

FABRICATION OF 1.3KW CLASS ANODE-SUPPORTED FLAT TUBULAR SOFC STACK

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Summary

KIER was developing anode-supported flat tubular SOFC stack for the intermediate temperature (700~800°C) operation. For this purpose, we have first fabricated anode-supported flat tubular cells by the optimization between the current collecting method and the induction brazing process. After that we designed the compact fuel & air manifold by adopting the simulation technique to uniformly supply fuel & air gas and the unique seal & insulation method to make the more compact stack. For making stack, the prepared anode-supported flat tubular cells with effective electrode area of 108cm² connected in series with 37 modules, in which one module consists of two cells connected in parallel. The performance of stack in 3% humidified H₂ and air at 800°C shows maximum power of 1.3kW.

Keywords

Anode-support, Flat Tubular, SOFC, Stack

Introduction

The SOFC has two type structures of the tubular and planar designs. The tubular design has been applied from small to large-scale power generation system. The planar design has also been studied for long time and was developed for the small power system. For the commercialization of SOFC technology, there are strong needs for establishing key technologies such as cell components and fabrication technology, high performance cell, and stacking technology, etc. In order to increase the durability and to allow cost reduction by less expensive materials such as metallic interconnect, many researchers are currently concentrating on development of SOFC operating at reduced temperatures below 800°C.

We developed first an anode-supported tubular SOFC(1-3) stack for the intermediate temperature operation. After our development, many research groups including Acumentrics started the development of the anode-supported tubular SOFC(4-7). In this work, we reported an anode-supported flat tubular SOFC stack to improve the power density of SOFC cell and make the compact stack system. The 1.3kW class anode-supported flat tubular SOFC stack was fabricated by the optimized fabrication method and its performance was evaluated.

Experimental

The extruded flat tubular anode support was served as fuel electrode and other cell components were fabricated in thin layers onto it. The 40 vol.% Ni-8YSZ(8mol. % Y₂O₃-stabilized ZrO₂) anode powder was prepared by mixing 8YSZ (TZ-8Y, Tosoh co.) and nickel oxide powders (J.T. Bakers co.). Anode powder and activated carbon as pore former were weighed and mixed in ethanol by ball milling for 14days and then dried. Organic binder and 25wt.% distilled water were added to the dried powder,

and then the well dispersed paste was extruded in the form of flat tube. The extruded flat tubes were dried and in the drying oven at 120°C for 12h. It was pre-sintered at 1100°C. The YSZ electrolyte layer was coated on the presintered anode tube by vacuum slurry dip coating to form a dense layer and cofired at 1400°C. Cathode material, LSM((La_{0.85}Sr_{0.15})_{0.9}MnO₃) and LSCF(La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O₃) were prepared by solid state powder reaction method by weighing in a selected proportion and mixed in ethanol by ball milling for 10days. The synthesized powder was calcined at 1000°C for 5h. The multi-layered cathode composed of LSM/8YSZ composite, LSM, and LSCF were coated onto the co-sintered flat tube by slurry dip process and sintered at 1200°C.

The flat tubular cell has four ribs inside the tube, which is considered to increase the mechanical strength and the electrical conductivity of the anode tube. The flat tubular cell was brazed with a metal cap by induction brazing process. The metal cap plays roles of the fuel flow path and the anode current collector. Two brazed flat-tube cells are connected in parallel, which is defined as a bundle. In one bundle, two brazed anode-supported flat tubular cell was connected in parallel. The anode-supported flat tubular SOFC was connected in-parallel with 2 cells and in-series again. The two-cell unit bundle was placed in air chamber. 3% humidified hydrogen as fuel was supplied through the chamber connected with brazing cap. The air was supplied through the air distributor. In the case of the fabrication for compact unit bundle, we designed the compact fuel & air manifold by adopting the simulation technique to uniformly supply fuel & air gas and the unique seal & insulation method to make the more compact unit bundle. The equipment of performance test

was composed of a gas control system, a heating unit, a preheating system, humidified chambers, an electronic load, and a data acquisition system. The stack performance was evaluated by adjusting the electronic load. Using the same concept as that of 2 cell-unit bundle, the 1.3kW class stack was designed and fabricated. The stack has the 37 bundles connected in series. The elective area of the flat tube cell is 108 cm². The stack performance was evaluated using hydrogen with 3 % water and air.

Results and discussion

An electron current path of the cylindrical tubular type SOFC structure is geometrically determined by half circle of the cell, so the power per mass or per volume is much lower than the planar type. On the other hand, the flat-tube structure is possible to increase the power density per unit volume by giving the electron current path through the ribs. Its mechanical strength is higher as compared to the conventional planar type.

The thickness of the anode-supported flat-tube was 1.9 mm, and each of electrolyte and cathode layers had thickness of 7, 25 μm, respectively. The electrolyte showed a dense microstructure without any detrimental defects. Gas Permeability tests were conducted to estimate the gas-tightness of electrolyte. The gas permeability for cells as a function of differential pressure by using He gas was measured. It has shown the value below $6 \times 10^{-8} \text{ Lcm}^{-2}\text{sec}^{-1}$ to the pressure difference of 3atm. The prepared anode-supported flat tubular cells were brazed by using induction brazing process, in which the metal cap was bonded to the end of the flat tubular cell without cathode layer. The cathode current-collection was made by the wiring of silver wires. The induction brazed anode and metal cap play a role of current-collecting of anode.

The 1.3kW class anode-supported flat tubular SOFC stack was manufactured on the basis of the experimental date of 2 cell-unit bundle. The stack has the pre-heater in air and fuel inlets and during the stack operation the temperature of the preheated gases was set at 550°C. Fig.1 shows a performance of the 1.3kW class anode-supported flat tubular SOFC stack. The stack furnace was set at 800°C but the measured stack temperatures were in the range of 790 to 810°C.

Conclusions

We have developed successfully the 1.3kW class anode-supported flat tubular SOFC stack. The end of the flat tube cell was connected with the metal cap by an induction brazing process. The brazed parts had efficient gas tightness. The metal cap played two roles of the anode current collection and the fuel supply path. The 1.3kW class anode-supported flat tubular SOFC stack with 74cells (2x37) was designed and fabricated, which showed performances of 1.3kW in air at 800°C. The improvement of the stack is in progress.

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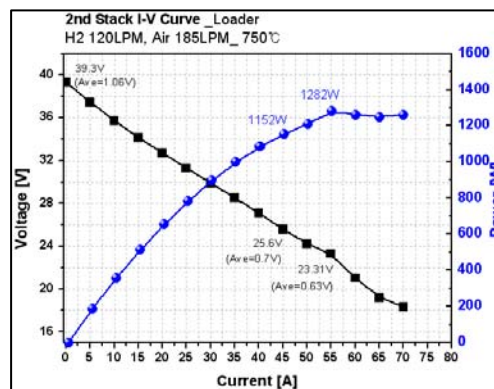


Fig.1. Performance characteristic of the 1.3kW class anode-supported flat tubular SOFC stack