Preparation of Ti_3SiC_2 and Ti_3AlC_2 MAX phases from $TiSi_2$-C and TiAl-C by SHS in river sand shield

D.M. Davydov, E.R. Umerov, V.A. Novikov

Samara State Technical University, 244, Molodogvardeyskaya str., Samara, Russia, 443100
davidovd77@mail.ru

Currently, MAX phases remain a hot topic for research due to their unique properties and possible areas of application [1]. The main problems in obtaining the MAX phases Ti_3SiC_2 and Ti_3AlC_2 by the SHS method are associated with the phase heterogeneity of the synthesis product and the presence of impurity phases of titanium carbide TiC and titanium silicides $TiSi_2$, Ti_3Si_5 (in the case of Ti_3AlC_2 - titanium intermetallic compounds TiAl, Ti_3Al, $TiAl_3$). This problem arises for many reasons, including the fact that during SHS in combustion mode, due to high reaction temperatures, part of the low-melting powder element of the charge evaporates, thereby violating the stoichiometry and reducing the amount of MAX phase in the resulting product. For the synthesis of MAX phases Ti_3SiC_2 and Ti_3AlC_2 in the initial charge, many authors use not elemental powders, but their compounds to increase the number of MAX phases in the product [2, 3].

The work carried out a study of the effect of replacing low-melting charge powders: silicon and aluminum with their chemical compounds - titanium disilicide ($TiSi_2$) and titanium intermetallic compound (TiAl). The samples were obtained by the SHS method in air in a protective shell of sand. As a result of the studies, it was established that replacing titanium and silicon powders with titanium silicide powder $TiSi_2$ in the initial charge during the synthesis of the porous frame of the MAX-phase Ti_3SiC_2 by the SHS method leads to the appearance of a silicon carbide phase SiC and an increase in the titanium carbide phase TiC relative to the MAX phase Ti_3SiC_2 in the resulting product. When replacing silicon by 50 wt% of the mass, the amount of silicon carbide phase reached 46 wt% of the total mass of the resulting SHS frame. At the same time, the amount of titanium carbide decreased to 12 wt% compared to the stoichiometric composition. The amount of the Ti_3SiC_2 MAX phase in the composition of the porous frame obtained by the SHS method in air with an increase in the amount of replacement of silicon with titanium disilicide $TiSi_2$ decreases from 66 wt% to 20 wt% of the total mass. Replacing titanium and aluminum powders with titanium aluminide TiAl powder in the initial charge leads to an increase in the amount of titanium carbide phase TiC and titanium aluminide TiAl relative to the MAX phase Ti_3AlC_2 in the resulting SHS composite. The maximum amount of MAX phase in the resulting composites does not exceed 35 wt%. For comparison, when using elemental powders in the initial charge after SHS, the amount of the MAX phase Ti_3AlC_2 fluctuates around 52 wt%.

Acknowledgments: The research was carried out with the financial support of the Ministry of Science and Higher Education of the Russian Federation within the framework of the state task (theme no. AAAAA12-2110800012-0).

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