Cell Fabrication and Performances of SOFC prepared by DBM and SPM

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The research and development for the solid oxide fuel cell have been promoted rapidly and extensively in recent years, because of their high efficiency and future potential. Therefore this paper describes the manufacturing method and characteristics of anode electrode for solid oxide fuel cell, by the way, Ni-YSZ materials are used as anode of solid oxide fuel cell widely. In order to reduce production costs, we have fabricated single solid oxide fuel cell by doctor blade and screen printing method. Disk-type planar solid oxide fuel cell with an effective electrode area of about 7 cm^2 were fabricated and run for 500 h to investigate cell performance. The current density at a voltage of 0.7 V was 850 mA/cm^2.

Keywords : Fuel cell, Solid oxide, Unit cell, Performance, Doctor blade, Screen printing

1. INTRODUCTION

Fuel cell is radically different way of making electrical power from a conversion device that produces electricity directly from a gasous fuel by electrochemical combination of the fuel with an oxidant[1-3].

And, fuel cell system is called clean generation system which does not cause NOx or SOx. It is generation efficiency come to 50-60 % in contrast to 40 % of combustion generation system[3,4]. Among the fuel cell system, solid oxide fuel cell is constructed of ceramics, so stack construction is simple, power density is very high, and there is no corrosion problems[2,4-6].

Solid oxide fuel cell have been widely studied by many researchers because of an oxide electrolyte sandwiched between an anode and cathode[7,8].

The object of this study is to develop various composing material for solid oxide fuel cell generating system, and to test unit cell performance manufactured. So we try to present a guidance for developing mass power generation system. We concentrated on development of manufacturing process for cathode, anode and electrolyte.

2. EXPERIMENTAL

A summary of the starting powders for cathode sample is shown in Table 1. Figure 1 shows the manufacturing process for the cathode powder by citrate method. Figure 2 and Fig. 3 show respectively the manufacturing process for the anode powder and electrolyte.

Unit cell were fabricated using conventional thick film processing techniques, i.e., doctor blade and screen printing. And we could make planar type unit cell about 7 cm^2 size, using by 8 mol% yttria stabilized zirconia(YSZ) electrolyte, perovskite type cathode, and Ni-YSZ cermet anode. As cathode material lanthanum-strontium-manganese(LSM) perovskite of optimized $La_{0.7}Sr_{0.3}MnO_3$ composition was used because of its high electric conductivity and good compatibility with the electrolyte, consisting of zirconia doped with 8 mol% yttria stabilized zirconia.

A schematic diagram of the fabrication is shown in Fig. 4. In this fabrication process, electrolyte and anode powders are first mixed with organic binders to form ceramic masses. Anode and cathode slurry were screen printed onto dense yttria stabilized zirconia electrolyte electrolytes and fired at 1,400 ^oC and 1,200 ^oC, respectively.

3. RESULTS AND DISCUSSION

Figure 5 shows a schematic diagram of the configuration of a unit cell, which consisted of a cell part and a cell holder. The cell holder were made of a heat resistant alloy(Inconel 600) and were used as current collectors and gas manifolds.

Table 1. Materials for cathode sample.

Reagent	Structure	Molecular Weight	Company
Lanthanum Nitrate	$La(NO_3)_3.6H_2O$	433.03	GFS Chemicals
Strontium Nitrate	$Sr(NO_3)_2$	211.63	Junsei chem. co.
Manganese Nitrate	$Mn(NO_3)_2.nH_2O$	178.95	Junsei chem. co.
Citric Acid	$C_6H_8O_7.H_2O$	210.14	Oriental chem. co.

$La(NO_3)_3.6H_2O$ +$Sr(NO_3)_2$ +$Mn(NO_3)_2.nH_2O$
↓
Water distillation
↓
Drying(70 °C,14 hr)
↓
Calcination

Fig. 1. Manufacturing process of cathode powder by citrate method.

NiO powder +alcohol
↓
Ball mill(24 hr)-YSZ
↓
Drying
↓
Calcination(1400 °C, 2 hr)
↓
Grinding

Fig. 2. Manufacturing process of anode powder.

YSZ powder +PVB, DBP +Toluene
↓
Ball mill(48 hr)
↓
Defoaming process(Vacuum)
↓
Tape casting(300 ㎛)
↓
Sintering(1300 °C)
↓
Electrolyte

Fig. 3. Manufacturing process of electrolyte.

Electrolyte sheet
| ← screen printing (Ni-YSZ powder)
Sintering (1400 °C, 2 hr)
| ← screen printing ($La_{0.7}Sr_{0.3}MnO_3$)
Sintering (1200 °C, 5 hr)
|
Unit Cell

Fig. 4. Manufacturing process of SOFC unit cell.

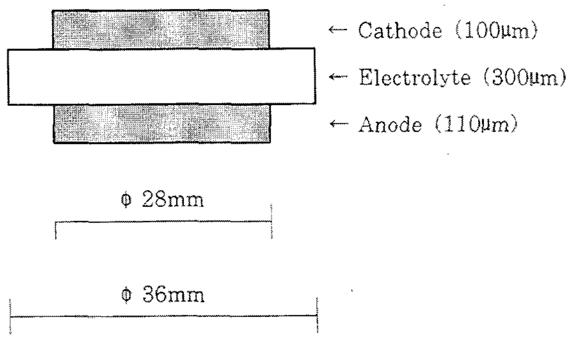

Fig. 5. Schematic diagram of a unit cell.

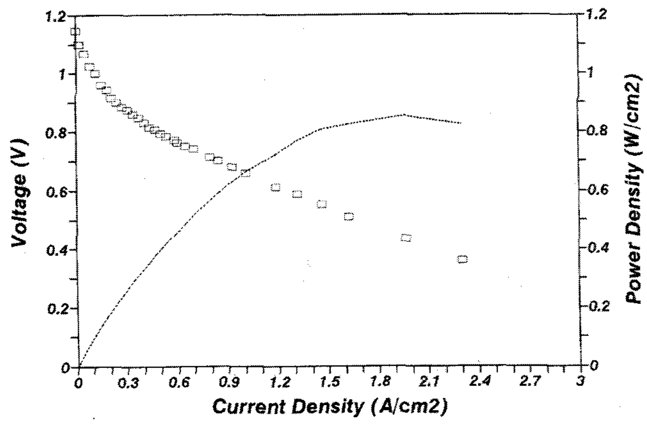

Fig. 6. Current-Voltage performance of unit cell.

Figure 6 shows the current-voltage characteristic for the fuel cell at 1,000 °C. The maximum power density is 0.85 W/cm^2(0.435 V, 1.96 A/cm^2). The good I-V characteristic implies that both the anode(Ni-YSZ) and cathode($La_{0.7}Sr_{0.3}MnO_3$) materials are suitable. The open circuit voltage obtained from the unit cell is 1.15 V.

Figure 7 shows the current-voltage characteristics of a unit cell for solid oxide fuel cell, for which the yttria stabilized zirconia film obtained by doctor blade method was applied. This high power density of solid oxide fuel cell suggests that the doctor blade method was a very useful method for preparing thin and dense yttria stabilized zirconia films for solid oxide fuel cell.

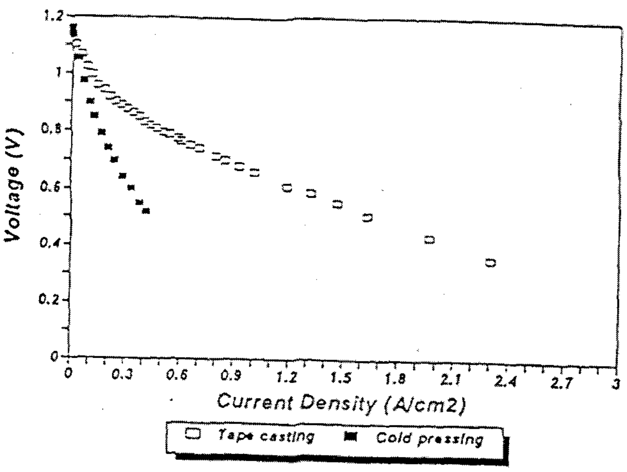

Fig. 7. Performance comparision of doctor blading cell with cold pressing cell.

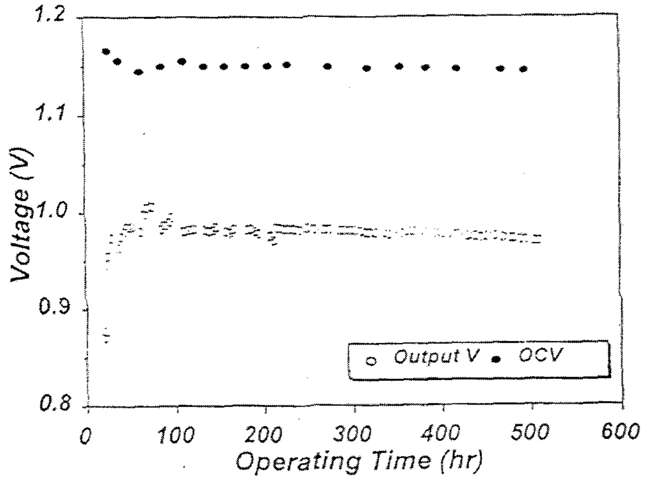

Fig. 8. Voltage drop in dependence on operating time.

Doctor blade method is a versatile processing technique to produce flat ceramic or metallic parts. In many case doctor blade is the most efficient way to manufacture thin, large area and flat parts impossible to press. Due to the flat nature of planar solid oxide fuel cell components, doctor blade is a widely applied technology in the manufacture of electrolytes. Another reason to choose doctor blade is its low cost and large-scale production potential.

Table 2 shows performance according to electrolyte manufacturing process.

It was generated the maximum electric power of 5.2 W at 1,000 °C with hydrogen and oxygen gas. The current density at the voltage of 0.7 V was 850 mA/cm^2.

The unit cell($La_{0.7}Sr_{0.3}MnO_3$/8YSZ/50Ni-YSZ) was operated over 500 hours. It is shown in Fig. 8. It's performance was 0.97 V at 150 mA/cm^2 using hydrogen/oxygen.

Table 2. Performance according to electrolyte manufacturing process.

Electrolyte manufacturing process	**Doctor blading**	**Cold pressing**
Thickness	300 ㎛	2 mm
Anode	50Ni-YSZ	50Ni-YSZ
Cathode	LSM0.3	LSM0.3
Current density	850 mA/cm^2	275 mA/cm^2
Power density	0.85 W/cm^2	0.21 W/cm^2

4. CONCLUSION

We concentrated on development of manufacturing process for cathode, anode and electrolyte. And we could make disk type planar unit cell of solid oxide fuel cell, and tested unit cell performance.

The unit cell of which the components were made by doctor blade and screen printing method, was found suitable in performance.

The unit cell performance consisted of a cell open circuit voltage of 1.15 V, a cell voltage of 0.97 V at 150 mA/cm^2 using H_2/O_2, and a cell maximum out of 0.85 W/cm^2. And, The unit cell was operated for over 500 hours.

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