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Phase stability and conductivity of rare earth co-doped nanocrystalline zirconia electrolytes for solid oxide fuel cells

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Abstract

Solid oxide fuel cell (SOFC) is a green energy technology that directly coverts chemical energy into electricity. Scandia stabilized zirconia (SSZ) shows the highest conductivity among zirconia based electrolytes for SOFCs. However, the stability of the cubic phase, which is the desirable phase for high conductivity, can be an issue in SSZ electrolytes due to its transformation to other low-conducting phases at higher temperatures. In the present investigation, SSZ electrolyte was co-doped with ytterbia, gadolinia and ceria with an objective of improving the high-temperature phase stability. Both the doped and co-doped compositions exhibited a single cubic phase in the as-processed condition. The phase stability at high temperature was studied by aging the sintered pellets at 900 °C for 500 h in air. X-ray diffraction and transmission electron microscopy analysis revealed formation of small amount of the low-conducting tetragonal phase in 1 mol % ytterbia and gadolinia co-doped compositions on ageing which resulted in conductivity degradation. Increasing the doping level to 2 mol% prevented the formation of the tetragonal phase. The ceria co-doped composition (1 mol%), on the other hand, was clean without any sign of the secondary phases even after high-temperature ageing. The rhombohedral 'β' phase formed in the binary composition (SSZ) after sintering but was absent in all the co-doped compositions. The conductivity of the co-doped samples was higher than the binary SSZ. Thus, it can be said that rare earth co-doping is an effective way of improving the phase stability and conductivity of SSZ electrolytes.

Keywords:

Fuel cells, Nanostructured materials, Ionic conduction, Electro chemical impedance spectroscopy, Phase transitions

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