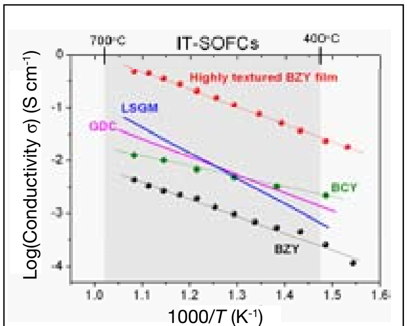
Energy Focus

Epitaxially grown BZY films display high ionic conductivity

Research in the field of solid oxide fuel cells (SOFC) spans more than 20 years in an attempt to synthesize a cost-effective oxide material with high ionic conductivity at intermediate-to-low temperatures and good chemical stability, for a wide range of applications such as SOFCs for portable power supply in small electronic devices. High-temperature proton conductors, like yttrium-doped barium zirconate, are now considered as alternatives to the oxygen-ion conductor electrolytes conventionally used in SOFCs, which have been proven to be environmentally benign and efficient energy production devices. D. Pergolesi, E. Fabbri, and E. Traversa of the University of Rome 'Tor Vergata', Italy and the National Institute for Materials Science, Japan and their co-workers, fabricated grain-boundary–free thin films of yttrium-doped barium zirconate ($BaZr_{0.8}Y_{0.2}O_{3-\delta}$; BZY) that showed the highest proton conductivity ever reported under such a low temperature (350°C) for any oxide material.

As reported in the September 19th issue of *Nature Materials* (DOI:10.1038/NMAT2837; p. 846), the researchers used pulsed laser deposition (PLD) to fabricate highly textured, epitaxially grown BZY films (1 μm thickness) deposited on (100)-oriented MgO substrates and achieved proton conductivity values of 0.11 S/cm at 500°C.

The researchers achieved a proton conductivity value of 0.01 S/cm, which is considered as the minimum conductivity value for practical applications in fuel cells, at a temperature as low as 350°C (see figure). As seen in the figure, BZY film conductivity is significantly larger than best performing, stable oxygen-ion conductors used for SOFC applications in the intermediate temperature range. The researchers carried out an extensive in-plane x-ray diffraction analysis to confirm the crystalline nature of epitaxially grown BZY films and to obtain reciprocal space maps.



Comparison between the electrical conductivity of the BZY films grown on MgO with that of BZY and BCY (Y-doped barium cerate) sintered pellets, measured in the intermediate temperature range. Conductivity values of the oxygen-ion conducting electrolytes ($La_{0.8}Sr_{0.2}Ga_{0.8}Mg_{0.2}O_3$; LSGM and $Ce_{0.8}Gd_{0.2}O_{1.9-\delta}$; GDC) are also reported.Reproduced with permission from *Nature Materials* **9** (10) (2010) 846; DOI: 10.1038/NMAT2837. © 2010 Nature Publishing group.

The researchers used electrochemical impedance spectroscopy to carry out electrical analysis of BZY films grown on MgO substrate in the temperature range of 350°C to 650°C, in a humid atmosphere of 5% H_2 in Ar. The proton conductivity of the BZY films grown on MgO substrate was measured to be about two orders of magnitude higher than sintered pellet of the same material. The researchers attribute the large proton conductivity observed in epitaxial films to the high crystalline nature of epitaxial films which minimizes nonconducting grain boundary regions. According to the researchers, the results from this study may open new perspectives in the development of miniaturized SOFCs for portable and low power-demanding applications.

Rohit Khanna

Nano Focus

Novel fabrication approaches yield continuous nanocomposite and nanoceramic fibers

Nanoscale composite materials are being increasingly used as biomaterials, catalysts, sensors, energy-storage materials, filters, and in many other applications. There is need for improved methods to fabricate nanocomposites with better control and reproducibility of material properties including microstructure, chemistry, and dimensions that can also be applied to a wide variety of materials. Y. de Hazan of the Swiss Federal Laboratories for Materials Testing and Research (Empa), T. Graule of Empa and Technische Universitat Freiberg, and their colleagues have developed a versatile spinning technique to fabricate continuous fibers of ceramic/polymer nanocomposites and nanoceramics.

As reported in the September issue of the *Journal of the American Ceramic Society* (DOI: 10.1111/j.1551-2916.2010.03802.x; p. 2456), the researchers developed a spinning process in which the feedstock consists of colloidal particles dispersed in a radiation-curable monomer. A number of techniques have been developed previously to fabricate ceramic and polymer/ceramic composite fibers. One class of techniques involves extrusion and spinning such as melt spinning, wet and dry spinning, and electrospinning. Another class involves direct writing or a free-form fabrication method of colloidal inks to form well-defined shapes. Most of these techniques to fabricate elongated structures use extrusion and drawing methods that utilize different variations of applied tension and elongation of the extruded filament, and are limited by the range of usable viscosity of the dispensed solution.

In the new method developed in this study, the curable dispersion is extruded through an extrusion/spinning die and cured using UV or heat immediately to a solid fiber and thus there is no lower limit of the feedstock viscosity. The method is versatile and can be applied for a wide variety of nanocomposites, including feedstock with high particle

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