Accepted Manuscript

Title: Design, Preparation and Properties of Carbon Fibers Reinforced Ultra-High Temperature Ceramic Composites for Aerospace Applications: a Review

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PII: S1005-0302(16)30126-8
DOI: http://dx.doi.org/doi: 10.1016/j.jmst.2016.08.004
Reference: JMST 767

To appear in: *Journal of Materials Science & Technology*

Received date: 21-6-2016
Revised date: 6-7-2016
Accepted date: 7-7-2016

Please cite this article as: Sufang Tang, Chenglong Hu, Design, Preparation and Properties of Carbon Fibers Reinforced Ultra-High Temperature Ceramic Composites for Aerospace Applications: a Review, *Journal of Materials Science & Technology* (2016), http://dx.doi.org/doi: 10.1016/j.jmst.2016.08.004.

Design, Preparation and Properties of Carbon Fibers Reinforced Ultra-high Temperature Ceramic Composites for Aerospace Applications: A Review

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[Received 21 June 2016, Received in revised form 6 July 2016, Accepted 7 July 2016]

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Carbon fibers reinforced ultra-high temperature ceramic (UHTC) composites, consisting of carbon fibers embedded in a UHTC-matrix or a C–SiC–UHTC–matrix, are deemed as the most viable class of materials that can overcome the poor fracture toughness and thermal shock resistance of monolithic UHTC materials, and also improve the oxidation resistance and ablation resistance of C/C and C/SiC composites at ultra-high temperatures. In this review, we summary the different processing routes of the composites based on the UHTC introducing methods, including chemical vapor infiltration/deposition (CVI/D), precursor infiltration and pyrolysis (PIP), reactive melt infiltration (RMI), slurry infiltration (SI), in-situ reaction, hot pressing (HP), etc; and the advantages and drawbacks of each method are briefly discussed. The carbon fibers reinforced UHTC composites can be highly tailorable materials in terms of fiber, interface, and matrix. From the perspective of service environmental applications for engine propulsions and hypersonic vehicles, the material designs (mainly focusing on the composition, quantity, structure of matrix, as well as the architecture of carbon fibers, UHTCs and pores), their relevant processing routes and properties (emphasizing on the mechanical and ablation properties) are discussed in this paper. In addition, we propose a material architecture to realize the multi-function through changing the distribution of carbon fibers, UHTCs and pores, which will be an important issue for future development of carbon fiber reinforced UHTC composites.

Key words: Carbon fiber composites; Ceramic matrix composites (CMC); Ultra-high temperature ceramic (UHTC); Ablation

1. Introduction