EFFECT OF Zr, B AND C ADDITIONS ON THE DUCTILITY OF MOLYBDENUM

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Molybdenum alloys possess high strength at elevated temperatures, high thermal conductivity, low coefficient of thermal expansion, and excellent performance in neutron flux environments. However, their application has been limited due to their temperature-dependent ductility. The room temperature ductility of 6-mm thick gas tungsten arc (GTA) weldments of molybdenum can be increased from the historically observed 3% to nearly 20% at normal rates of tensile strain by the addition of aluminum or zirconium, and carbon and boron in the low part per million range.[1] These alloys exhibit the highest ductilities ever observed in GTA weldments of molybdenum.

The composition of the alloy used in this investigation was Mo - 0.16 at. % Zr, 53 appm B, 96 appm C, 178 appm N and 250 appm O. Mechanical property tests of this alloy indicated that uniform tensile elongation occurred over the 25 mm gauge length and that the fracture mode was intergranular. The distribution of the alloying elements in the microstructure of this alloy was characterized by a combination of field ion microscopy and atom probe tomography. Microstructural characterizations were performed in the Oak Ridge National Laboratory (ORNL) energy-compensated atom probe and the ORNL energy-compensated optical position-sensitive atom probe.

Atom probe tomography revealed segregation of zirconium, boron and carbon to the grain boundaries. The controlled addition of interstitial and substitutional elements strengthened the grain boundaries, the historical site of tensile failure in Mo alloys. By strengthening the grain boundaries, the fracture stress exceeds the yield stress to allow the observed increase in ductility.

1. A. J. Bryhan, "Joining of Molybdenum Base Metals and Factors Which Influence Ductility", Welding Research Council Bulletin 312, ISSN 0043-2326, Feb. 1986, New York.

Research at the Oak Ridge National Laboratory SHaRE User Facility was sponsored by the Division of Materials Sciences and Engineering, U.S. Department of Energy, under contract number DE-AC05-00OR22725 with UT-Battelle, LLC.