PREPARATION OF CERAMIC NITRIDE-CARBIDE COMPOSITION AlN-SiC BY SHS METHOD USING HALIDE SALT AND SODIUM AZIDE*

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Micro-and nanopowders AlN and SiC are very promising for creating new composite materials AlN-SiC, giving them a set of unique properties, such as high strength, thermal stability, and chemical resistance [1]. There are several different methods for obtaining the AlN-SiC composition: mechanical mixing of commercially available SiC and AlN powders, thermal reduction of synthetic silicon dioxide and aluminum oxide, mixing Si_3N_4 and Al_4C powders to form a solid solution of $Si_3Al_4N_4C_3$, hot pressing of a mixture of SiC and AlN powders [2]. Much attention is drawn to the use of a simple energy-saving method of self-propagating high-temperature synthesis (SHS) in various ways of organizing the combustion process of a powder mixture: Si_3N_4+4Al+3C=3SiC+4AlN under an electric field or on microwave heating, Si_3N_4+8Al+3C in air, Al+Si+C in low-pressure nitrogen gas, 2.3 Al+SiC in high-pressure nitrogen gas [3]. Each of these options has its own advantages and disadvantages. In this paper, we investigate the use of another variant that is azide SHS, in which the nitriding reagent is not nitrogen gas, but sodium azide (NaN_3) powder, as well as halide salts [4]. The process of azide SHS provides great opportunities for regulating the dispersion and structure of synthesized ceramic powders, bringing them to the nanoscale level. A successful experience have been accumulated in using the azide SHS process to produce nanopowders of nitride compositions TiN-BN, AlN-BN, Si_3N_4-TiN [5].

The compositions of initial reagent mixtures for obtaining single-phase powders AlN and SiC using the SHS azide technology are known [4]. On this basis, the following chemical reaction equations are used for the synthesis of the AlN-SiC composition:

$$Si + 20Al + 6NaN_3 + (NH_4)_2SiF_6 + 2C = 2SiC + 20AlN + 6NaF + 4H_2, \quad (1)$$

$$4Si + 20Al + 6NaN_3 + (NH_4)_2SiF_6 + 5C = 5SiC + 20AlN + 6NaF + 4H_2, \quad (2)$$

$$6Si + 20Al + 6NaN_3 + (NH_4)_2SiF_6 + 7C = 7SiC + 20AlN + 6NaF + 4H_2, \quad (3)$$

$$8Si + 20Al + 6NaN_3 + (NH_4)_2SiF_6 + 9C = 9SiC + 20AlN + 6NaF + 4H_2, \quad (4)$$

$$10Si + 20Al + 6NaN_3 + (NH_4)_2SiF_6 + 11C = 11SiC + 20AlN + 6NaF + 4H_2, \quad (5)$$

The results of thermodynamic calculations of these reactions are presented, according to which, adiabatic temperatures are sufficient for the combustion regime, and the condensed reaction products are the target phases of AlN and SiC with an admixture of a water-soluble side salt NaF. The experimental study showed that in combustion of mixtures (1)-(5) it is possible to synthesize the target composition AlN-SiC in the form of equiaxed particles of size from 100 to 600 nm, but the condensed reaction products, along with AlN, SiC and an impurity of NaF, easily removed by water washing, also includes a water-insoluble impurity of cryolite Na_3AlF_6 in noticeable quantities from 7.7 to 15.5 wt.%. The washed product of azide SHS of this composition can be used for liquid-phase hybrid reinforcement of aluminum-matrix composites with ultrafine AlN and SiC powders, in which the impurity of cryolite plays a positive role of flux and is not included in the final composition of the composite, without contaminating it [6].

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