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 2.1 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 anodes before and after fuel cell operation. The cells’ durability and performance were evaluated in 200 hrs life tests in hydrogen at 850 °C. The chemical composition of the new anode was modified successfully reducing the anode degradation from 40% to 8.4% in 1000 hrs and retaining its microstructure.

FUEL CELL DURABILITY TESTS

• The performance and stability tests and the SEM analysis confirms the importance of not only the electrode material but also the electrolyte preparation process on the performance and especially the long term stability of the fuel cell.
• 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 interconnected 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.
• Adding magnesium to the anode electrode helped to retain the microstructure after the cell performance and decreased the amount of nickel ‘waxing’ 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

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CURRENT AND FUTURE WORK

• Ni anodes reduced at higher temperatures, currently being tested, demonstrate better performance and stability.
• More 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 studied for the optimization. The reduction temperature also will be increased for the cells.
• The study of other compositions also is expected.