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

**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 a 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 better cell performance. In this research, multi-layer anodes were prepared varying the chemistry of each layer to optimize the performance of the cells. Microstructure analyses were done to the new better cell performance. In this research, multi-layer anodes were prepared varying the chemistry of each layer to optimize the performance of the cells. Microstructure analyses were done to the new better cell performance. In this research, multi-layer anodes were prepared varying the chemistry of each layer to optimize the performance of the cells. Microstructure analyses were done to the new better cell performance.

**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.

**SOFC Advantages:**

- High efficiency
- High power density
- Virtually emissions-free
- Unique flexibility

**Fuel Cell Mode**

- Power generation (High Pressure O2)

**Electrolysis Mode**

- Water electrolysis

**Space Applications**

- Long Endurance Flight
- Fuel Cell Auxiliary Power Unit
- Bi-Electrode-Supported Cells

**Advantages of BSC:**

- The cell is electrolytically connected with both electrolytes supporting the two electrolytes.
- Electrodes containing microchannels for gas diffusion.
- Lower volume and lower weight
- Cathode design provides a large area for gas diffusion.
- High electrical efficiency and reduced thermal gradients to ceramic seals.
- The BSC design has the potential to increase the power density by three times over the state of the art.

**Current and future work:**

- The performance and stability tests and the SEM analysis confirms the importance of not 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. Showing a decrease in the percent of degradation per 1000 hrs from 40.7 % to 8.4 %. The SEM analysis reveals that although the nickel particles appear intermingled and its microstructure near the electrode is maintained after the performance, the nickel near the top of the electrode shows particle coarsening and separation affecting their performance and stability.
- Adding magnesium to the anode electrode helped to retain the microstructure after the cell performance and decreased the amount of nickel exaggerated growth on the top of the electrode. The performance was comparable to the Ni/SDC Red cell with a 9.6 % of degradation per 1000 hrs. Using a thinner electrolyte provides greater power per cm2 but had only a minor effect on degradation. More studies are needed to have a final conclusion.

**CONCLUSIONS**

- **Bi-Electrode-Supported Cells**
  - Performance and stability tests and the SEM analysis confirm the importance of not 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, showing a decrease in the percent of degradation per 1000 hrs from 40.7 % to 8.4 %. The SEM analysis reveals that although the nickel particles appear intermingled and its microstructure near the electrode is maintained after the performance, the nickel near the top of the electrode shows particle coarsening and separation affecting their performance and stability.
  - Adding magnesium to the anode electrode helped to retain the microstructure after the cell performance and decreased the amount of nickel exaggerated growth on the top of the electrode. The performance was comparable to the Ni/SDC Red cell with a 9.6 % of degradation per 1000 hrs. Using a thinner electrolyte provides greater power per cm2 but had only a minor effect on degradation. More studies are needed to have a final conclusion.
- **CONCLUSIONS**
  - The performance and stability tests and the SEM analysis confirm the importance of not 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, showing a decrease in the percent of degradation per 1000 hrs from 40.7 % to 8.4 %. The SEM analysis reveals that although the nickel particles appear intermingled and its microstructure near the electrode is maintained after the performance, the nickel near the top of the electrode shows particle coarsening and separation affecting their performance and stability.
  - Adding magnesium to the anode electrode helped to retain the microstructure after the cell performance and decreased the amount of nickel exaggerated growth on the top of the electrode. The performance was comparable to the Ni/SDC Red cell with a 9.6 % of degradation per 1000 hrs. Using a thinner electrolyte provides greater power per cm2 but had only a minor effect on degradation. More studies are needed to have a final conclusion.
  - The performance and stability tests and the SEM analysis confirm the importance of not 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, showing a decrease in the percent of degradation per 1000 hrs from 40.7 % to 8.4 %. The SEM analysis reveals that although the nickel particles appear intermingled and its microstructure near the electrode is maintained after the performance, the nickel near the top of the electrode shows particle coarsening and separation affecting their performance and stability.
  - Adding magnesium to the anode electrode helped to retain the microstructure after the cell performance and decreased the amount of nickel exaggerated growth on the top of the electrode. The performance was comparable to the Ni/SDC Red cell with a 9.6 % of degradation per 1000 hrs. Using a thinner electrolyte provides greater power per cm2 but had only a minor effect on degradation. More studies are needed to have a final conclusion.