

Following deposition of the patterned catalyst, a shutter is moved into place to protect the sputtering equipment against CVD of carbon, then a hydrocarbon feed gas (primarily CH<sub>4</sub>, C<sub>2</sub>H<sub>2</sub>, or C<sub>2</sub>H<sub>4</sub>) heated to a suitable temperature is admitted into the chamber. Optionally, the feed gas can be part of a mixture that includes an inert carrier gas. The heated feed gas decomposes into hydrogen and carbon, with deposition of the carbon on the cata-

lyst. Whether what are grown are single-walled nanotubes (SWNTs), multi-walled nanotubes (MWNTs), or nanofibers depends primarily on the feed gas and temperature used in CVD and secondarily on the structures and compositions of the first layer and the patterned catalytic second layer. For example, for growing SWNTs, the preferred gas is CH<sub>4</sub> and the preferred temperature is ≈900 °C. For growing MWNTs, the preferred gas is C<sub>2</sub>H<sub>2</sub> or

C<sub>2</sub>H<sub>4</sub>, the preferred temperature is ≈750 °C. For growing nanofibers, it is preferable to form a plasma discharge in the chamber and to maintain the temperature between 400 and 700 °C.

*This work was done by Lance D. Delzeit of Ames Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14613.*

---

## **Lightweight, Rack-Mountable Composite Cold Plate/Shelves**

*Lyndon B. Johnson Space Center, Houston, Texas*

Rack-mountable composite-material structural components that would serve as both shelves and cold plates for removing heat from electronic or other equipment mounted on the shelves have been proposed as lightweight alternatives to all-metal cold plate/shelves now in use. A proposed cold plate/shelf would include a highly thermally conductive face sheet containing oriented graphite fibers bonded to an aluminum honeycomb core, plus an extruded stainless-steel substructure containing optimized flow passages for a cooling fluid, and an inlet and outlet that could be

connected to standard manifold sections. To maximize heat-transfer efficiency, the extruded stainless-steel substructure would be connected directly to the face sheet. On the basis of a tentative design, the proposed composite cold plate/shelf would weigh about 38 percent less than does an all-aluminum cold plate in use or planned for use in some spacecraft and possibly aircraft. Although weight is a primary consideration, the tentative design offers the additional benefit of reduction of thickness to half that of the all-aluminum version.

*This work was done by Kathryn M. Hurl-*

*bert of Johnson Space Center and Warren Ruennele, Hai D. Nguyen, Kambiz K. Andish, and Sean McCalley of Lockheed Martin.*

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

*Lockheed Martin Space Operations*

*2400 NASA Road 1*

*Nassau Bay, TX 77058*

*Refer to MSC-23160, volume and number of this NASA Tech Briefs issue, and the page number.*