Solid oxide fuel cells with YSZ films prepared using spray pyrolysis

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Spray pyrolysis has been applied to deposit thin, dense electrolyte films on porous anode substrates. Unlike many other film deposition techniques, spray pyrolysis represents a simple and cost-effective processing method. Thin film deposition using spray pyrolysis involves the spraying of a metal salt solution onto a heated substrate.

Two different atomizers were used for generation of aerosol: an electrostatic atomizer and an air blast atomizer. Solutions of yttrium chloride and zirconium acetylacetonate in butyl carbitol and ethanol mixtures were used as precursors. The 8 mol% yttria stabilized zirconia (YSZ) films were deposited on porous NiO-YSZ anode substrates (35 mm in diameter). The deposition temperature ranged from 280°C to 320°C.

A cathode layer of $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_3$ (LSCF) of typically 50 μm was finally applied on the electrolyte by screen-printing without subsequent sintering. Ferritic stainless steel plates with gas channels were used as current collectors. The cell was operated using dry hydrogen as fuel and air as oxidant. Figure 1 shows the cross-section of a fuel cell structure with a thin YSZ electrolyte prepared by electrostatic spray deposition (ESD).

Figure 2 shows the I-V and I-P characteristics of fuel cells, for which the YSZ film was sprayed using either electrostatic or air blast atomizer. Both cells were operated under similar conditions at 770°C. An open circuit voltage (OCV) of 880 mV was measured for the cell with the electrolyte deposited using ESD and 970 mV for the cell with the electrolyte sprayed using an air blast atomizer. Due to gas leakage through the YSZ film and unsealed experimental setup, OCV of the cells was lower than the theoretical value of 1.1 V, calculated from the Nernst equation. This indicates that open porosity can exist in the electrolyte film deposited using ESD. On the other hand, high power densities of 450 mW/cm^2 and 550 mW/cm^2 were generated.

The different OCV values of the cells can be explained by comparison of the droplet size distribution. It was more difficult to deposit gas-tight films when the precursor solution is sprayed by an electrostatic atomizer, because the spray consists of many small droplets. These droplets are almost dry when they get in to contact with the surface of the substrate because small ones evaporate faster than large ones. Therefore, the open pores of the substrate are covered faster with large droplets. Usually, the droplets generated using air blast atomizers are much larger than those obtained using electrostatic atomizers.

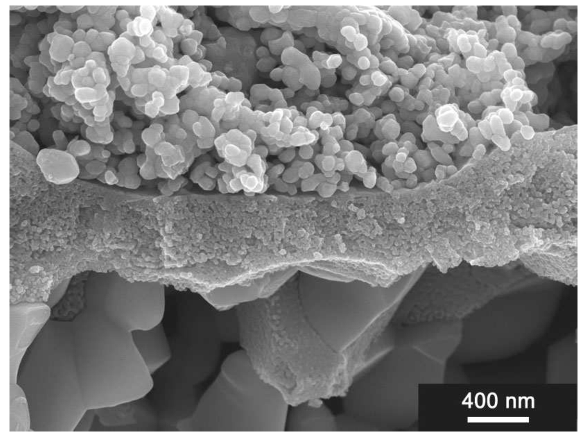

Fig. 1. Cross-section image of a solid oxide fuel cell with a sprayed electrolyte. From the top to the bottom: screen-printed cathode (LSCF), YSZ electrolyte prepared by electrostatic spray deposition and anode substrate (Ni-YSZ cermet).

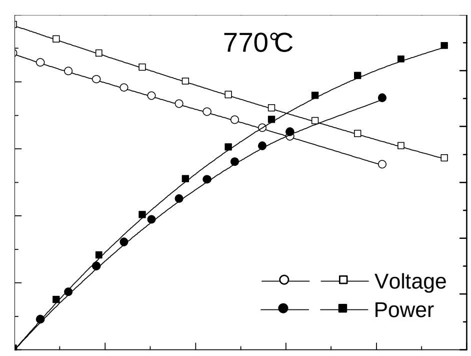

Fig. 2. Comparison of fuel cell performances at 770°C. A thin YSZ film was sprayed using either electrostatic (○●) or air blast atomizer (□ ■) on a NiO/YSZ anode substrate.

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