

Seminar

Fundamental studies of Cathodic and Anodic Reactions in Solid Oxide Fuel Cells (SOFCs)

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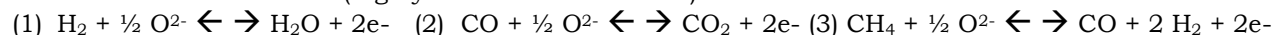
NFTDC, Hyderabad

Solid Oxide Fuel Cells (SOFCs) can offer very high electrical efficiencies (55-60 %) when used with commercial Natural Gas as fuels and Air as the oxidant. They operate in the range of 600 - 1000 deg. C, depending upon the choice of the electrolyte, influenced by the latter's ionic conductivity under those temperatures. SOFC systems have a range of components, from cell materials (Doped Cerias, Stabilized Zirconias as electrolytes, Ni-Ceria/ Ni-Zirconias, along with many novel perovskite compositions as anodes, and La, Sr - doped Ferrites, Manganites, and novel cuprates/ Nickelates as emerging materials for cathodes), to Interconnects (Ferritic steels with high Cr) to Sealants (glass, mica, Ti-Cu-Ag and other brazes), and followed by the manufacturing and the engineering that goes with the systems build.

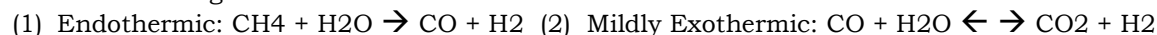
While the cathodic Oxygen Reduction Reaction (ORR) can be rate limiting under certain conditions, its kinetics are determined by either the Oxygen dissociative adsorption or surface diffusion of O-ad-atoms or by the reduction reaction $O + 2e^- \leftarrow \rightarrow O^{2-}$ which releases the oxide ions that move through the ionic conducting electrolyte towards the anode. The mechanisms can change with the materials used, the proportion of the electronically conducting phase and the ionic conducting phase, and the microstructure at the electrode-electrolyte interface as well, known as the 3 phase boundary (where the reduction reaction actually occurs).

Similarly the anodic process has its own dynamic, with the key oxidation reactions of H²- rich syngas taking place at the 3 phase boundary, and in many cases, methane actually undergoing a non-electrochemical but heterogeneous steam reforming reaction internally in the anodic structure, as per the following reactions -

Electrochemical Oxidation (highly exothermic reactions)



Steam Reforming of fuels in the anode itself



Regardless of the mix of reactions and the rate limiting reaction, certain electrodic properties are essential - porosity, electronic conductivity, 3 phase boundary microstructure; the activation barrier associated with these reactions and transport processes within the electrodes is reflected by a mixture of Ohmic and non-Ohmic resistances that can be measured effectively by Frequency Response Analysis (FRA, commonly known as Electrochemical Impedance Spectroscopy), in addition to measuring cell performance by I-V characteristics.

In this presentation, I would like to focus on the electrochemistry (Ohmic and non-Ohmic Processes) that takes place at the cathodes and anodes of a single electrochemical SOFC, and a few interesting modifications that were done to enhance cell performance. In the course of the talk, I hope to go back to basic electrochemical models, defect chemistries in electrodes and electrolytes, and the de-convolution of cathodic and anodic overpotentials during SOFC operations by using Electrochemical Impedance Spectroscopy.

The work presented is primarily done by me at UPENN (with the Gorte group, ~ 2002) and my former research group from IIT Delhi (~2009-10).

Monday, Jun 8th 2015

4:00 PM (Tea/Coffee at 3:45 PM)

Seminar Hall, TCIS