Exploring the possibility of synthesis of Si_3N_4-SiC highly dispersed ceramic nitride-carbide composition during combustion in Si–NaN_3–$(NH_4)_2SiF_6$–C system

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Ceramic single-phase materials silicon nitride (Si_3N_4) and silicon carbide (SiC) have good chemical stability and strength at high temperatures. Their Si_3N_4-SiC composites have such enhanced properties as high hardness, high-temperature strength and fracture toughness [1]. It is well known that the structure of these composite materials (particle size and shape) has an important influence on their properties. Traditional methods of manufacturing Si_3N_4-SiC composites have disadvantages such as complexity, high cost and low productivity, which complicates the production and use of these composites.

In this paper, the possibility of obtaining Si_3N_4-SiC composites using a simple energy–saving method of azide self–propagating high–temperature synthesis (SHS) in the combustion mode of a mixture of Si-NaN_3-$(NH_4)_2SiF_6$-C powders was investigated [2]. Experimental studies were carried out in a 4.5-liter SHS laboratory reactor in a nitrogen atmosphere at a relatively low pressure of 4 MPa and at a bulk density of mixtures of initial powders. The "xSi-6NaN_3–$(NH_4)_2SiF_6$–yC" system was used to synthesize the Si_3N_4–SiC composition with a molar ratio of the target phases from 1:4 to 4:1. It was found that the combustion products of the charge "3Si+6NaN_3+$(NH_4)_2SiF_6$+C" consist mainly of ultrafine particles of equiaxed and fibrous forms with a particle size of 100-300 nm and a fiber diameter of 50-500 nm with a length of up to 3 μm. The XRD results show the formation of four phases: the main phase of silicon nitride of two modifications (α-Si_3N_4 and β-Si_3N_4) with a significantly higher content of α-modification, silicon carbide (SiC), as well as a small amount of free silicon (Si) and carbon (C), (hereinafter indicated in wt.%): α-Si_3N_4 - 57.6%, β-Si_3N_4 - 22.1%, SiC - 17.0%, Si - 1.3%, C - 2.0%. With a fourfold increase in the carbon content and a twofold increase in silicon in the charge "6Si+6NaN_3+$(NH_4)_2SiF_6$+4C", the combustion products are mainly fibrous particles with a fiber diameter of 50-250 nm with a length of up to 3 μm. The XRD results show the formation of the same phases, but with a slight decrease in silicon nitride and an increase in the content of silicon carbide: α-Si_3N_4 - 33.3%, β-Si_3N_4 - 27.1%, SiC - 29.2%, Si - 5.3%, C - 5.1%.

Thus, the technology of azide SHS made it possible to produce in one stage a promising ceramic nitride-carbide ultrafine powder composition Si_3N_4-SiC, moreover, with a different ratio of the target phases Si_3N_4-SiC.

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