APPLICATION OF SHS PROCESS FOR FABRICATION OF COPPER-TITANIUM SILICON CARBIDE COMPOSITE (Cu-Ti_3SiC_2) [1]

A.P. AMOSOV, E.I. LATUKHIN, A.M. RYABOV, E.R. UMEROV, V.A. NOVIKOV

Samara State Technical University, 244, Molodogvardeiskaya str., Samara, 443100, Russia, egundor@yandex.ru, +7(846)242-28-89

Metal matrix composite of copper - titanium silicon carbide (Cu-Ti_3SiC_2) attracts the attention of researchers as a promising electrical material with a low coefficient of friction, good electrical conductivity and thermal conductivity, high erosion resistance, which is important for the use in sliding electrical contacts and electrodes for electrical discharge machining of materials [1, 2]. Such properties of the composite are largely due to the structure and properties of titanium silicon carbide (Ti_3SiC_2), belonging to a new class of ternary compounds with a layered structure – the so-called MAX phases, which occupy, in their properties, an intermediate position between ceramic and metal materials [3]. Cu-Ti_3SiC_2 composite is produced by two-stage technologies: at the first stage, Ti_3SiC_2 is synthesized from a mixture of Ti, Si and C powders (most often by reaction sintering), and then at the second stage, the composite is produced from a mixture of Cu and Ti_3SiC_2 powders by powder metallurgy methods: vacuum sintering, infiltration or spark plasma sintering. Obviously, such technologies are long-term, energy-consuming, require complex and expensive equipment, so the study of the possibility of using a simple, energy-saving powder technology based on the process of self-propagating high-temperature synthesis (SHS) for the single-stage production of Cu-Ti_3SiC_2 composite from relatively inexpensive powders of its constituent elements is of great interest.

Results of our previous investigations on application of SHS process for fabrication of a porous skeleton of Ti_3SiC_2 and composites on its basis with simultaneous infiltration by melts Ni, Ti or Fe are presented in works [4, 5]. This paper presents the results of a similar study to fabricate Cu-Ti_3SiC_2 composite.

To synthesize Ti_3SiC_2, a SHS charge was used, which was an initial mixture of powders of titanium, silicon and carbon (soot) with a ratio of components 3Ti+1,25 Si+2C. From this powder mixture, the charge briquettes in the form of a cylinder with a diameter of 40 mm and a mass of 20 g were formed by unilateral compaction. The porosity of the charge briquettes was about 0.5. Powder briquettes of copper weighing 20, 25, 30 and 35 g were compacted separately in a mold of 40 mm diameter. The SHS process was carried out in the assembly of three contiguous briquettes (the copper briquette between two charge briquettes) in the air atmosphere. For a more intimate contact of the briquettes and prevention of warping the reaction products during the synthesis process, the upper briquette was forced to the others by a weight of 500 g. Due to the heat of the SHS reaction, initiated simultaneously in the charge briquettes and resulted in formation of porous skeleton of Ti_3SiC_2 in these briquettes, the copper in the middle briquette was heated, melted and impregnated porous reaction products of the upper and lower briquettes. Using X-ray diffraction, scanning electron microscopy and energy dispersive analysis, it was established that the melt of copper reduces the amount of MAX phase of Ti_3SiC_2, partially destroying it and leading to the formation of phases of titanium carbide, titanium silicide, silicon carbide and copper silicide. The study of distribution of copper over sample body showed that copper is distributed unevenly, the maximum amount of copper is contained in the central part of the composite sample. The deintercalation of silicon from Ti_3SiC_2 and dissolution of the silicon in molten copper can be considered as the main reason for the destruction of Ti_3SiC_2. The addition of 10% silicon to the composition of initial copper briquette and, accordingly, the presence of 10% silicon in the copper melt led to an increase in the height of the peaks of the MAX phase and a decrease in the height of the peaks of titanium carbide and pure copper on the diffractogram of the composite, but reduced the uniformity of copper distribution in the composite sample body.

REFERENCES

[1] *Ngai T.L., Zheng W., Li Y.* // Prog. Natur. Sci.: Mater. Int. - 2013. - Vol. 23. – No. 1. - P. 70-76.
[2] *Oglezneva S.A., Kachenyuk M.N., Ogleznev N.D.* // Rus. J. Non-Ferr. Met. - 2017. – Vol. 58. - No. 6. - P. 649–655.
[3] *Barsoum W.* // Prog. Solid State Chem. - 2000. - Vol. 28. - P. 201—281.
[4] *Amosov A.P., Latukhin E.I., Davydov D.M.* // Modern Applied Science. – 2015. – Vol. 9. – No. 3. – P. 17-24.
[5] *Latukhin E.I., Amosov A.P., Ryabov A.M., Illarionov A.Y., Novikov V.A.* // SHS 2017. XIV Int. Symp. on SHS (September 25-28, 2017, Tbilisi, Georgia): Book of Abstracts. P. 32-34.

[1] This work was executed at financial support of RFBR under the project No. 16-08-00867.