LOW COST SOLID OXIDE FUEL CELL STACK DESIGN USING EXTRUDED HONEYCOMB TECHNOLOGY

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ABSTRACT

Cost has become a critical issue commercialization of solid oxide fuel cell (SOFC) technology. While many seek new materials to improve cell performance, functional stacks may drive commercialization faster than any performance issue. To this end, a novel fabrication technique is described which allows the simultaneous fabrication of both electrolytes and interconnects in a single hermetic package. Two key issues in this design involve the fabrication of honeycomb structures and the reduction of metal oxides during the sintering process to develop integral interconnects. This is a highly scalable and cost effective method to produce SOFC stacks.

INTRODUCTION

Both the planar and the tubular designs focused on today have evolved from a single cell and the concept of producing a stack has been problematic. The tubular design offers the possibility of creating gas seals outside of the functional high temperature zone, but power densities are relatively low. Planar stacks have the advantage of high power densities, but difficulties associated with sealing and manifolding issues are yet to be overcome. Honeycomb stack design offers the energy density of planar stacks with the possibility of cold gas seals from tubular design.

Honeycomb stacks are produced by extruding precursor pastes into a linear cellular structure, which is essentially composed of parallel plates with intermediate supports. Two different honeycomb fuel cells are under development with very different approaches. The first is an all electrolyte extrusion, called a monolithic design. The second is produced as a co-extrusion of electrolyte and interconnect in alternating layers called a hybrid.

Both designs rely on the advantages of extrusion for efficient manufacture and to fabricate multiple layers simultaneously. The number of layers and width of cell produced is dictated by the extrusion die. Extrusions can be cut to any length to meet the required power of a specific application.

EXPERIMENTAL

The dies designed for experimental work produce a 4x4 square cell honeycomb with wall thickness from 375µm to 100µm. Powders of electrolyte materials of yttria stabilized zirconia (YSZ) and gadolinia doped ceria (GDC) are obtained from commercial sources. The powders are made into pastes, produced in a 150 gram batch using a Haake rheometer, which has a paste-compounding chamber. The pastes produced have a yield strength in the range of 400 to 500 kPa as measured by capillary rheometer. Similar pastes are produced using transition metal oxide (TMO) precursors for the interconnect portion of the extrusion.

RESULTS AND DISCUSSION

Monolithic and hybrid extrusions have been produced. Figure 1 shows a fired YSZ extrusion with a wall thickness of 280µm. To produce an functional cell, the extrusion would typically go through a manifolding process to create gas pathways as shown in Figure 2. After firing, electrodes are applied through the gas channels by slurry coating.

For the hybrid structure, the choice for the metal interconnect is Inconel 617 due to its close match to zirconia for thermal expansion. A special barrel fitted to the die allows the feed of multiple pastes to the die head. Firing is performed in a controlled gas atmosphere to match the shrinkage of the ceramic to that of the metal. Initial firings of hybrid structures have been produced. Hybrid structures consisting of three interconnects and two electrolytes have been successfully fabricated and fired.

SUMMARY

Honeycomb fuel cells represent a unique method of producing fuel cell stacks. Both monolithic and hybrid honeycomb fuel cells have produced.

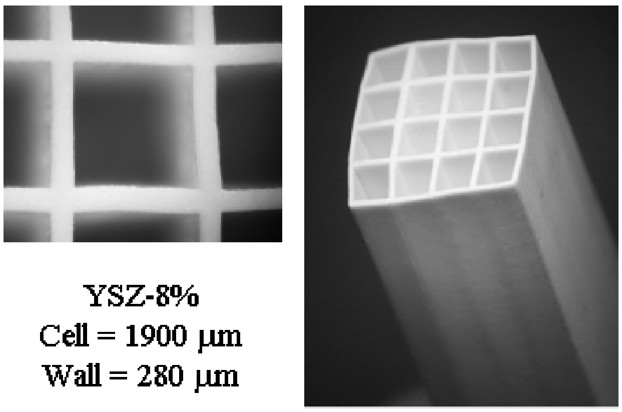

Figure 1. Fired YSZ monolithic extrusion.

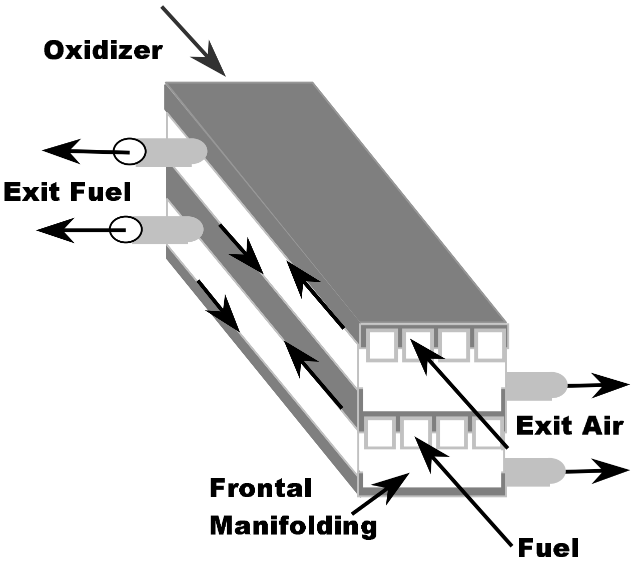

Figure 2. Schematic of gas flow and manifolding.

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