DESIGN OF ULTRA-HIGH TEMPERATURE CERAMICS FOR OXIDATION RESISTANCE

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Ultra-high temperature ceramics (UHTCs) are capable of withstanding extreme temperatures above 2500°C. Specifically, hafnium carbide (HfC) and tantalum carbide (TaC) have the highest melting points amongst UHTCs, however, rapid oxidation of these materials is a persistent problem. In this work, HfC, TaC, and nominally single phase (Hf,Ta)C (Hf:Ta molar ratios of 80:20, 70:30, 60:40) were densified using spark plasma sintering. Oxidation exposures were conducted in a resistive heating system at 1400°C in 1% oxygen/argon for times up to 10 minutes. Scanning electron microscopy (SEM) and energy dispersive spectroscopy were used to characterize the oxide morphology, composition, and to determine the oxide thickness. Oxide thickness results demonstrated that pure TaC oxidizes more rapidly than pure HfC. The resulting oxide of the mixed (Hf,Ta) carbides was denser and thinner compared to the end members. X-Ray diffraction (XRD) analysis was used to determine the phases present post oxidation. The complex oxide $Hf_6Ta_2O_{17}$ was observed on the mixed (Hf,Ta) carbides, contributing to the change in oxide morphology and reduced oxide thickness. Thermogravimetric analysis (TGA) experiments were also conducted on HfC and TaC powder mixtures that were not sintered (HfC:TaC ratios of 80:20, 70:30, 60:40) at 1400°C in 1% oxygen/argon for 60 minutes. The TGA results demonstrated that 80HfC-20TaC mixture has the lowest oxidation rate compared to the other HfC/TaC powder mixtures (Figure 1). XRD analysis showed that the $Hf_6Ta_2O_{17}$ phase preferentially formed for the 80HfC-20TaC composition. The results for the powder mixtures agree with those for the single phase (Hf,Ta)C samples, that $Hf_6Ta_2O_{17}$ increases oxidation resistance.

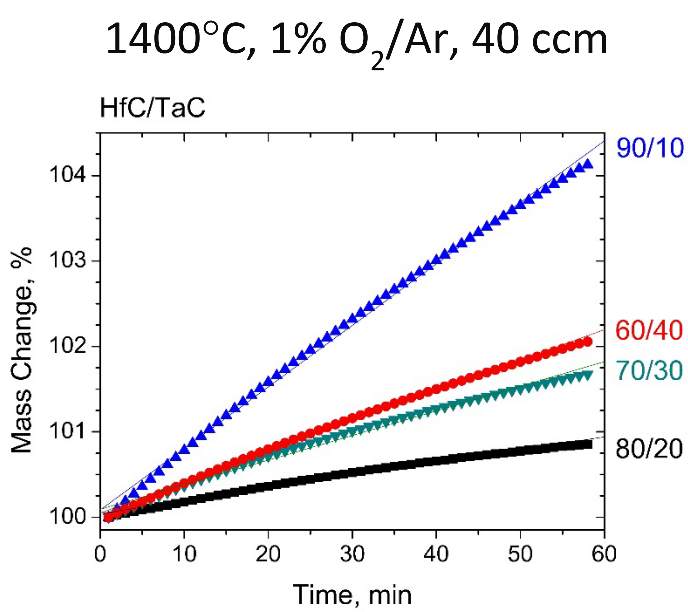

Figure 1. Thermogravimetric analysis of HfC/TaC carbide mixtures