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Предназначен для студентов, аспирантов, молодых ученых, преподавателей в области естественных наук и высшей математики.

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PHASE TRANSFORMATIONS OF THE Ti-40% Nb ALLOY UNDER EXTERNAL INFLUENCE

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ФАЗОВЫЕ ПРЕВРАЩЕНИЯ В СПЛАВЕ Ti-40%Nb ПРИ ВНЕШНИХ ВОЗДЕЙСТВИЯХ

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В работе исследуются фазовые изменения в сплаве Ti-40 мас. % Nb после интенсивной пластической деформации. При помощи РСА и оптической металлографии проводится сравнительный анализ фазовых превращений в сплаве в зависимости от типа и условий внешних воздействий.

One of the main drawbacks of metallic implants is a significant difference of mechanical behavior as compared to the bone [1]. The nearest on mechanical behavior to the bone are the alloys of titanium with β-stabilizing elements, such as niobium, zirconium and tantalum [2-4].

Phase composition of such alloys, their physico-mechanical properties and structure could change by means of severe plastic deformation (SPD) [5]. To estimate an SPD influence on the phase composition of the alloy is possible by the methods of X-ray diffraction and metallographic analysis.

The aim was to investigate SPD influence on changes in phase composition of Ti-40 mas. % Nb alloy ingots.

Materials and methods

Ti-40 mass.% Nb alloy ingots were used as study material. They were produced by arc melting with nonconsumable electrode in a water-cooled copper crucible. Samples were quenched (heated to 1000 ^{o}C during 3 hours in Ar atmosphere, cooled in water) and deformed using two schemes in the Institute of strength physics and material science SB RAS [3, 4].

By the 1st scheme of SPD the quenched samples were multistage pressed (three forging operations with the change of the loading axis in constrained conditions). There was the same pressure treatment followed by a multistage rolling in the 2nd scheme of SPD.

To estimate changes of phase composition the XRD was carried out on Panalytical Empyrean diffractometer in monochromatic CuK$_{\alpha}$-radiation at the University of Duisburg-Essen (Germany). The microstructural analysis was carried out on Carl Zeiss Axio Observer at Tomsk Polytechnic University.

As a result of the 2nd scheme of SPD the samples had too small dimensions for the research. Therefore two longitudinal sections were adhesive fastened. The same operations were carried out with four transverse sections. A large number of adhesive composition peaks is observed on the XRD patterns.

Results and discussion

There are reflections from the β-phase (high temperature metastable, bcc) planes on the XRD pattern of casted sample (fig. 1a) [3, 4]. Peaks are slightly displaced towards large angles. The β-phase peaks are absent on the XRD pattern of quenched sample (fig. 1b). However it can be seen the reflections from α''-phase planes (metastable phase with orthorhombic lattice) (fig. 1b). Absence of reflections intensities from some planes shows the formation of textures in the sample. Thus, β→α'' phase transformation occurs as a result of quenching of the alloy. XRD in other sections of the ingot fixes β-phase. The peaks are displaced towards large angles and it can be noticed redistribution of its peaks intensities. Phase composition differences in various sections means non equilibrium distribution of the billet elements. It leads to the formation of regions with the different contents of Nb. Thus, α''-phase forms in the Nb-depleted areas and β+α'' forms in the areas with the high content of Nb.

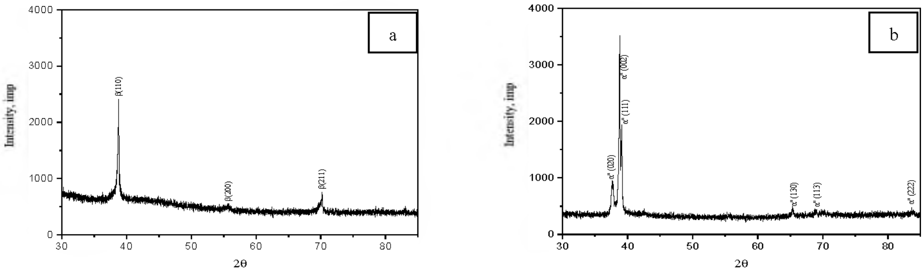

Fig. 1The results of XRD of cast (a) and quenched (b) samples

The metallographic images of cast alloy shows clear grain structure and primary dendrite structure (fig. 2a). Subgrain boundaries which are not fully formed are observed inside the large grains. The presence of various structures n the ingot means dendritic segregation but only β-phase grains are formed under such conditions.

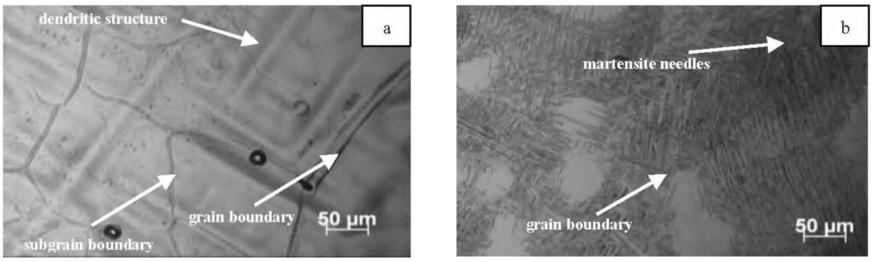

Fig. 2The results of microstructural analysis of cast (a) and quenched (b) samples

The dendritic structure contrast can be observed on metallographic mages (fig. 2b). Grains boundaries and α''-martensite needles are observed in quenched sample. Thus, α''-phase with partial saving of β-phase forms.

The reflections from the β-phase planes and peaks which belong to another phase are observed on the XRD pattern of the alloy after 1st SPD scheme (fig. 3a). One can assume that the second phase is α'' and unidentified peaks are reflections from its (002), (111), (021), (022), (113) planes. Redistribution of all β-phase peaks intensities means the formation of oriented grains. And the width change of its peaks means reducing the size of these grains. One can conclude that partial phase transformation with the formation of β-phase takes place in the alloy as a result of 1st SPD scheme.

The reflections from β-phase planes can be seen on the x-ray pattern of the alloy after the 2nd SPD scheme (fig. 3b). The redistribution of intensities and noticeable broadening of the all phase peaks takes place, what means the formation of direct textures and reducing the grains size. Thus, one can conclude that the 2nd SPD scheme leads to the complete α''→β phase transformation.

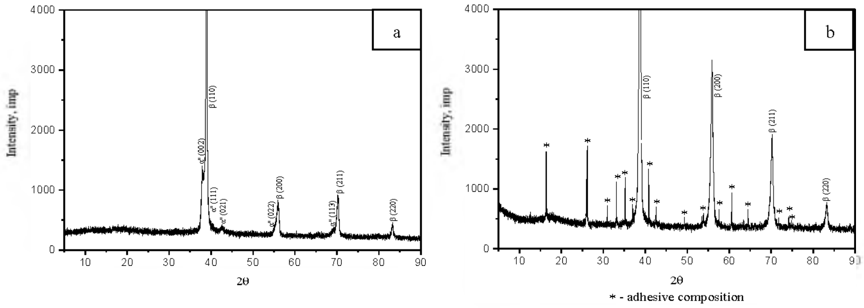

Fig. 3The results of XRD of the alloy after 1st (a) and 2nd (b) SPD schemes

The direct slip bands can be seen on metallographic images of samples after 2nd SPD scheme (fig. 4). The presence of dark and light areas is due to partial saving of dendritic segregation after heat treatment.

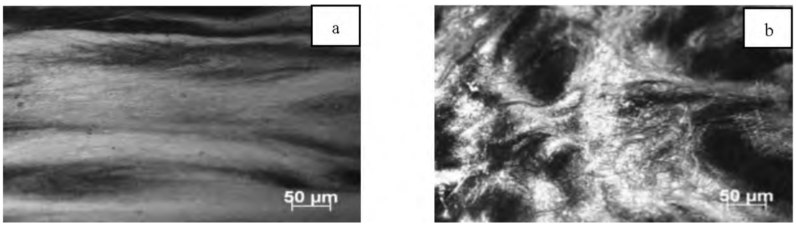

Fig. 4The results of microstructural analysis of the alloy after 1st (a) and 2nd (b) SPD schemes

Conclusion

The partial β→α'' phase transformation in the Ti-40 mas. % Nb alloy is carried out as a result of quenching. Saving of dendritic segregation causes the structural heterogeneity of the quenched sample.

SPD consisting of three forging operations in constrained conditions leads to the partial inverse α''→β phase transformation and to the formation of oriented grains. The additional multistage rolling operation leads to the complete phase transformation into β-phase in the sample as well as grain size reducing.

REFERENCES

1. Dubinsky S.M. [and others] Structure formation during thermo mechanical treatment of the Ti-Nb-(Zr, Ta) alloys and the manifestation of the shape memory effect. // Physics of the metals and metal science. – 2011. – Vol. 112. – № 5. – P.529–542.
2. Mechanical and electrochemical characteristics of thermo-mechanically treated superplastic Ti-Nb-(Ta, Zr)-alloys. V. A. Sheremetiev [and others] // Metal science and thermal treatment of metals. – 2013. – № 2 (692). – P. 43–52.
3. Evaluation of Physical and Mechanical Properties of Structural Components of Ti-Nb Alloy. Kovalevskaya Zh. G., Khimich M. A. [and others] // Advanced Materials Research. – 2014. – V. 1040. – P. 39–42.
4. Investigation of the Influence of Ti-Nb Alloy Composition on the Structure f the Ingots Produced by Arc Melting. Sharkeev Yu. P., Kovalevskaya Zh. G., Zhu Q., Khimich M. A. [and others] // Advanced Materials Research. – 2015. – V.1085. – P. 307–311.
5. Improving the mechanical properties of low modulus Ti-40 mass.% Nb alloy due to grain refinement by severe plastic deformation. Gluhov I. A., Mayrambekova A. M., Khimich M. A. [and others] // High technology in modern science and engineering. – Tomsk, 2014. – P. 122–125.