

SiC-BASED CERAMIC MATRIX COMPOSITE BEHAVIOR ENHANCEMENT FOR GAZ TURBINES HOT SECTIONS

Eric Bouillon, Safran Ceramics
eric.bouillon@safrangroup.com
Nicolas Laval, Safran Ceramics
David Marsal, Safran Ceramics

Key Words: SiC/SiC CMC, EBC, Matrix Cracking Strength, Thermomechanical Behavior

Silicon carbide fibers reinforced silicon carbide based-matrix composites (SiC/SiC CMC's), are probably becoming a major leading alternative for the design and manufacturing of the next gaz turbine engines hot parts as airfoils, shroud, combustion chambers. These materials offer higher temperature capability than the current state-of-the-art metallic superalloys and tougher than the monolithic ceramic. The growing interest in CMC technologies development is directly linked to the new short-term engine design constraints in the context of air travel booming, namely : a drastic decreasing of community noise and air polluting emissions and a specific fuel consumption decrease. During the last fifteen years, substantial research efforts have been devoted towards evaluating for a wide range of CMCs, as oxide and carbide and manufacturing routes, as CVI, MI, powder impregnation, PIP.

Building on past materials efforts in the field of both space launchers and military engines aircraft, Safran continued to enhance CMC technologies for commercial aircraft engines. Considering this new target, one of the key issues related to this emerging technology is to develop and industrialize materials offering high thermomechanical design allowables and stable lifetime properties, in representative environment. To reach these goals, an important work has been done, in the implementation of Melt -Infiltrated SiC/SiC CMC and T/EBC top-coat.

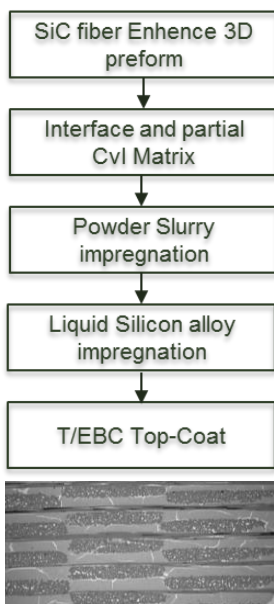


Figure 1 – SiC/SiC MI Route

In order to limit the risk of material damage under operating conditions, a design criteria below the elastic limit must be applied. For SiC/SiC CMC, this level is driven by the Matrix Cracking Strength (MSC) limit. On the other hand, previous studies have shown a direct link between residual bulk porosity and Matrix Cracking Strength. Therefore, an iterative approach based on an optimization of each block, coupled with precise mechanical behavior studies, at meso and macro scale, was carried out. This allowed us to define a robust manufacturing process, leading to a MSC of around to 250MPa.

To prevent accelerated water corrosion of SiC/SiC CMCs, an Environmental Barrier Coating (EBC) must be applied as top-coat. Long term Efficiency of EBC, in representative environment (temperature, water content, totale pressure, gaz velocity, CMAS), depends on many criteria : CMC/EBC CTE mismatch, temperature stability, oxygen permeability, recession rate. Compared to previous system, as Mullite/BSAS, new generation of EBC is currently developed, based on rare earth silicates. A detailed study of the CMC/EBC functioning, leads to propose enhanced architectures, based on mixed RE-silicates.

The CMC technology development also requires an extensive work of thermomechanical damage behavior analysis, based on sub-element part tests, in increasingly representative conditions.

In this oral presentation, a brief description of the CMC/EBC enhancement approach is proposed, including material allowables proposal and sub-element behavior analysis. A focus will be done on specific tests methodologies development, for a better understanding of damage mechanism