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Porous Electrolyte and Fuel Utilization in Single Chamber Solid Oxide Fuel Cells

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A single chamber solid oxide fuel cell (SC-SOFC), which is operated in a mixture of fuel and oxidant gas, provides several advantages over the conventional SOFC such as simplified cell structure (no sealing required) and direct use of hydrocarbon fuel. A number of studies have been reported with the results of promising performance using a mixture of air and hydrocarbon fuel[1-3]. A typical SC-SOFC consists of Sm doped ceria (SDC) as electrolyte, Ni-SDC cermet as anode and (Sm, Sr)CoO_3 as cathode. In the single chamber configuration, the oxygen activities at the anode and the cathode are not fixed. When one of the electrodes has a higher catalytic activity for oxidation of fuel than the other electrode, an oxygen activity difference exists between the electrodes, which results in an EMF. Since the oxygen activity difference occurs only in the region of electrodes, it may allow the oxygen potential to be maintained between electrodes without requiring gas tightness.

The use of surface migration of ions in fuel cells was proposed by van Gool[4] several decades ago and the possibility of using porous electrolyte to improve fuel cell performance by making use of the surface migration of fuel and oxygen was suggested. In this study, the applicability of using a porous electrolyte in a single chamber solid oxide fuel cell (SC-SOFC) has been examined using a cell which consists of a 18 μm thick Y doped ZrO_2 (YSZ) porous electrolyte on a NiO-YSZ anode substrate and a cathode using (La, Sr)(Co, Fe)O_3.

The cell performance was evaluated using a tube furnace in which a gas mixture with a composition of methane (17 vol%) and air (83 vol%) was flowing. Pt and Au mesh were used as current collectors with the size adjusted to the area of the cathodes, which was 0.18 cm^2. The gas flow controllers maintained the gas flow between 300 ~ 900 cm^3min^{-1}, which gave a linear velocity (gas flow rate /gas flow cross section area where cell was placed) in the tube ranging from 40 ~ 120 cm s^{-1}. Figure 1 shows the I-V discharge profile of the porous electrolyte SOFC in single chamber configuration. Data were collected at 556 ^oC set temperature. As can be seen, cell temperatures were strongly affected by the linear velocity due to increasing catalytic activity. The results showed that the cell generated an open circuit voltage of about 0.78 V and a maximum power density ~ 0.56 W cm^{-2} (@ 0.4 V) at set temperature = 556 ^oC (cell temperature = 730 ^oC), which indicate that a porous ion conducting membrane may provide sufficient separation of oxygen activity at the electrodes as well as low electrolyte resistance to make a useful fuel cell. The fuel utilization in the single chamber configuration will also be discussed by use of the current efficiency.

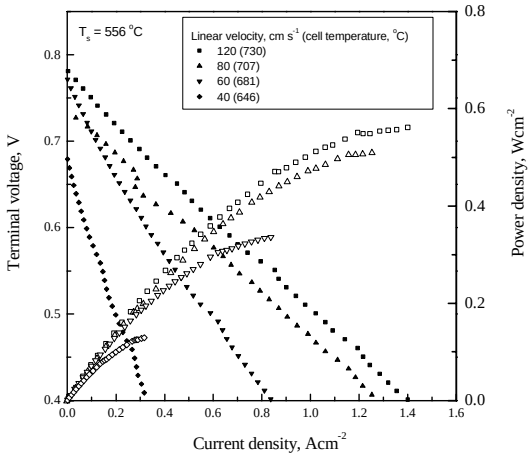

Figure 1: The I-V discharge profile (filled symbols) and the power density (open symbols) of the porous electrolyte SOFC in single chamber configuration.

References

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