Modeling Solid Oxide Fuel Cell Performance Affected by Microscale Electrode Surface Variations

by

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ABSTRACT

A solid oxide fuel cell (SOFC) model was developed to determine the effect of electrode/electrolyte interface surface variations on cell voltage. As a result of manufacturing, the electrode/electrolyte interface is not perfectly planar as it is usually modeled in the literature. The objective of this research was to determine whether or not the microscale surface area increases as a result of discontinuities created during the electrode/electrolyte manufacturing process lead to a change in the performance characteristics as determined by the model.

A 20 mm long channel fuel cell was created as a baseline model in the commercial computational fluid dynamics code FLUENT and validated against results found in literature. This full length model was able to be reduced to 0.1 mm to reduce the computational power necessary for further calculations. The reduced length model was proven to have the same performance characteristics as the full length model.

FLUENT was then used to simulate a number of electrode/electrolyte surface interface geometries, including a random surface from an SEM image and controlled sine wave surfaces. A linear relationship was shown between surface area increase and performance increase. At higher current densities the performance increases were greater. Regardless of the type of surface variation, the results were the same for matching surface area increases.

The results indicated that surface variations at the electrode/electrolyte interface lead to increased performance as a result of the increased surface area between the electrode and electrolyte (as compared to a perfectly smooth interface). If the surfaces of the electrode and electrolyte were capable of being controlled to a very high level to include surface patterns that increase the area, significant performance increases could be obtained without adding extra volume to the fuel cell stack.