# HIGH-TEMPERATURE CERAMIC MATRIX COMPOSITES USING MICROWAVE ENHANCED CHEMICAL VAPOUR INFILTRATION

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To deliver the next generation of aerospace propulsion systems, major modifications to the materials used and their manufacture are required. High-temperature ceramic fibre reinforced ceramic matrix composites (HT-CMCs), specifically $SiC_f$/SiC, have been identified as potential candidates to operate in the hostile aero-thermo-chemical environments experienced in service without compromising structural integrity, whilst keeping mass at a premium. Presently a lack of notably higher temperature properties and durability compared to Ni-super alloys, combined with high manufacturing costs, is preventing widespread utilisation of these composites. Current advanced manufacturing techniques are able to produce these HT-CMCs, which are starting to come into service but all of these techniques introduce compromising features, such as a residual silicon phase, thermal stresses or micro cracking in the matrix microstructure.

One of these advanced methods, chemical vapour infiltration (CVI), is an effective manufacturing route capable of creating near fully dense components with an extremely refined microstructure with little or no preform degradation and minimal residual stresses. CVI's challenges, however, are three fold; i) processing uses isothermal heating rates so batch production times are typically 2 – 3 months; ii) premature pore closure results in a need for repeated machining stages to re-open the closed channels, which reduces process efficiency to between 5-10%; iii) as a consequence of the previous two points, associated costs are very high and the product expensive. Microwave energy (MCVI) has been proposed as a potential solution to heat the SiC fibre preform for CVI; it produces a favourable inverse temperature profile, meaning the temperature is hottest at the centre of the component in contrast to conventional CVI. This inverse profile initiates densification at the centre of the sample, thus avoiding surface porosity closure. It is expected that the use of a microwave-enhanced CVI processing routes could yield near fully dense products in as little as 72 – 96 hours.

This poster presents an update on the forming and characterising of the SiC matrix inside the SiC fabric preform (the latter made of Tyranno ZMI, UBE industries) using the MCVI technique. Kinetics, composition, densification profile, morphology and mechanism of growth of the SiC matrix have all been observed and analysed using a suite of characterisation techniques to see the effect of changing the processing variables. Transmission electron microscopy (TEM) and high resolution scanning electron microscopy (SEM) have been used to observe the degree of crystallinity of the resulting SiC and more specifically the grain growth mechanism and thus the resulting morphology. Wave dispersive spectroscopy (WDS) and Raman has been used to determine the (consistently near stoichiometric) Si to C ratio with an accuracy of ±2% due to a small contribution from traces of oxygen present, the results corroborating the data obtained using the TEM. Raman identified the deposit as ß-SiC and, after further analysis, a number of common polytopes were found including 3C, 6H/15R and 4H. Presented results suggest MCVI is a viable method of producing SiC composites that are potentially suitable for the next generation of aerospace material, though a better understanding of the extent to which full densification can be achieved is still required.