COMPOSITE SYNTHESIS FROM THE POWDER MIXTURE Ti-Al-CuO BY SELECTIVE LASER MELTING *

A.G. KNYAZEVA[1,2], *M.G. KRINITCYN*[1,2]

[1]*Institute of Strength Physics and Materials Science, Tomsk, Russia*
[2]*Tomsk Polytechnic University, Tomsk, Russia*

Synthesis of composite coatings and products in modern 3D technologies attracts attention due to the possibility to combine in a single cycle the features of different technologies - selective laser melting and SHS. Examples of successful studies in this direction are contained, for example, in [1-3]. The properties of the resulting materials depend to a large extent on the structure and phase composition of the formed material (which are determined by the elemental and chemical composition of the initial powder material), the composition of the environment, and the thermal conditions that depend on the laser exposure modes [4].

The purpose of the present work is to experimentally and numerically investigate the process of obtaining samples from a mixture of Ti-Al-CuO powders by selective laser melting.

Samples for research were obtained by selective laser sintering on the LUCH-500 unit developed at Tomsk Polytechnic University. The unit is equipped with an ytterbium fiber laser with a maximum power of 500 W. Mixtures of powders of different compositions were treated by the laser. The processing was carried out on 1 mm high mounds to eliminate the influence of the substrate during processing. The experiments were carried out on a steel substrate (12X18N10T) in a closed chamber in high purity argon under pressure of 1.4 - 1.5 atm.

It was found that all synthesized samples contain both pure metals Al, Ti, Cu) and oxides (Al_2O_3, Cu_2O, Ti6O, Ti_3O, etc.) and intermetallic compounds of Al_xCu_y type (Al_4Cu_9, Al_2Cu, $AlCu_3$, etc.). Triple compounds were not found in the products.

The two-dimensional mathematical model includes the heat conduction equation and a system of chemical kinetics equations corresponding to one or another reaction scheme. The scanning mode of the powder layer surface corresponds to the experimental conditions. The problem formulation, in general, is similar to those presented in [5-7]. Parameters of chemical reactions are found from the literature or calculated using approximate methods. In the reactions, a large role belongs to liquid phase. The numerical study shows a significant dependence of the product composition on the synthesis conditions and powder composition.

REFERENCES

[1] Y.M.Z. Ahmed, Z.I. Zaki, R.K. Bordia, D.H.A. Besisa, A.M.M. Amin, “Simultaneous synthesis and sintering of TiC/Al2O3 composite via self propagating synthesis with direct consolidation technique”, Ceramics International, vol. 42, pp. 16589–16597 , 2016, http://dx.doi.org/10.1016/j.ceramint.2016.07.080

[2] Haodong Wang, Chun Yu, Zhiyuan Yu, Yifeng Huang, Xiaoning Zhang, Le Mei, Jieshi Chen, Yajie Wang, Hao Lu, Jijin Xu, “Revealing the evolution of microstructure and mechanical properties with energy density to achieve high-strength Ti-6wt%Cu alloy by laser metal deposition”, Materials Science & Engineering A, vol. 885, paper 145599, 2023, https://doi.org/10.1016/j.msea.2023.145599

[3] J.J.S. Dilip, H. Miyanaji, Austin Lassell, Thomas L. Starr, Brent Stucker, “A novel method to fabricate TiAl intermetallic alloy 3D parts using additive manufacturing”, Defence Technology, vol. 13, pp. 72-76, 2017, http://dx.doi.org/10.1016/j.dt.2016.08.001

[4] Sohini Chowdhury, N. Yadaiah, Chander Prakash,Seeram Ramakrishna, Saurav Dixit, Lovi Raj Gupta, Dharam Buddhi, “Laser powder bed fusion: a state-of-the-art review of the technology, materials, properties & defects, and numerical modelling”, Journal of materials research and technology, vol.20, pp. 2109 -2172, 2022, https://doi.org/10.1016/j.jmrt.2022.07.121

[5] A. A. Bakinovskii, A. G. Knyazeva, M. G. Krinitcyn, O. N. Kryukova, I. L. Pobol, V. V. Fedorov and J. Rajczyk, “Electron Beam Assisted Deposition of Ni–Al Coatings onto Steel Substrate”, Journal of Self-Propagating High-Temperature Synthesis, Vol. 28, No. 4, pp. 245–255,2019,. https://doi.org/10.3103/S1061386219040034

[6] A.G.Knyazeva, O.N. Kryukova, “The synthesis of composites with reinforcing particles on a thin substrate”, Materials Physics and Mechanics, vol. 47, pp. 254-265, 2021, http://dx.doi.org/10.18149/MPM.4722021_8

[7] A.G. Knyazeva, “Nonstationary thermokinetic model of surface laser scanning”, Journal of Applied Mechanics and Technical Physics, vol. 62, pp. 1001–1007, 2021, https://doi.org/10.1134/S0021894421060158

* The work was supported by Russian Science Foundation, project 22-11-00100. https://rscf.ru/project/22-11-00100/.