Multiscale investigation of microstructural and mechanical properties of spark plasma sintered Ni-SiC composites

S. Nosewicz[1*], P. Jenczyk[1], D. Jarząbek[1], A. Strojny-Nędza[2], K. Kaszyca[2], K. Kowiorski[2], P. Bazarnik[3], Z. Pakieła[3], B. Romelczyk Baishya[3] and M. Chmielewski[2]

[1]*Institute of Fundamental Technological Research, Polish Academy of Sciences, 5B Pawinskiego, 02-106 Warsaw, Poland*

[2]*Łukasiewicz Research Network, Institute of Microelectronics and Photonics, Center of Functional Materials, 133 Wolczynska Str, 01-919 Warsaw, Poland*

[3]*Warsaw University of Technology, Faculty of Materials Engineering, 141 Woloska Str, 02-507 Warsaw, Poland*

[*]snosew@ippt.pan.pl

Abstract: In the case of the sintering of composite materials exhibiting mutual solubility, intermediate phases with varying concentrations of elements may appear during the densification process. Microstructural and structural changes, especially in the area of the interface, strongly influence mechanical or thermal properties [1]. A good example of such materials is nickel – silicon carbide composites. At elevated temperatures nickel reacts with silicon carbide, which causes total SiC decomposition, and as a result, new Ni-Si phases are formed and free carbon is precipitated within the reaction zone. In this work, nickel-silicon carbide composites were obtained via the Spark Plasma Sintering method. The detailed microstructural analyses using X-ray diffraction, Raman spectroscopy, scanning electron microscopy and transmission electron microscopy revealed the material's evolution during sintering. To investigate the correlation between microstructure and properties of obtained materials, the mechanical test at three different length scales (in macro-, micro- and nanoscale) was conducted. To evaluate the strength of Ni-SiC composites at a macroscopic scale the uniaxial tensile and compression tests were employed. The sample deformation and failure mechanism for different stages of sintering were analyzed. The strength of the nickel-silicon carbide interface was determined by bending tests of micro-cantilever beams. Nanoindentation was used to evaluate the hardness of each composite component. The conducted research revealed a strong relation between mechanical strength and sintering conditions.

Keywords: spark plasma sintering, Ni-SiC composite, multiscale analysis, nanoindentation, mechanical properties.