ADVANCES AND CHALLENGES IN THE DEVELOPMENT OF UHTCMCs - A REVIEW OF THE C3harme PROJECT

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Thermal protections for hypersonic vehicles must withstand extreme temperatures and intense mechanical vibrations at launch, during cruising and re-entry into the Earth's atmosphere. UHTCMCs (Ultra-high temperature Ceramic Matrix Composites) are a new class of composites consisting of a UHTC matrix reinforced with C or SiC fibres, capable of superior erosion/ablation resistance, thermal shock resistance, elevated temperature stability and damage tolerance. They are the latest potential candidates for thermal protection systems, able to outperform UHTCs. C3HARME is a 4-years EU funded project involving 12 European partners focused on the design, fabrication and testing of UHTCMCs for near-zero erosion nozzles and near-zero ablation TPS tiles.

This talk will summarize findings and advances of the project, with special emphasis on the innovative approaches implemented. Different technological processes were developed to produce UHTCMCs, including sintering techniques (e.g. hot pressing and spark plasma sintering) and non-sintering techniques (e.g. polymer infiltration and pyrolysis, reactive melt infiltration and chemical vapor infiltration). Extended test campaigns were carried out to compare and screen materials, including plasma wind tunnel tests and nozzle propulsion tests in Italy and Germany, tensile tests, retained strength tests after conditioning over 2000°C. For the TPS application, three technologies were scaled-up to reach the final testing in relevant environment. 190x240x4 mm3 plates, integrated with fastening elements made of the same UHTCMC material were tested 3 times in PWT without significant damage, allowing the achievement of TRL5. For application in propulsion nozzles, a TRL=6 was achieved by integrating UHTCMC nozzle inserts into small and intermediate scale solid and hybrid propellant engines. Inserts tested 3 times with hybrid propellants did not show significant wear or structural damage. The results achieved demonstrate that UHTCMC materials are the class of composites of choice for applications at temperatures between 1500 and 3000°C, with a considerable potential in terms of reusability.

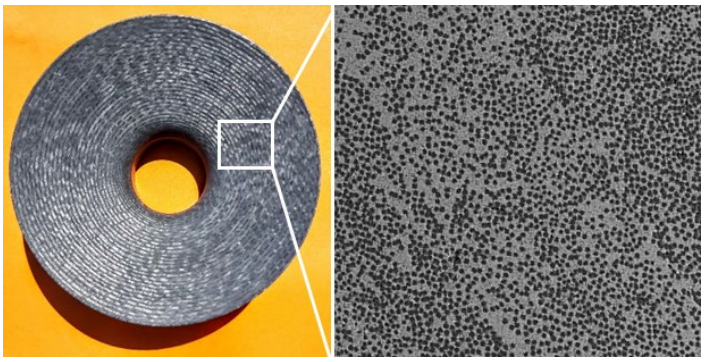

Figure 1. UHTCMC component and its typical microstructure

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