Nanocomposites and nanomaterials

Oxidation resistance of materials based on Ti_3AlC_2 nanolaminat

A.D. Ivasyshyn[1], O.P. Ostash[1], T.O. Prikhna[2], V.Y. Podhurska[1], T.V. Basyuk[2]

[1] Karpenko Physical-Mechanical Institute, Natl. Acad. of Sci. of Ukraine. Naukova str., 5, Lviv-79060, Ukraine. E-mail: ivasyshyn@ipm.lviv.ua

[2] V. Bakul Institute for Superhard Materials, Natl. Acad. of Sci. of Ukraine. Avtozavodskaya str., 2, Kiev-04074, Ukraine.

Solid oxide fuel cell (SOFC) is clean and effective technology for generating electricity. This technology consists in direct converting chemical energy into electrical energy avoiding combustion and mechanical work. Recent SOFC operate at 600…800 °C that require using structural materials resistant to high temperature degradation. In general SOFC includes single cell (anode, electrolyte and cathode) and interconnect. The interconnect serves as electric conductor and separator for fuel gas at the anode side and air at the cathode side in adjacent single cell.

Ti_3AlC_2 nanolaminat due to high electrical and thermal conductivity, appropriate to electrolyte thermal expansion coefficient, high oxidation resistance and low density is attractive for SOFC application, particularly for interconnect manufacturing.

The oxidation resistance of three modifications of material based on the Ti_3AlC_2 nanolaminat has been investigated at 600 °C in air during 1000 hours. Modification №1 was sintered in vacuum from TiC, TiH_2 and Al powders. It consists of 95 mass. % Ti_3AlC_2 and 5 mass. % TiC and have porosity of 22 %. Modification №2 have been obtained by hot pressing of modification №1. Phase composition of this material includes 89 mass. % Ti_3AlC_2, 6 mass. % TiC and 5 mass. % Al_2O_3 and there porosity decreases to 1 %. Additional alloying with 3.5 mass. % Nb (modification №3) leads to decrease of Ti_3AlC_2 (56 mass. %) and Al_2O_3 (2.6 mass.%) and increase of TiC (41 mass.%) content. Niobium was uniformly distributed in all phases.

It was shown that modification №1 have the worse oxidation resistance as a result of high porosity. The mass per area increment of modification №2 and №3 during first 250 hours increases to 0.75 and 0.15 mg/cm^2 respectively and than decreases to 0.03 mg/cm^2 and remains almost stable up to the end of a test. This phenomenon can be explained by “self-healing” of the small pores and covering of specimen surface with Al_2O_3 and TiO_2. In comparison with chromium ferrite steel Crofer, specially developed for SOFC interconnects, materials based on the Ti_3AlC_2 nanolaminat with porosity of 1% have higher oxidation resistance after exposure at 600 °C in air during 1000 hours.