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ARC PLASMA SYNTHESIS OF IV-V GROUPS TRANSITION METALS HIGH-ENTROPY CARBIDES CUBIC PHASES[*]

A.A. GUMOVSKAYA, A.YA. PAK, ZH.S. BOLATOVA, P.V. POVALYAEV, R.D. GERASIMOV

National Research Tomsk Polytechnic University, Tomsk, Russian Federation

Carbides of transition metals of groups IV-V of the periodic table are usually superhard refractory compounds [1]. In the last 5–7 years, reports have appeared on the possibility of synthesizing single-phase multicomponent carbides containing 4–5 metals and carbon, and the proportion of each metal should be 5 – 35 % (atomic) [2]. Such materials are solid solutions with a cubic NaCl-type lattice and a high degree of configurational entropy; therefore, these crystalline phases are called “high-entropy” carbides (HEC) [3]. Many different combinations of the chemical composition of HEC (combinations of 4-5 elements from known transition metals, in particular, IV-V groups) give a hope for new results in the field of creating ultrahigh temperature ceramics materials. A number of HECs have already been synthesized; many of crystalline HEC phases have been theoretically predicted [4].

HEC synthesis requires high temperatures as well as high energy density. The most common approach to the synthesis of HEC is spark plasma sintering. The issue of developing simple and low-cost methods for obtaining HEC for rapid testing of hypotheses about the possibility of obtaining one or another hypothetical HEC phase is topical. The method of electric arc melting looks promising due to the possibility of achieving high temperatures high heating rates [5-6].

Our group had achieved some success in the field of synthesis of one of the most studied HEC phases TiZrNbHfTaC5 using the original plasma arc reactor [7-8]. In a series of experiments, the synthesis of a number of HECs was carried out using metal powders as raw material, as well as ultrafine carbon. The starting raw materials were mixed in a ball mill and processed by electric arc plasma in the volume of a hollow graphite cathode. In all cases, a cubic lattice of the NaCl-type is formed, which is confirmed by the results of X-ray diffractometry. The lattice parameters estimated from the XRD data are close to the known data on the HEC structure.

According to the scanning electron microscopy data and transmission electron microscopy, mapping of the chemical composition, it was found that in a number of experiments it is possible to achieve a uniform distribution of the chemical composition. This proves the possibility of obtaining HEC by the developed electric arc method. The disadvantage of the method used at the current research stage is the contamination of the synthesis product with anode erosion material (graphite). Further work will be aimed at increasing the concentration of the desired HEC phases, proving the possibility of obtaining HEC of various compositions by the claimed method, and studying the properties of the synthesized HEC.

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