UDC 541.135.3.:546.77

А.І. Габ [(1)], associate professor, c.ch.s.
Д.Б. Шахнін [(2)], staff scientist. c.ch.s.
В.В. Малишев [(1,2)], professor, d.t.s.
З. Устундаг [(3)], associate professor, c.ch.s.

STRUCTURE AND PHYSICAL AND CHEMICAL PROPERTIES FOR DOUBLE TUNGSTEN AND MOLYBDENUM CARBIDES

[(1)] University «Ukraine», Kyiv
[(2)] V.I. Vernadskij Institutes of general and inorganic chemistry NASU, Kyiv
[(3)] University «Dumlupinar», Turkey, Kyutah′ya

Diagrams of «tungsten-molybdenum-carbon», «tungsten-molybdenum-ferrum-carbon», «tungsten-molybdenum-cobalt-carbon», and «tungsten-molybdenum-nickel-carbon» systems were considered.

Keywords: constitution diagram, tungsten, molybdenum, carbon, cobalt, nickel

Entry. The carbides of tungsten and molybdenum remain main components of ceramet carboloies, which widely use in metal-treatment and other industry.

One of major tasks at the production of carboloies there is creation of wolfram-free carboloies or search of equivalent substitutes which are able to save high physics-mechanical and operating properties. One of such substitutes there can be molybdenum, which has ability to form compounds, analogical to connections of tungsten.

Among the methods of synthesis of carbides powders able to decide the task of making of nandimension particles, very perspective is a high temperature electrochemical synthesis (HES). Such method eliminates a necessity for the intermediate stages of preparation of initial material and considerably abbreviates the technological chart of production these. It does not need difficult equipment and is ecologically safe [1,2].

Raising of task. The purpose of work was systematization of data in relation to the diagrams of the state for systems *W-Mo-C*, *W-Mo-Fe-C*, *W-Mo-Co-C*, and also *W-Mo-Ni-C.*

Results and their discussions

1. Diagram of the state of the system *W-Mo-C*»

In the double systems *Mo-C* and *W-C* [3,4] there are monocarbides α-MeC_{1-x} cube-textured as *NaCl* and semicarbides *MeC* with a hexagonal structure as *NiAs*, which at cooling of alloys passes to well-organized rhombic modification of type ζ,-Fe_2N. Except for the mentioned connections in system *Mo-C* a monocarbide η-MeC_{1-x} appears and in system «tungsten-carbon-carbide» *WC*, which have hexagonal structures of own type. Connections α-WC_{1-x}, α-MoC_{1-x}, η-MoC_{1-x} and *WC* test eutectoid disintegration for temperatures 2803, 2233, 1928 and 1523 K respectively. Unlimited solubility of components is set in the system *Mo-W*.

Phase equilibrium in the system *Mo-W-C* we studied in works [5,6]. On the basis of x-ray photography analysis of alloys in this work the schematic isothermal cut of diagram of the state is built at temperature 1983 K. There is confirmed possibility of formation of double carbides of tungsten and molybdenum.

Study of solubility of carbon in molybdenum- tungsten sosoloid showed that area of homogenity for triple sosoloid (*Mo,W,C*) for temperature 2273 K fluently narrows from the side of *Mo-C* (0,6 % *C*) to the side of *W-C* (0,2-0,1 % *C*). At temperature 1273 K boundary on a molybdenum end lies within the limits of 0,10-0,05 % *C*, and on a tungsten end is outside sensuality of chemical analysis on a carbon [7].

At this temperature carbides α-MoC_{1-x} and η-MoC_{1-x} does not exist and free carbon is in an equilibrium with sosoloid on the basis of *WC* and sosoloid $(Mo,W)_2C$, which contains a to 3,0. % *W*. Area of homogenity $(Mo,W)_2C$ in relation to carbon is breadthways less than 2,0. %, and lower - higher, than 31,0 % *C*. A top limit passes below, than 33,0 % *C*. On the sciagrams of all alloys after of annealing for temperatures 1273 K at 400 hour are looked after expansion of some lines, which testifies to arrangement of carbon atoms and decline of symmetry of structures $(Mo,W)_2C$ from hexagonal to rhombic. At duration of annealing to 1500 hour, except for formation of rhombic modification, it is possible it was to look after eutectoid disintegration of part of $(Mo,W)_2C$ from the side of rich after a tungsten (to 10,0 % *Mo*), on hard solutions (*Mo,W*)*C* and (*Mo,W,C*). In work [13] complete disintegration of W_2C on *WC* and *W* was it is attained for a 1500 o'clock of annealing at temperature 1273 K. Presumably, speed of eutectoid disintegration W_2C and $(Mo,W)_2C$ and $(Mo,W)_2C$ depends on the conditions of making and heat treatment of alloys.

Authors of work [5] got the alloys of the system *W-Mo-C* by melting of releate and ligature. Ligature was prepared by melting like to preparation of alloys. There are investigated the methods of high temperature DTA, microscopic and x-ray photography (on powders in *Cu*K_α-radiation) analyses and by measuring of hardness and microhardness.

2. Diagram of the state of the system *W-Mo-Fe-C*.

Diagram of the state of the system *W-Mo-Fe-C* authors of work [8] calculated with the use of model of a few sublattices and literary experimental data from phase equilibriums in the system *C-Fe-Mo-W*. The parameters of models of different phases optimized on computer by means of the program of optimization, which is worked out Jansson.

3. Diagram of the state of the system *W-Mo-Co-C*

The diagram of the state of the system *W-Mo-Co-C* is studied in works [9,10]. Research was executed by the methods of DTA, microscopic, x-ray photography and microx-rayspectial analyses. Content of carbon in alloys was determined by a chemical way. DTA carried out in the atmosphere of argon by means of *Pt*/*Pt-Rh* thermoelectric thermometer, which calibrated on the melting-points of gold, copper and nickel. DTA added alloys, that it is burned at temperature 1373 K during 170-300 hour. Common quantity of the studied alloys ~ 50.

4. Diagram of the state of the system *W-Mo-Ni-C*

In works [9,10] DTA added alloys which were burned for temperature 1373 K at 70-300 hour. Common quantity of the studied alloys ~ 50. The carbides *MoC* and *WC* form inter se the continuous rows of sosoloids. In the system *W-Mo-Ni-C* possible existence of nonvariant of metastable eutecticum equilibrium sort ↔ (*Ni*) + M_2C + *C* + *MC*, where *Ni* - sosoloid on the basis of nickel.

Conclusions.

1. Literary data in relation to a structure and physical and chemical properties of double carbides of tungsten and molybdenum are generalized.

2. Expediency of the use of the difficult systems of transitional metals with non-metals in quality heatproof and heat-resistant materials is confirmed.

REFERENCE

1. **Малишев, В. В.** Високотемпературна електрохімія та електроосадження металів IV-VIA груп та їх сполук в іонних розплавах [Текст] / В. В. Малишев. – Київ : Університет «Україна», 2004. – 323 с.
2. **Malyshev, V. V.** Chapter 3. Tungsten Carbide: High Temperature Electrochemical Synthesis from Ionic Melts, Technologies of Obtaining and Regeneration [Text] / V. V. Malyshev, I. A. Novoselova, A. I. Gab etc. // Advances in Chemistry Research. ; C. James. Taylor, Ed. – 2016. – Vol. 33. – Pp. 71-123.
3. **Kurlov, A. S.** Tungsten and Molybdenum Carbides and W(Mo)-C Diagram [Text] / A. S. Kurlov, A. I. Gusev // Inorganic Materials. – 2006. – Vol. 42. – P. 121-127.
4. **Лякишев, Н. П.** Диаграммы состояния двойных металлических систем [Текст] / Н. П. Лякишев. – Справочник в трех томах. – М. : Машиностроение, 1996. – 992 с. – ISBN 5-217-02688-X.
5. **Єременко, В. Н.** Структура и некоторые свойства сплавов системы Mo-W-C по разрезу $MoC_{0.65}$-$WC_{0.62}$. [Текст] / В. Н. Еременко, Т. Я. Великанова, С. В. Слепцов и др. // Диаграмма состояния в материаловедении. – Киев : Наукова думка, 1984. – С. 37-50.
6. **Gustafson, P.** A thermodynamic evolution of the C-Mo-W system [Text] / P. Gustafson // Z. Metallk. – 1988. – Vol. 79. – Pp. 397-402.
7. **Горшкова, Л. В.** Сплавы вольфрама, молибдена и ниобия с бором и углеродом [Текст] / Л. В. Горшкова, Ф. И. Шамрай, В. И. Харитонов. – М. : Наука, 1974. – 118 с.
8. **Gustafson, P.** A thermodynamic evaluation of the C-Fe-Mo-W system [Text] / P. Gustafson // Z. Metallk. – 1988. – Vol. 79. – Pp. 421-425.
9. **Schubert, W. D.** Phasengleichgewichte in den Systemen Co-Mo-W-C und Ni-Mo-W-C [Text] / W. D. Schubert, P. Ettmayer, B. Lux etc. // High Temperatures - High Pressures. – 1982. – Vol. 14. – P. 87-100.
10. **Агеев, О. А.** Фазы внедрения в технологии полупроводниковых приборов и СБИС [Текст] / О. А. Агеев, А. Е. Беляев, Н. С. Болтовец и др. – Харьков : НТК Институт монокристаллов, 2008. – 392 с.