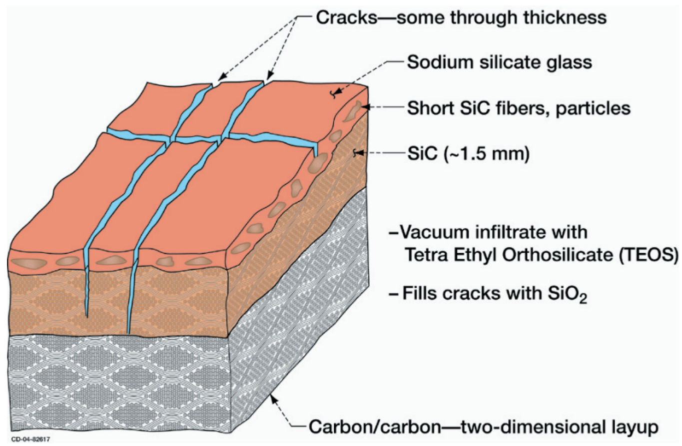
National Aeronautics and Space Administration
Glenn Research Center

Return To Flight

Reinforced Carbon-Carbon

Team Lead: Anthony Calomino

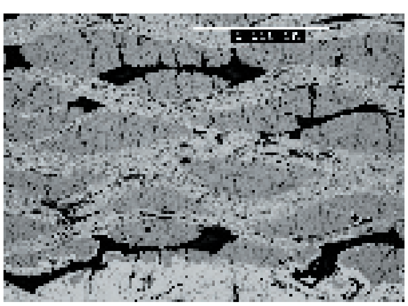
The requirements for reusability, weight, thermal protection, and structural performance of the space shuttle leading edge imposes significant engineering challenges to the existing fleet of orbiters. Reinforced carbon-carbon (RCC) is a critical material for application on the wing leading edge and nose cap, where maximum temperatures are reached on reentry.



Schematic of reinforced carbon-carbon material used for the space shuttle.

The existing leading-edge system is a prime, reliable thermal protection scheme for the vehicle, as the leading-edge structure of the vehicle comprises single-plate RCC composite panels with a wall thickness of approximately 6.0 millimeters. The figure to the right is an illustration of the as-fabricated structure of the RCC material. The primary factor limiting mission life of a panel is high-temperature oxidation of the carbon-carbon composite core, which generates porosity and leads to a time-dependent loss of material strength. Return to flight activities at NASA Glenn Research Center (GRC) are studying the RCC material to gain a deeper understanding of how the material degrades with each mission cycle and the impact that has on safe mission limits.

After 25 years of Shuttle operations, leading-edge material with actual exposures of up to 30 missions is now available to assess the severity of actual strength reduction. More than 20 years of advances in nondestructive evaluation of analytical material science techniques are now available to provide a more detailed understanding of the effects of microstructural changes on material strength. A detailed microstructural examination of as-fabricated RCC is an essential part of this task to understand the baseline material. Samples were obtained in various stages of the process and examined with optical and electron optical techniques. Quantitative image analysis was used to determine porosity in polished cross sections. Gas adsorption techniques were used to measure internal surface areas.



Published cross section showing pores in substrate.

The microstructure was found to show large variations in a variety of areas including porosity, coating morphology, and crack density. The figure to the left shows a region of the carbon-carbon substrate. The origin of these pores can be traced to processing steps. Many of the voids are due to shrinkage of the resin material during pyrolysis.

Establishing a well-documented database for the as-fabricated material will assist in safely assessing aging effects from high-temperature and environmental exposure of the flown and furnace or arcjet conditioned material.