

## Materials Department Colloquium

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# Decoupling Geometry from Densification in Ultra-High Temperature Materials

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### Abstract

Ultra-high temperature ceramics (UHTCs) are leading candidates for hypersonic and other extreme-environment applications, yet their defining attributes—strong covalent bonding, high melting temperatures, and chemical stability—make them exceptionally difficult to manufacture into large, dense, defect-free shapes. Carbides and borides in this class require extreme sintering temperatures, exhibit limited defect tolerance, and are difficult to machine because of their hardness and brittleness. Pressure-assisted consolidation is largely restricted to simple geometries, while pressureless sintering requires temperatures exceeding 2000°C and still fails to achieve full density due to grain coarsening and 15–20% linear shrinkage. These constraints impose persistent trade-offs among shape complexity, density, and defect population.

Our group is developing processing strategies that decouple geometric shaping from high-temperature densification. For example, direct ink writing (DIW) of highly loaded suspensions enables fabrication of near-net-shape green architectures with minimal machining. When combined with ultra-fast high-temperature sintering (UHS), brown bodies densify in seconds while limiting grain growth. In a complementary effort, self-propagating high-temperature synthesis (SHS) is being used as a constrained shaping strategy to form intermetallic (and ultimately UHTC) components.

**Don M. Lipkin** is Professor of Materials Science and Engineering at Texas A&M University, with a courtesy appointment in Aerospace Engineering. Lipkin received a B.S. in Materials Science from Northwestern University and Ph.D. in Materials from UC Santa Barbara, working with Professors Anthony G. Evans and David R. Clarke. He brings over three decades of experience developing high-performance structural materials for extreme thermochemical environments. His research group focuses on alloy and coating design, advanced synthesis and manufacturing, high-temperature physical property measurements, and high-enthalpy/high-heat-flux testing to enable durable turbine and hypersonic components. Prior to joining Texas A&M, Lipkin spent more than 25 years at GE Research leading multidisciplinary programs on coatings and structural materials, directing the development and transition to flight of environmental barrier coatings for ceramic matrix composites, and shaping coating strategy across GE's Aerospace and Power businesses. During that time, he mentored several UCSB graduate students during internships at GE Research and collaborated with UCSB faculty in several collaborative research projects. He has authored influential research on thermal and environmental barrier coating phase stability and thermally grown oxide evolution, holds over 50 U.S. patents, and earned the TMS Application to Practice Award in 2019. Lipkin was elected to the National Academy of Engineering in 2025, the first alumnus of the Materials Department to be so-honored. In the same year he was also elected to the Texas Academy of Medicine, Engineering, Science and Technology.

