ТЕЗИСЫ ДОКЛАДОВ

МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ

**«Физическая мезомеханика.
Материалы с многоуровневой иерархически организованной структурой и интеллектуальные производственные технологии»,**

посвященная 90-летию со дня рождения основателя и первого директора ИФПМ СО РАН **академика Виктора Евгеньевича Панина**

**в рамках
Международного междисциплинарного симпозиума
«Иерархические материалы: разработка и приложения для новых технологий и надежных конструкций»**

**5–9 октября 2020 года
Томск, Россия**

Томск
Издательство ТГУ
2020

DOI: 10.17223/9785946219242/327

ANALYSIS OF THE STRUCTURE AND MECHANICAL PROPERTIES IN MEDICAL ALLOYS BASED ON TITANIUM AND COBALT MANUFACTURED BY SELECTIVE LASER MELTING

[1]Ezhov I.V., [1]Kazantseva N.V., [1]Davidov D.I., [2]Merkushev A.G.
[1]M.N. Miheev Institute of Metal Physics UB RAS, Yekaterinburg, Russia
[2]Ural Federal University, Yekaterinburg, Russia

We used for study spherical argon-atomized Ti-6Al-4V (ELI) (45 μm) powder from TLS Technik and spherical Co-Cr-Mo (30 μm) powder from the Russian company Polema. Samples were manufactured by 3D printing using the selective laser melting (SLM) with the EOSINT M280 (EOS GmbH) 3D printing machine equipped with an Ytterbium fiber laser, and operating at 1075 nm wavelength (IPG Photonics Corp.). Argon was used as the protective atmosphere for titanium alloy and nitrogen was used the protective atmosphere for cobalt alloy. To relieve elastic stresses in Co-Cr-Mo samples, standard annealing was performed for 1150 °C for 30 minutes in vacuum, followed by cooling with a furnace. For samples of the Ti-6Al-4V alloy, relaxation annealing was performed for 650 °C for 30 minutes in vacuum, followed by quenching in water.

We found that the structure of SLM titanium sample has two different variants of martensite such as the HCP martensite of α′-phase and orthorhombic martensite of α″-phase. Both of these phases are metastable. The martensitic α′-phase was formed because of the high cooling rates of the SLM method. The {1012} ⟨1011⟩ hexagonal martensite tensile twins were observed in the microstructure of the as-build alloy [1]. It has been found that the hardness and elastic modulus (EIT) measured by the nanoindentation method depend on the sample built geometry [2]. The occurrence of a martensitic transformation in SLM samples was detected. Using the nanoindentation method, it was found that the HIT microhardness of the SLM alloy is higher than that of the cast alloy, which is probably due to the detected high level of surface residual stresses in the SLM sample. It was found that the SLM alloy after standard annealing has a two-phase (FCC + HCP) structure, in contrast to the cast alloy, which after such annealing retains a single-phase FCC structure [3].

Table 1 shows the nanoindentation data obtained on the samples at room temperature using a NanoTest device under a maximum test load of 32 mN for 10 s. The measurement error calculated by the Student's method was 2%. Optimized process parameters for manufacturing high-density medical 3D printing materials Ti-6Al-4V and Co-Cr-Mo are discussed.

Table 1. Nanoindentation results [2-3].

	Ti-6Al-4V	Ti-6Al-4V (annealing)	Co-Cr-Mo	Co-Cr-Mo (annealing)
EIT, GPa	149	132	295	310
HIT, GPa	6.3	5.3	6.3	5.3
Residual internal stresses σ, MPa	458	297	1200	200

1. N. Kazantseva, P. Krakhmalev, M. Thuvander, Yadroitsev I., N. Vinogradova, I. Ezhov. Martensitic transformations in Ti-6Al-4V (ELI) alloy manufactured by 3D Printing // Materials Characterization. 2018. vol., 146, pp., 101–112.
2. N. V. Kazantseva, I. V. Ezhov, N. I. Vinogradova, M. V. Il'inykh, A. S. Fefelov, D. I. Davydov, O. A. Oleneva, M. S. Karabanalov. Effect of Built Geometry on the Microstructure and Strength Characteristics of the Ti–6Al–4V Alloy Prepared by the Selective Laser Melting // Physics of Metals and Metallography. 2018. vol., 119, pp., 1079–1086.
3. N. V. Kazantseva, I. V. Ezhov, D. I. Davydov, A. G. Merkushev. Analysis of Structure and Mechanical Properties of Co–Cr–Mo Alloy Obtained by 3D Printing // Physics of Metals and Metallography. 2019. vol., 120, pp., 1172–1180.