

that the addition of fumed silica stiffens the aerogel network and reduces shrinkage during the supercritical-drying stage. Minimization of shrinkage enables establishment of intimate contact between thermolectric legs and the composite material, thereby maximizing the effectiveness of the material for thermal insulation and suppression of sublimation.

To some extent, the properties of the composite can be tailored via the proportions of titania and other ingredients. In particular (see figure), the addition of a

suitably large proportion of titania (e.g., 0.6 g/cm³) along with a 10-percent increase in the amount of tetraethylorthosilicate [TEOS (an ingredient of the sol)] to an aerogel component having a density 40 mg/cm³ makes it possible to cast a high-average-density (>0.1 g/cm³) aerogel/particle composite having low shrinkage (2.3 percent).

This work was done by Jong-Ah Paik, Jeffrey Sakamoto, and Steven Jones of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

*Innovative Technology Assets Management
JPL*

*Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-2240*

E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-42031, volume and number of this NASA Tech Briefs issue, and the page number.

Patches for Repairing Ceramics and Ceramic-Matrix Composites

Patches are simply pressed in place, then heated.

Lyndon B. Johnson Space Center, Houston, Texas

Patches consisting mostly of ceramic fabrics impregnated with partially cured polymers and ceramic particles are being developed as means of repairing ceramics and ceramic-matrix composites (CMCs) that must withstand temperatures above the melting points of refractory metal alloys. These patches were conceived for use by space-suited, space-walking astronauts in repairing damaged space-shuttle leading edges: as such, these patches could be applied in the field, in relatively simple procedures, and with minimal requirements for specialized tools. These design characteristics also make the patches useful for repairing ceramics and CMCs in terrestrial settings.

In a typical patch as supplied to an astronaut or repair technician, the polymer would be in a tacky condition, denoted as an "A" stage, produced by partial polymerization of a monomeric liquid. The patch would be pressed

against the ceramic or CMC object to be repaired, relying on the tackiness for temporary adhesion. The patch would then be bonded to the workpiece and cured by using a portable device to heat the polymer to a curing temperature above ambient temperature but well below the maximum operating temperature to which the workpiece is expected to be exposed. The patch would subsequently become pyrolyzed to a ceramic/glass condition upon initial exposure to the high operating temperature. In the original space-shuttle application, this exposure would be Earth-atmosphere-reentry heating to about 3,000 °F (about 1,600 °C).

Patch formulations for space-shuttle applications include SiC and ZrO₂ fabrics, a commercial SiC-based pre-ceramic polymer, and suitable proportions of both SiC and ZrO₂ particles having sizes of the order of 1 μm. These formulations have been tailored for the space-shuttle

leading-edge material, atmospheric composition, and reentry temperature profile so as to enable repairs to survive re-entry heating with expected margin. Other formulations could be tailored for specific terrestrial applications.

This work was done by Peter A. Hogenson, Gordon R. Toombs, Steven Adam, and James V. Tompkins of The Boeing Co. for Johnson Space Center.

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)}, to The Boeing Company. Inquiries concerning licenses for its commercial development should be addressed to:

*The Boeing Company
PO Box 2515*

*2201 Seal Beach Blvd.
Seal Beach, CA 90740-1515
Phone No. (562) 797-2020*

Refer to MSC-24018, volume and number of this NASA Tech Briefs issue, and the page number.

Lower-Conductivity Ceramic Materials for Thermal-Barrier Coatings

Thermal conductivities of certain pyrochlore oxides can be reduced by doping.

John H. Glenn Research Center, Cleveland, Ohio

Doped pyrochlore oxides of a type described below are under consideration as alternative materials for high-temperature thermal-barrier coatings (TBCs). In comparison with partially-yttria-stabilized zirconia (YSZ), which is the state-of-the-art TBC

material now in commercial use, these doped pyrochlore oxides exhibit lower thermal conductivities, which could be exploited to obtain the following advantages:

- For a given difference in temperature between an outer coating surface and

the coating/substrate interface, the coating could be thinner. Reductions in coating thicknesses could translate to reductions in weight of hot-section components of turbine engines (e.g., combustor liners, blades, and vanes) to