Preparation of SOFCs by Microwave Induced Co-Firing

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Reduction of the thickness of dense solid electrolyte is one of the most effective methods to improve solid oxide fuel cell (SOFC) performance. By reducing the thickness, high efficient SOFCs or low temperature operating SOFCs can be achieved. It is for that reason that anode or cathode-supported SOFCs are investigated. The electrode-supported SOFCs require co-firing between electrodes and an electrolyte, but it is difficult to obtain electrode-electrolyte interface with high performance by co-firing due to the difference in sintering temperature between the electrode and the electrolyte. Generally, the co-firing of the cell leads to a porous electrolyte and dense electrodes.

Materials can be fired by microwave depending on their dielectric loss. The higher the dielectric loss is, the higher would be the temperature reached by the materials during the process. In general, the loss of the electrolyte is larger than that of the electrode. Therefore, the microwave-induced firing would result in high-performance SOFC composed of a dense and thin electrolyte and porous electrodes. Indeed, the electrolyte will reach a higher temperature than the electrode due to its high dielectric loss.

The microwave-induced sintering conditions for SOFC electrolytes of $Zr_{0.84}Y_{0.16}O_{1.92}$ (8YSZ) and $La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_{3-\delta}$ (LSGM) were investigated using various sintering temperatures and heating rates in order to obtain dense and crack-free electrolyte. The sintering of 8YSZ at 1300°C for 10 min in air resulted in a dense ceramic with a relative density >99%. Moreover, the microwave-induced sintering lowered the sintering temperature by more than 200°C as compared with electric furnaces sintering (Fig. 1). The grain size of microwave-derived 8YSZ was also larger than that of ordinary 8YSZ ceramics; this is also due to the sintering enhancement (Fig. 2). The reduction of sintering temperature was also observed with LSGM sample, but small pores remained at grain boundaries in the case of ceramics obtained by microwave-induced sintering at 1300°C for 10 min in air.

SOFC single cell was then constructed by co-firing with $La_{0.9}Sr_{0.1}MnO_3$ cathode, 8YSZ electrolyte and NiO-YSZ cermet anode. Adequate sintering temperature and heating rate was chosen and resulted in crack free SOFCs with an interface showing dense 8YSZ electrolyte and porous NiO-8YSZ cermet anode (Fig. 3). The power generation performance of the single cell obtained by the co-firing showed that the cells have sufficient density (no pin-holes).

Consequently, the microwave-induced co-firing resulted in proper interfaces for SOFC. Thus, the use of microwave would be one of the most effective sintering processes for anode-supported SOFCs.

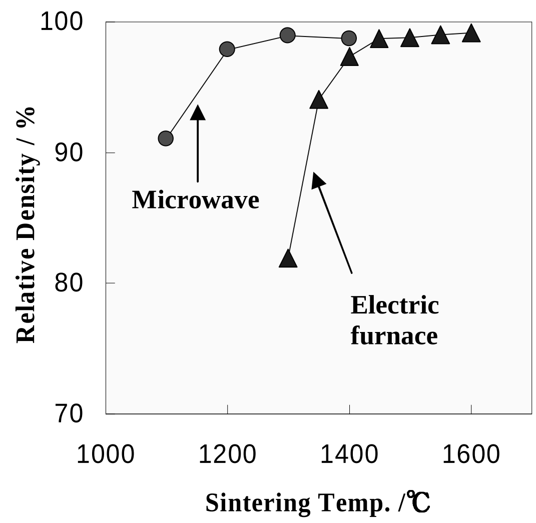

Fig. 1 Relationship between relative densities of 8YSZ ceramic and sintering temperatures.

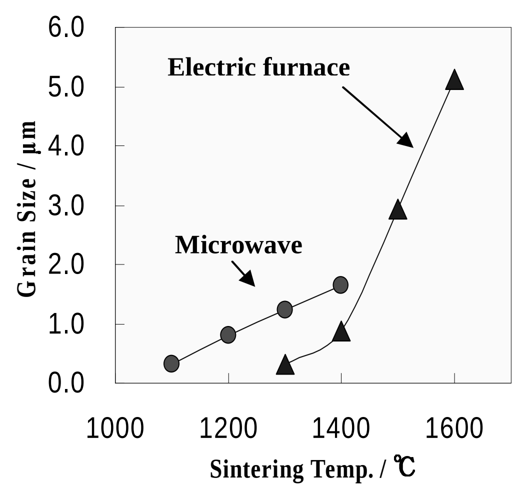

Fig. 2 Relationship between grain sizes of 8YSZ ceramic and sintering temperatures.

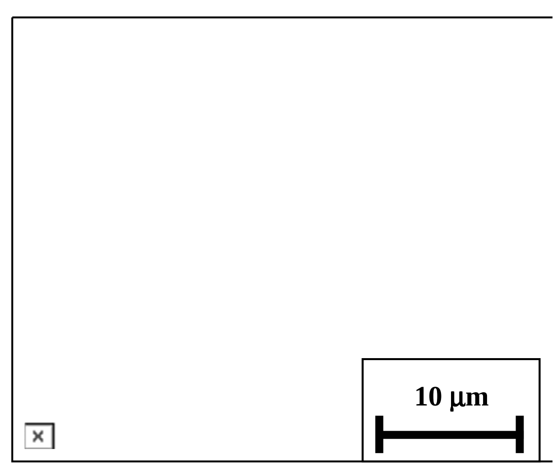

Fig. 3 SEM photograph for anode-electrolyte interface of SOEC obtained by microwave induced co-firing.