPL's topology optimization capabilities, mentoring new practitioners, integrating the workflow into flight project practices, and engaging with the broader topology optimization community.

Dr. Yutai Kato is the Director for Materials Science and Technology Division, and Program Manager, ORNL Fusion Materials at Oak Ridge National Laboratory. His research interest are: Development and characterization of ceramics, graphite, composites and other advanced materials for high temperature and severe environment applications; Effects of neutron and high energy particle irradiation in metals, alloys and ceramics, with emphases on irradiation effects on properties and microstructures of silicon carbide and influences of helium on irradiation effects in metals and ceramics; and Development and qualification of emerging materials for nuclear energy. He was previously Group Leader for Advanced Nuclear Materials (2018-2020); Fusion Materials and Nuclear Structures (2014-2016), Materials Science and Technology Division, Oak Ridge National Laboratory

Dr. Chris Spadaccini is currently the Materials Engineering Division Leader in the Engineering Directorate at Lawrence Livermore National Laboratory. He has been working in advanced additive manufacturing process development and architected materials for over 14 years and has over 70 peer-reviewed publications including 4 book chapters, more than 100 invited presentations, and over 50 patents awarded or pending. Spadaccini founded several new fabrication laboratories at LLNL for process development focused on micro and nano-scale features and mixed material printing, as well as scale-up for higher throughput. He was the founding Director of the Center for Engineered Materials and Manufacturing prior to becoming a division leader and co-led efforts to establish the Advanced Manufacturing Laboratory, a new facility in the Livermore Valley Open Campus. He has been a member of the LLNL technical staff for 18 years. Spadaccini has also been a lecturer in the Chemical, Materials, and Biomedical Engineering Department at San Jose State University, where he taught graduate courses in heat, mass, and momentum transport. He is currently an adjunct faculty member at the University of California, Davis, in the Chemical Engineering Department.

Professor Chang-Hwan Choi is a professor in the Department of Mechanical Engineering at the Stevens Institute of Technology. Dr. Choi received his PhD in Mechanical Engineering from the University of California at Los Angeles (UCLA) in 2006, specializing in MEMS/Nanotechnology and minoring in Fluid Mechanics and Biomedical Engineering. He earned his MS in Fluids, Thermal, and Chemical Processes from Brown University in 2002.

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Before he moved to US, he acquired his BS (1995) and MS (1997) in Aerospace Engineering from Seoul National University in Korea. He was a visiting professor at the Max Planck Institute for Polymer Research, Ecole Polytechnique Fédérale de Lausanne (EPFL), and Technische Universität Darmstadt for 2016-2017. He worked as a researcher at Korea Aerospace Research Institute for 1997-2000. He also worked as an instructor at Chandrakasem Rajabhat University in Thailand for 1997-1999. Working at Stevens since 2007, Choi's research perspectives have centered on the fundamental understanding of micro/nano-scale interfacial phenomena and the development of scalable micro/nano-manufacturing techniques that can allow the scientific studies of micro/nano-mechanics and the broad applications of micro/nanostructures, ultimately targeted for the engineering of multifunctional/adaptable surfaces, devices, and systems for multiscale civil/military/energy/bio applications.

Professor Shirley J. Dyke is the Don and Patricia Coates Professor of Innovation in Mechanical Engineering and a Professor of Civil Engineering at Purdue University. She received her B.S. in Aeronautical and Astronautical Engineering from the University of Illinois, Champaign-Urbana and her Ph.D. degree in Civil Engineering from the University of Notre Dame in 1996. Director of the NASA funded Resilient ExtraTerrestrial Habitat Institute (RETHi) and the Director of Purdue's Intelligent Infrastructure Systems Lab. She was the Edward C. Dicke Professor of Engineering at Washington University in St. Louis until 2009. Dr. Dyke was awarded the Presidential Early Career Award for Scientists and Engineers, the Short-term Invitation Fellowship from the Japan Society for the Promotion of Science, the International Association on Structural Safety and Reliability Junior Research Award and the ANCRiSST Young Investigator Award. She is the co-leader for Information Technology for the NSF-funded Network for Earthquake Engineering Simulation (NEES). Dr. Dyke's research efforts have addressed a variety of issues related to the development and implementation of "smart" structures, including innovative control technologies for natural hazard mitigation, structural health monitoring and real-time hybrid simulation methods.

Dr. Slade Gardner is President of Big Metal Additive, a manufacturing company using large scale metal additive manufacturing to produce customer parts. Dr. Gardner has led BMA from startup to an internationally recognized company serving customers in the aerospace, maritime, heavy equipment, oil & gas, and energy markets. He is the 2022 SME Additive Manufacturing Industry Achievement award winner recognizing outstanding accomplishments of significant impact advancing industrial additive manufacturing. Previously, Slade was distinguished Fellow at Lockheed Martin Space Systems and Fellow at Lockheed Martin Aeronautics Skunk Works™. He has served national laboratory, US Government, and industry boards, notably as chair of External Advisory Board for Sandia National Lab's 'Born Qualified' program. He serves additive manufacturing standards committees for API, AWS and ASME. His PhD in Chemical Engineering was earned at Virginia Tech and his BS is from Lafayette College. Personal interests include traveling and dining with his wife, all seasons of mountain sports, and he is an avid motorcycle enthusiast.

Professor James M. Tour (NAE) is a synthetic organic chemist, received his Bachelor of Science degree in chemistry from Syracuse University, his Ph.D. in synthetic organic and organometallic chemistry from Purdue University, and postdoctoral training in synthetic organic chemistry at the University of Wisconsin and Stanford University. After spending 11 years on the faculty of the Department of Chemistry and Biochemistry at the University of South Carolina, he joined the Center for Nanoscale Science and Technology at Rice University in 1999 where he is presently the T. T. and W. F. Chao Professor of Chemistry, Professor of Computer Science, and Professor of Materials Science and NanoEngineering. Tour has won several other national awards including the National Science Foundation Presidential Young Investigator Award in Polymer Chemistry and the Office of Naval Research Young Investigator Award in Polymer Chemistry.

Professor Xiaoyu (Rayne) Zheng is an associate professor in the Department of Materials Science and Engineering. His research focuses on developing additive manufacturing/3D printing techniques for materials and structures with controlled topologies and encoded properties. His current interests are in developing new additive fabrication techniques, multi-material synthesis, structure property relationships and leveraging novel artificial intelligence to create intelligent materials and systems for structural, robotics, electronics, energy, and healthcare. His group is a global pioneer in developing 3D printing technologies and materials for electronic and multi-functional materials, including dielectrics, conductive, piezoelectric and structural materials. These capabilities are being used in the next generation of sensors, transducers, electronics and robotics.

Dr. Kyle Matthews is Co-Founder and CTO at MXene Inc. since 2022. and a leading innovator in the scalable production of MXenes, a groundbreaking class of 2D nanomaterials. With over four years of experience developing MXene technologies during his Ph.D. studies at Drexel University, Matthews led advancements that enable high-quality, large-scale synthesis of MXenes. His work has already secured major defense sector partnerships and commercial/exclusive IP rights, positioning MXene Inc. as a leader in advanced materials innovation. Matthews is passionate about bridging the gap between research and commercialization, driving transformative solutions that address critical industry challenges and foster innovation. Kyle has a PhD from the AJ Drexel Nanomaterials Institute where his focus was to use MXenes as electrodes in zinc-based energy storage systems.

Professor Stefano Curtarolo is the Edmund T. Pratt, Jr. Distinguished Professor of Materials Science, Electrical Engineering and Physics, and the director of the Center for Autonomous Materials Design at Duke University. Curtarolo's research interests lie at the intersection of materials science, artificial intelligence, and autonomous discovery of new materials. Current research focuses on theory and discovery of disordered super-hard and ultra-high-temperature ceramics and machine learning approaches to phase stability of alloys. Curtarolo directs the Center for Autonomous Materials Design, which has started and currently maintains the AFLOW international data consortium about materials-information and tools for millions of compounds. The Center and the consortium have also

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organized several educational and outreach initiatives in accelerated materials design [aflow.org/seminars/]. Curtarolo currently leads a MURI team, awarded in 2021, on “SPICES: Spinodal-hardened high-entropy ceramics.” Curtarolo has received many national/international awards and recognitions (e.g., ONR Yip, NSF Career, PECASE, IUPAP, Humboldt-Bessel, Highly-Cited 2021). Curtarolo earned a Ph.D. in materials science and engineering from the Massachusetts Institute of Technology.

TRANSFORMATIVE S&T STANDING COMMITTEE

The Standing Committee on Transformative Science and Technology for the Department of Defense (DoD) will organize a seminar series, designed for a non-expert audience, on emerging trends in science and technology (S&T) that could transform the Department's approach to research and engineering (R&E). The seminar series will aim to (1) foster scientific awareness within the DoD leadership of emerging trends in S&T; (2) generate robust discussion on the applications of these most recent scientific discoveries; and (3) explore opportunities to transform and disrupt traditional R&E strategies and adopt innovative solutions that enable the United States to maintain a scientific and military advantage.

Members

Richard M. Murray, NAE
Chair

Thomas E. and Doris Everhart Professor, Control and Dynamical Systems and Bioengineering
Caltech

Samuel Achilefu, NAM

Inagural Chair and Professor, Biomedical Engineering
University of Texas Southwestern

Nadya T. Bliss

Executive Director, Global Security Initiative
Arizona State University

William J. Dally, NAE

Chief Scientist
NVIDIA

Markita P. Landry

Assistant Professor, Chemical and Biomolecular Engineering
University of California, Berkeley

Ivett A. Leyva

Department Head and Arthur McFarland Professor, Aerospace Engineering
Texas A&M University

Jill C. Pipher

Vice President for Research and Elisha Benjamin Andrews Professor, Mathematics
Brown University

Darlene Solomon, NAE
Vice Chair

Former CTO and Senior Vice President
Agilent Technologies

Cecilia Bitz

Professor, Atmospheric Sciences
University of Washington

Robert Braun, NAE

Head, Space Exploration Sector
Johns Hopkins Applied Physics Laboratory

Deepakraj M Divan, NAE

John E. Pippin Chair Professor, Georgia Research Alliance Eminent Scholar
Georgia Institute of Technology

Robert H. Latiff

Private Consultant

Laura A. McNamara

Research and Development Manager
Sandia National Laboratory

Amina A. Qutub

Burzik Professor, Engineering Design
University of Texas at San Antonio

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