SH-SYNTHESIS OF COMPOSITION MATERIALS ON THE BASIS OF TiB_2-TiC- MgO

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ABSTRACT

In the present study TiB_2, TiC containing composite materials were obtained by SHS from a mixture of TiO_2, B_2O_3 (ore), C - carbonated rice husk (CRH) and Mg. The products SH-synthesis were characterized using X-ray diffraction analysis and scanning electron microscopy.

INTRODUCTION

Boron, borides and related compounds have unique bonding characteristics, structural, peculiarities and superior intrinsic properties. These materials, especially transition metal borides show high hardness, high melting point and electrical conductivity. Hence borides are strong candidates for wear resistant applications metals lead to low plasticity and low strength that considerably limits the field of their application [1]. However, strong covalent bonds inherent to the phases of pure diborides of transition. In this regard, at present great attention is paid to the technology of producing multi-component metals in combination with more plastic materials playing the role of binding. They are, for example, aluminium or magnesium oxide which play the role of a high-temperature binder and filler decreasing the content of expensive diboride, when obtaining composition materials.

One of the promising methods for obtaining composition materials is the method of self-propagating high temperature synthesis. Self-propagating high-temperature synthesis (SHS) is a method for producing inorganic compounds by exothermic reactions, usually involving salts. Since the process occurs at high temperatures, the method is ideally suited for the production of refractory materials with unusual properties, for example: powders, metallic alloys, or ceramics with high purity, corrosion–resistance at high–temperature or super-hardnessity [2].

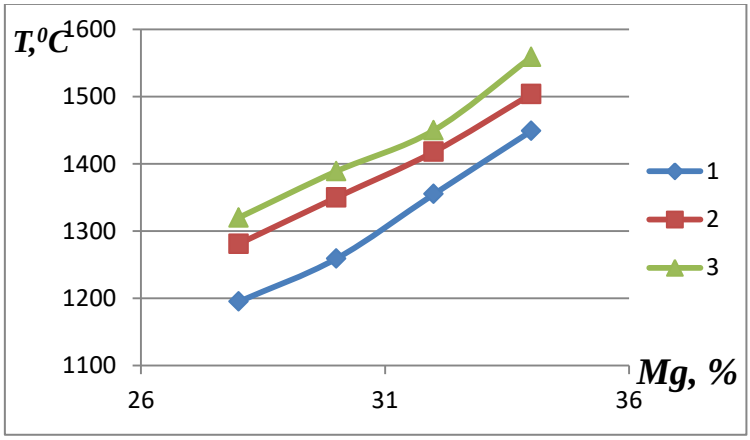
One of the main sources of boron ores in Kazakhstan are borates from the Inder deposit [3]. These wide available raw materials can be used to obtain boron-containing refractory composition materials [4].

METHODOLOGY OF EXPERIMENT

The mixtures were prepared with the different ratio of components: magnesium powder, borate ore, titanium oxide, carbonated rice husk (CRH). Preliminary mechanical activation of the samples was performed in the «Pulverizette-5» of a high-energy planetary centrifuge mill. Cylinders with the diameter of 20 mm and height 20÷30 mm were obtained with the help of a hydraulic press of the brand CARVER for production of pressed samples. The dried samples were burned at room temperature initiating ignition by magnesium. The temperature of SHS was measured using optical pyrometer. After combustion, the samples were structurally characterized by X-ray diffraction (XRD) using Dron – 4 diffractometers (operating with a Cu- Ka radiation source). The microstructure of the ceramic composite was studied by scanning electron microscopy (QUANTA 3D 200i, FEI, USA) electron.

RESULTS AND DISCUSSION

The study on the effect of preliminary mechanical activation (MA) of the charge on macrokinetic characteristics of SHS, phase composition and structure of the obtained composites in the system B_2O_3–Mg–TiO_2-C with the use of borate ore is of both theoretical and practical application. The preliminary series of experiments showed that for initiating synthesis by burning local heating up to short duration with the help of initiation of the system by magnesium is quite enough, then the process occurs in the mode of a self-propagating combustion. The system under study is so active that does not require an additional heating up of the reaction medium.



1- non-activated; 2- activated for 5 min; 3- activated for 10 min

Figure 1- Dependence of the combustion temperature of activated and non-activated systems in the atmosphere on the time of MA and the content of magnesium in the system Mg–TiO_2–B_2O_3(ore)-C

The use of preliminary MA of the charge in a high-power planetary mill significantly decreases the temperature of beginning of exothermal interaction of the mixture components, reduces the synthesis time of the final product, and results in a more complete procedure of chemical reactions [5].

Therefore, the powder of the prepared charge was activated for 3-10 minutes before SH-synthesis. As is seen in Figure 1, maximum temperature of combustion increases with both the increase in the content of magnesium and increase in the time of preliminary mechanical activation of the charge.

Acceleration of the chemical reaction after mechanical reaction is conditioned by «pumping » of additional (excessive) energy into the reacting substances, the energy accumulating in the formed structural defects. Excessive energy reduces the activation barrier of the chemical reaction. The effect of excessive energy on the reaction rate is a kinetic factor of acceleration of a chemical reaction [5,6].

A qualitative and semi-qualitative X-ray phase analysis of the composition of SHS products for the system Mg–TiO2 – B2O3(ore) -C was carried out. The presence of high temperature phases – titanium diboride, titanium carbide, magnesium oxide and their spinels in the SHS products are determined by the method of X-ray analysis.

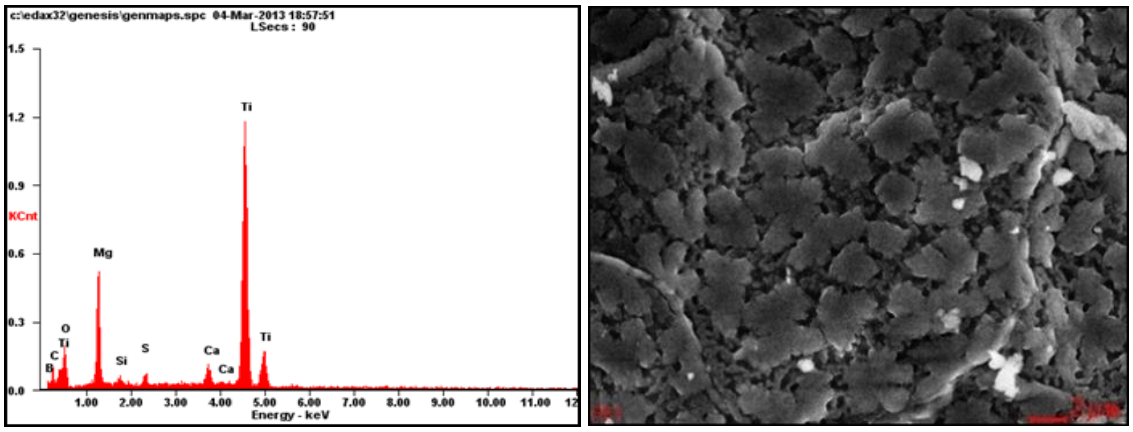


Figure 2 – Microstructure of the composition material on the basis of TiB_2-TiC- MgO

Figure 2 shows the microstructure of the resulting composite.

CONCLUSIONS

The possibility of using borate ore of Inder deposit of the Republic of Kazakhstan and model compounds of boron for production of boron containing composition materials in the system Mg–TiO_2– B_2O_3-C is shown. The effect of preliminary mechanical activation of the charge on macrokinetic characteristics of SHS, the phase composition and structure of the obtained composites in the system Mg–TiO_2– B_2O_3-C using borate ore is stated. The regularities of combustion depending on the charge composition and conditions of SH-synthesis have been studied.

REFERENCES

1. W.Weimin, F.Zhengyi, W.Hao, Y.Runzhang. Chemistry reactions processes during combustion synthesis of B_2O_3-TiO_2 - Mg system // J. Mater. Proc.Technol. - 2002. – P. 162-168.
2. Promising materials and technologies of self-propagating high-temperature synthesis / E.A. Levashov, A.S. Rogachev, V.V. Kurbatkina, Yu.M. Maximov, V.I.Yukhvid - MISIS, Moscow, 2011. - 377p.
3. Inder's natural wealth and use / M.D. Diyarov, D.A. Kalicheva, S.V. Meshcheryakov – Almaty. Science,1981. - 102p.
4. A.A. Aytkalieva, A. Zh. Seydualieva, R.G. Abdulkarimova Obtaining composite materials based on ZrB2-Al2O3 by the method of self-propagating high-temperature synthesis // Chemical Journal of Kazakhstan. 2016. – №2. – p.10-15.
5. Fundamental bases of mechanical activation, mechano-synthesis and mechano-chemical technologies / under ed. of E.G. Avakumov. – Novosibirsk: Nauka, 2009. – 342 p.
6. M.A.Kopchagin, D.V. Dudin The use of self-propagating high temperature synthesis and mechanical activation for production of nanocomposites // Physics of combustion and explosion. – 2007. – Vol.43, №2. – P. 58-71.