ALL OXIDE CERAMIC MATRIC COMPOSITES FOR THERMOSTRUCTURAL APPLICATIONS

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INTRODUCTION

Thermostructural composites as thermal shields for reusable space vehicles must combine high temperature resistance with adequate toughness[1], so limiting the need of replacement and maintenance. Traditional thermal protection systems based on Ceramic Matrix Composites (CMC) such as C/C, C/SiC suffer the well known problem of oxidation at high temperature[2]. On the other hand ceramic matrix composites (CMC) based on all oxide constituents are immune to oxidation but distinct damage tolerant mechanisms must be developed with respect to non-oxide composites[3].
In this work a 2D satin fabric perform of alumina fibers (Nextel N720) is used as reinforcement in an alumina based matrix composite. The composite fabrication is performed by liquid infiltration with an alumina slurry. Static flexural properties were measured at room temperatures before and after repeated heating at 1450 °C. Furthermore a comparison between the mechanical effects of thermal shock cycles on alumina samples and alumina composites was performed. The samples for bending tests were suddenly drop from 1000 °C in a water vat and tested in three point bending. SEM analyisis is also performed on fracture surfaces of composite samples. An improved toughness was obtained by the application of an immiscible oxide coating on the fibres

RESULTS AND DISCUSSION

The microstructural characterization indicated that the fabrication process, favouring the formation of a microporous matrix and a weak bonding with the fibers, leads to a damage tolerant composite. In particular in Figure 1 the SEM picture of the cross section of a fractured samples is shown. It is interesting to observe the good level of infiltration within and between the fibre layers. Another clearly visible feature is the crack propagation pattern on the left. It takes place without breaking any fibre while causing a fibre-matrix debonding. Fibre matrix debonding during crack propagation is an essential feature for a damage tolerating CMC[4].
A representative stress-strain plot obtained from a three point bending test on a composite sample is reported in Fig. 1. The test was performed after an annealing of 90 min at 1350 °C. A linear behaviour was observed up to maximum load. Then, a pseudo plastic deformation at decreasing loads value was. The material is retaining a residual strength even after the test was stopped .
Finally, as shown in figure 3, the rapid prototyping of a complex shape component was performed. The moulds were built using stereolithography. Combining this rapid prototyping technique and the newly developed infiltration process a nose cap prototype was fabricated from a CAD model of the Italian Centre for Aerospace Research (CIRA). The proposed infiltration process allows the fabrication of very complex shape CMC components with no limitation on size and thickness.

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[2] L. Filipuzzi, R. Naslain, C. Jaussaud, J. of Mat. Science, 27 (1992) 33330-3334
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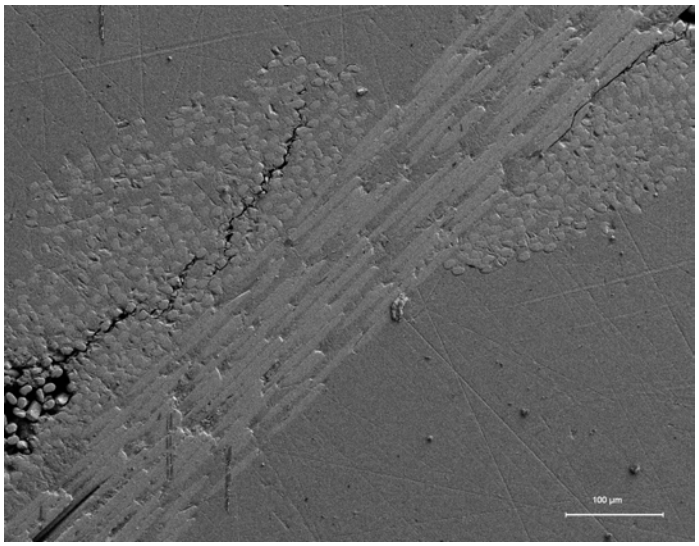

Fig:1 A microstructural SEM view of all-oxide composite based on N720 woven fibre performs.

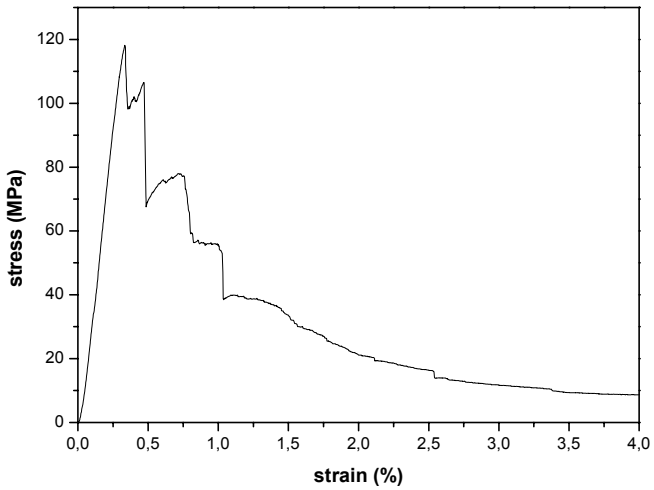

Fig.2 A representative stress–strain curve recorded in three point bending test is reported. The test was performed after air treatment at 1350°C, 90 minutes.

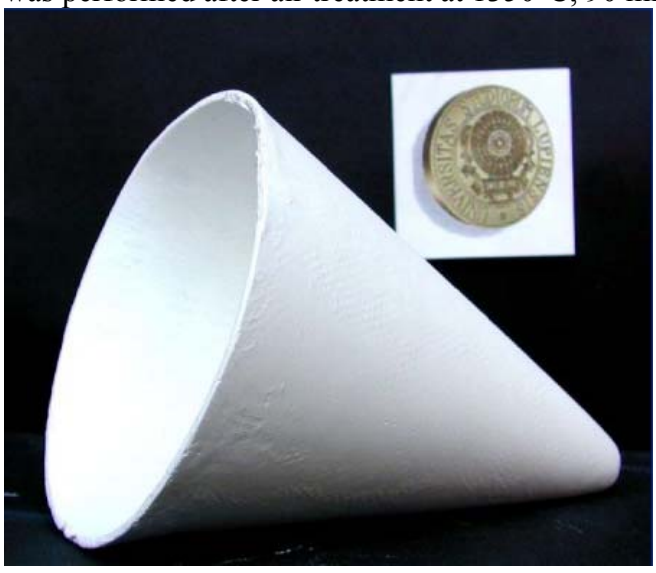

Fig. 3 A nose cap prototype of space vehicle based on the from a CAD model of the Italian Centre for Aerospace Research (CIRA).