$Ce_{0.9}Gd_{0.1}O_{1.95}$ kietųjų elektrolitų keramikų sintezė, kepinimas ir impedanso spektroskopija

Synthesis, sintering and impedance spectroscopy of $Ce_{0.9}Gd_{0.1}O_{1.95}$ solid electrolyte ceramics

Theo Grivois[1], Gustas Levickis[2], Algimantas Kežionis[2], Anthony Rousseau[1], Vilma Kavaliukė[2], Tomas Šalkus[2], Maud Barre[1]

[1]Le Mans University, Institute of Molecules and Materials, Olivier Messiaen av., 72085 Le Mans Cedex 9, France

[2]Vilnius university, Faculty of Physics, Saulėtekio av. 3, 10257 Vilnius, Lithuania

vilma.kavaliuke@ff.vu.lt

Solid oxide fuel cells (SOFC) are characterized by high overall efficiency (up to 90 %) as they directly convert chemical energy of fuel gas to electrical energy. The working temperature of SOFC is mainly determined by thickness and electrical conductivity of solid electrolyte. Yttria-stabilized zirconia (YSZ) is a classic example of oxygen vacancy conductive solid electrolyte used in SOFC. The ionic conductivity of 8YSZ (zirconia doped by 8mol% yttria) is about 1 S/m at 800-900°C. Therefore, the working temperature of YSZ based SOFC reaches 800-1000°C. In order to reduce the working temperature of SOFCs, solid electrolytes with higher ionic conductivity are sought. Gadolinia doped ceria (GDC) reaches the ionic conductivity of 1 S/m at 600°C and is considered as one of the alternative materials to replace YSZ in SOFCs[1-2].

Electrical properties of GDC ceramics depend on stoichiometry, synthesis process, sintering condition, etc. Different synthesis processes affect the size and shape of crystallites, distribution of particle size, defect concentration and lattice parameters. Sintering conditions and powder morphology affect density and homogeneity of ceramic, silica phase formation in grain boundaries [4]. The total electrical conductivity in ceramic is determined by grain and grain boundary conductivities. The level of densification and homogeneity of composition will mostly affect grain conductivity. Impurities, morphology and space charge layers will mostly affect grain boundary conductivity [4].

The aim of this work was to investigate electrical properties dependence on different powder synthesis methods.

$Ce_{0.9}Gd_{0.1}O_{1.95}$ powders were synthesized by solid state reaction (heating at 1200°C for 12 hours) and co-precipitation (heating at 850°C for 2 hours) methods. The synthesized powders were analyzed by X-ray diffraction (XRD) and lattice parameters (cubic symmetry) were determined to be 5.4147(2) Å and 5.4249(2) Å for powders synthesized by solid state reaction and co-precipitation methods respectively. The pellets were sintered at 1400°C for 2 hours. The obtained ceramics were shaped into cylindrical samples and Pt electrodes were applied. Electrical properties of the samples were investigated by impedance spectroscopy in the temperature range from 300 to 800 K and in the 10 Hz - 10 GHz frequency range with impedance spectrometer developed in Nanoionics laboratory [5]. Three semicircles can be visible in a typical Nyquist plot of a ceramic. Low frequency semicircle can be attributed to electrode polarization processes. The medium and high frequency semicircles can be attributed to ion relaxation processes in grain boundaries and grains. The Nyquist plots for both samples were fitted with ZView program and grain and total conductivities were determined. The grain and grain boundary conductivities were increasing with temperature according to Arrhenius law. The activation energies were determined from total and grain conductivities dependences on reciprocal temperature.

Keywords: gadolinia doped ceria, impedance spectroscopy, ionic conductivity, solid state reaction, co-precipitation.

Literature

[1] E. Ivers-Tiffee, . Weber, J. Eur. Ceram **21**, 1805 (2001).
[2] O. Yamamoto, Electrochim. Acta **45**, 2423 (2000).
[3] S. Anirban, A. Dutta, Int. J. Hydrog. Energy **45**, 25139 (2020).
[4] G. Kim, N. Lee, K.-B. Kim, B.-K. Kim, H. Chang, S.-J. Song, J.-Y. Park, Int. J. Hydrog. Energy **38**, 1571 (2013).
[5] A. Kežionis, E. Kazakevičius, T. Šalkus, A.F. Orliukas, Solid State Ion. **188**, 110 (2011).

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