PLASMODYNAMIC SYNTHESIS OF NANODISPERSED TI-B PHASES AND OBTAINING TI-B CERAMICS

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Nowadays, titanium boride (TiB) and titanium diboride (TiB_2) have a lot of physical and mechanical properties, such as high hardness, high melting point, high thermal and electrical conductivity, good wear resistance. TiB and TiB_2 can be used for obtaining functional ceramics, for producing electrodes for melting metals and in mechanical engineering and metallurgy [1]. So the problem of synthesis becomes urgent. Different approaches have been directed to synthesize titanium diboride nanopowders, including mechanical alloying, sol-gel reduction and high energy ball milling [2]. However, there are some problems in synthesis nanopowders of the Ti-B system: high time and energy costs, unsatisfactory phase composition and dispersity of the product [1].

The present work reported a novel way of making nanocrystalline Ti-B phases (titanium boride and titanium diboride) in a hypersonic plasma jet. A hypersonic plasma jet was generated by an original electrical installation called a coaxial magnetoplasma accelerator with titanium electrodes. Principal construction of a coaxial magnetoplasma accelerator is shown in Fig.1. This method has been already successfully used for synthesis of different nanopowders (including the system with titanium) [3]. According to the purpose to synthesize nanosized Ti-B phases, three experiments with different ways of discharge initiations were implemented: 1) using titanium conductors; 2) using carbon fibers; 3) using graphite aerosol (graphitization).

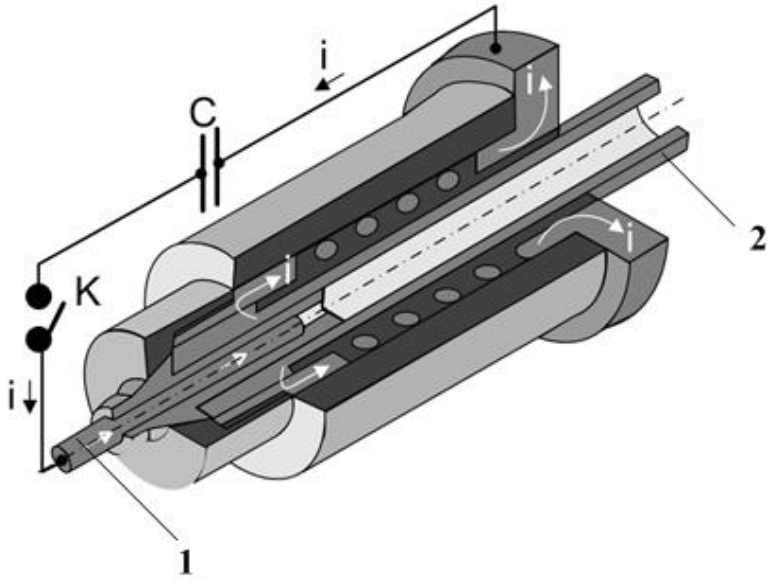

Fig.1. The construction of CMPA: 1 – central electrode; 2 – coaxial electrode

Argon was used as an atmosphere of a reactor chamber. The chamber pressure was 2 atm., its purity was provided by double pumping. A magnetoplasma accelerator was suplied by a capacitive energy storage with a charging voltage U_{ch} = 3.75 kV and

a capacity C = 9.6 mF, the value of input energy was W_{in} = 67.5 kJ. The level of released energy reached about W_r = 35 kJ. Amorphous boron in a form of powder was placed into the plazma formation zone. Titanium was introduced into the system by electroerosion from surface of a titanium accelerating channel. Synthesized powder products were analyzed without any preparation by the method of X-ray diffraction (XRD) using Shimadzu 7000 diffractometer. Figure 2 presents typical X-ray diffraction patterns of the powders.

The main results of the experiments were the powder products with mass up to 2.2 g. The main parameters of the experiments and the results of the study are given in Table 1. We can see the phases of TiB and TiB_2 predominate in the synthesized product, which depends on the method of discharge initiation. In the experiment with using graphitization the content of TiB_2 was 93.2%.

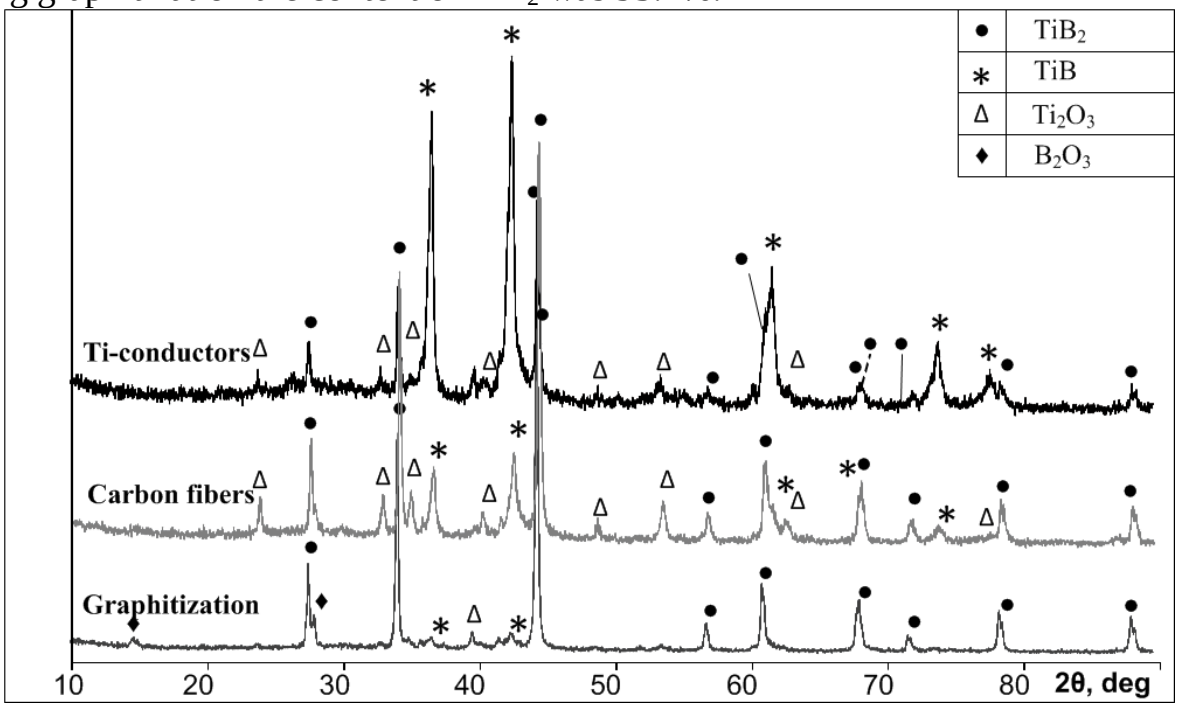

Fig. 2. Diffraction patterns of the synthesized powders

Table 1. The main results of the experiments

№	Ways of discharge initiations	m, g	U_{ch}, kV	P_{max}, kW	W, кJ	Phase composition, %	
						TiB_2	TiB
1	Ti-conductors	2.20	1.40	201	38.3	26.8	66.2
2	Carbon fibers	1.90	1.34	174	36.8	62.1	21.2
3	Graphitization	1.45	1.26	182	33.9	93.2	6.8

Ceramic simples, which were based on the synthesized powders, were obtained by the method of spark plasma sintering (SPS). The advantages of this method are efficiency, speed of the process and suppression grain growth microstructure [3]. The installation of spark plasma sintering SPS-10-4, Thermal Technology was used for obtaining ceramics. The process of obtaining ceramics was characterized by the next parameters: pressure P = 60 MPa, temperature T = 1800˚C and holding time t_T = 5 minutes. Density of the resulting ceramics for each of the experiments was:

1) using titanium conductors ρ = 3.40 g/cm3;

2) using carbon fibers ρ = 3.88 g/cm3;

3) using graphite aerosol (graphitization) ρ = 4.45 g/cm3.

These samples were processed on a grinding polishing machine for the preparation thin sections Forcipol 1V. The ceramics samples were measured for microhardness on a Galileo hardness tester. The values of microhardness were: 1) P = 24.7 GPa; 2) P = 28.3 GPa; 3) P = 30.3 GPa. Thus, the obtained ceramics showed high values of hardness, depending on the phase composition of the initial powder and hence the way of obtaining the powdered product.

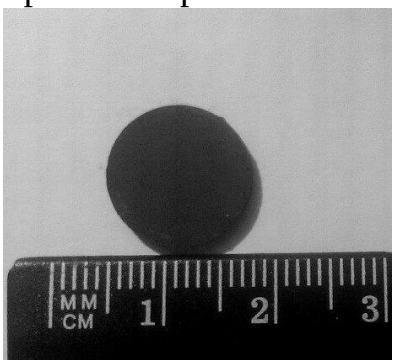

Fig. 3. The ceramic sample obtained from a powder (Experiment 3)

This work was supported by the Russian Science Foundation (project no. 15-19-00049).

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Scientific adviser: A.A. Sivkov, Grand PhD in Engineering sciences, Prof. of the Department of Industrial Electric Power Supply of the Power Engineering Institute of TPU.