Methodology for Producing a Uniform Distribution of UO_2 in a Tungsten Matrix

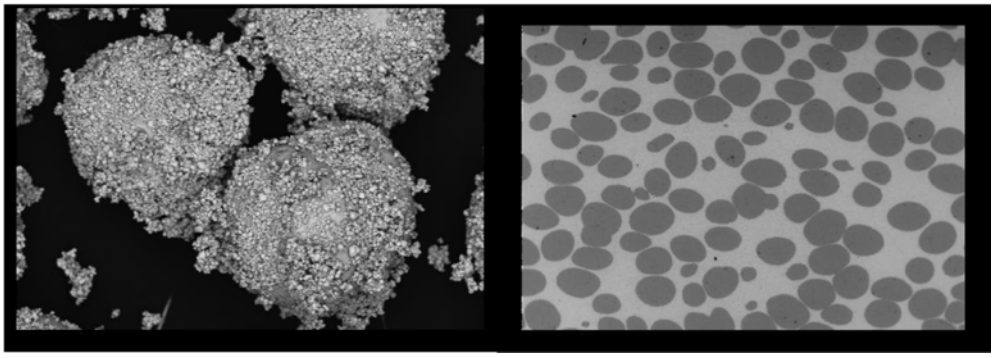
Dennis S. Tucker[1], Andrew O'Conner[2], Robert Hickman[1], Jeramie Broadway1 and Grace Belancik

[1] *EM32, Marshall Space Flight Center, MSFC, Alabama 35812*

[2]*School of Nuclear Engineering, Purdue University, West Lafayette, Indiana 42907*

Current work at NASA's Marshall Space Flight Center (MSFC) is focused on the development CERMET fuel materials for Nuclear Thermal Propulsion (NTP). The CERMETs consist of uranium dioxide (UO_2) fuel particles embedded in a tungsten (W) metal matrix. Initial testing of W-UO_2 samples fabricated from fine angular powders performed reasonably well, but suffered from significant fuel loss during repeated thermal cycling due to agglomeration of the UO_2 (1). The blended powder mixtures resulted in a non-uniform dispersion of the UO_2 particles in the tungsten matrix, which allows rapid vaporization of the interconnected UO_2 from the sample edges into the bulk material. Also, the angular powders create areas of stress concentrations due to thermal expansion mismatch, which eventually cracks the tungsten matrix. Evenly coating spherical UO_2 particles with chemical vapor deposited (CVD) tungsten prior to consolidation was previously demonstrated to provide improved performance. However, the CVD processing technology is expensive and not currently available.

In order to reduce cost and enhance performance, a powder coating process has been developed at MSFC to produce a uniform distribution of the spherical UO_2 particles in a tungsten matrix. The method involves utilization of a polyethylene binder during mixing which leads to fine tungsten powders clinging to the larger UO_2 spherical particles. This process was developed using HfO_2 as a surrogate for UO_2. Enough powder was mixed to make 8 discs (2cm diameter x 8mm thickness) using spark plasma sintering. A uniaxial pressure of 50 MPa was used at four different temperatures (2 samples at each temperature). The first two samples were heated to 1400C and 1500C respectively for 5 minutes. Densities for these samples were less than 85% of theoretical, so the time at temperature was increased to 20 minutes for the remaining samples. The highest densities were achieved for the two samples sintered at 1700C (~92% of theoretical). Scanning electron microscopy (SEM) of the mixed powders and the sintered samples along with energy dispersive x-ray analysis was obtained. The SEM of the powders clearly show the fine W powder adhered to the larger HfO_2 particles and a uniform distribution of HfO_2 particles in a tungsten matrix upon densification. Vicker's Microhardness testing was also performed on all samples using 0.5, 1.0 and 2.0 kg loads. Five indents were made at each load level. All indents were placed in the tungsten matrix to assist as a proxy in measuring densification. The highest hardness value was obtained for the 1700C specimens. The hardness average for these samples was 312.14 MPa. This powder processing method has been applied to W/UO_2 powders with the SEM of the powders appearing similar to the W/HfO_2 powder images.



SEM Images of Tungsten Coated HfO_2 particles and Resultant Densified Structure

1. R.J. Baker, J.L. Daniel, W.J. Lobsinger, R.J. Scott, F.A. Snojds, E.A. Roake. *Basic Behavior and Properties of W-UO2 CERMETS*, Pacific Northwest Laboratory, 1966. BNWL-394, NASA Report NASA-CR-54840.