Thin and Dense YSZ Electrolyte Membranes for IT-Temperature SOFCs

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Recent developments of Solid Oxide Fuel Cells (SOFCs) have focused on lowering the operating temperature below 800℃. However, it also increases the electrolyte resistivity and decrease the ionic conductivity in result. This can be overcome by lowering the electrolyte resistance either by using a thin Y_2O_3 stabilized ZrO_2 (YSZ) electrolyte or by using higher ionic conductive materials such as doped ceria, $La_{0.9}Sr_{0.1}Ga_{0.8}Mn_{0.2}O_3$ or $BaCe_{0.8}Gd_{0.2}O_{3-\alpha}$ [1-4]. As a method for manufacturing the thin YSZ electrolyte, colloidal process is very simple and cost effective way that is hardly restricted by geometric limitations (e.g. shape, size, etc.). The major challenge is to build up the thin YSZ electrolyte onto the porous anode support without any defects (e.g. cracks, pin holes, etc) so that the system is not short-circuited by gas crossover through the electrolyte.

In this work, anode supported electrolyte thin films for improving the SOFC performance at the low temperature have been manufactured by the wet-chemical process, and their microstructures, gas permeability, and electrical performances were investigated. NiO-YSZ anode supports were prepared in the shape of a flat tube by the extrusion method [5] and their surfaces were modified via slurry-coating of fine NiO-YSZ particles for controlling the surface roughness and the pore size. Anode supported YSZ (8 mol % Y_2O_3) electrolytes were fabricated by dip-coating of YSZ slurry (viscosity 4.5 cP, solid contents 2.7 vol %) on the modified anode support, followed by YSZ sol (viscosity 2.5 cP) coating, and then were sintered at 1400℃. The coating sequence for the anode supported electrolyte of each cell is summarized in Table 1. The cathode consisted of three layers of LSM-YSZ, LSM, and LSCF, and each layer was manufactured by co-firing at 1200□ after slurry coating successively.

The effects of the type of electrolyte layer on the nitrogen permeability of anode supported electrolytes at room temperature are given in Fig. 1. In case of cell 8, the thickness of YSZ electrolyte layers could be controlled below 15 ㎛ and the YSZ layers were estimated to be acceptable as an electrolyte film for SOFC from the result of the gas impermeability in the range below 2 bar. Fig. 2 shows the performance of the single cell at various temperatures. The unit cell fabricated in this work showed a good electrical performance of 550 ㎽/㎠ at 850 ℃ and the power density at 700 ℃ still reaches about 300 ㎽/㎠ attributed to the reduced resistance through the thin YSZ electrolyte.

Referencs

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Table 1. Coating sequence for fabrication of anode supported electrolyte (flat tube type).

Sample No.	Anode 2nd layer for surface modification	Electrolyte layer	
	NiO-YSZ slurry coating	YSZ slurry coating	YSZ sol coating
Cell 1		1	
Cell 2		1	1
Cell 3	1	1	
Cell 4	1	2	
Cell 5		2	2
Cell 6	1	1	1
Cell 7	1	1	3
Cell 8	1	1	2

unit: time(s)

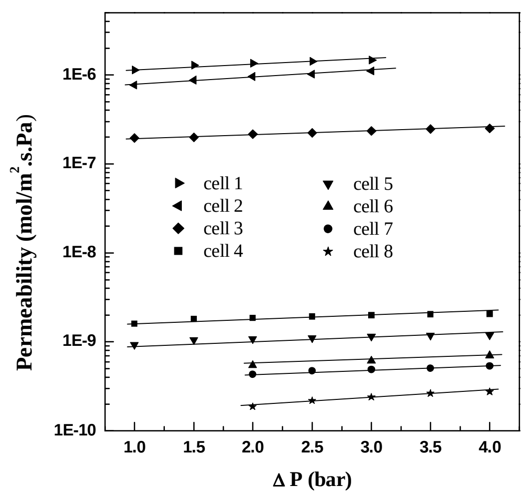

Fig. 1. N_2 permeabilities of anode supported electrolytes.

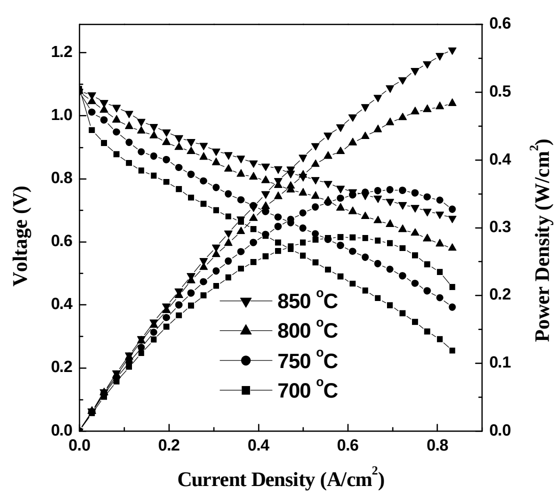

Fig. 2. Performance curves of the anode supported single cell (cell 8) with effective area of 18 ㎠ at various temperatures.