Graduate Student Research Seminar

Fall 2023

Additive Manufacturing of Porous Tungsten Carbide Multifunctional Energy Components using Direct Ink Writing

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Advisor: Dr. Rodrigo Martinez–Duarte

Monday, October 9th

3:00 pm (EST) – 132 Fluor Daniel Building

Abstract

Thanks to ideal mechanical and electrochemical properties, Tungsten Carbide (WC) shows excellent potential as a structural electrode material for multifunctional devices. These devices have applications in electric vehicles, for example, structural fuel cells and massless batteries. In such a context, structural WC electrodes will also benefit from porosity, both to decrease their weight and to increase their surface area and chemical reactivity. Porous WC is an extremely useful material for this field because of its high strength-to-weight ratio and electrical properties. However, current manufacturing methods can be expensive, complex, and limited, so the intent herein is to provide a more simplistic and sustainable method through additive manufacturing. The research focuses on validating direct ink writing (paste 3D printing) as a suitable manufacturing method for complex shapes and components made from porous tungsten carbide. The technique utilizes a modified 3D printer to extrude a biopolymer precursor paste containing tungsten oxide nanoparticles into lattice shapes. Heat treatment of the printed lattice structures results in 3D cellular architectures of porous WC. The compressive strength of the WC lattices is measured in situ with electrical resistance to highlight the multifunctional potential. 3D scanning and analysis are implemented to determine geometric shrinkage, surface accuracy, and manufacturing-related defects. The results are used to support an understanding of process parameter effects. The significance of this analysis is toward enabling control over the macroscopic and microscopic structure based on 3D printing parameters, precursor composition, and heat treatment. Eventually, the goal is to tailor and optimize the fabrication process for specific material performance.

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