Technology Focus: Engineered Materials

Diamond-Coated Carbon Nanotubes for Efficient Field Emission

Lyndon B. Johnson Space Center, Houston, Texas

Field-emission cathodes containing arrays of carbon nanotubes coated with diamond or diamondlike carbon (DLC) are undergoing development. Multiwalled carbon nanotubes have been shown to perform well as electron field emitters. The idea underlying the present development is that by coating carbon nanotubes with wide-band-gap materials like diamond or DLC, one could reduce effective work functions, thereby reducing threshold electric-field levels for field emission of electrons and, hence, improving cathode performance. To demonstrate feasibility, experimental cathodes were fabricated by (1) covering metal bases with carbon nanotubes bound to the bases by an electrically conductive binder and (2) coating the nanotubes, variously, with diamond or DLC by plasma-assisted chemical vapor deposition. In tests, the threshold electric-field levels for emission of electrons were reduced by as much as 40 percent, relative to those of uncoated-nanotube cathodes. Coating with diamond or DLC could also make field emission-cathodes operate more stably by helping to prevent evaporation of carbon from nanotubes in the event of overheating of the cathodes. Cathodes of this type are expected to be useful principally as electron sources for cathode-ray tubes and flat-panel displays.

This work was done by Stevan Dimitrijevic and James C. Withers of Materials and Electrochemical Research Corp. for **Johnson Space Center**.

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:

Materials and Electrochemical Research Corp.
7960 South Kolb Road
Tucson, AZ 85706
Phone: (520) 574-1980
Fax: (520) 574-1983
E-mail: mercorp@mercorp.com

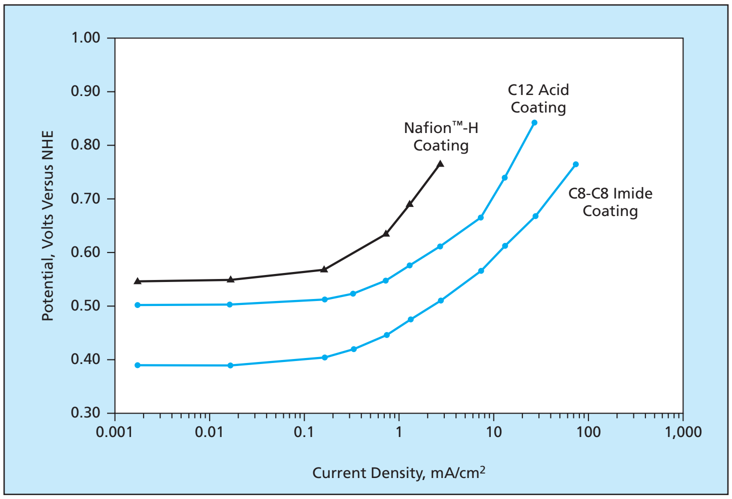
Refer to MSC-23133, volume and number of this NASA Tech Briefs *issue, and the page number.*

Improved Anode Coatings for Direct Methanol Fuel Cells

Two perfluoroalkanesulfonic compounds offer increased fuel-utilization rates and reduced polarization levels.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two perfluoroalkanesulfonic acids and perfluoroalkanesulfonimides have shown promise as anode-coating materials for improving the performances of direct methanol fuel cells (DMFCs). Heretofore, the state-of-the-art material commonly used for coating anodes in DMFCs has been Nafion™-H — a perfluorosulfonic acid-based hydrophilic, proton-conducting ion-exchange polymer that exhibits relatively high thermal and electrochemical stability. Relative to Nafion™-H, the present coating materials afford greater rates of electro-oxidation of methanol, smaller polarization losses and, hence, greater energy-conversion efficiencies.



Polarization Levels [potentials versus a normal hydrogen electrode (NHE)] of variously coated carbon-supported Pt-Sn electrodes were measured over a range of current densities in a test cell containing a solution of 1.0 M methanol in 0.50 M sulfuric acid.

Perfluorinated solid polymer electrolytes — in particular, Nafion™-H — have been used as anode coatings in DMFCs to (1) ensure contact between electrolyte membranes and electrocatalytic anode materials (typically, alloys containing Pt) and (2) help prevent catalysts from being poisoned by adsorption of anions. However, the performances of electrodes coated by perfluorinated solid polymer electrolytes have not been ideal, especially at room temperature. Consequently, there has been continued interest in developing means of reducing polarization losses and increasing rates of oxidation and efficiencies of utilization of methanol in order to improve the performances and increase the energy-conversion efficiencies of DMFCs.

In preparation for experiments, DMFC anodes made of carbon-supported Pt, Pt-Ru, and Pt-Sn were prepared and coated, variously, with Nafion™-H or six different perfluoroalkanesulfonic materials: perfluorooctanesulfonic acid (C8 acid), perfluorododecanesulfonic acid (C12 acid), perfluoroheptadecanesulfonic acid (C17 acid), bis-perfluoro-*n*-butyl sulfonyl acid