November 8th, 2019

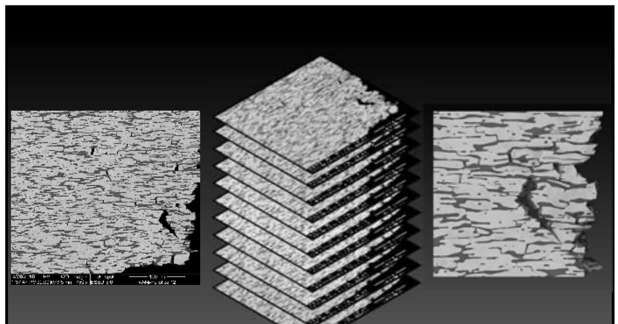
Characterization of Tungsten-Based Composites for PFM Applications

James V. Haag IV [1], Dan J. Edwards [2], Charles H. Henager Jr [2], Mitsu Murayama [1,2]

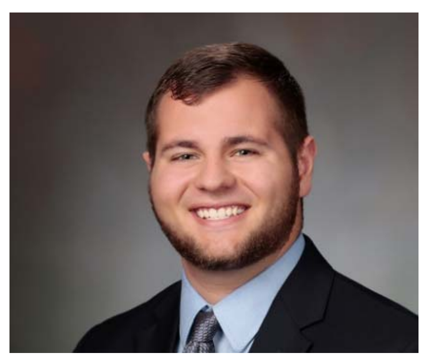
[1] Department of Materials Science and Engineering, Virginia Tech
[2] Energy and Environmental Directorate, Pacific Northwest National Laboratory

Abstract

Tungsten alone is unable to withstand extended operation as a plasma facing material component in fusion reactors due to its low fracture toughness and high ductile-to-brittle transition temperature. Tiles of polycrystalline tungsten have been noted to crack and fail catastrophically when exposed to conditions analogous to what would be experienced during reactor operation. It is possible to overcome this brittle behavior while still retaining many of the favorable aspects of polycrystalline tungsten by the addition of a ductile phase into a matrix of otherwise brittle tungsten to increase its resistance to cracking, thereby ductile phase toughening the material. This work provides results aimed at validating the proposed adoption of a thermomechanically treated W-Ni-Fe alloy as an alternative to polycrystalline tungsten for plasma facing materials applications. This biologically inspired bi-phase composite is characterized via TEM, in-situ SEM mechanical testing, and 3D microstructure observation both pre- and post-mortem to analyze the mechanisms which give rise to this extreme accommodation of plastic deformation and ductile phase toughening behavior.



Process for the 3D Reconstruction via the mechanical serial sectioning method. (Left) Initial surface SEM image. (Middle) Stack of SEM images after sequential polishing steps. (Right) Volume reconstruction compiled from stacked SEM images.



Biography

James (Jacob) began his Ph.D. work with Dr. Mitsu Murayama in Fall 2017. His work focuses on in-situ mechanical testing and 3D microstructure reconstruction of materials designed to withstand the interior of nuclear fusion reactors. He plans to graduate in the Spring of 2021.