Formation of the titanium based Max-Phases in Hydride Cycle

The creation and development of new methods and technologies for obtaining the MAX-phases, demanded in modern materials science as structural materials, are urgent tasks. The current methods of their producing are complex, energy-consuming and multistage. It is of scientific and practical interest to develop commercial offers, diminishing MAX-phases cost and scaling their manufacturing.

For the first time, the single-phase hexagonal MAX-phases Ti_2AlC (211, a = 3.0553 ÷ 3.568, c = 13.6459 ÷ 3.658, c/a = 4.47) and Ti_3AlC_2 (312, a = 3.0706, c = 18.5905, c/a = 6.305**) were synthesized by hydride cycle (HC) method, using titanium carbohydrides and aluminum as initial reagents.**

The processes of Ti_2AlC MAX-phase formation in HC are studied, using as the initial reagents powders HCP $TiC_{0.45}H_{1.07–1.17}$ (H_2 content - 1.97–2.17 wt. %) and powders FCC $TiC_{0.5}H_{0.22–0.73}$ (H_2 content - 0.44–1.48 wt %) SHS titanium carbohydrides according the reaction: $\mathbf{TiC_{0.45–0.5}H_{0.22–1.17} + 0.5Al \rightarrow Ti_2AlC + H_2\uparrow}$.

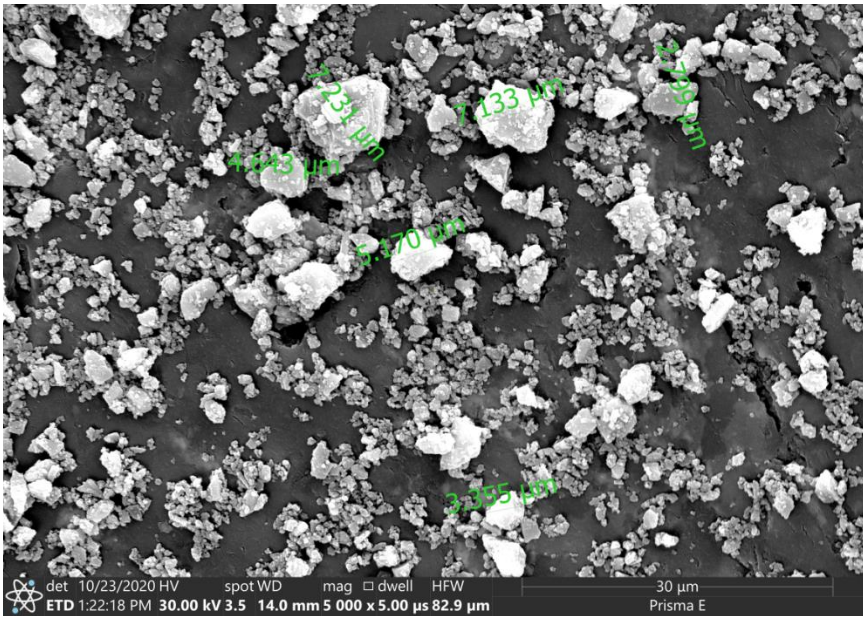

Fig.1. The microstructure of the initial powders carbohydride HCP $TiC_{0.45}H_{1.17}$

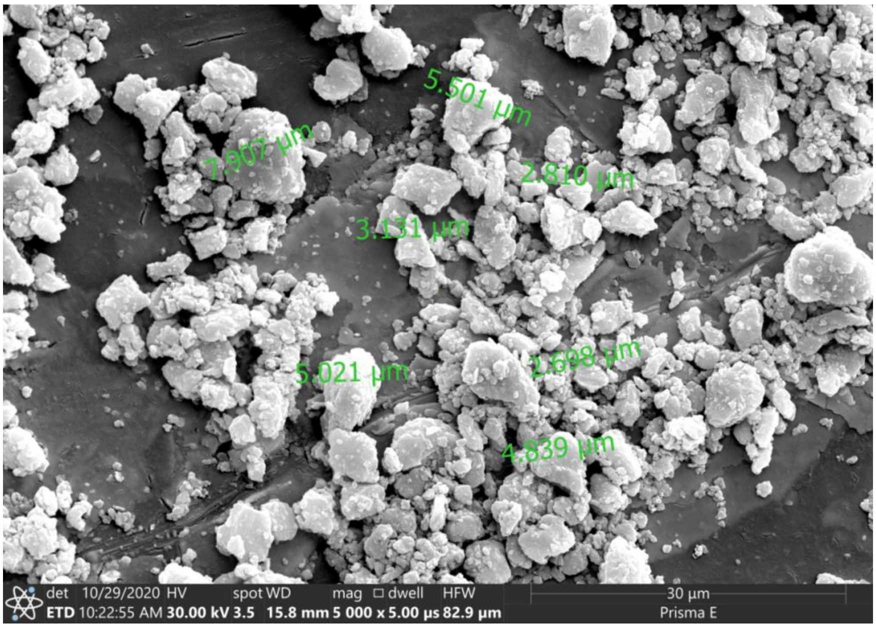

Fig.2. The microstructure of formed in HC powders $Ti_2AlC_{0.9}$ MAX- phase

The Ti_2AlC MAX-phase is formed in the HC by the solid-phase mechanism, in one technological stage, during heating at 1000°C for 30 minutes. The HC advantages in synthesis of Ti_2AlC MAX-phase regarding

traditional methods are in the simplifying the technological process, reducing energy consumption and improving MAX-phase quality.
It is worth to note that the initial titanium carbohydrides synthesis in SHS mode is simple and available.

In HC, Ti_2AlN, Ti_3AlC_2, $Ti_{0.9}Nb_{0.1}C_{0.4}Al_{0.5}$, $Ti_{0.8}Nb_{0.2}C_{0.4}Al_{0.5}$ MAX-phases were synthesized in our Laboratory.

The hexagonal unit cell of the MAX phases belongs to the P63/mmc space group.
Like metals, MAX phases are of excellent heat resistance, thermal and electrical conductivity, easily machined at room temperature, resistant to crack propagation and thermal shock, plastically deform at elevated temperatures.
Like ceramics, they have low density, high elasticity modulus, excellent heat resistance and high-temperature strength.
Potential applications of MAX phases: light armor for personnel carriers, patrol vehicles, helicopters , battle tanks, shell materials for nuclear power, etc.

LIST OF MAIN PUBLICATIONS

1. S.K. Dolukhanyan, A.G. Aleksanyan, G.N.Muradyan, O.P. Ter-Galstyan, N.L. Mnatsakanyan, A.S. Mnatsakanyan. Producting of Ti-Nb-Zr based alloys prospective for production of implants. ***Russian Journal of Physical Chemistry B, 2021, Vol. 15, No. 4, pp. 740–747. ISSN 1990-7931.***
2. Barsoum M.W. The MAX phases: unique new carbide and nitride materials // Am. Sci. 2000. V. 89. P. 336-345.
3. S.K. Dolukhanyan, N.A. Martirosyan, A.G. Merzhanov, A.B. Nalbandian. A method for producing titanium carbohydride. Author's certificate No. 683191, Bull. № 32. 1979.
4. S.K. Dolukhanyan, SHS of Binary and Complex Oxides, In: Self-Propagating High-Temperature Synthesis of Materials, Edited by A. A. Borisov, L. De Luca, and A. Merzhanov Translated by Y. B. Scheck, Combustion Science and Technology Book Series, New York: Taylor & Francis, v. 5, pp. 219-237. 2002.