

Single Chamber Solid Oxide Fuel Cells with Mixed Ionic Electronic Conducting Electrolyte

B.E. Buegler*, M.E. Siegrist, L.J. Gauckler

Nonmetallic Inorganic Materials, Swiss Federal Institute of Technology

Wolfgang-Pauli-Str.10, CH-8093 Zurich, Switzerland
e-mail: brandon.buegler@mat.ethz.ch

Single Chamber Solid Oxide Fuel Cells (SC-SOFCs) offer the possibility for simplified cell designs as compared to conventional SOFCs. Both the anode and cathode are exposed to the same mixture of fuel and oxidant. Thus only one gas compartment is needed for the whole cell. The difference of catalytic activity of the two electrodes for the partial oxidation of a hydrocarbon generates the observable open circuit voltage (OCV) [1]. SC-SOFCs based on the mixed ionic electronic conducting $\text{Ce}_{0.9}\text{Gd}_{0.1}\text{O}_{1.95}$ electrolyte were investigated in this work. $\text{Sm}_{0.5}\text{Sr}_{0.5}\text{CoO}_{3-\delta}$ and $\text{Ni-Ce}_{0.8}\text{Gd}_{0.2}\text{O}_{1.90}$ was used as the cathode and the anode material respectively. Pt-mesh and wire were used as current collectors for both electrodes. The current collectors were embedded in the screen printed electrodes and subsequently fired.

Figure 1 shows the voltage current characteristic of a SC-SOFC at 600°C with a constant CH_4 -flow of 100 ml/min and air flows ranging from 100 to 300 ml/min. The highest OCV and maximum power output (P_{max}) were obtained for 300 ml/min and this corresponds to a CH_4 to O_2 ratio of 1.6. The OCV as well as P_{max} of the fabricated cells was strongly dependent on the operating temperature (Figure 2). At a gas flow of 100 ml/min CH_4 and 300 ml/min air the OCV decreased from 0.8 V at 500°C to 0.58 V at 700°C. The fabricated cells generated 271 mW/cm^2 at 500°C and 468 mW/cm^2 at 600°C. At 700°C both the OCV and P_{max} were lower than at 600°C. This was due to the pronounced electronic conduction in the electrolyte and some degradation occurring at such high operating temperatures.

For a prospective co-sintering step of anode and electrolyte or even all three cell components it is necessary to reduce the sintering temperature of the electrolyte. It has been shown that this can be done by Cobalt-addition to nano-sized ceria powder [2]. In this work we wanted to check the feasibility of this approach for SC-SOFCs because it has been shown that doping the electrolyte may have a large impact on the cell performance [3]. Identical cells were fabricated with a 2 cat% Co-doped electrolyte that could be sintered at 1200°C instead of 1400°C for the undoped powder. The density exceeded 96% of the theoretical density. Figure 3 shows the influence of the Co-doped electrolyte at 100 ml/min methane and 100 ml/min airflow. Cobalt increases the OCV and also P_{max} . In contrast, at 300 ml/min airflow (not shown here), for which the maximum power output usually is obtained, only the OCV voltage of the cells with Cobalt is increased. P_{max} is inferior as compared to the undoped cells. Further experiments concerning the measurement of electrode overpotentials will have to be carried out for clarifying which electrode attributes for the main electrical loss of the cell.

1. T. Hibino and H. Iwahara, *Chemistry Letters*, **1993**, 7: p. 1131.
2. C. Kleinogel and L.J. Gauckler, *Solid State Ionics*, **2000**, 135(1-4): p. 567.
3. T. Hibino, S. Wang, S. Kakimoto, and M. Sano, *Electrochemical and Solid-State Letters*, **1999**, 2(7): p. 317.

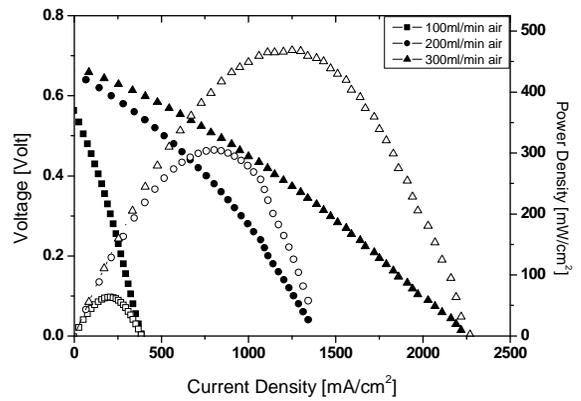


Figure 1 Performance of a SC-SOFC with 0.29 mm thick electrolyte at 100 ml/min CH_4 and different air flow at 600°C

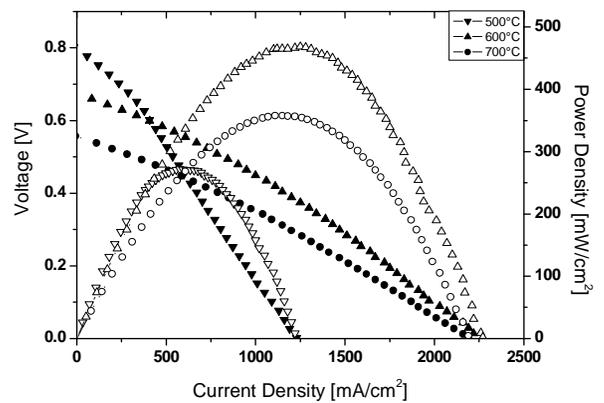


Figure 2 Performance of a SC-SOFC at different temperatures for 300 ml/min airflow and 100 ml/min CH_4

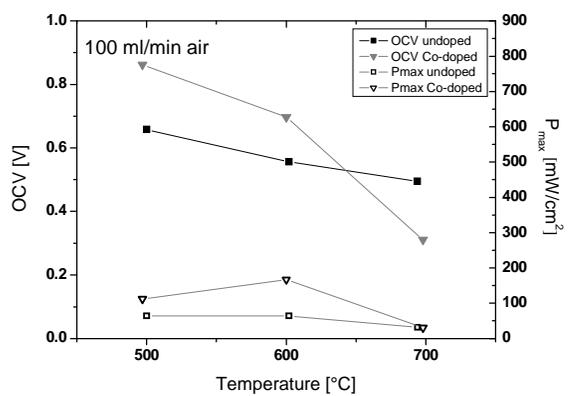


Figure 3 Influence of Co-doped electrolyte on OCV and maximum power density of a SC-SOFC