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Guest Editorial: Ultra-high temperature ceramics

This issue of the Journal of Materials Science contains a special section on Ultra-High Temperature Ceramics (UHTCs) with particular emphasis on summarizing recent progress in the field while highlighting the emerging research sponsored by Air Force Office of Scientific Research.

The Air Force basic research program in ceramics provides fundamental knowledge for improving the *performance*, *cost* and *reliability* of structural ceramics. Structural materials research studies a broad range of material properties such as strength, toughness, fatigue resistance, and corrosion resistance of airframe, turbine engine, and spacecraft materials. The development of new classes of materials for sustained use in the extreme environments experienced by a maneuverable hypersonic vehicle is a renewed emphasis area.

Many have viewed the search for structural materials that can withstand the hypersonic operating environment as the quest for "unobtainium." Indeed, a hypersonic flight vehicle poses many daunting physical and mechanical requirements that are further complicated if the system is to be affordable, reusable and sustainable. Key challenges facing the structure or skin of the vehicle include an operating environment that has temperatures in excess of 1500°C in combination with corrosive gases (both oxidizing and reducing) and dynamic pressures in the range of 1,500 psf. However, the engine of the hypersonic vehicle will experience the most demanding environment of the structure with temperatures at the combustor exit in excess of 2500°C. Active cooling can be used to lower temperatures significantly; however, this will create new engineering challenges since the cooling fuel can degrade the UHTC mechanical properties and decrease overall system performance.

In the late 1960's, a survey of diboride composites illustrated that an 80% HfB_2-20% SiC composite could be fabricated that would satisfy the initial requirements of sustained operation at elevated temperatures in an oxidizing environment; however, processing was limited to conventional hot-pressing methods that limited the manufacturability of the components. During the last 30 years, research in the discovery of new classes of materials and development of processing methods for UHTCs has been sporadic. As a result, there is a scarcity of fundamental research data available on the mechanical performance and manufacturability of UHTCs.

In an effort to renew fundamental research interest, AFOSR sponsored a Workshop on Ultra-High Temperature Ceramic Materials November 5–7, 2003 in Wintergreen, Virginia. The Workshop included invited speakers from NASA, Navy, Air Force, industry and academia with a special emphasis on the current design requirements driving the research investments in ultra-high temperature materials. The JMS special section herein contains seventeen papers presented at the Workshop. Fifteen of these papers describe investigations of specific UHTC materials concerning: synthesis and/or processing; characterization of properties (mechanical, thermal, corrosion); and processing-structure-property relationships. Two papers (Van Wie et al. and Jackson et al.) provide descriptions of the operating conditions and design considerations for high-speed flight, as well as describing various approaches to thermal management including the use of ultra-high temperature materials.

As guest editors, we are grateful to the authors and other Workshop participants for their contributions. We acknowledge the reviewers for their valuable service and many of the authors also expressed their gratitude for the thoughtful reviews that were provided. Special thanks are extended to several reviewers who accepted an extra burden by providing timely reviews for more than one paper. Finally, we also thank Professor Helen Chan of Lehigh University (Special Sections Editor of JMS) and the staff at Kluwer Academic Publishers, especially Angela DePina, for their efforts in making this special section a reality.

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