Nano-micro scaled active site imaging of porous composite cathode in solid oxide fuel cell by quenching and oxygen isotope labeling

T. Nagasawa[1,2] and K. Hanamura[3]

[1] Department of Mechanical and Control Engineering, Tokyo Institute of Technology, 2-12-1, O-okayama, Meguro-ku, Tokyo 152-8550, Japan
[2] Research Fellow of Japan Society for the Promotion of Science, Japan
[3] School of Engineering, Department of Mechanical Engineering, Tokyo Institute of Technology, Japan

Solid oxide fuel cell (SOFC) is one of the promising energy conversion devices because of high conversion efficiency from chemical energy to electricity beyond 60 % and high fuel flexibility. As an electrode for SOFC, composite materials are commonly used such as Ni/yittria-stabilized zirconia (YSZ) for anode or strontium-doped lanthanum manganite (LSM)/YSZ for cathode. These electrodes have micro/nano-scaled complex structures consisting of electron conductor, oxide ion conductor, and pore phases, where chemical species are transported accompanied by electrochemical reaction at the triple-phase boundary (TPB). The distributions of ionic/electronic flows and of active reaction sites in the microstructures have a great impact on the electrode performance, which have been explored by only numerical approaches so far. Here, we show a particle-scaled visualization of active sites in a LSM/scandia-stabilized zirconia (ScSZ) composite cathode by means of an oxygen isotope labeling.

In order to achieve a 1μm-particle scale visualization of active sites in SOFC electrodes, a quenching system of a SOFC single cell has been developed. A SOFC power generation equipment with a nozzle for helium impinging jet was prepared. The nozzle is covered by a water cooling jacket to keep a supplied helium at room temperature. The quench experiment shows that the temperature of YSZ electrolyte could be decreased from 830 to 150 ^{o}C within 1.5 sec, which was in good agreement with analytical results based on the average Nusselt number of impinging jet heat transfer. This rapid cooling makes it possible to keep the electrode in an operating state by suppressing the diffusion of oxide ion. By using constructed quench equipment and oxygen isotope labeling, active reaction sites in LSM/scandia-stabilized zirconia (ScSZ) composite cathode was visualized. A typical YSZ electrolyte-supported cell was operated in $^{18}O_2$ at 800 ^{o}C and subsequently quenched to room temperature. The ^{18}O distribution in cross section of the quenched cathode was obtained by secondary ion mass spectroscopy (SIMS) with a spatial resolution of 50 nm. The obtained ^{18}O mapping gives the first experimental visualization of highly-distributed active sites in the microstructure of porous composite cathode in SOFC [1].

[1] T. Nagasawa and K. Hanamura, *submitted*.