Microstructural investigation and mechanical performance of hybrid thermal protection systems for aerospace applications

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The development of new concepts for Thermal Protection Systems (TPS) is critical for space applications where resistance to extreme oxidative environments and high temperatures are required. In the current study a hybrid thermal protection solution for atmospheric earth re-entry based on low density ablator on top of a thermo-structural ceramic composite is investigated.

The joints of Ceramic Matrix Composite (CMC) material (carbon fibers embedded in silicon carbide matrix C_f/SiC, SICARBON^{TM}) to ablative material (carbon fibers and phenolic resin, ASTERM^{TM}) using commercial high temperature inorganic adhesives are microstructurally and mechanically studied. Three types of adhesives were used based on Al_2O_3, ZrO_2-$ZrSiO_4$ and graphite. The cross section of the joints was analysed using Scanning Electron Microscopy with Energy Dispersive Analysis. Mechanical tests were performed at ambient and cryogenic conditions in order to assess the shear strength of the joints. All the joints exhibit good bonding with both base materials with similar shear strength at ambient conditions. Joints with ZrO_2-$ZrSiO_4$ and graphite based adhesives have the highest ultimate shear strain. At liquid nitrogen the shear strength compared to that at ambient conditions increases from 30 up to 100%. This is attributed to the increase of stiffness of the ablative material. The fracture takes place inside the ablative material and the shear strength is similar (for the tests performed at the same conditions), reflecting the shear strength of the ablative material.

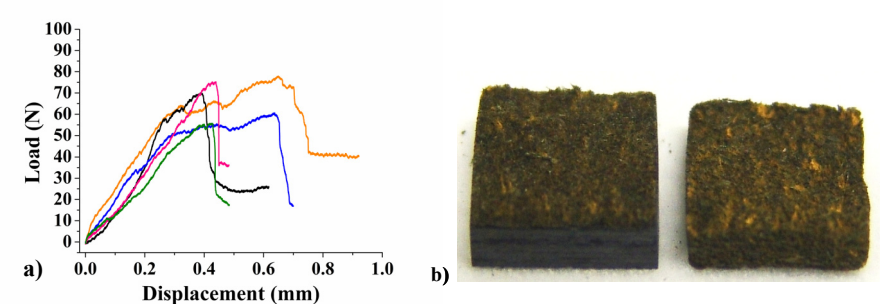

Figure: a) Curves of shear tests at ambient conditions of the SICARBON/ASTERM joints using ZrO_2-$ZrSiO_4$ based adhesive and b) Fracture surfaces of a joint using graphite adhesive.

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