

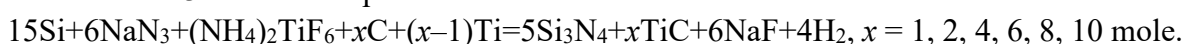
# Preparation of highly dispersed ceramic nitride-carbide composition $\text{Si}_3\text{N}_4\text{-TiC}$ by SHS method using halide salt and sodium azide

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Currently,  $\text{Si}_3\text{N}_4$  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  $\text{Si}_3\text{N}_4$  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  $\text{Si}_3\text{N}_4$  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  $\text{Si}_3\text{N}_4$  ceramics, therefore much attention is paid to obtaining electrically conductive composite ceramics based on  $\text{Si}_3\text{N}_4$ , primarily  $\text{Si}_3\text{N}_4\text{-TiC}$  ceramics [3]. The best conductivity is observed in samples with a TiC content of more than 30% and is  $2.3 \cdot 10^{-2}$  S/cm [4].

In this paper, the possibility of obtaining a  $\text{Si}_3\text{N}_4\text{-SiC}$  composition by the azide self-propagating high-temperature synthesis (SHS-Az) method using  $\text{NaN}_3$  as a nitriding reagent, as well as the halide salt  $(\text{NH}_4)_2\text{TiF}_6$  is investigated [5]. The compositions of mixtures for obtaining single-phase  $\text{Si}_3\text{N}_4$  and TiC powders by this method are known, from the analysis of which the equation was used to synthesize the  $\text{Si}_3\text{N}_4\text{-TiC}$  composition:



Experimental studies of the possibility of obtaining the  $\text{Si}_3\text{N}_4\text{-SiC}$  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  $\alpha$ - and  $\beta$ - $\text{Si}_3\text{N}_4$  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 " $15\text{Si} + 6\text{NaN}_3 + (\text{NH}_4)_2\text{TiF}_6 + x\text{C} + (x-1)\text{Ti}$ " provides the preparation of compositions of ceramic highly dispersed  $\text{Si}_3\text{N}_4\text{-TiN-TiC}$  and  $\text{Si}_3\text{N}_4\text{-SiC-TiN-TiC}$  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  $\text{Si}_3\text{N}_4\text{-TiC}$  nanopowder composition.

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## References

1. M. Nalbant, A. Altın, H. Gökkaya, *Materials and Design*. **2007**, 28, 4.
2. G. Zheng, J. Zhao, Y. Zhou, Z. Gao, *Advanced Materials Research*. **2011**, 152.
3. C. Tian, N. Liu, M. Lu. *International Journal of Refractory Metals & Hard Materials*. **2008**, 26.
4. Y. Jiang, L. Wu, W. Sun, *AIP Conference Proceedings*. **2013**, 1542, 125.
5. Yu.V. Titova, A.P. Amosov, D.A. Maidan, G.S. Belova, *AIP Conf. Proceedings*. **2020**, 2304, 020008.
6. L.A. Kondratieva, I.A. Kerson, et al., *IOP Conf. Series: Mater. Sci. Eng.* **2016**, 156, 012032.