Physico-chemical nanomaterials science

Preconditioning the YSZ-NiO fuel cell anode in hydrogenous atmospheres containing water vapor

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Favorable conditions for preconditioning the YSZ-NiO fuel cell anode in high-temperature hydrogenous atmospheres containing water vapor have been investigated. A series of YSZ–NiO ceramic specimens (of size of 1x5x25 mm) were singly reduced in a hydrogenous atmosphere (the Ar–5 vol%H_2 mixture) at 600°C under the pressure of 0.15 MPa or subjected to 'reduction in the mixture – oxidation in air' (redox) cycling at 600°C. After both the treatment conditions, corresponding structures of YSZ–Ni cermets were formed and then subjected to the dwell in 'water vapor – the Ar–5 vol% H_2 mixture' atmosphere at 600°C under the pressure of 0.15 MPa. Additionally, behaviour of the as-received material in this atmosphere was studied.

It was revealed that a small quantity of water vapor in Ar–5 vol% H_2 mixture (water vapor pressure below 0.03 MPa) accelerates a reduction of the nickel phase at 600°C with formation of nanopores on tiny Ni particles. Resulting strength of the YSZ–Ni cermet increases by 10–12% as compared to the material reduced in the atmosphere without water vapor.

A higher concentration of water vapor in the mixture (water vapor pressure above 0.03-0.05 MPa) causes a converse change in the reduction kinetics. For as-received material, such a quantity of water vapor in the mixture is an obstacle for its reduction and causes re-oxidation of a nickel phase at 600°C.

For the material treated by redox cycling, better physical and mechanical properties were revealed after dwelling at 600°C in a water depleted gas mixture. Contrary to this, after dwelling at 600°C in a water enriched gas mixture, the material showed lower resistance against re-oxidation.

Based on the scanning electron microscopy, X-ray analysis and the data on the conductivity and strength, the dual effect of water vapor on durability of a nickel-zirconia anode is discussed.