

**Professor W.G. Fahrenholtz**  
**Missouri University of Science and Technology**  
*Ultra-High Temperature Ceramics for Hypersonic  
Aerospace Applications*



Ultra-high temperature ceramics (UHTCs) are an emerging class of structural materials that are capable of withstanding extreme environments that are beyond the capabilities of existing materials. Among the UHTCs, zirconium diboride exhibits an extraordinary combination of ceramic-like strength and stiffness along with metal-like electrical and thermal conductivities. Our group at Missouri S&T has built specialized facilities for processing and characterizing these materials with recent research focusing on mechanical and thermal properties at ultra-high temperatures. Recent research has focused on identifying the intrinsic properties of these materials. Our research has utilized reactive hot pressing to synthesize and densify ultra-high purity zirconium diboride from zirconium hydride and boron powders. Sintering mechanisms and kinetics were studied by analyzing displacement during the hot pressing cycle for temperatures ranging from 1800°C to 2100°C. Below 2000°C, the densification mechanism was identified as grain boundary diffusion with an activation energy of 240 kJ/mole while at higher temperatures densification proceeded by lattice diffusion with an activation energy of about 700 kJ/mole. The change in mechanism corresponds to a significant change in densification rate and microstructure development for these ceramics. Reactive hot pressing was used to produce a series of  $ZrB_2$  ceramics with Hf contents ranging from 0.03 at% up to 0.39 at%. These ceramics showed increasing thermal conductivity and heat capacity as Hf content decreased. The effects of Hf content on lattice vibrations and electronic structure revealed the likely mechanisms responsible for the changes.

William G. (Bill) Fahrenholtz is a Curators' Professor of Ceramic Engineering at Missouri University of Science and Technology. His current research focuses on the processing, characterization, and mechanical testing of advanced structural ceramics for use in environments with extreme thermal loads, mechanical forces, and/or chemical reactivities. He has published over 120 papers in peer-reviewed journals, given over 40 invited presentations, and has been PI or Co-PI on nearly 50 grants from sources including industry, the NSF, and the Air Force Office of Scientific Research. He was elected a Fellow of the American Ceramic Society in 2007.

**Host:**  
**Dr. Bai Cui**

**Department of  
Mechanical & Materials  
Engineering**

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**Wednesday, September 16, 4:00 pm**  
**136 Jorgensen Hall**