OXIDATION OF ULTRA-HIGH TEMPERATURE CERAMICS IN WATER VAPOR

QuynhGiao N. Nguyen†, Elizabeth J. Opila*, and Raymond C. Robinson&

†NASA Glenn Research Center, Cleveland, OH 44135
*Cleveland State University, Cleveland, OH 44115
&QSS Group Inc., Cleveland, OH 44135

Ultra high temperature ceramics (UHTCs) including HfB_2 + SiC (20% by volume), ZrB_2 + SiC (20% by volume) and ZrB_2 + SiC (14% by volume) + C (30% by volume) have historically been evaluated as reusable thermal protection systems for hypersonic vehicles [1]. This study investigates UHTCs for use as potential combustion and aeropropulsion engine materials. These materials were oxidized in water vapor (90%) using a cyclic vertical furnace at 1atm. The total exposure time was 10 hours at temperatures of 1200, 1300, and 1400°C. CVD SiC was also evaluated as a baseline comparison. Weight change measurements, X-ray diffraction analyses, surface and cross-sectional SEM and EDS were performed. These results will be compared with tests ran in static air at temperatures of 1327, 1627, and 1927°C [2]. Oxidation comparisons will also be made to the study by Tripp [3]. A small number of high pressure burner rig (HPBR) results at 1100 and 1300°C will also be discussed.

Specific weight changes at all three temperatures along with the SiC results are shown in Figure 1. SiC weight change is negligible at such short duration times. HfB_2 + SiC (HS) performed the best out of all the tested UHTCS for all exposure temperatures. ZrB_2 + SiC (ZS) results indicate a slightly lower oxidation rate than that of ZrB_2 + SiC + C (ZCS) at 1200 and 1400°C, but a clear distinction can not be made based on the limited number of tested samples.

Scanning electron micrographs of the cross-sections of all the UHTCs were evaluated. Figure 2 is a representative area for HS at 1400°C for 26 hours, which was the composition with the least amount of oxidation. A continuous SiO_2 scale is present in the outer most edge of the surface. Figure 3 is an image of ZCS at 1400°C for 10 hours, which shows the most degradation of all the compositions studied. Here, the oxide surface is a mixture of $ZrSiO_4$, ZrO_2 and SiO_2.

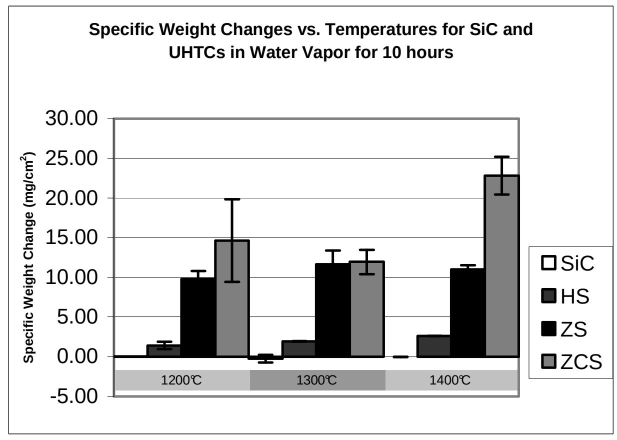

Figure 1. Sample weight change for UHTCs and SiC

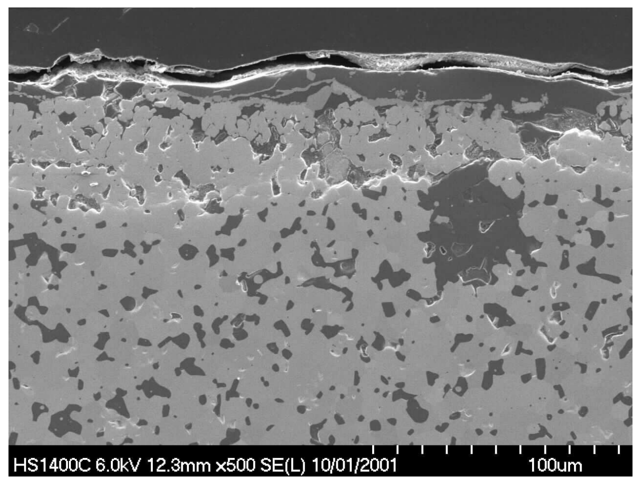

Figure 2. Cross-section image of HS at 1400°C for 26 hours

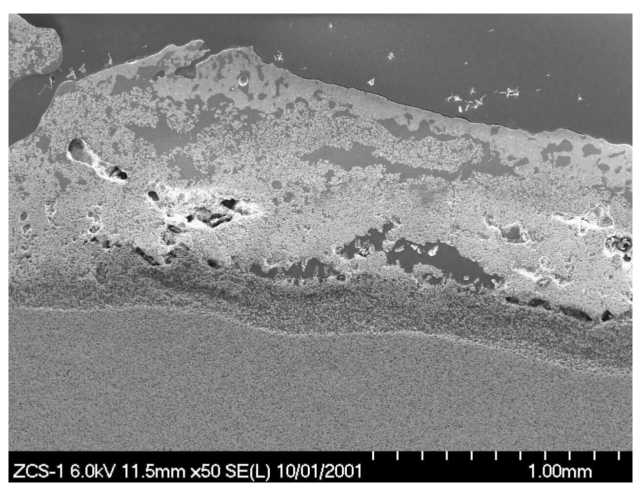

Figure 3. Cross-section image of ZCS at 1400°C for 10 hours

References

1. J.D. Bull, D. J. Rasky, and J. C. Karika, "Stability Characterization of Diboride Composites under High Velocity Atmospheric Flight Conditions," 24th International SAMPE Technical Conference, p. T1092 (1992).

2. S.R. Levine, E.J. Opila, M.C. Halbig, J.D. Kiser, M. Singh, and J.A. Salem, "Evaluation of Ultra-High Temperature Ceramics for Aeropropulsion Use," J. European Cer. Soc., **22**, 2757 (2002).

3. W.C. Tripp, H.H. Davis, and H.C. Graham, "Effect of SiC Addition on the Oxidation of ZrB_2," Cer. Bull., **52**, 8, 612 (1973).