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STRATEGY FOR SIMULTANEOUS HYDROGEN TRAPPING AND METALLIC GRAIN SIZE CONTROL IN CERMET FUELS FOR NUCLEAR THERMAL PROPULSION

Abstract

Nuclear thermal propulsion (NTP) is a leading technology for beyond earth orbit space travel. NTP uses a cermet fuel that is composed of a ceramic nuclear fuel, such as UO2 or UN, and a protective refractory metal (W or Mo) matrix. Previous work by these authors has shown that W coated yttria stabilized zirconia (W-YSZ) powder can reduce the amount of metal fraction in the cermet while still retaining sufficient ceramic-ceramic particle separation. Here, YSZ served as a surrogate to the nuclear fuel. In this paper, we further those studies to address how nanoparticles of ZrC can be added to the metal matrix. The carbides act as pinning sites for the grain size in the metal matrix, where finer metal grain sizes have been proposed to improve the survivability of the cermet fuel. These carbides also act as hydrogen traps, which may prove critical in preventing deleterious hydrogen reactions with the nuclear fuel. ZrC also offers the advantage of having a low neutron absorption cross-section. Using a powder process route, the nanoparticles at different concentrations are ultrasonically separated and then dispersed with the coated powders and then sintered forming the cermet. The dispersion of these carbides within the microstructure is quantified and related to the sintering process, the cermet's mechanical behavior, and the grain size stability under different thermal loading states.