복합박막법 및 공소결법을 이용해 제조된 고체산화물 연료전지 성능 특성

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Performance Characteristics of Planar Solid Oxide Fuel Cell Fabricated by Composite Plate and Co-firing Process

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Introduction

For low cost production of the planar SOFC, many attentions have been given to tape cast methods such as doctor blade, by which one can easily fabricate electrolyte and interconnector as non-supported films. One demerit of these processes is the difficult handling of fragile non-supported thin films. After tape cast, the individual components are usually sintered at different temperatures and then are assembled as one cell. Here is another demerit, because many sintering steps are required for making cells by this method. In commercialization of SOFC, it is important to reduce these sintering steps as few as possible.

To simplify the sintering steps many investigators have studied co-firing processes. In a conventional co-firing process, the four green films that consist of anode, cathode, electrolyte and interconnector are co-fired for making cell. This method has the following disadvantages: the difficulty in fabricating large cells, the Ca migration in the interconnector and the Mn loss in the cathode.

In this study to overcome these problems a composite plate process has been investigated, in which green films were co-fired in the forms of two layers of anode/electrolyte and three layers of anode/electrolyte/cathode with gas distributors. The cells composed of the co-fired layers were tested for characterizing the performance by current interrupt method. Some problems in composite plate process were also discussed

Experimental

The electrolyte powder was 8 mol.% yttria-stabilized zirconia (YSZ) supplied by TOSOH Co.(TZ-8YS). The anode material was nickel YSZ cermet (NY). The NY powder had 37 vol.% nickel metal after reduction. The $(La_{0.85}Sr_{0.15})_{0.9}MnO_{3-\delta}$ (LSM) powder for the cathode was prepared by co-precipitation method. The nitrate solutions were mixed in a proper ratio and the mixture was poured into the ethanol solution that oxalic acid was dissolved in. The $La_{0.67}Ca_{0.33}CrO_3$ (LCC) powder used as interconnector was prepared by a ceramic method.

The doctor blade method was used for making the green films. Two types of single cell were considered in this study. One was made by co-firing a layered green film of anode, cathode and electrolyte with two green foam plates of gas distributor. Hereafter we call this type as "co-fired cell of three layers." The green films were layered in order of anode, electrolyte and cathode by triple doctor blade method. The gas distributor was prepared from polyurethane foam plate, being dipped with YSZ slurry in order to give similar shrinkage to YSZ electrolyte. The gas distributors were attached to both anode and cathode sides of the green three layers. The other was made by co-firing two layers of anode and electrolyte with a gas distributor. Hereafter this type is named "co-fired cell of two layers." The gas distributor was attached to only anode side of green two layers.

All the green cells were burnt out at 350 °C, followed by sintering at 1380 °C for 3 h in air. The size of the sintered cell was 10.8×7.7 cm^2; the shrinkage is 23 %. After sintering, the gas distributors consisted of a very porous YSZ material, being not electronically conductive. Thus additional treatments were carried out in order to impart electronic conduction to the gas distributor. In the sintered cell of three layers the gas distributors for the anode and cathode were impregnated with NiO and LSM slurries, respectively. In the sintered cell of two layers the anode gas distributor was impregnated with NiO slurry.

Results

(1) A very flat cell of 7.7×10.8 cm^2 was fabricated successfully by composite plate process.
(2) A co-fired cell of two layers yielded a power of 200 mW/cm^2 : about 608 mV at 328 mA/cm^2. Its performance loss was mainly due to iR drop in the anodic gas distributor.
(3) The performance in the co-fired cell of three layers was much lower than that of two layers, which resulted from large iR drops at gas distributors, especially at cathodic side.
(4) The co-fired cell of two layers is preferable to that of three layers for making an efficient stack when YSZ-based gas distributors are adopted.

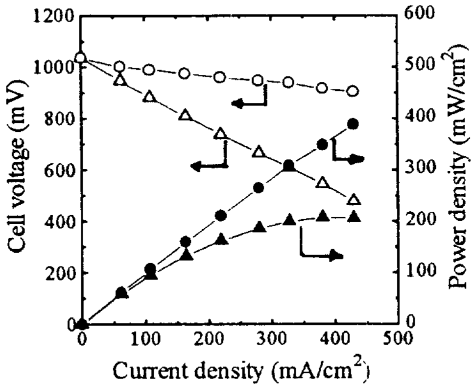

Fig.1 Performance of the co-fired cell of two layers after operation of 24 h. (Δ, ▲) iR-included; (O, ●) iR-free.

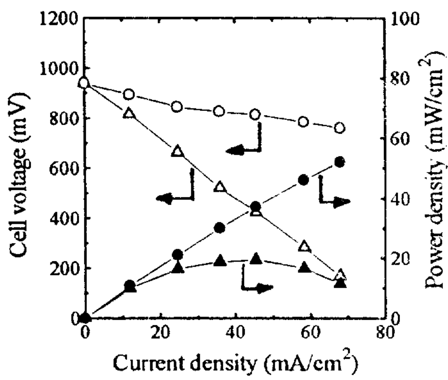

Fig.2 Performance of the co-fired cell of three layers after operation of 24 h. (Δ, ▲) iR-included; (O, ●) iR-free.

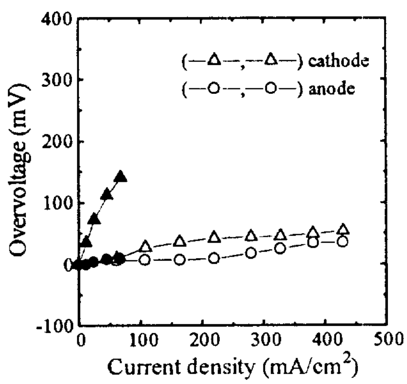

Fig.3 Comparison of electrode overvoltages in the co-fired cells of two layers (O, Δ) and three layers (●, ▲) after operation of 24 h.

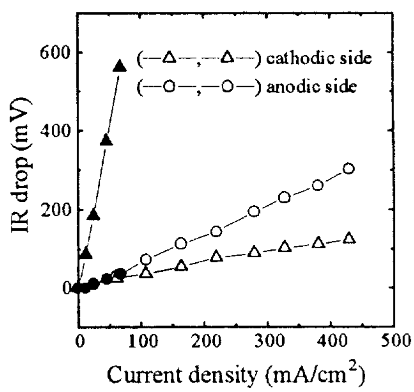

Fig.4 Comparison of iR drops in the co-fired cells of two layers (O, Δ) and three layers (●, ▲) after operation of 24 h.

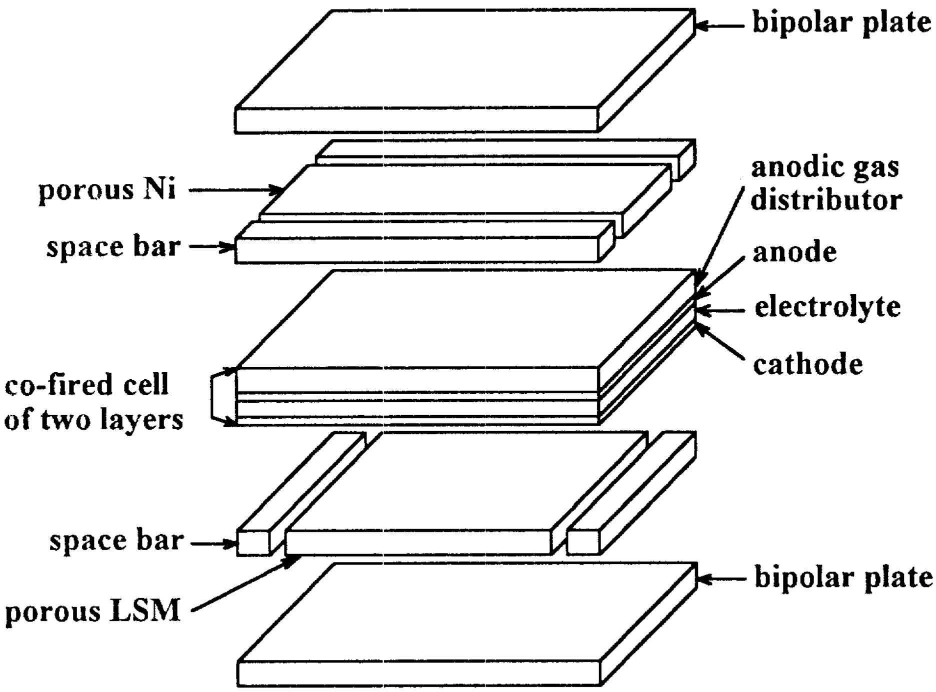

Fig.5 Single cell structure composed of the co-fired cell of two layers with an area of 83 cm^2. This unit cell will be used for making stack.