Single Chamber Fuel Cell using $BaLaIn_2O_{5.5}$ Solid Electrolyte

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Introduction

$Ba_2In_2O_5$ with defect perovskite-related structure has a characteristic order-disorder transition at about 930 °C, and shows high oxide ion conductivity at the higher temperature. In order to utilize as the electrolyte for solid oxide fuel cells (SOFCs), various attempts to stabilize the high temperature phase had been made until now, and it had been clarified that the high conductivity was maintained even at low temperature by doping Ga, Gd or La to $Ba_2In_2O_5$. Especially, it is found that La doped $Ba_2In_2O_5$; $BaLaIn_2O_{5.5}$ (BLI) has higher oxide ion conductivity than yttria-stabilized zirconia[1,2,3]. However, there was a problem for the utilization as a solid electrolyte because In ion is reduced at the oxygen partial pressure as low as that of the fuel electrode.

Single chamber fuel cells (SCFCs)[4] operate in mixture of fuel and air based on catalyst selectivity of an anode and a cathode. SCFCs do not need to separate fuel and air, which makes cell design simpler than that of conventional SOFCs and leads to reduction of fabrication cost.

In this study, we have attempted to use BLI as an electrolyte of SCFCs. Because SCFCs operate in the mixture of oxygen and fuel, it is considered that the atmosphere of SCFC is not so reductive and that In ion would not be reduced.

Experimental

BLI powder was prepared by usual solid-state reaction starting with Bariumu cabonate (Wako Chemical Co. Inc., 99%), indium oxide (Wako Chemical Co. Inc., 99.9%), and lanthanum oxide (Wako Chemical Co. Inc., 99.99%).

The BLI powder was shaped into disk and pressed by cold isostatic press in 392 MPa. Then it was sintered in air at 1400 °C for 10 h. After that, pellet surface was polished with abrasive paper and a disk (15 mm diameter, 0.5 mm thick) was obtained. An Ni-$(La_{0.75}Sr_{0.25})_{0.9}Cr_{0.5}Mn_{0.5}O_3$ (Ni-LSCM, mixing ratio 5 wt% NiO : 95 wt% LSCM) cermet [5] was applied as anode and an $Sm_{0.5}Sr_{0.5}O_3$ (SSC) was applied as cathode. Either sample was prepared by a solid state reaction, ground using a planetary ball mill at 500 revolutions per minute for 1 h and then mixed in ethyl carbitol in a mortar, respectively. To the obtained paste, 5 wt% carbon powder was added to make the electrode porous after calcination. Either paste was applied on the opposite side of the BLI disk surface each other with 0.5 cm^2 area and then calcined in air. A Pt mesh and an Au mesh were used as electrical collector for anode and cathode, respectively. A schematic illustration of SCFC is given in Fig. 2.

For thus obtained SCFC, the cell performance was measured by typical *I-V* measurements. The operating temperature was fixed at 800 °C. CH_4 and air were supplied at 50 $cm^3 min^{-1}$ and 200 $cm^3 min^{-1}$, respectively. Voltage was changed from open-circuit voltage to 0.01 V at 20 mV intervals and each point was held for 10 s. For reference, the performance of a SCFC with YSZ (Nikkato Co., Ltd) electrolyte prepared by the same process described above was also measured.

Results and Discussion

Fig. 2 shows the performances of SCFCs with BLI and YSZ electrolyte. For the SCFC with BLI electrolyte, an OCV of 617 mV was generated and a maximum output power density of around 38 $mWcm^{-2}$ was attained. Compared with the value of the SCFC with YSZ electrolyte (an OCV of 631 mV and a maximum output power density of around 4.8 $mWcm^{-2}$), the OCV was slightly lower, however, the maximum output power density was much higher. This result indicates that BLI electrolyte will be sufficiently utilized as electrolyte of SCFCs.

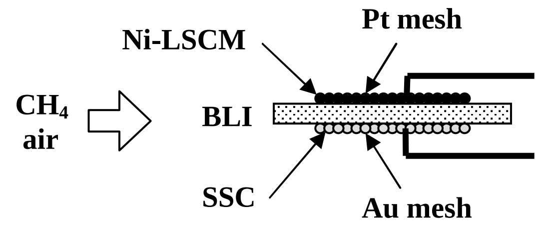

Fig. 1 Schematic illustration of single chamber fuel cell.

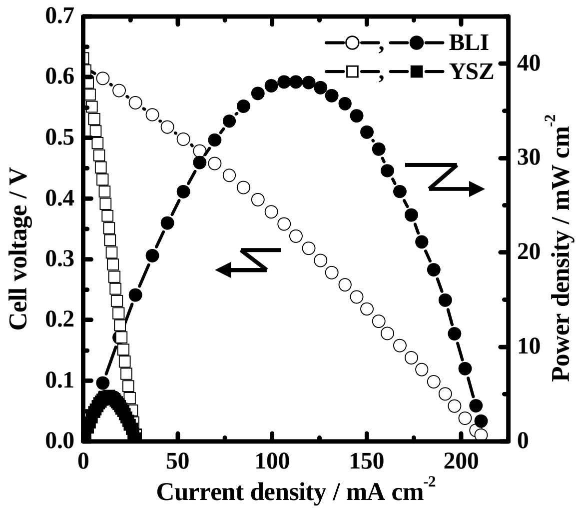

Fig. 2 Voltages (○, □) and power densities (●, ■) of single chamber SOFCs using BLI and YSZ in a flowing mixture of methane and air at 1073 K.

References

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