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High Temperature Oxidation of Additively Manufactured Silicon Carbide/Carbon Fiber Nanocomposites

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Abstract : An additive manufacturing process and subsequent pyrolysis cycle were used to fabricate SiC matrix/carbon fiber hybrid composites. The matrix was fabricated using a mixture of preceramic polymer and acrylate monomers, while polyacrylonitrile (PAN) precursor was used to fabricate fibers via electrospinning. The precursor matrix and reinforcing fibers at 0, 2, 5, or 10 wt% were printed using digital light processing, and both were simultaneously pyrolyzed to yield the final ceramic matrix composite structure. After pyrolysis, XRD and SEAD analysis proved the existence of SiC nanocrystals and turbostratic carbon structure in the matrix, while the reinforcement phase was shown to have a turbostratic carbon structure similar to commercial carbon fibers. Thermogravimetric analysis (TGA) in the air up to 1400 °C was used to evaluate the oxidation resistance of this material. TGA results showed some weight loss due to oxidation of SiC and/or carbon up to about 900 °C, followed by weight gain to about 1200 °C due to the formation of a protective SiO2 layer. Although increasing carbon fiber content negatively impacted the total mass loss for the first heating cycle, exposure of the composite to second-run air revealed negligible weight chance. This is explained by SiO2 layer formation, which acts as a protective film that prevents oxygen diffusion. Oxidation of SiC and the formation of a glassy layer has been proven to protect the sample from further oxidation, as well as provide healing of surface cracks and defects, as revealed by SEM analysis.

Keywords : silicon carbide, carbon fibers, additive manufacturing, composite
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