# Formulations for Stronger Solid Oxide Fuel-Cell Electrolytes

## Alumina is added to yttria-stabilized zirconia.

*John H. Glenn Research Center, Cleveland, Ohio*

Tests have shown that modification of chemical compositions can increase the strengths and fracture toughnesses of solid oxide fuel-cell (SOFC) electrolytes. Heretofore, these solid electrolytes have been made of yttria-stabilized zirconia, which is highly conductive for oxygen ions at high temperatures, as needed for operation of fuel cells. Unfortunately yttria-stabilized zirconia has a high coefficient of thermal expansion, low resistance to thermal shock, low fracture toughness, and low mechanical strength. The lack of strength and toughness are especially problematic for fabrication of thin SOFC electrolyte membranes needed for contemplated aeronautical, automotive, and stationary power-generation applications.

The modifications of chemical composition that lead to increased strength and fracture toughness consist in addition of alumina to the basic yttria-stabilized zirconia formulations. Techniques for processing of yttria-stabilized zirconia/alumina composites containing as much as 30 mole percent of alumina have been developed. The composite panels fabricated by these techniques have been found to be dense and free of cracks. The only material phases detected in these composites has been cubic zirconia and a alumina: this finding signifies that no undesired chemical reactions between the constituents occurred during processing at elevated temperatures.

The flexural strengths and fracture toughnesses of the various zirconia-alumina composites were measured in air at room temperature as well as at a temperature of 1,000 °C (a typical SOFC operating temperature). The measurements showed that both flexural strength and fracture toughness increased with increasing alumina content at both temperatures. In addition, the modulus of elasticity and the thermal conductivity were found to increase and the density to decrease with increasing alumina content. The oxygen-ion conductivity at 1,000 °C was found to be unchanged by the addition of alumina.

*This work was done by Narottam P. Bansal and John C. Goldsby of* **Glenn Research Center** *and Sung R. Choi of Ohio Aerospace Institute. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17380.*