Figure 2. A **UHTC Cone** is shown during testing in the NASA Ames Arc Jet facility. Surface temperatures on the tip of the cone model exceeded 2,000°C during this test.

As part of this effort, researchers are exploring compositions and processing changes that have yielded improvements in properties. Computational materials science and nanotechnology are being explored as approaches to reduce materials development time and improve and tailor properties.

This work was done by Sylvia M. Johnson, Donald T. Ellerby, Sarah E. Beckman, and Edward Irby of Ames Research Center and Matthew J. Gasch and Michael I. Gusman of ELORET. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at (650) 604-2954. Refer to ARC-15258-1.

Improved C/SiC Ceramic Composites Made Using PIP

These materials are expected to remain strong for longer times at high temperatures.

Marshall Space Flight Center, Alabama

Improved carbon-fiber-reinforced SiC ceramic-matrix composite (C/SiC CMC) materials, suitable for fabrication of thick-section structural components, are producible by use of a combination of raw materials and processing conditions different from such combinations used in the prior art. In comparison with prior C/SiC CMC materials, these materials have more nearly uniform density, less porosity, and greater strength. The majority of raw-material/processing-condition combinations used in the prior art involve the use of chemical vapor infiltration (CVI) for densifying the matrix.

In contrast, in synthesizing a material of the present type, one uses a combination of infiltration with, and pyrolysis of, a preceramic polymer [polymer infiltration followed by pyrolysis (PIP)]. PIP processing is performed in repeated, tailored cycles of infiltration followed by pyrolysis. Densification by PIP processing takes less time and costs less than does densification by CVI. When one of these improved materials was tested by exposure to a high-temperature, inert-gas environment that caused prior C/SiC CMCs to lose strength, this material did not lose strength. (Information on the temperature and exposure time was not available at the time of writing this article.)

A material of the present improved type consists, more specifically, of (1) carbon fibers coated with an engineered fiber/matrix interface material and (2) a ceramic matrix, containing SiC, derived from a pre-ceramic polymer with ceramic powder additions. The enhancements of properties of these materials relative to those of prior C/SiC CMC materials are attributable largely to engineering of the fiber/ matrix interfacial material and the densification process.

The synthesis of a material of this type includes processing at an elevated temperature to a low level of open porosity. The approach followed in this processing allows one to fabricate not only simple plates but also more complexly shaped parts. The carbon fiber reinforcement in a material of this type can be in any of several alternative forms, including tow, fabric, or complex preforms containing fibers oriented in multiple directions.

This work was done by Timothy Easler of COI Ceramics Inc.(an Affiliate of ATK Space Systems) for Marshall Space Flight Center. Further information is contained in a TSP (see page 1). . Refer to MFS-32384-1.

Coating Carbon Fibers With Platinum

Uniform coats are produced relatively inexpensively.

Marshall Space Flight Center, Alabama

A process for coating carbon fibers with platinum has been developed. The process may also be adaptable to coating carbon fibers with other noble and refractory metals, including rhenium and iridium. The coated carbon fibers would be used as ingredients of matrix/fiber composite materials that would resist oxidation at high temperatures. The metal coats would contribute to oxidation resistance by keeping atmospheric oxygen away from fibers when cracks form in the matrices.

Other processes that have been used to coat carbon fibers with metals have significant disadvantages:

- Metal-vapor deposition processes yield coats that are nonuniform along both the lengths and the circumferences of the fibers.
- The electrical resistivities of carbon fibers are too high to be compatible with electrolytic processes.
- Metal/organic vapor deposition en-

tails the use of expensive starting materials, it may be necessary to use a furnace, and the starting materials and/or materials generated in the process may be hazardous.

The present process does not have these disadvantages. It yields uniform, nonporous coats and is relatively inexpensive.

The process can be summarized as one of pretreatment followed by electroless deposition. The process consists of the following steps:

- The surfaces of the fiber are activated by deposition of palladium crystallites from a solution.
- The surface-activated fibers are immersed in a solution that contains platinum.
- A reducing agent is used to supply electrons to effect a chemical reduction *in situ*.

The chemical reduction displaces the platinum from the solution. The displaced platinum becomes deposited on the fibers. Each platinum atom that has been deposited acts as a catalytic site for the deposition of another platinum atom. Hence, the deposition process can also be characterized as autocatalytic. The thickness of the deposited metal can be tailored via the duration of immersion and the chemical activity of the solution.

This work was done by Michael R. Effinger of Marshall Space Flight Center, Peter Duncan and Duncan Coupland of Johnson-Matthey Noble Metals, and Mark J. Rigali of Advanced Ceramics Research. Further information is contained in a TSP (see page 1).
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