Studies of Grain Size Effects of the Anode of a Solid Oxide Fuel Cell Fabricated by Plasma Spray Deposition

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The long term structural stability of a solid state fuel cell (SOFC) is an important goal. A Ni–YSZ cermet has been used as an anode material for SOFC typically. In this anode, the electrochemical activity of the cermet anode strongly depends on a three-phase boundary (TPB) composed of Ni grains, YSZ grains and pores. The electrochemical reaction occurs on the TPB in the anode. It is crucial to obtain better morphology including larger TPB composed of Ni and YSZ grains for the achievement of high-performance anode. In this study, high quality Ni and YSZ composite nanoparticles were fabricated by thermal plasma spray method. The composite nanoparticles of SOFC anode created by this method have larger TPB than the existing commercial anode. To understand the particle size effect of SOFC anode and electrochemical performance of a Ni–YSZ cermet anode is of great importance.

The Ni/YSZ cermet anode has two important functions. One of the features is suppress sintering of Ni grains during high-temperature operation of SOFC. In general, fuel gas is electrochemically oxidized at the Ni/YSZ/porous interface. Therefore, the stability and activity of Ni/YSZ cermet anodes are strongly influenced by the morphology of Ni and YSZ interface. This restraint is based on Ni being an electronic conductor with very limited oxide ionic conductivity. Additionally, a range of electrode characteristics such as porosity, nickel particle distribution, grain size and particle to particle contact may result from these different electrode microstructural properties [1-3].

The anode was made by a reduction process from the plasma spray NiO/YSZ thin film. The reduction atmosphere in the furnace was maintained during the cooling cycle to inhibit the formation of oxidation layer at the surface of Ni/YSZ cermet. XRD analysis was made to check the phase composition of the samples and estimate the Ni or YSZ grain sizes. Fig. 1 shows the XRD data that the NiO/YSZ was reduced and quenched in a reduction environment from high temperature. We also observed the Ni or YSZ phase transition and grain growth (see Fig.2). XAS experiment and analysis was also used to yield the local structural information. No appreciated change of the local structure of Ni/YSZ can be found after several hours of operation at 800 ℃ under hydrogen gas.

References:

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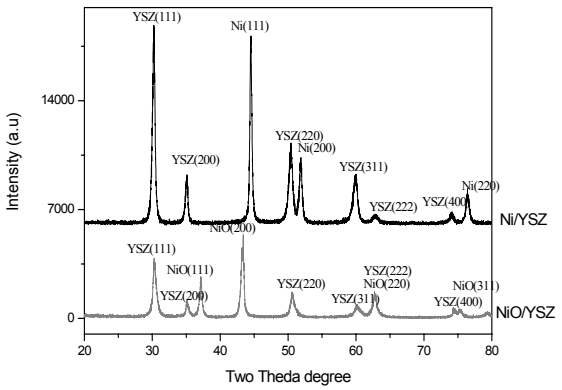

Figure 1. XRD patterns of Ni/YSZ powder calcined from the reduction at high temperature H_2 gas.

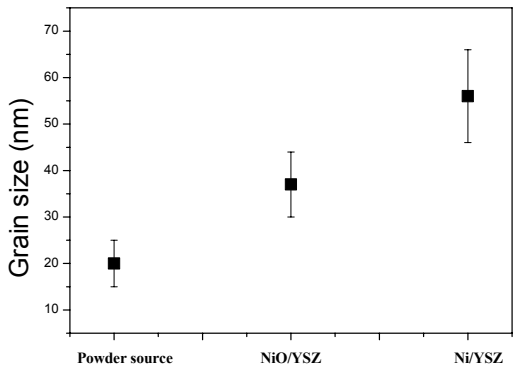

Figure 2. The grain size of SOFC anode deduced from XRD at different annealing conditions.