Synthesis of porous MAX phases Ti_3SiC_2 and Ti_3AlC_2 by combustion in air and river sand

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MAX phases occupy an intermediate position in properties between ceramics and metals and are attractive for use in energy, mechanical engineering and other industries due to their unique properties [1]. Porous MAX phases Ti_3SiC_2 and Ti_3AlC_2 can be used as filters, bone bioimplants, in catalysis and electrochemistry. A new method for producing cermets is also known, in which a hot porous workpiece from the MAX phase immediately after combustion synthesis (CS) in air serves as a base (skeleton) for spontaneous filling with molten metal [2].

Porous skeletons of the MAX phases Ti_3SiC_2 and Ti_3AlC_2 were obtained using the CS method under the simplest conditions of reactorless combustion in air or in a backfill of river sand. The total porosity (open and closed) is 60% by volume, of which the proportion of open pores is more than 40%. The average pore size ranges from 10 to 350 μm. Quantitative XRD of the resulting porous skeletons showed that the content of the MAX phases Ti_3SiC_2 and Ti_3AlC_2 is about 60 wt.%. In addition to the MAX phases Ti_3SiC_2 and Ti_3AlC_2, a titanium carbide phase TiC of about 40-50 wt.% and a titanium silicide phase $TiSi_2$ (or titanium aluminide TiAl in the synthesis of Ti_3AlC_2) were formed in an amount of 2 – 5 wt.%. It was found that the fractional composition (particle size) of the initial titanium and carbon powders, as well as the form of the powdered carbon (graphite or soot) significantly influence the macrostructure of the porous CS skeletons of the MAX phases Ti_3SiC_2 and Ti_3AlC_2. It has been experimentally proven that the CS skeleton, obtained using coarse titanium powder of the TPP-7 grade and graphite powder of the S-2 grade, better preserved the cylindrical shape of the original pressed charge billet and has a uniform fine-porous macrostructure without macrodefects (cavities, cracks, delaminations), and also has the highest, compared to other brands of titanium and carbon powders used, uniaxial compressive strength of 104 MPa. The influence of the composition of the gas atmosphere and vacuum on the formation of surface films formed during the production of porous skeletons of MAX phases Ti_3SiC_2 and Ti_3AlC_2 by the synthesis in combustion mode was studied. During the CS of the MAX phases Ti_3SiC_2 and Ti_3AlC_2 in air, oxide-nitride films about 100 μm thick were formed on the surface of the samples, and about 20 μm thick by the synthesis in the river sand backfill.

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References

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