



Wider-Opening Dewar Flasks for Cryogenic Storage

Lyndon B. Johnson Space Center, Houston, Texas

Dewar flasks have been proposed as containers for relatively long-term (25 days) storage of perishable scientific samples or other perishable objects at a temperature of $-175\text{ }^{\circ}\text{C}$. The refrigeration would be maintained through slow boiling of liquid nitrogen (LN_2). For the purposes of the application for which these containers were proposed, (1) the neck openings of commercial off-the-shelf (COTS) Dewar flasks are too small for most NASA samples; (2) the round shapes of the COTS containers give rise to unacceptably low efficiency of packing in rec-

tangular cargo compartments; and (3) the COTS containers include metal structures that are too thermally conductive, such that they cannot, without exceeding size and weight limits, hold enough LN_2 for the required long-term-storage.

In comparison with COTS Dewar flasks, the proposed containers would be rectangular, yet would satisfy the long-term storage requirement without exceeding size and weight limits; would have larger neck openings; and would have greater sample volumes, leading to a packing efficiency of about double the sample volume as a

fraction of total volume. The proposed containers would be made partly of aerospace-type composite materials and would include vacuum walls, multilayer insulation, and aerogel insulation.

This work was done by Warren P. Ruemele of Johnson Space Center; John Manry, Kristin Stafford, and Grant Bue of Lockheed Martin Corp.; George R. Rowland, Jr., and John Krejci of Hernandez Engineering; and Bent Evernden of Rothe Joint Venture, L.P. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809. MSC-23761-1

Silicon Oxycarbide Aerogels for High-Temperature Thermal Insulation

Marshall Space Flight Center, Alabama

This work has shown that the use of SOC-A35 leads to aerogel materials containing a significant concentration of carbidic species and limited amorphous free carbon. Substitution of the divalent oxide species in silica with trivalent carbidic carbon has directly led to materials that exhibit increased

network viscosity, reduced sintering, and limited densification. The SiOC aerogels produced in this work have the highest carbide content of any dense or porous SiOC glass reported in the literature at that time, and exhibit tremendous long-term thermal stability.

This work was done by Owen Evans, Wendell Rhine, and Decio Coutinho of Aspen Aerogels, Inc. for Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32692-1.

Supercapacitor Electrolyte Solvents With Liquid Range Below $-80\text{ }^{\circ}\text{C}$

New formulations extend operation into lower temperatures.

NASA's Jet Propulsion Laboratory, Pasadena, California

A previous NASA Tech Brief ["Low-Temperature Supercapacitors" (NPO-44386) *NASA Tech Briefs*, Vol. 32, No 7 (July 2008), page 32] detailed ongoing efforts to develop non-aqueous supercapacitor electrolytes capable of supporting operation at temperatures below commercially available cells (which are typically limited to charging and discharging at $\geq -40\text{ }^{\circ}\text{C}$). These electrolyte systems may enable energy storage and power delivery for systems operating in extreme environments, such as those encountered in the Polar

regions on Earth or in the exploration of space. Supercapacitors using these electrolytes may also offer improved power delivery performance at moderately low temperatures (e.g., -40 to $0\text{ }^{\circ}\text{C}$) relative to currently available cells, offering improved cold-cranking and cold-weather acceleration capabilities for electrical or hybrid vehicles.

Supercapacitors store charge at the electrochemical double-layer, formed at the interface between a high surface area electrode material and a liquid electrolyte. The current approach to extend-

ing the low-temperature limit of the electrolyte focuses on using binary solvent systems comprising a high-dielectric-constant component (such as acetonitrile) in conjunction with a low-melting-point co-solvent (such as organic formates, esters, and ethers) to depress the freezing point of the system, while maintaining sufficient solubility of the salt.

Recent efforts in this area have led to the identification of an electrolyte solvent formulation with a freezing point of $-85.7\text{ }^{\circ}\text{C}$, which is achieved by using a 1:1 by volume ratio of acetonitrile to 1,3-dioxolane

(as determined by differential scanning calorimetry). This is in contrast to a freezing point of -45.7°C for the pure acetonitrile solvent used in typical supercapacitor cells. This solvent system readily solubilizes salts commonly used in supercapacitor electrolytes, such as tetraethylammonium tetrafluoroborate (TEATFB) and lithium hexafluorophosphate.

Full electrolyte systems were formulated through the addition of TEATFB to the 1:1 solvent blend, over a range of salt concentrations. Coin cells were then filled with the var-

ious electrolytes for low-temperature electrical testing. Commercially available high surface area carbon-based materials were used as the electrode material, in conjunction with a polyethylene-based separator material. Representative DC discharge data for the 0.50 M concentration system have shown a highly linear discharge over a wide range of temperatures (with little fade in capacitance at the lowest measured temperatures).

This work was done by Erik Brandon, Marshall Smart, and William West of Caltech for NASA's Jet Propulsion Laboratory.

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:

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Designs and Materials for Better Coronagraph Occulting Masks

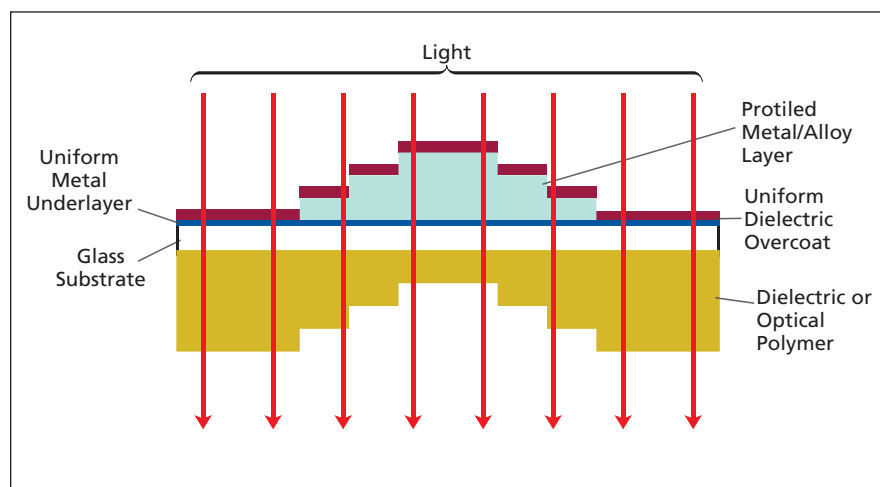
Optical density and phase profiles are achromatized over a broad wavelength range.

NASA's Jet Propulsion Laboratory, Pasadena, California

New designs, and materials appropriate for such designs, are under investigation in an effort to develop coronagraph occulting masks having broad-band spectral characteristics superior to those currently employed. These designs and materials are applicable to all coronagraphs, both ground-based and spaceborne. This effort also offers potential benefits for the development of other optical masks and filters that are required (1) for precisely tailored spatial transmission profiles, (2) to be characterized by optical-density neutrality and phase neutrality (that is, to be characterized by constant optical density and constant phase over broad wavelength ranges), and/or (3) not to exhibit optical-density-dependent phase shifts.

The need for this effort arises for the following reasons:

- Coronagraph occulting masks are required to impose, on beams of light transmitted through them, extremely precise control of amplitude and phase according to carefully designed transmission profiles.
- In the original application that gave rise to this effort, the concern has been to develop broad-band occulting masks for NASA's Terrestrial Planet Finder coronagraph. Until now, experimental samples of these masks have been made from high-energy-beam-sensitive (HEBS) glass, which becomes locally dark where irradiated with a high-energy electron beam, the amount of darkening depending on the electron-beam energy and dose. Precise mask profiles have been written on HEBS glass blanks by use of electron beams,



Thin Metal and Dielectric Films would be deposited on a glass substrate. Their thicknesses would be stepped to obtain a specified spatial transmission profile with a uniform phase profile. This drawing is simplified and is not to scale.

and the masks have performed satisfactorily in monochromatic light. However, the optical-density and phase profiles of the HEBS masks vary significantly with wavelength; consequently, the HEBS masks perform unsatisfactorily in broad-band light.

The key properties of materials to be used in coronagraph occulting masks are their extinction coefficients, their indices of refraction, and the variations of these parameters with wavelength. The effort thus far has included theoretical predictions of performances of masks that would be made from alternative materials chosen because the wavelength dependences of their extinction coefficients and their indices of refraction are such that the optical-density and phase profiles of masks made from these materials can be expected to

vary much less with wavelength than do those of masks made from HEBS glass. The alternative materials considered thus far include some elemental metals such as Pt and Ni, metal alloys such as Inconel, metal nitrides such as TiN, and dielectrics such as SiO_2 .

A mask as now envisioned would include thin metal and dielectric films having stepped or smoothly varying thicknesses (see figure). The thicknesses would be chosen, taking account of the indices of refraction and extinction coefficients, to obtain an acceptably close approximation of the desired spatial transmittance profile with a flat phase profile.

*This work was done by Kunjithapatham Balasubramanian of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.
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