Development of Performance Evaluation Testing Method for SOFCs

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This paper describes results of experimental research in which the damage and electrical properties of a ceria-based solid oxide fuel cells (SOFCs) is observed by an acoustic-emission (AE) method. With the single cell performance test under simulated operating condition, AE monitoring was conducted, and the relation between the AE characteristics and fracture behavior was examined.

Electrolyte-supported single cells were tested with the objective of developing a simple method for determining the mechanical performance of SOFCs. Dense sheets of 1mm thickness and 16 mm diameter made of $(CeO_2)_{0.8}(SmO_{1.5})_{0.2}$ (this particular composition will hereafter be abbreviated as 20SDC) were used as the electrolyte. A cermet of NiO-20SDC (weight ratio of 60:40) and $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_3$ (LSCF) were used as an anode and cathode, respectively. The anode and cathode (10mm diameter) were applied by a screen-printing method symmetrically on opposite sides of the 20SDC electrolyte. Thickness of the anode and cathode was 30mm, and 15mm, respectively.

Schematic of the SOFC single cell performance test apparatus is shown in Fig.1. The cell performance was measured in the range of 550-800˚C, using AE method. AE signals were detected using a broadband piezoelectric transducer (PAC R15 S/N CM16). After the electronic signals from the transducer were preamplified (40dB) and bandpass filtered between 20kHz and 2MHz, they were further amplified with a variable broad-band amplifier that provided an additional gain of 45dB. After measurement, in order to observe the fracture behavior of ceria based single cell, the cross section of single cell was observed by scanning electron microscopy (SEM).

The energy of the AE signal E_{AE} for various stages of the compositional stresses test is plotted against the temperature-time in Fig. 2. The onset of AE occurs approximately at the temperature level at which the temperature becomes 640˚C. The AE activity increases with increasing temperature and a number of AE signals are emitted prior to 720˚C. It can be considered from the AE behavior that the development of numerous microcrack precedes the macrocrack propagation in the single cell. Typical cross section SEM image of the cathode (LSCF) and electrolyte (20SDC) is shown in Fig. 3. Many cracks exist on the surface of cathode, and delaminations occurred from the inside of cathode. However, no damage was found in the single cell caused by thermal expansion induced stress. It is seems that damage of ceria-based fuel cell is caused by chemical expansion induced stress.

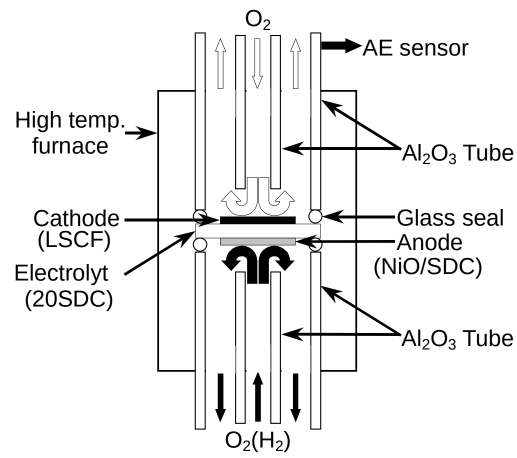

Fig.1 Schematic layout of the SOFC single cell performance test apparatus.

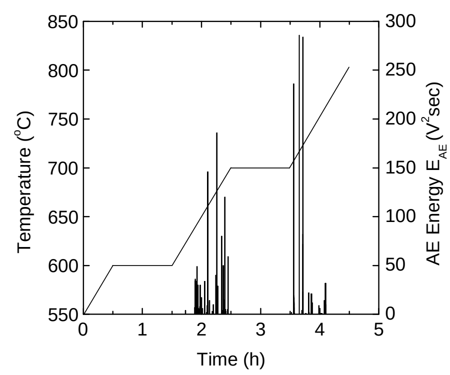

Fig.2 A typical temperature - time curve from the SOFC single cell test under simulated operating condition, and acoustic - emission behavior.

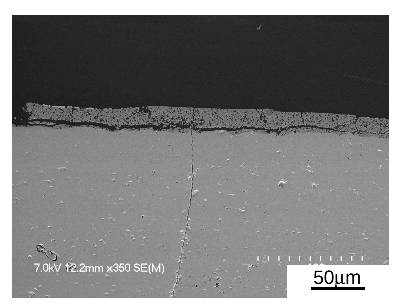

Fig.3 A Scanning electron image of a cross section of the single-cell after the performance test under simulated operating condition.