MATERIALS ENGINEERING SEMINAR

"Near-Net-Shape Syntheses, Joining, and Properties of Ceramic/Metal Composites"

Yujie Wang

Purdue MSE Ph.D. Final Exam

Advisor: Professor Kenneth Sandhage

ABSTRACT

Ceramic/metal composites are being explored as potential replacements for conventional metal alloys in high-temperature components used in aerospace and power generation applications. Co-continuous ceramic/metal composites can offer attractive combinations of properties, such as improved mechanical toughness and thermal conductivity (relative to monolithic ceramics) and enhanced stiffness and corrosion/erosion resistance (relative to monolithic metals). However, development of cost-effective and scalable manufacturing routes to dense, complex-shaped ceramic/metal composites is a non-trivial challenge.

This study has been focused on fabricating complex and near-net-shaped WC/Cu composites, ZrC/W composites, and graded ZrC/W-to-WC/Cu composites (such as for use in compact printed circuit heat exchangers and thin-wall rocket nozzles), using scalable pressureless liquid metal infiltration methods. Low-cost uniaxial compaction and tape casting have been examined for generating porous, shaped WC preforms. The influences of the conditions of pressureless infiltration of Cu liquid into porous WC preforms (for WC/Cu composites), of the pressureless reactive infiltration of Zr_2Cu liquid into porous WC preforms (for ZrC/W composites), and of the liquid-phase diffusion of Zr in a Zr_2Cu liquid into dense WC/Cu composites (for graded ZrC/W-to-WC/Cu composites) on composite microstructures and properties (thermal and mechanical) have been investigated. Quantitative analyses of the phase contents of these composites were obtained from calibrated X-ray diffraction analyses. Microstructural and microchemical analyses of the composites were conducted using electron microscopy.

The use of a high-temperature metal alloy braze for joining Al_2O_3/Cr composites to Ni-based alloys has also been examined. Common metallic brazes can exhibit poor wetting to ceramic phases, and can possess modest melting temperatures and poor high-temperature oxidation resistance. Differential scanning calorimetry was used to evaluate the solidus and liquidus temperatures of potential high-temperature braze alloys. The microstructure and microchemistry of bonded interfaces were examined through electron microscopy of polished cross-sections. The oxidation behavior of the braze alloys were also assessed to ensure reliable joining of ceramic-based composites to Ni-based alloys for use in high-temperature applications in air.

Date: Monday, July 10, 2023
Time: 9:00 A.M.
Place: ARMS 3109 or via this link: https://purdue.webex.com/meet/sandhage

PURDUE UNIVERSITY | School of Materials Engineering