Preparation and Evaluation of Multi-Layer Anodes of Solid Oxide Fuel Cell

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ABSTRACT
The development of an energy device with abundant energy generation, ultra-high specific power density, high stability and long life is critical for enabling longer missions and for reducing mission costs. Of all different types of fuel cells, the solid oxide fuel cells (SOFC) is a promising high temperature device that can generate electricity as a byproduct of a chemical reaction in a clean way and produce high quality heat that can be used for other purposes. For aerospace applications, a power-to-weight of 21.0 kW/kg is required. NASA has a patented fuel cell technology under development, capable of achieving the 1.0 kW/kg figure of merit. The first step toward achieving these goals is increasing anode durability. The catalyst plays an important role in the fuel cells for power generation, stability, efficiency and long life. Not only the anode composition, but its preparation and reduction are key to achieving durability. The catalysts are made of ceramic powders that are infiltrated into a shapable body of the fuel cell. Processes include tradition tape casting, presintering of tapes, sintering and co-firing. The performance and stability tests and the SEM analysis confirms the importance of only the electrode material but also the electrode preparation process on the performance and especially the long term stability of the fuel cells. The fuel cells Ni/SDC Red have better stability than the fuel cells of Ni Standard. The SEM analysis reveals that although the nickel particles appear intermixed and its microstructure near the electrode is maintained after the performance, the nickel near the top of the electrode show particle coarsening and separation affecting their performance and stability.

SOFC: MULTIPLE APPLICATIONS WITH SINGLE TECHNOLOGY

Solid oxide fuel cell is a high temperature (700 – 1000 ºC) ceramic fuel cell that generates energy from an electrochemical reaction. Power generation or regenerative “Reversible” SOFC Power System is a power-to-weight of approximately 85 m/kg and the second group is using a thinner electrolyte (5 m approximately). All fuel cells were prepared with the same oxide material, 6 infiltrations of LSCF.

SOFC Advantages:
- High efficiency
- High energy density
- Possible fuel capability from dry hydrogen and hydrocarbon-based fuels
- Power generation from methane generated by In-situ Resource Utilization
- Fuel Cell Auxiliary Power Unit for power generation or consumption.
- SOFC/GT Gas Turbine

SOFC/DV Durability Tests

<table>
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<tr>
<th>Electrolyte</th>
<th>Cell Preparation</th>
<th>Lamination and Sintering</th>
<th>Liquid Infiltration</th>
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<tr>
<td>Electrolyte 2</td>
<td>Ceramic Powder</td>
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<td>Ceramic Powder 4</td>
<td>4.05</td>
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</table>

Conclusions
- All components are bonded together in a single firing creating a stable structural body.
- Electrode materials are fixed after sintering the structural elements.
- Low temperature infiltration processes greatly expand the usage of catalysts which can be used to provide maximum functional flexibility.

SEM Analysis
- Monographs of the cell Ni/SDC Red B after its performance and near the electrode (Fig 4a) show a great coating of the fuel cell layers that are visible and extends beyond the SDC net near the top of the electrode (Fig 4b).
- Monographs of the cell Ni/Mg Red show a great coating of the layer electrode materials that are visible and extend beyond the SDC net as compared to the sample Ni/SDC Red B.
- X Ray fluorescence of the cell Ni/Mg Red shows the formation of the clusters with the desirable elements: nickel, magnesium, cerium and samarium.

CURRENT AND FUTURE WORK
- Ni anodes reduced at higher temperatures, currently being tested, demonstrate better performance and stability.
- New anodes will be created alternating the layers of nickel, magnesium and SDC and increasing the reduction temperature.
- Better performance and stability is expected with these electrodes.
- Different proportions between nickel and magnesium will be used for the optimization. The reduction temperature will also be increased for the cells.
- The study of other compositions also is expected.