Preparation of highly dispersed ceramic nitride-carbide composition Si_3N_4–TiC by SHS method using halide salt and sodium azide

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Currently, Si_3N_4 is the main ceramic material for the production of products operating under high loads, for example, it is used for processing Ni-based superalloys [1]. However, the use of modern cutting tools based on pure Si_3N_4 for processing iron-containing alloys is limited due to the strong chemical interaction between Si and Fe [2]. It should also be taken into account that ceramics made of pure Si_3N_4 are very hard and difficult to machine even with a diamond tool, which significantly increases the cost of finished parts made of it. A simpler and cheaper method of electroerosion treatment turns out to be inapplicable here due to the very low electrical conductivity of Si_3N_4 ceramics, therefore much attention is paid to obtaining electrically conductive composite ceramics based on Si_3N_4, primarily Si_3N_4-TiC ceramics [3]. The best conductivity is observed in samples with a TiC content of more than 30% and is $2.3*10^{-2}$ S/cm [4].

In this paper, the possibility of obtaining a Si_3N_4-SiC composition by the azide self–propagating high–temperature synthesis (SHS-Az) method using NaN_3 as a nitriding reagent, as well as the halide salt $(NH_4)_2TiF_6$ is investigated [5]. The compositions of mixtures for obtaining single-phase Si_3N_4 and TiC powders by this method are known, from the analysis of which the equation was used to synthesize the Si3N4-TiC composition:

$15Si+6NaN_3+(NH_4)_2TiF_6+xC+(x–1)Ti=5Si_3N_4+xTiC+6NaF+4H_2$, x = 1, 2, 4, 6, 8, 10 mole.

Experimental studies of the possibility of obtaining the Si_3N_4-SiC composition were carried out in a laboratory SHS reactor in a nitrogen atmosphere at a relatively low pressure of 4 MPa and at a bulk density of mixtures of initial powders. The results of microstructure studies, energy dispersion and X-ray phase analyses have shown that combustion products of all initial mixtures consist of α- and β-Si_3N_4 fibers with a diameter of 70-150 nm and equiaxed TiN and TiC particles with a size of 100 to 500 nm. Note that combustion products also contain free Si at $x < 4$ mole. At $x \geq 4$ mole, free Si is replaced by SiC.

Thus, the use of the initial mixtures "$15Si+6NaN_3+(NH_4)_2TiF_6+xC+(x-1)Ti$" provides the preparation of compositions of ceramic highly dispersed Si_3N_4-TiN-TiC and Si_3N_4-SiC-TiN-TiC powders by the SHS-Az method, which differ significantly in the content or absence of free Si and the absolute absence of free Ti of compositions previously obtained by the SHS method [6]. It is planned to conduct further research in this direction in order to obtain a Si_3N_4-TiC nanopowder composition.

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