



## Low-Pt-Content Anode Catalyst for Direct Methanol Fuel Cells

The costs of fuel-cell anodes could be reduced substantially.

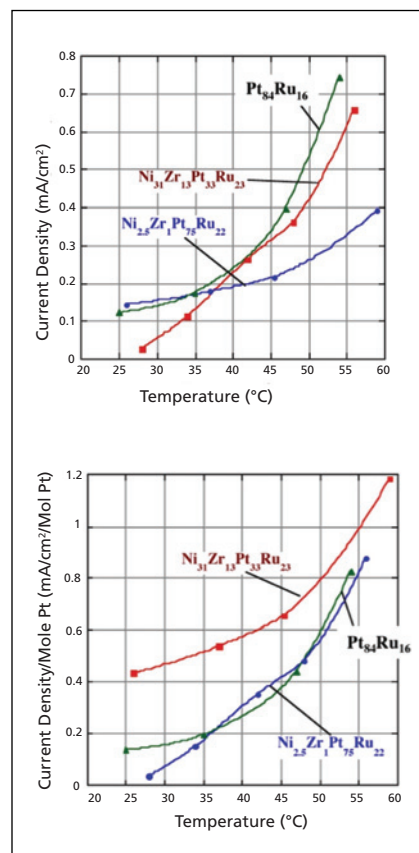
NASA's Jet Propulsion Laboratory, Pasadena, California

Combinatorial experiments have led to the discovery that a nanophase alloy of Pt, Ru, Ni, and Zr is effective as an anode catalyst material for direct methanol fuel cells. This discovery has practical significance in that the electronic current densities achievable by use of this alloy are comparable or larger than those obtained by use of prior Pt/Ru catalyst alloys containing greater amounts of Pt. Heretofore, the high cost of Pt has impeded the commercialization of direct methanol fuel cells. By making it possible to obtain a given level of performance at reduced Pt content (and, hence, lower cost), the discovery may lead to reduction of the economic impediment to commercialization.

In the experiments, alloys of various Pt/Ru/Ni/Zr compositions and Pt/Ru compositions were made by co-sputter deposition onto patterned Au on glass substrates at various positions relative to a Pt<sub>40</sub>Ru<sub>60</sub> and Ni<sub>70</sub>Zr<sub>30</sub> sputter targets (the numbers denote atomic percentages). X-ray diffraction analysis of the alloys led to the conclusion that the quaternary alloy most likely consisted of one or two crystalline phases characterized by grain sizes of 1 to 5 nm.

The electrochemical performances of the alloys were tested using both cyclic voltammetry and potentiostatic current measurements. The most promising Pt/Ru/Ni/Zr alloy had a composition of Pt<sub>33</sub>Ru<sub>23</sub>Ni<sub>30</sub>Zr<sub>13</sub>. Comparative poten-

tiostatic tests of Pt<sub>33</sub>Ru<sub>23</sub>Ni<sub>30</sub>Zr<sub>13</sub> and an optimized, state-of-art Pt<sub>84</sub>Ru<sub>16</sub> catalysts were performed (in a solution of 1M



Plotted Test Results compare current densities for Pt<sub>33</sub>Ru<sub>23</sub>Ni<sub>30</sub>Zr<sub>13</sub> with current densities of the state-of-art Pt-Ru under the same test conditions.

methanol + 1M sulfuric acid at temperatures ranging from 25 to 60 °C). The results of these tests, plotted in the figure, show that the current density [after 5 minutes at 0.7 V vs. NHE (normal hydrogen electrode)] for Pt<sub>33</sub>Ru<sub>23</sub>Ni<sub>30</sub>Zr<sub>13</sub> met (as normalized to test structure area), or exceeded (if normalized to surface Pt atoms), the current densities of the state-of-art Pt-Ru under the same test conditions. These data indicate that the new quaternary alloy induced a significantly higher Pt surface site utilization. X-ray photoelectron spectroscopy data indicate that the Pt electron structure in the quaternary material was also very different from that observed in the Pt-Ru alloys.

This work was done by Sekharipuram Narayanan and Jay Whitacre of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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:

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](mailto:iaoffice@jpl.nasa.gov)

Refer to NPO-40841, volume and number of this NASA Tech Briefs issue, and the page number.

## Graphite/Cyanate Ester Face Sheets for Adaptive Optics

Unlike glass face sheets, these would be nearly unbreakable.

Marshall Space Flight Center, Alabama

It has been proposed that thin face sheets of wide-aperture deformable mirrors in adaptive-optics systems be made from a composite material consisting of cyanate ester filled with graphite. This composite material appears to offer an attractive alternative to low-thermal-expansion glasses that

are used in some conventional optics and have been considered for adaptive-optics face sheets.

Adaptive-optics face sheets are required to have maximum linear dimensions of the order of meters or even tens of meters for some astronomical applications. If the face sheets were to be made

from low-thermal-expansion glasses, then they would also be required to have thicknesses of the order of a millimeter so as to obtain the optimum compromise between the stiffness needed for support and the flexibility needed to enable deformation to controlled shapes by use of actuators.