Novel Fuel Cell Electrolyte

A step towards clean and efficient energy production

Professor Judith Driscoll and her team in the Department of Materials Science and Metallurgy, University of Cambridge, have developed a new electrolyte material capable of enhancing thin film ionic devices by dramatically increasing the ionic conductivity. This is expected to enable either lower temperature operation or enhanced efficiency at high temperatures in solid oxide fuel cells, oxygen separation membranes or sensors. The team is now keen to collaborate with partners to validate this exciting new material. Depending on the materials to be coupled together in the composite, possible applications include chemical sensors, oxygen separation membranes and micro-solid oxide fuel cells.

Key Benefits

- Using standard thin film deposition, up to three orders of magnitude higher oxygen ionic conductivity than current commercial standard, enabling:
- **Lower temperature operation ionic devices**
- **More efficient devices at usual operating temperatures**

Judith Driscoll is Professor of Materials Science. Her research focuses on nanoscale design and tuning of functional oxide thin film materials for a variety of energy applications.

In addition to her position in Cambridge, she is also a Long Term Visiting Staff Member at Los Alamos National Laboratory, New Mexico.

For further information please contact:

Dr Charlanne Ward
Charlanne.Ward@enterprise.cam.ac.uk
+44 (0)1223 767855
Cambridge Enterprise Limited, University of Cambridge
Hauser Forum, 3 Charles Babbage Road, Cambridge CB3 0GTUK
www.enterprise.cam.ac.uk

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What problem does this material solve?

As shown in Figure 1, our electrolyte is capable of high ionic conductivities and can be used at much lower temperatures than are possible in alternative technologies (~0.1 $\Omega^{-1}cm^{-1}$ at 350°C). Compared with YSZ films (the current electrolyte standard) our electrolyte has an ionic conductivity up to 3 orders of magnitude higher over a wide temperature range.

Applications

Solid Oxide Fuel Cells (SOFCs) comprise a cathode, anode and electrolyte material sandwiched between them (Figure 2). The electrolyte transports oxygen ions from the cathode to the anode, thus generating an electric charge. Compared to conventional batteries, fuel cells have the potential to run indefinitely, if supplied by a source of fuel (e.g. H_2 or a hydrocarbon) and a source of O_2. As shown in Figure 3 (*A. Evans, Journal of Power Sources 194 (2009) 119*), micro-(μ)SOFCs are promising future energy generation devices, particularly for portable electronics. The composite films here can be grown on buffered metallic substrates, the buffer being made into a *porous* anode after growth. The cathode may be comprised of a highly nanoporous film for easy gas exchange.

Thin film oxygen separation membranes allow the permeation of oxygen from air without the need for cryogenic technology. Such membranes could be integrated in catalytic process reactors, allowing O_2 separation and catalytic processing in one step.

The technology may also offer a superior O_2 sensor for determining oxygen levels in various industries, including surface supplied breathing gas mixtures.

Benefits of the new composite material

In addition to providing significantly improved ionic conductivity, our electrolyte exhibits the following:

- Minimal heat loss and short circuiting due to low (but tunable) electronic conductivity
- Minimal cracking due to nm-scale feature sizes (below the critical crack size)
- Relatively large density, which means that the risk of fuel leakage is reduced
- Simple fabrication (the epitaxial composite nano-structured thin film forms by self assembly from a single mixed target material)
- Tunable relative ionic and electronic conductivities by appropriate choice of materials (particularly useful for the oxygen separation membrane and sensor applications)

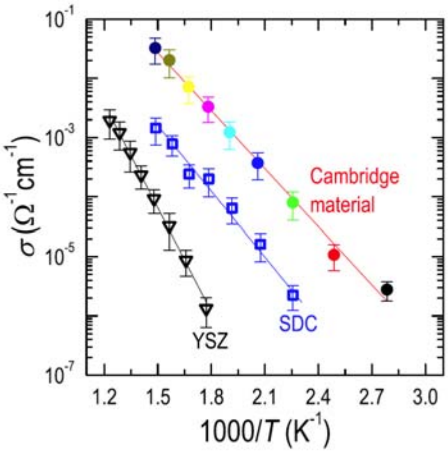

Figure 1: Comparison of ionic conductivity for Cambridge material and leading alternatives (YSZ = Yttria-stabilized zirconia, SDC = Samaria-doped ceria)

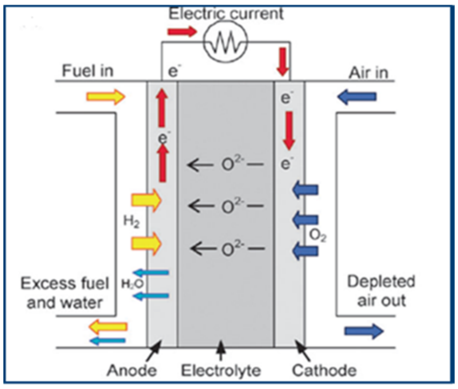

Figure 2: Diagram of a solid oxide fuel cell

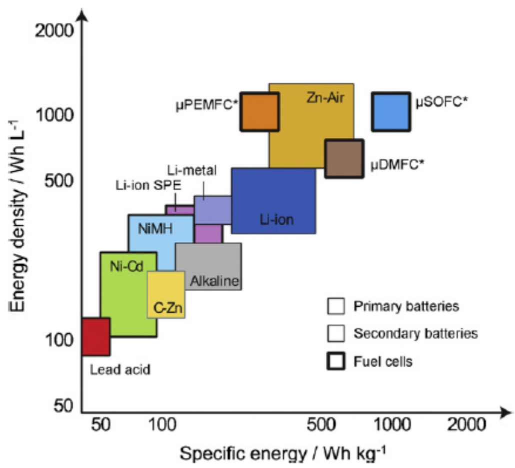

Figure 3: Specific energy (per mass of device) and energy density (per volume of device) of portable energy sources

Next steps

This technology is protected by a patent application in the US. We are now looking for partners to help us validate the material in ionic applications. Please contact us to explore this opportunity with us.