PHASE COMPOSITION, MICROSTRUCTURE OF COMPOSITES BASED ON TI_3SIC_2 AND NITROGEN-CONTAINING PHASES OBTAINED BY THE SHS METHOD FOR ELECTRICALLY CONDUCTIVE COATINGS

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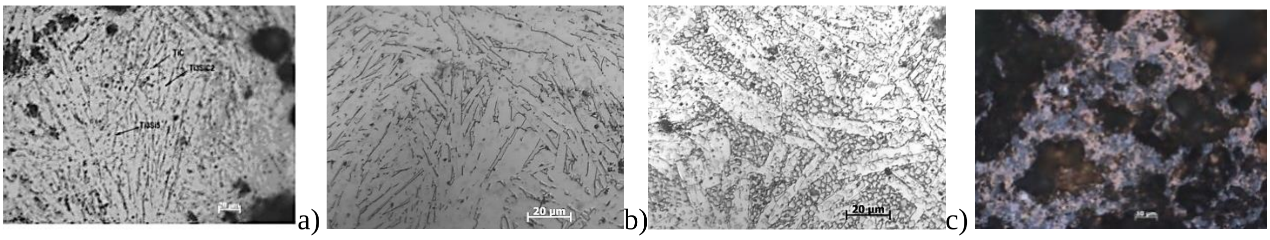
One of the promising applications of titanium carbosilicide is its use as antifriction coatings. Porous titanium carbosilicide is an attractive material for electrodes operating in aggressive chemical environments, microbial fuel cells (MFCs), and solar volumetric collectors. Ti_3SiC_2, titanium carbonitride and titanium nitride powders are promising fillers for electrically conductive polymer coatings and film heaters. The simplest method for producing these materials is self-propagating high-temperature synthesis (SHS).

Therefore, the goal of this work is to synthesize a composite material based on carbosilicide and nitrogen-containing titanium compounds by the SHS method. Study of the microstructure and phase composition of synthesis products depending on the composition of the reaction mixture. As well as studying the electrical conductivity of composite polymer coatings.

The phase composition of the samples was studied using X-ray machines: Dron-3M (Co Kα radiation) and “XRD - 6000” Shimadzu (Cu Kα radiation). The Powder Cell 2.4 program was used to process the diffraction patterns. The microstructure of the materials was studied using an optical microscope (Axiovert 200M) and a scanning electron microscope SEM-515 (Philips). The electrical conductivity of polymer composite coatings was determined using an F410 miliohmmeter (range from $1 \cdot 10^{-2}$ to $1 \cdot 10^{7}$ Ohm).

In the first version of the synthesis, a mixture of elemental powders (Ti, Si and C), designed to produce titanium carbosilicide (Ti_3SiC_2), and was pressed into tablets. The synthesis was carried out in a high-pressure reactor in a nitrogen atmosphere at different pressures. In this case, the main phase of SHS products is titanium carbosilicide Ti_3SiC_2. Titanium carbide TiC and titanium silicide $TiSi_2$ are also present. During synthesis in nitrogen, a shift of all reflections belonging to titanium carbosilicide and titanium carbide towards larger angles is observed. This can be explained by the formation of $Ti_3Si(C_xN_y)_2$ and $Ti(C_xN_y)$ c, respectively. The main structural component in all microstructures during synthesis in an atmosphere of argon (Fig. 1a), nitrogen at a pressure of 14 atm. (Fig. 1b), 60 atm. (Fig. 1c) are plate-like crystals corresponding to Ti_3SiC_2. Round crystals – titanium carbide. The greatest changes in the microstructure are observed during synthesis in nitrogen at a pressure of 60 atm. This is confirmed by X-ray phase analysis data (Fig. 1c).



a) b) c) d)

Fig. 1. Microstructures of the products of SHS of the composition 3Ti-1.2Si-2C in atmospheres of argon (a) and nitrogen (b - 14 atm., c - 60 atm.) d - microstructure of the combustion product in nitrogen of a mixture of 80:20 wt. %.

In the second option, the product Ti_3SiC_2 (85 wt. % Ti_3SiC_2 + 15 wt. % TiC) was preliminarily synthesized in argon. The product powder with a particle size of less than 80 microns was mixed with a mixture of powders of the composition 3Ti + 1.2Si + 2C in the ratios 20:80, 40:60, 60:40, 80:20, 90:10, 95:5 wt. %. The prepared mixtures were poured into cylindrical cups made of metal mesh, which were placed in the reaction chamber. The synthesis was carried out in nitrogen (20 atm.). It was found that as the initial 3Ti-1.2Si-2C mixture is diluted with the SHS product (85 wt. % Ti_3SiC_2 + 15 wt. % TiC), the amount of the Ti_3SiC_2 phase decreases and more phases reacted with nitrogen appear, such as, for example, Ti_2CN and TiCN (Fig. 1d). Electrically conductive coatings fired at a temperature of 400 °C in air have a sufficiently high electrical conductivity for making electric heaters from them. Thus, the use of this material will make it possible to expand the temperature range of their operation compared to coatings filled with Ti_3SiC_2. In addition, the Ti_2CN and TiCN phases found in combustion products of the Ti-Si-C-N system can be used as hard coatings, for cutting hard materials, stainless steel, cast iron, brass, plastic.