Development of Solid Oxide Fuel Cells (SOFCs) for the Realization of Biogas-Fueled Autonomous Decentralized Power Supply with High Efficiency

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[Abstract]

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A new Solid oxide fuel cell (SOFC) that uses real biogas as direct fuel and can suppress carbon deposition in the medium temperature range of 500-700° C has been developed. Electrolyte-supported single test-cells were fabricated with gadolinia-doped ceria (GDC) electrolyte powder, the prepared $Ni_xCu_{1-x}O$/GDC powder, and commercial $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_3$ (LSCF) cathode powder. The cell performances were evaluated at 700°C, using biogas (model or real) and dry air as fuel and oxidant, respectively. The voltage changes with time for constant current measurements (100 mA/cm^2) performed at 700°C using Ni_xCu_{1-x}/GDC (x = 1, 0.8, 0.6 and 0.4) as anodes and a model biogas feed rate of 6 mL/min were investigated. 24 hours of continuous power generation and a carbon deposition of less than 1 mass% were achieved with anodes with x = 0.6 and x = 0.4. Next, a constant current measurement was just performed at a current density of 33 mA/cm2 using a $Ni_{0.6}Cu_{0.4}$/GDC (ϕ14 mm, three-layer) anode with actual biogas as fuel at 700°C, 24 hours of continuous power generation and a carbon deposition of less than 1 mass% were achieved. It has also achieved 24-hour power generation at 600°C and continuous power generation for over 90 hours at 700°C. On the other hand, the formation of a new cathode material with an unparalleled high cathode orientation of over 50 % was achieved using $Pr_4Ni_3O_{10}$. For $Pr_4Ni_3O_{10}$, the voltage drop due to polarization loss at a current density of 300 mA/cm^2 at 700 °C was found to be about 0.1 V for a non-oriented cathode. The final power generation efficiency for the consumed methane was 20%, but higher efficiency of utilization can be expected in combination with the desired new cathode. In addition, higher power generation efficiency can be achieved by utilizing residual methane and hydrogen through more precise design of the cell configuration, such as multiple stages.

[References]

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