

BaLaIn₂O_{5.5} electrolyte single chamber solid oxide fuel cells with novel porous electrolyte surface structure

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Introduction

Since BaLaIn₂O_{5.5} (BLI) shows characteristic of high ion conductivity,^{[1],[2]} which is higher than that of Yttria-Stabilized Zirconia (YSZ), it could be utilized as the electrolyte of solid oxide fuel cell (SOFC). However, in common dual chamber SOFC system, the oxygen partial pressure is low enough that In ion would be reduced under anode atmosphere. Single chamber solid oxide fuel cell (SC-SOFC) provides the platform to use BLI with mild reducing atmosphere.^[3]

In the microstructure of SOFCs electrode with mixed conducting property, the electrode-electrolyte interface is the area where the oxygen ion transfers from electrode into electrolyte. Traditionally, the electrolyte surface is flat and polished, and the electrode-electrolyte interface area is same as cell surface area. Increasing the electrode-electrolyte interface without increasing the cell surface area would be benefit to the oxygen ion transfer. We would like to propose a new strategy that porous electrolyte surface will greatly increase the electrode-electrolyte interface without increasing cell surface area. After the electrode material was filled into the micro pores on the electrolyte surface, the oxygen ion pass channel will be 3 dimensional spherical surface compared with the 2 dimensional flat electrode-electrolyte interface studied before.

In this study, we utilized the BLI electrolyte to introduce the porous surface electrolyte structure to increase the electrode-electrolyte interface area.

Experimental

BaLaIn₂O_{5.5} (BLI) powder was synthesized by a solid state reaction of barium carbonate, indium oxide, and lanthanum oxide. BLI powder was slightly pressed into pellet-like shape by using the `KBr pellet forming set`. Then, uniformly cover a layer of fumaric acid on both surfaces of the BLI pellets, which was used to create coarse surfaces after removing during the thermal treatment. The particle sizes of fumaric acid were 50 μ m and 150 μ m. The pellets were vacuumed for 5 min in the `KBr pellet set`, and subsequently, the pellets were uniaxially pressed under 60 Mpa for 5 min under vacuum condition. Then the pressed pellets were pressed by CIP under 392Mpa. Finally, the pellets were heated at 250 °C for 3h to remove the fumaric acid to create the coarse structure, and then sintered at 1400 °C for 10 h.

(La_{0.75}Sr_{0.25})_{0.9}Cr_{0.5}Mn_{0.5}O_{0.3} (LSCM) mixed with 5wt% NiO and Sm_{0.5}Sr_{0.5}CoO₃ (SSC) were employed as anode and cathode, respectively. In this study, L-valine was selected as pore forming material due to its sublimation property^[4]. It was mixed into both LSCM and SSC with composition at 30 wt%. The mixture was then painted on anode and cathode face of BLI electrolyte pellets. The painted pellets were treated at 200°C, far below the sintering temperature, for sublimation of the pore former and then pores were created in the electrodes. Subsequently, the pellets were heated at 1100°C. The power generation tests at 800°C were carried out to examine the cell performance. A mixture of methane and air was supplied with 1:4 volume ratios.

Results and Discussion

The cell performance was investigated by power generation test through the measurement of cell's open-circuited voltage (OCV) and maximum power density (MPD). The cell performances were shown in Fig.1, in comparison, normal cell with flat electrolyte surface was also illustrated in the figure. The OCV and MPD were compared in the Table.1. The MPD achieved by the coarse electrolyte surface cell with large pore is 46.2 mW/cm², which is lower than that achieved by the normal cell with MPD 53.8 mW/cm². The coarse electrolyte surface cell with small pore whereas achieved 74 mW/cm².

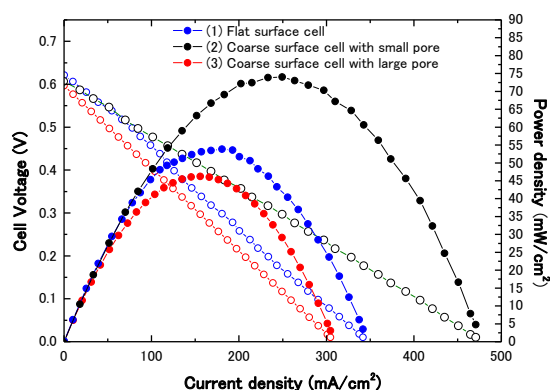


Fig.1 Power generation of cells with coarse electrolyte surface and normal flat surface

| Cell components | OCV(V) | MPD(mW/cm ²) |
|---|--------|--------------------------|
| (1) Flat surface cell | 0.62 | 53.8 |
| (2) Coarse surface cell with small pore | 0.61 | 74 |
| (3) Coarse surface cell with large pore | 0.60 | 46.2 |

The possible reason for the low performance of group (3) would be that the size of the pore is too large. The depth of the pore on the surface is approximate 75 μ m, when the electrode materials were filled into the pore and printed on the electrolyte surface. The totally thickness of the electrode was too thick, which increase the resistance of electrode. The group (2) shows much improvement of cell performance for the enlarged electrolyte-electrode interface area.

References

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