Lanthanum Gallate Electrolyte for Intermediate
Temperature Operation
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It has long been recognized that lowering the operating temperature would provide a more expeditious route to commercialization of Solid Oxide Fuel Cell (SOFC) based power systems. The intermediate operating temperature (600 to 800°C) allows the use of lower cost materials in both the stack and the balance of plant, and additionally significantly slows down potential deleterious materials interaction, thus extending the useful stack life. When the operating temperature is in the range of 600 to 700°C, it is also possible to reform hydrocarbon fuels within the stack. The endothermic nature of this reaction provides a significant cooling effect, thereby reducing the parasitic losses associated with excess air requirements for stack cooling.

The operating temperature of the fuel cell system is largely governed by the electrolyte material. Electrolyte materials such as doped bismuth oxide or doped ceria exhibit superior ionic conductivity at lower temperatures. However, the material instability of bismuth oxide and the mixed conduction of ceria under fuel gas conditions are difficult to overcome. Sr and Mg doped $LaGaO_3$ (LSGM) has been shown to have an ionic conductivity at 800° C equivalent to that of YSZ at 1000° C. Unlike other materials possessing a high oxygen ion conductivity, lanthanum gallate not only possesses high conductivity relative to zirconia, it is stable in both fuel and air. Ishihara et al., reported a power density of ~ 0.35 W/cm^2 at 800° C in single cells (1). Goodenough et al., (2,3) have reported extensive materials characterization information.

The relative performance degradation of LSGM based cells has limited the wide use of the material by SOFC developers. The primary degradation of LSGM single cells is electrode related (4), and in particular occurs at the anode-electrolyte interface. Investigations by Huang and Goodenough (3) suggested that the likely the formation of an insulating phase, $LaNiO_3$, at the anode – electrolyte interface may be the source of degradation. In addition to long-term stability, the reaction between the anode and electrolyte limits the cell fabrication options. For example, anode supported thin electrolyte approach that has been successfully demonstrated in zirconia based cells cannot be readily employed. The gallate electrolyte based cells presently have been fabricated only as electrolyte supported cells. A zirconia matrix supported thin gallate electrolyte has been reported (5). Again, the reactivity with zirconia to form lanthanum zirconate insulating phase at the interface is of concern.

The primary approaches of our investigation is to understand the fabrication process boundaries of the anode–electrolyte reaction and modify the anode material to mitigate such reactions. It was determined, using powder mixtures of LSGM and NiO that not only the severity of the reaction but the nature of the second phase depends on the reaction temperature. At 1250 C the reaction phase formed was La_2NiO_4, while the predominant phase at 1350 C was $LaNiO_3$. A chemical modification to the anode reduced the reaction

considerably [6]. The modified anode composition is also shown to perform equivalent to standard NiO based anode. The performance of an electrolyte supported LSGM cell, using the modified anode is shown in Figure 1.

Recent focus has been to lower the sintering temperature of LSGM electrolyte material and evaluating sintering of anode-electrolyte bi-layers. A micrograph from the initial work on a sintered bi-layer is shown in Figure 2. The bi-layers were sintered at 1350 – 1400 C to provide a 10-micron thick LSGM electrolyte supported on the anode. Some nickel diffusion was seen in the electrolyte region. Further characterization and process modification trials are underway to evaluate the bi-layers.
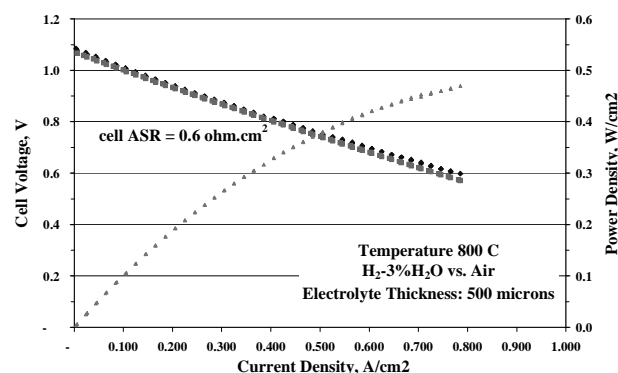

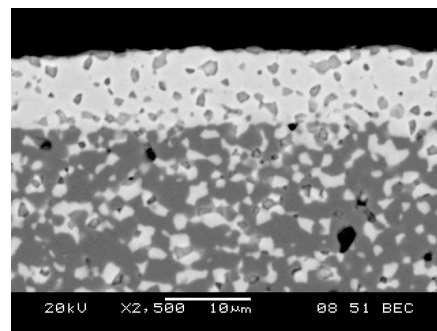**Figure 1: Performance of LSGM single cell**

Figure 2: LSGM-Anode bilayer

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4.   K. Huang and J. Goodenough, *Superior Perovskite Oxide-ion Conductor: Strontium- and Magnesium-Doped $LaGaO_3$,* EPRI Final Report No. TR-108742 (1977).
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