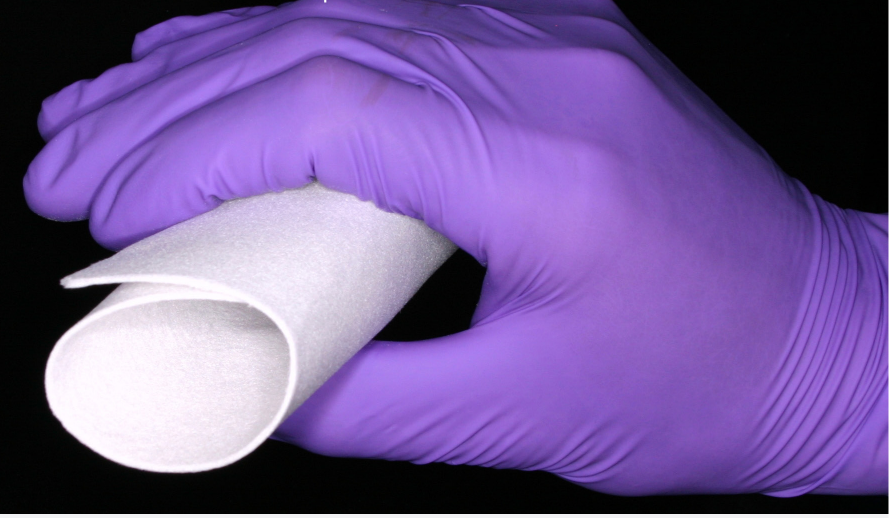
National Aeronautics and Space Administration



Materials and Coatings

Aerogel-Reinforced Composites

Improving the state of the art with insulation materials for environments of up to 1200 °C

NASA's Glenn Research Center (GRC) has developed a method for fabricating low-density, flexible aerogel composites for use as thermal insulation for myriad applications. It is ideal for a variety of environments that require insulation materials that can withstand temperatures of up to 1200 °C. This innovation significantly advances the state of the art for composite insulation systems, reducing adherence problems and thermal conductivity limitations of conventional aerogel insulations while improving performance with lower weight and lower density, and higher efficiency—all factors contributing to greater applicability of aerogel insulation.

BENEFITS

- Robust—strong adhesion to reinforcing fibers greatly reduces "flaking" and loss of aerogel particles compared with other aerogel insulations
- High thermal range—very low thermal conductivity provides better insulating capability at higher temperatures
- Low density—its very low density is one-third that of the state-of-the-art insulation materials
- Resilient—testing of the aerogels showed they can successfully withstand temperatures of at least 1100 °C without collapse of the pore structure
- Flexible—the strength and handling capabilities resulting from the method have not previously been seen with existing seals and aerogels

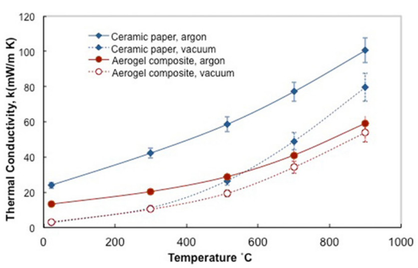
technology solution

THE TECHNOLOGY

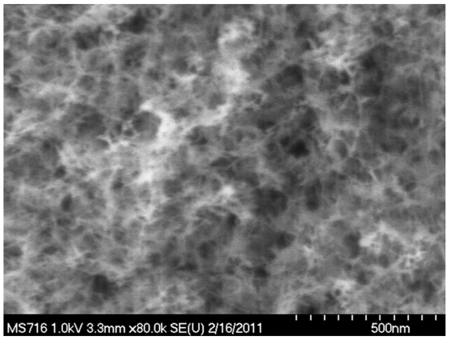
GRC's aluminosilicate aerogel composites are fabricated using a sol-gel technique. A sol is formed by hydrolyzing an alumina dispersion in acid solution; the alumina may be combined with a silicon precursor to create a sol.

Fabrics, papers, and felts are used as reinforcing fibers to form an aerogel composite. The aerogel adheres to the reinforcement without use of sizing or organic binders. (In the case of sized fabrics, the sizing is first removed by heat cleaning.) Composites can be fabricated in a batch process, impregnating individual layers of paper, felt or fabric with the precursor sol, or in a roll-to-roll process. The sol is allowed to gel, and then aged for several days prior to supercritical drying using liquid CO_2. Heat treatment of the super critically dried composites can be used to tailor the alumina or Aluminosilicate crystal structure and pore size.

In contrast to commercially available insulations, GRC's innovation provides extremely low thermal conductivity (60 mW/m-K at 900°C in argon) at high temperatures, thus enabling use at higher temperatures and improving applicability. In addition, GRC's unique process provides very good adhesion of the aerogel to its reinforcing fibers in alumina papers and zirconia felts, eliminating the spalling seen in other aerogel composites. Finally, GRC's innovation demonstrates low density and extreme resilience to high temperatures and harsh conditions. Seven layers of composite material of 1.25 mm/layer produced a temperature drop of 700 °C when tested in the 8-foot high-temperature wind tunnel (8' HTT) at NASA's Langley Research Center. The technology also has withstood heat tests of up to 1200 °C. In combination with other insulators, it has withstood fluxes of up to 65 W/cm2, producing a temperature drop of 625˚C across 8 mm.



A comparison of thermal conductivity of ceramic paper versus aluminosilicate aerogel and ceramic paper composite. The addition of aluminosilicate aerogel greatly improves thermal conductivity.



Micrograph of aluminosilicate aerogel shows pore size and distribution

APPLICATIONS

The technology has applications in myriad environments requiring insulation in temperatures of up to 1100 °C, including insulation for:

- Thermal protection systems (TPSs)
- Inflatable decelerators
- Heat shields
- Fire blankets
- Oil and gas industries
- Radioisotope power systems
- Thermoelectrics
- Aerospace and aviation

PUBLICATIONS

Patent Pending

More Information

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