



## Hybrid Composite Cryogenic Tank Structure

**A number of materials can be used to produce external and internal layers of the structure.**

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A hybrid lightweight composite tank has been created using specially designed materials and manufacturing processes. The tank is produced by using a hybrid structure consisting of at least two reinforced composite material systems. The inner composite layer comprises a distinct fiber and resin matrix suitable for cryogenic use that is a braided-sleeve (and/or a filament-wound layer) aramid fiber preform that is placed on a removable mandrel (out-fitted with metallic end fittings) and is infused (vacuum-assisted resin transfer molded) with a polyurethane resin matrix with a high ductility at low temperatures. This inner layer is allowed to cure and is encapsulated with a filament-wound outer composite layer of a distinct fiber resin system. Both inner and outer layer are in intimate contact, and can also be cured at the same time. The

outer layer is a material that performs well for low temperature pressure vessels, and it can rely on the inner layer to act as a liner to contain the fluids.

The outer layer can be a variety of materials, but the best embodiment may be the use of a continuous tow of carbon fiber (T-1000 carbon, or others), or other high-strength fibers combined with a high ductility epoxy resin matrix, or a polyurethane matrix, which performs well at low temperatures. After curing, the mandrel can be removed from the outer layer.

While the hybrid structure is not limited to two particular materials, a preferred version of the tank has been demonstrated on an actual test tank article cycled at high pressures with liquid nitrogen and liquid hydrogen, and the best version is an inner layer of PBO (poly-phenylenebenzobisoxazole) fibers with a

polyurethane matrix and an outer layer of T-1000 carbon with a high elongation epoxy matrix suitable for cryogenic temperatures. A polyurethane matrix has also been used for the outer layer. The construction method is ideal because the fiber and resin of the inner layer has a high strain to failure at cryogenic temperatures, and will not crack or produce leaks. The outer layer serves as more of a high-performance structural unit for the inner layer, and can handle external environments.

*This work was done by Thomas DeLay of Marshall Space Flight Center.*

*This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at [sammy.a.nabors@nasa.gov](mailto:sammy.a.nabors@nasa.gov). Refer to MFS-32390-1.*

## Nanoscale Deformable Optics

**This technology has potential applications in medical imaging, robotics, precision machining, and threat detection.**

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Several missions and instruments in the conceptual design phase rely on the technique of interferometry to create detectable fringe patterns. The intimate emplacement of reflective material upon electron device cells based upon chalcogenide material technology permits high-speed, predictable deformation of the reflective surface to a sub-nanometer or finer resolution with a very high degree of accuracy.

In this innovation, a layer of reflective material is deposited upon a wafer containing (perhaps in the millions) chalcogenic memory cells with the reflective material becoming the front surface of a mirror and the chalcogenic material becoming a means of selectively deforming the mirror by the application of heat to the chalcogenic material. By doing so, the mirror surface can

deform anywhere from nil to nanometers in spots the size of a modern day memory cell, thereby permitting real-time tuning of mirror focus and reflectivity to mitigate aberrations caused elsewhere in the optical system.

Modern foundry methods permit the design and manufacture of individual memory cells having an area of or equal to the Feature (F) size of the design (assume 65 nm). Fabrication rules and restraints generally require the instantiation of one memory cell to another no closer than 1.5 F, or, for this innovation, 90 nm from its neighbor in any direction.

Chalcogenide is a semiconducting glass compound consisting of a combination of chalcogen ions, the ratios of which vary according to properties desired. It has been shown that the applica-

tion of heat to cells of chalcogenic material cause a large alteration in resistance to the range of 4 orders of magnitude. It is this effect upon which chalcogenide-based commercial memories rely. Upon removal of the heat source, the chalcogenide rapidly cools and remains frozen in the excited state. It has also been shown that the chalcogenide expands in volume because of the applied heat, meaning that the coefficient of expansion of chalcogenic materials is larger than 1.

In this innovation, chalcogenide-based cells are addressed (as though they are a memory), and heated and cooled according to well-established criteria. In doing so, the exact size of chalcogenide cell deformation is known and predictable; therefore, the deformation of the reflective surface is, likewise,