CONCLUSIONS

The electrophysical features of spark-plasma sintering (SPS) of HfN–HfB_2 i Hf + BN powder mixtures to produce ceramic composite material based on HfN–HfB2 are studied and the dependence of its properties on direct-current density at the initial stage of sintering is established. To determine the direct current density, the method for calculating the effective cross-sectional area Seff of “die–sample” subcircuit is proposed. The basic part of electric current passes through the graphite matrix at the initial stage of sintering because of resistances on contacts and presence of α-BN dielectric. The basic part of electric current passes through the sintered sample at the final stage of sintering since HfN–HfB_2 composite is synthesized and densified and, consequently, the conductivity of the sintered sample sharply increases. Higher initial direct-current density during sintering of HfH_x hydride samples leads to increase in relative density and, respectively, conductivity, microhardness, fracture toughness, and abrasive wear resistance.

An analysis of the temperature dependence of the Gibbs free energy variation on some chemical reactions that are possible with intensive grinding and reactive spark-plasma sintering of powder mixtures HfN_2 + BN and HfN_2 + BN + B in the temperature range from 300 to 2000-2300 K.

All reactions of obtaining borides, nitrides Hf and their composites, as well as oxides and carbides of these metals, are thermodynamically advantageous. There is an increase in the probability of reaction of formation of oxides, borides, nitrides and carbides in the series of corresponding starting metals Hf, and in the reactions of decarbisation due to interaction with the oxygen dissolved in the crystalline carbide lattices, respectively, there is a reverse sequence.

The most thermodynamically probable reactions are the formation of oxides. In the temperature range from 500 to 1800-2000 K, the refractory combinations studied can be arranged in the following order, with the probability of formation: oxides - borides - nitrides - carbides. At temperatures below 500 K, formation of nitrides is more beneficial than borides. At temperatures above 1800-2000 K, it is more advantageous to form carbides than nitrides.