# Materials

## Microsphere Insulation Panels

**Thermal performance and lifetime exceed those of foam insulation.**

*John F. Kennedy Space Center, Florida*

Microsphere insulation panels (MIPs) have been developed as lightweight, long-lasting replacements for the foam and vacuum-jacketed systems heretofore used for thermally insulating cryogenic vessels and transfer ducts. Whether preformed or applied in place, foam insulation deteriorates fairly rapidly: on cryogenic transfer lines, it has a life expectancy of about three years. Vacuum-jacketed insulation is expensive and heavy. For both foam and vacuum-jacketed insulation, intensive maintenance is necessary to keep performance at or near its original level. Relative to a polyurethane foam insulation panel, a comparable MIP offers greater thermal performance and longer service life at approximately the same initial cost.

The microsphere core material of a typical MIP consists of hollow glass bubbles, which have a combination of advantageous mechanical, chemical, and thermal-insulation properties heretofore available only separately in different materials. In particular, a core filling of glass microspheres has high crush strength and low density, is noncombustible, and performs well in soft vacuum. A typical MIP includes microspheres in an evacuated space between flexible vacuum-barrier layers made of a multilayer polyester-based laminate [Mylar® 250SBL300 (or equivalent)]. Included in the laminate are several non-foil layers that serve as barriers to permeation by water vapor and other atmospheric gases. The polyester-based laminate material has a projected life in excess of 20 years.

An MIP can be made in clamshell-like halves that can be fitted into a cryogenic vessel or transfer duct. In general, MIPs can be applied to transfer ducts along with jacketing materials conventionally used on foam insulation, and can be installed by use of essentially the same techniques used to install preformed foam insulation. On the basis of tests according to standards C518 and C177 of the American Society for Testing and Materials, the thermal performance of a flexible vacuum-barrier MIP is about two times better than that of a comparable polyurethane foam insulation panel.

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*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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## Single-Wall Carbon Nanotube Anodes for Lithium Cells

**Capacities are greater than those of graphite anodes.**

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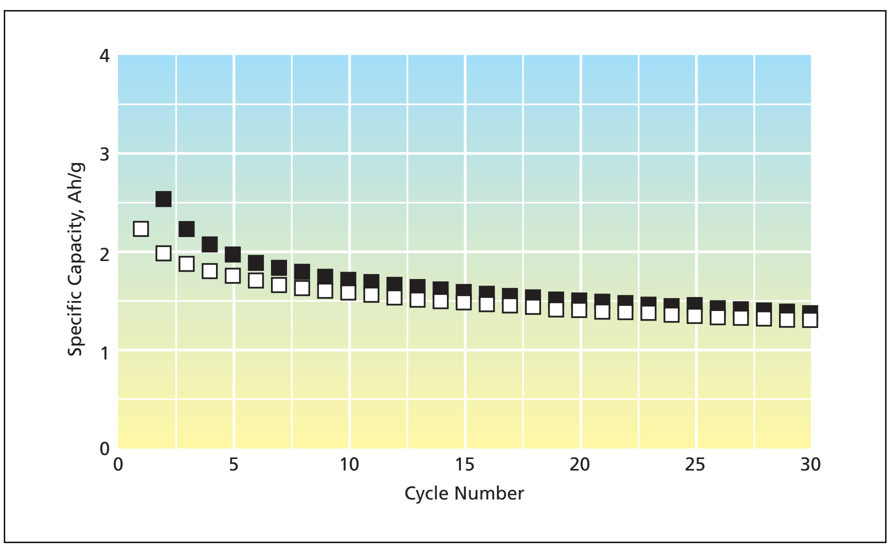
In recent experiments, highly purified batches of single-wall carbon nanotubes (SWCNTs) have shown promise as superior alternatives to the graphitic carbon-black anode materials heretofore used in rechargeable thin-film lithium power cells. The basic idea underlying the experiments is that relative to a given mass of graphitic carbon-black anode material, an equal mass of SWCNTs can be expected to have greater lithium-storage and charge/discharge capacities. The reason for this expectation is that whereas the microstructure and nanostructure of a graphitic carbon black is such as to make most of the interior of the material inaccessible for intercalation of lithium, a batch of SWCNTs can be made to have a much more open microstructure and nanostructure, such




**Specific Capacity** of a carbon-nanotube anode material as a function of cycle number was calculated from charge and discharge times measured in galvanostatic cycling.