

# Corresponding Member of the Academy of Sciences of the USSR N. V. AGEEV and L. A. PETROVA

Table 1

1961

SovietRxiv

---

View the original and related papers at <https://sovietrxiv.org/items/ru-196101.72306>

Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.

## Abstract

## Full Text

## Chemistry

Corresponding Member of the Academy of Sciences of the USSR N. V. AGEEV and L. A. PETROVA

# GENERAL REGULARITIES IN THE STABILIZATION OF THE BETA SOLID SOLUTION IN TITANIUM ALLOYS

The stability of the  $\beta$ -phase under equilibrium conditions is characterized by the phase diagram. At present, phase diagrams of titanium with almost all  $\beta$ -stabilizers are known (<sup>1</sup>). In the metastable state, a  $\beta$ -solid solution can be obtained by rapidly cooling an alloy from the region of equilibrium existence of the  $\beta$ -phase. On the basis of data obtained in studying the conditions for stabilization of a  $\beta$ -solid solution during quenching (<sup>2</sup>), the minimum content of alloying addition required for stabilization of the  $\beta$ -phase is known.

**Table 1**

Alloying elements	Critical stabilizing concentration, at. %	Critical stabilizing concentration, electron conc., el/atom	Literature source	Alloying elements	Critical stabilizing concentration, at. %	Critical stabilizing concentration, electron conc., el/atom	Literature source
Iron	4.5*-4.9**	4.2	( <sup>2</sup> )	Chromium	8.4**	4.2	
Cobalt	4.9**	4.2	( <sup>4</sup> )	Tungsten	8.7**	4.2	
Manganese	5.0*	4.2	( <sup>2</sup> )	Vanadium	18.4**	4.2	( <sup>2</sup> )
Nickel	5.8*-6.3**	4.2-4.3	( <sup>2</sup> )	Tantalum	21.0***	4.2	( <sup>6</sup> )
Molybdenum	8***	4.1	( <sup>2</sup> )	Niobium	23.0**	4.2	
Rhenium	6.0**	4.2	( <sup>5</sup> )				

As the initial titanium, magnesiothermic (\*), iodide (\*\*), and calcium-hydride (\*\*\*) titanium was used.

Table 1 gives the minimum concentrations of alloying elements required to obtain a single-phase structure of the  $\beta$ -solid solution in a metastable state at room

Fig. 1

Figure 1: Fig. 1

temperature. The alloying elements are arranged in Table 1 according to the effectiveness of their action on stabilization of the  $\beta$ -solid solution.

The minimum critical content of the alloying addition required for stabilization of the  $\beta$ -phase depends on a number of factors that must be established in order to derive general regularities governing stabilization of the  $\beta$ -solid solution in titanium alloys. Elements stabilize the  $\beta$ -phase the more effectively, the farther they are from titanium in Mendeleev's periodic system of elements. Thus, in the fourth period the effectiveness of stabilization decreases from nickel, cobalt, and iron to chromium and vanadium; in the fifth period from molybdenum to niobium; in the sixth from rhenium and tungsten to tantalum. The indicated dependence is due to the influence of the dissolving component of the solid solution on the rearrangement of the lattice of the titanium solvent during rapid cooling. Rearrangement of the  $\beta$ -phase lattice will be hindered by the introduction of a foreign atom, and to a greater extent the greater the difference in the chemical nature of the atoms of titanium and of the second component of the solid solution and the greater the difference in the sizes of these

atoms. Consequently, the greater the indicated differences, the more effective the action of the element on stabilization of the  $\beta$ -phase will be, and the smaller the concentration of the additive needed to obtain the metastable  $\beta$ -phase upon quenching.

Since both the chemical nature of the atom and its dimensions depend on the number of electrons in the atom, i.e., on the electron concentration, this makes it possible to determine the dependence of the critical stabilizing concentration of the  $\beta$ -phase upon quenching on the electron concentration of the solid solution.

### Fig. 1

Table 1 presents the electron concentration corresponding to the critical stabilizing concentration of the  $\beta$ -phase, with the number of electrons of an atom taken as equal to the group number of the given element. From the calculation results given, it is evident that the  $\beta$ -phase can be obtained in a metastable state in titanium-base alloys at a practically identical electron concentration, equal on average to 4.2 electrons per atom.

The established regularity was checked on ternary titanium alloys of the systems titanium–iron–vanadium, titanium–iron–chromium, titanium–vanadium–molybdenum, titanium–molybdenum–iron, and titanium–molybdenum–manganese. Knowing the value of the electron concentration at which the  $\beta$ -phase can be obtained, one can calculate the compositions of alloys which, upon quenching, should give the structure of a  $\beta$ -solid solution.

Figure 1 shows, as an example, a ternary metastable phase-composition dia-

gram of the titanium–iron–vanadium system. The straight line drawn in the titanium corner, separating the  $\beta$ -phase region from the  $\beta + \omega$ -phase region, was obtained by connecting the points corresponding to the critical stabilizing concentration of alloying elements in the binary systems titanium–iron and titanium–vanadium. Ternary alloys with an electron concentration less than 4.2 lie in the  $\beta + \omega$ -phase region. Such proved to be a titanium alloy with 3.11 at.% iron and 5.37 at.% vanadium, corresponding to an electron concentration of 4.18 el/at (1). Alloys with 4.35 at.% iron and 7.64 at.% vanadium (2), 2.61 at.% iron and 11.4 at.% vanadium (3), and 2.86 at.% iron and 14.18 at.% vanadium (4), having electron concentrations of 4.24, 4.21, and 4.25 el/at, respectively, have the structure of the  $\beta$ -phase.

In the remaining ternary systems studied<sup>3</sup>, the established regularity was also confirmed.

Institute of Metallurgy named after A. A. Baikov  
Academy of Sciences of the USSR

Received  
6 II 1961

## CITED LITERATURE

1. I. I. Kornilov, P. B. Budberg, *Itogi nauki. Tekhnicheskie nauki*, 2, Chemistry, Metallurgy and Metalworking, Publishing House of the USSR Academy of Sciences, 1959, p. 31; V. N. Eremenko, *Titanium and Its Alloys*, Publishing House of the Ukrainian SSR Academy of Sciences, 1955.
2. N. V. Ageev, L. A. Petrova, *Titanium and Its Alloys*, Metallurgy and Metal Science, Publishing House of the USSR Academy of Sciences, 1958, p. 3; N. V. Ageev, Z. M. Smirnova, *Titanium and Its Alloys*, Metallurgy and Metal Science, Publishing House of the USSR Academy of Sciences, 1958, p. 17; N. V. Ageev, L. A. Petrova, *ZhNKh*, 4, no. 5, 1092 (1959); N. V. Ageev, L. A. Petrova, *ZhNKh*, 5, no. 3, 615 (1960).
3. N. V. Ageev, Z. M. Smirnova, *ZhNKh*, 4, no. 5, 1100 (1959); N. V. Ageev, Z. M. Rogachevskaya, *ZhNKh*, 4, no. 10, 2323 (1959); *ZhNKh*, 5, no. 3, 619 (1960).
4. F. L. Orrell, M. G. Fontana, *Trans. Am. Soc. Metals*, 47, 554 (1955).
5. E. M. Savitskii, M. A. Tylkina, Yu. A. Zot'ev, *ZhNKh*, 4, no. 3, 702 (1959).
6. Yu. A. Bagaryatskii, G. I. Nosova, T. V. Tagunova, *DAN*, 122, no. 4, 593 (1958).

*Note: Figure translations are in progress. See original paper for figures.*

*Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.*