Sol-Gel Thin Film YSZ for Oxygen Generation/removal and Solid Oxide Fuel Cell Applications

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Oxygen generator/removal and Solid Oxide Fuel Cell systems are devices based on oxygen ion conducting technology. Oxygen is transported from one side of a solid ceramic membrane to the other side when a potential is applied across the membrane at about 700-1000^{o}C. Schematically, the oxygen generation device is similar to that shown in Fig. 1.

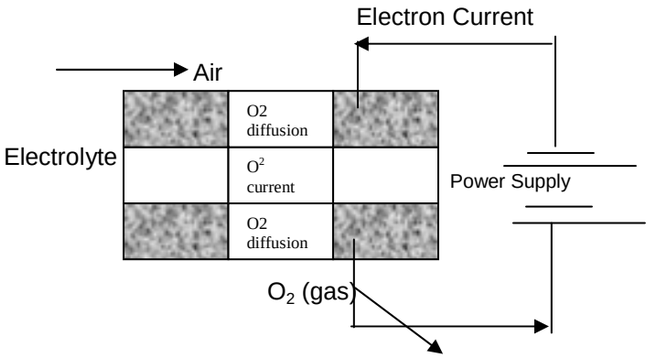

Figure 1 - Schematic of a Ceramic Oxygen Generator

Ceramic membrane electrolyzers operate at high temperature (800-1000^{o} C). The high operating temperature can lead to complex materials problems (interfacial diffusion, electrode sintering, mechanical stress, thermal and mechanical fragility, leaks, and electrode debonding) (1). In order to reduce the high temperature the resistive loss in the electrolyte should be minimized. One of the solutions would be to decrease the thickness of the solid electrolyte. We chose to use the sol-gel process. This method allows to fabricate thin electrolyte layer in the desired shape. Sol-Gel processing is a convenient way of sintering YSZ at low temperature (2).

The goal of this research program is to prepare, characterize and test thin yttria-stabilized zirconia (YSZ) membranes. The overall objective is to increase current density, to obtain higher oxygen production of O_2 per unit weight, and to achieve higher stability and reliability. The unique benefits of our design should be realized due to the chemical bonding of the membrane layers. The key innovations of this technology are (3,4):

- The thin ceramic layers results in lower voltage across the membrane. This allows the system configuration to operate at higher current density and lower electrode area (lower system weight/unit volume of oxygen production or hydrogen consumption).
- A molecular bond is produced which results in excellent strength and no leakage.
- Use of thin, very stable yttria stabilized zinconia (YSZ) as the solid electrolye will help to achieve lower operating temperature.

The anodic layer, oxygen-conducting layer, and cathodic layer are applied by placing successive coatings on top of a porous support tube (3,4). Sol-gel process is performed either by brush coating or dip coating depending on the natures of substrate and thickness and quality of the film required. The results so far obtained show that thin electrolyte layers can be obtained and tailored through the sol-gel process. The thin electronically insulating YSZ layer is non-porous, and gas tight. Mercury porosimeter, SEM analysis and pressure testing are used to make sure that YSZ layer is dense and non-porous. The electrolyte thickness is about 20 μm, which is about 5-10 times thinner than conventional laminated electrolyte thickness and hence lead to good electrochemical properties. Impedance spectroscopy has been used to determine the conductivity of the samples.

Prototype tests are being conducted for oxygen generation and as well as solid oxide fuel cell performance using thin sol-gel processed YSZ thin films. The performance is compared with commercially available laminated YSZ disks. Results will be presented.

References:

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