Development of Intermediate-Temperature SOFC Module Using Doped Lanthanum Gallate

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Mitsubishi Materials Corporation (MMC) and the Kansai Electric Power Co., Inc. (KEPCO) have been jointly developing intermediate temperature SOFCs that utilize doped lanthanum gallate electrolyte. Primary target of the collaboration is the development of modular SOFC systems for on-site power generation. Manufacturing technology of electrochemically active cells composed of $(La,Sr)(Ga,Mg,Co)O_3$ electrolyte, $Ni-(Ce,Sm)O_2$ anode and $(Sm,Sr)CoO_3$ cathode was established. The first generation module successfully provided the output power of 1 kW with thermal self-sustainability below 800 °C. Recent achievements in the joint module development effort will be presented in this symposium.

The intermediate temperature operation of SOFC is one of the key factors to realize compact and low-cost power generating system. However, it demands the use of thinner or highly efficient oxide ion conducting electrolyte materials to achieve high power densities. In that sense, lanthanum gallate based oxide ion conductor is one of the most appropriate materials for reduced temperature SOFCs. High performance planar cells are fabricated via screen-printing electrodes on the dense electrolytes.

Seal-less planar type stack design is employed for manufacturing the module. It generates high output power per unit stack volume without facing the gas sealing problem which is frequently significant for planar SOFC. Each cells are interconnected in series via metallic separators and current collectors. The uniform distribution of gas over each electrode is maintained via structured current collectors placed between the cell and the separators. Exhaust fuel and depleted air are collected around the stack, and combustion heat of the excess fuel is utilized to heat up the stack.

The first generation module of 1 kW class contains a stack of 25 cells with 154 mm diameter. Hydrogen and air at room temperature are supplied to the module, heated up by the exhaust gas, and fed to each cell. The balance between the gas flow rates and the electrical output is carefully maintained. The module temperature is controlled by adjusting the air flow rate.

Figure 1 shows the current-voltage-power characteristics of the module. Output power of 1 kW is obtained when the hydrogen flow rate is 14.0 Nl/min. The module stability tests were performed in stages with special emphasis on the thermal self-sustainability. The first stage was carried out for 102 hours with the fuel flow rate of 14.0 Nl/min, and the second stage was conducted for 7 hours with that of 13.2 Nl/min. Profiles of the output power and stack maximum temperature are shown in the figure 2. The electrical conversion efficiency and the fuel utilization are 40%[LHV] and 68%, respectively at the first stage, and 43%[LHV] and 78% at the second. During the stability tests, average stack temperature was 770 °C. Air/fuel ratio was kept at about 5 throughout the stability tests.

Dynamic performance test of the module was carried out via controlling the fuel flow rate. Figure 2 shows output power, electrical conversion efficiency and fuel utilization. Output power was changed stepwise between 600 and 1000 W. Temporary decreases in electrical conversion efficiency and fuel utilization accompanied by the change in output power were recovered within relatively short periods.

The above mentioned tests demonstrated that the first generation module is capable of producing targeted output powers with high conversion efficiency. Further testing and modification of the module for methane fuel utilization are in progress.

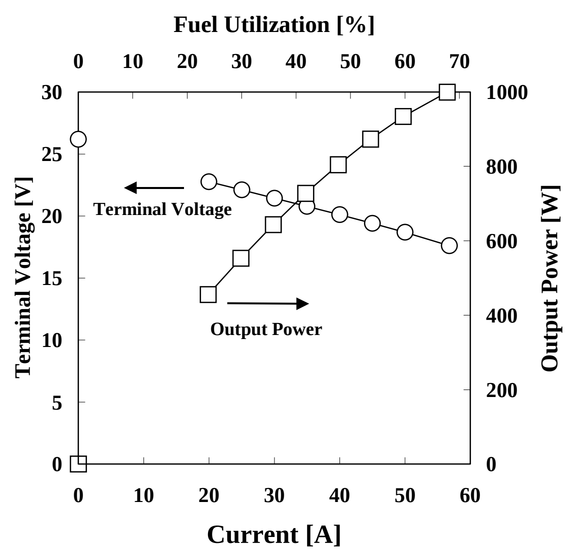

Fig.1. I-V, I-P characteristics of the module.

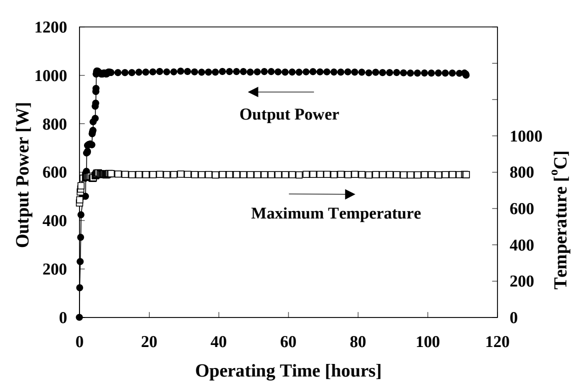

Fig. 2. Results of the module stability test.