etch masks to define the 50-µm apertures on a silicon substrate. In the second step, which is part of the previously reported process, the non-masked silicon area between the apertures is subjected to reactive ion etching (RIE) under a special combination of conditions that results in the growth of fluorine-based compounds in randomly distributed formations, known in the art as “polymer RIE grass,” that have dimensions of the order of microns.

The polymer RIE grass formations serve as microscopic etch masks during the next step, in which deep reactive ion etching (DRIE) is performed. What remains after DRIE is the carpet of nanotips, which are high-aspect-ratio peaks, the tips of which have radii of the order of nanometers. Next, the nanotip array is evaporatively coated with Cr/Au to enhance the absorption of light (more specifically, infrared light in the Sun-sensor application). The photosensitive etch masks protecting the apertures are then removed by dipping the substrate into acetone. Finally, for the Sun-sensor application, the back surface of the substrate is coated with a 57-nm-thick layer of Cr for attenuation of sunlight.

This work was done by Youngsam Bae, Sohrab Mobasser, Harish Manohara, and Choonsup Lee of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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Innovative Technology Assets Management
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-2240
E-mail: iaoffice@jpl.nasa.gov
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![Nano-Engineered Catalysts for Direct Methanol Fuel Cells](https://ntrs.nasa.gov/search.jsp?R=20080048174)

Small particle sizes and large surface areas can be produced economically and consistently.

NASA’s Jet Propulsion Laboratory, Pasadena, California

Nano-engineered catalysts, and a method of fabricating them, have been developed in a continuing effort to improve the performances of direct methanol fuel cells as candidate power sources to supplant primary and secondary batteries in a variety of portable electronic products. In order to realize the potential for high energy densities (as much as 1.5 W·h/g) of direct methanol fuel cells, it will be necessary to optimize the chemical compositions and geometric configurations of catalyst layers and electrode structures. High performance can be achieved when catalyst particles and electrode structures have the necessary small feature sizes (typically of the order of nanometers), large surface areas, optimal metal compositions, high porosity, and hydrophobicity.

The present method involves electrodeposition of one or more catalytic metal(s) or a catalytic-metal/polytetrafluoroethylene nanocomposite on an alumina nanotemplate. The alumina nanotemplate is then dissolved, leaving the desired metal or metal/polytetrafluoroethylene-composite catalyst layer. Unlike some prior methods of making fine metal catalysts, this method does not involve processing at elevated temperature; all processing can be done at room temperature. In addition, this method involves fewer steps and is more amenable to scaling up for mass production.

Alumina nanotemplates are porous alumina membranes that have been fabricated, variously, by anodizing either pure aluminum or aluminum that has been deposited on silicon by electron-beam evaporation. The diameters of the pores (7 to 300 nm), areal densities of

These Are Scanning Electron Micrographs of catalysts fabricated by the method described in the text. The platinum/ruthenium rods, about 0.2 µm wide and 1 µm long, were electrodeposited from a plating bath containing H₂PtCl₆, K₂RuCl₅, and H₂SO₄. The platinum/polytetrafluoroethylene composite was electrodeposited from a solution containing H₂PtCl₆, H₂SO₄, CH₃OH, and suspended polytetrafluoroethylene nanoparticles having sizes from 0.1 to 0.2 µm.
Capillography of Mats of Nanofibers
These mats can be the basis of small devices and instruments.

NASA’s Jet Propulsion Laboratory, Pasadena, California

Capillography (from the Latin capillus, “hair”, and the Greek graphein, “to write”) is a recently conceived technique for forming mats of nanofibers into useful patterns. The concept was inspired by experiments on carpetlike mats of multiwalled carbon nanotubes. Capillography may have the potential to be a less-expensive, less-time-consuming alternative to electron-beam lithography as a means of nanoscale patterning for the fabrication of small devices and instruments.

In capillography, one exploits the lateral capillary forces exerted on small objects that pierce the surface of a liquid. If the small objects are identical, then the forces are always attractive. Two examples of the effects of such forces are the agglomeration of small particles floating on the surface of a pond and the drawing together of hairs of a wet paintbrush upon removal of the brush from water. Because nanoscale objects brought into contact remain stuck together indefinitely due to Van der Waals forces, patterns formed by capillography remain even upon removal of the liquid.

For the experiments on the mats of carbon nanotubes, a surfactant solution capable of wetting carbon nanotubes (which are ultra-hydrophobic) was prepared. The mats were wetted with the solution, then dried. Once the mats were dry, it was found that the nanotubes had become ordered into various patterns, including nestlike indentations, trenches, and various combinations thereof (see figure).

When polytetrafluoroethylene is included, it is for the purpose of imparting hydrophobicity in order to prevent water from impeding the desired diffusion of gases through the catalyst layer. To incorporate polytetrafluoroethylene into a catalytic-metal/polytetrafluoroethylene nanocomposite, one suspends polytetrafluoroethylene nanoparticles in the electrodeposition solution. The polytetrafluoroethylene content can be varied to obtain the desired degree of hydrophobicity and permeability by gas.

This work was done by Nosang Myung, Sekharipuram Narayanan, and Dean Wiberg of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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Pasadena, CA 91109-8099
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