Oxygen Transport in Materials for Solid Oxide Fuel Cells

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The Solid Oxide Fuel Cell (SOFC) is a device for the clean, efficient conversion a fuel into electrical power. One major attribute of the SOFC is that it has fuel flexibility, and thus can operate with the hydrocarbon fuels that dominate the current energy mix to the renewable hydrogen and biofuels proposed in many low carbon scenarios. The SOFC is constructed from thin layers of oxide materials that must display very high rates of oxygen ion transport for the device to be practical. Most of the common materials used in SOFC construction only show these high transport rates at temperatures above 700°C and have meant that, historically, the SOFC has been a device that operates in the region 800-1000°C. Over the last decade there has been an increasing awareness that to fulfil the potential of the SOFC, this temperature of operation needs to be reduced into the intermediate temperature (IT) regime (500-700°C), where cost and durability targets for large scale commercialisation are more likely to be met.

The reduction of operating temperature has posed some difficult problems in the search for materials that are active at this temperature regime. In particular materials for the cathode have been a major target because it has been recognised for some time that the cathode is the major source of losses in the ITSOFC. Mixed Electronic Ionic Conductors (MEICs) have been the materials of choice because of their high electrocatalytic properties, however it is not easy to characterise the oxygen transport in these materials because of their high electronic conductivity. Electrical methods to determine the oxygen transport kinetics are possible (but difficult) and in many cases are ambiguous in their outcome. For this reason oxygen isotopic exchange is often used to measure oxygen surface exchange and diffusion rates in MEICs proposed as candidates for ITSOFC cathodes.

In this seminar details will be given of the Isotopic Exchange-Depth Profiling (IEDP) method, using SIMS, developed at Imperial over the past two decades to measure oxygen diffusion and surface exchange rates in mixed conducting oxides. The materials chosen as examples will include some of the conventional perovskite cathode materials, such as $La_{1-x}Sr_xCo_{1-y}Fe_yO_{3-\delta}$ materials, and the newer perovskite related oxygen excess materials with layered structures, such as the novel material $La_2NiO_{4+\delta}$ where oxygen transport takes place via an interstitialcy mechanism.