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THERMAL STABILITY OF POLYMER DERIVED ULTRA-HIGH TEMPERATURE CERAMIC MATRIX COMPOSITES

Abstract

The demand for materials that can withstand temperatures exceeding 2000 C is increasing for the production of the next generation of leading edges, thermal protection systems (TPS), rocket nozzles, and turbine blades for propulsion in hypersonic vehicles. To address this need, ultra-high temperature ceramic matrix composites (UHTCMCs) have emerged as a novel class of materials that can surpass the limitations of existing materials. For example, silicon carbide matrix composites (SiC/SiC and C/SiC) are limited to temperatures below 1800C, while carbon/carbon is not limited in temperature but shows low wear and oxidation resistance. UHTCMCs typically consist of a matrix of ultra-high temperature ceramic (UHTC) phases belonging to borides, carbides, or nitrides of groups IV and V metals, which are reinforced with carbon fibers. In addition to their high-temperature properties, UHTCs also exhibit excellent wear resistance and chemical stability, making them attractive for use in harsh chemical environments.[1-7] This study investigates the thermal stability and mechanical properties of a ZrB2/SiC/Cf ultra-high temperature ceramic matrix composite (UHTCMC) fabricated through powder slurry infiltration (SI) and six cycles of Polymer Infiltration and Pyrolysis (PIP) with allylhydrido polycarbosilane (SMP-10 from Starfire Systems, Inc.). [8,9] The material was first investigated after consolidation under mild conditions at 1000 C, at which point the polymer-derived SiC remained amorphous. Post-consolidation thermal treatments were then carried out at temperatures ranging from 1100 C to 1900 C to evaluate the microstructural evolution of the matrix, including crystallization and an increase in porosity. Finally, elevated temperature mechanical properties were studied through bending tests up to 1500 C. Post pyrolysis heat treatments up to 1400 C did not significantly affected the porosity neither the morphology of SiC(O), while annealing at temperature of 1500 C and beyond led to conversion of amorphous SiC(O) into crystalline -SiC and consequently to an increase of open porosity up to 30