Physico-chemical nanomaterials science

On the structural degradation of Ni-containing anode materials caused by hydrogen sulfide

B.D. Vasyliv[1], V.Ya. Podhurska[1], O.P. Ostash[1]

[1] Department of Structural Fracture Mechanics of Materials, Karpenko Physico-Mechanical Institute, Natl. Acad. of Sci. of Ukraine. 5 Naukova str., Lviv 79060, Ukraine.
E-mail: frankivsk@email.ua

The aim of this work is to study the effect of hydrogen sulfide content in a hydrogenous atmosphere on the structure, physical, and mechanical properties of solid oxide fuel cell (SOFC) anode materials. A series of specimens of porous metallic Ni, Ni–Al composite, and YSZ–Ni cermet have been investigated. In order to obtain the corresponding YSZ–Ni cermet structure, specimens of the YSZ–NiO anode ceramics were singly reduced in hydrogenous atmosphere (Ar–5 vol% H_2 mixture) for 4 h at 600 °C under the pressure of 0.15 MPa. A part of the specimens of each series was then aged in “hydrogen sulfide in Ar–5 vol% H_2 mixture” atmosphere for 4 h at 600 °C under the pressure of 0.1 MPa. According to a test mode, the atmosphere contained 7 or 18 vol% H_2S.

After aging, the physical and mechanical behaviours of specimens were studied and compared with those of the as-received materials. Material microstructure and fracture surface morphology of the specimens were also investigated.

It was revealed that the atmosphere containing up to 7 vol% H_2S does not affect the strength and electrical conductivity of the YSZ–Ni cermet. Increased content of H_2S (18 vol%) causes some changes in the YSZ–Ni cermet structure. A large number of fully reduced tiny nickel particles is formed. These nickel particles react with hydrogen sulfide. Sulfur is segregated on the boundaries between the zirconia and nickel phases and pores. Finally, multiple breaking of the zirconia-nickel bonds occurs that results in reduced strength of the cermet (by 39% as compared to as-received ceramics).

It was established that the Ni–Al composite is not sensitive to high temperature hydrogenous atmosphere containing up to 18 vol% H_2S. The material displayed stable values of strength, stiffness, and electrical conductivity. Thus, this composite is a promising material for manufacturing novel SOFC anodes resistible against hydrogen sulfide assisted structural degradation.