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ИЗУЧЕНИЕ ТАНТАЛОВЫХ И НИОБИЕВЫХ ПОКРЫТИЙ НА МЕДНОЙ ПОДЛОЖКЕ, ПОЛУЧЕННЫХ ЭЛЕКТРОННО-ЛУЧЕВОЙ ТЕХНОЛОГИЕЙ

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STUDY OF TANTALUM AND NIOBIUM COATINGS ON COPPER SUBSTRATES OBTAINED BY ELECTRON-BEAM TECHNOLOGY

1. Introduction

In the modern era, with the development of industry, innovative materials are created and technologies are developed. In this regard, the methods of depositing coatings of different materials on the surface of products are noteworthy, which leads to the improvement of the performance characteristics of the products. With electron-beam technology it is possible to obtain coatings on any material, including refractory metals, with good adhesion to the substrate.

2. Objectives

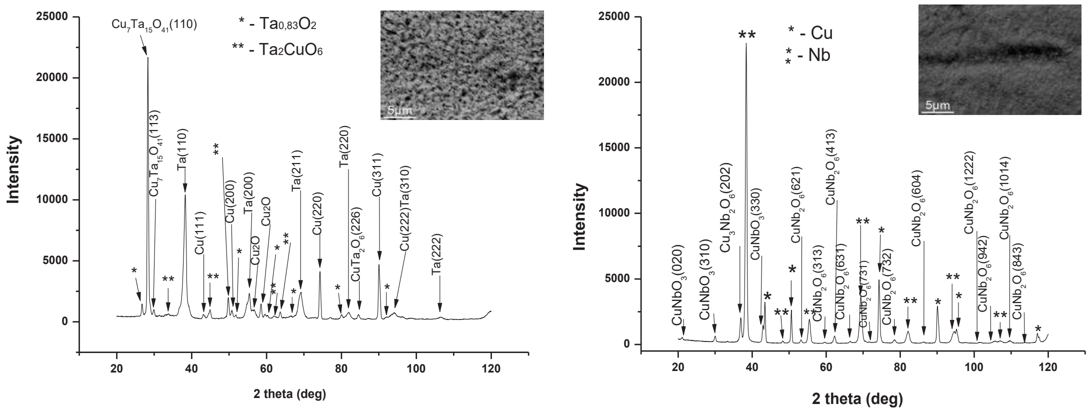
The aim of this paper is to study the coatings of refractory metals (Nb, Ta) obtained by electron-beam technology on copper substrates at the temperatures experimentally defined by us. In particular, the morphology of the coatings, the phase composition of the "substrate-condensate" intermediate zone studied by diffraction analysis and the mechanism of phase merging are analyzed [1, 2].

3. Main Part

Electron beam evaporation of the refractory metals and subsequent condensation of Ta (Nb) powders on the copper substrate provides formation of coatings with good adhesion that can be used in a variety of industries and technique, especially in high-temperature, aggressive environments.

It is known that copper does not form intermediate chemical compounds with niobium and tantalum and is characterized by negligible solubility of the components. The possibility of obtaining coatings of refractory metals (Ta, Nb), with such strongly different melting temperatures and chemical nature, on the selected substrates and studying their peculiarities was of great interest.

The study of morphology, elemental and phase compositions of the coatings, and also their adhesion to the substrate was carried out by electron-beam technology at the condensation temperature intervals established by us (for Ta, t_{cond}=600–750°C; for Nb, t_{cond}=300-500°C) [1, 2, 3].



a **b**

Fig. 1 - a) X-ray diffraction pattern of a Ta coating on a copper substrate. Condensation temperature: t_{cond} ≈ 670°C and surface microstructure; b) X-ray diffraction pattern of a Nb coating on a copper substrate. Condensation temperature: t_{cond} ≈ 500-520°C and surface microstructure

Apart from substrate and coating metal peaks the presence of copper tantalates (Ta_2CuO_6, $Cu_7Ta_{15}O_{41}$) and niobates ($CuNbO_3$, $CuNb_2O_3$, $Cu_3Nb_2O_6$) on the Ta(Nb) coated copper specimens are revealed by diffraction analysis (Figure 1 (a), (b)).

The obtained coatings can withstand 10-12 alternative bendings and no condensation detachment from the substrate is observed even after the breaking of the sample, indicating the high quality adhesion between the substrate and the coating.

One of the main factors determining the conditions for application of the coating and selection of the technology for its obtaining is the amount of residual stresses in the product. Nevertheless, for good adhesion of condensed phase to the substrate the foremost factor is the lattice structural and geometric matching degree; i. e. the intergrowthed planes must be geometrically similar, and the relative difference of their periods must not exceed 15%: $\Delta = (a_1-a_2)/a_1$, where a_1 is the lattice period of the substrate material and a_2 - the period of the condensed phase [4, 5].

Therefore, the similarity of crystal lattices and a very low mismatching degree of their parameters should play a key role in ensuring satisfactory adhesion between copper substrate and niobium and tantalum coatings.

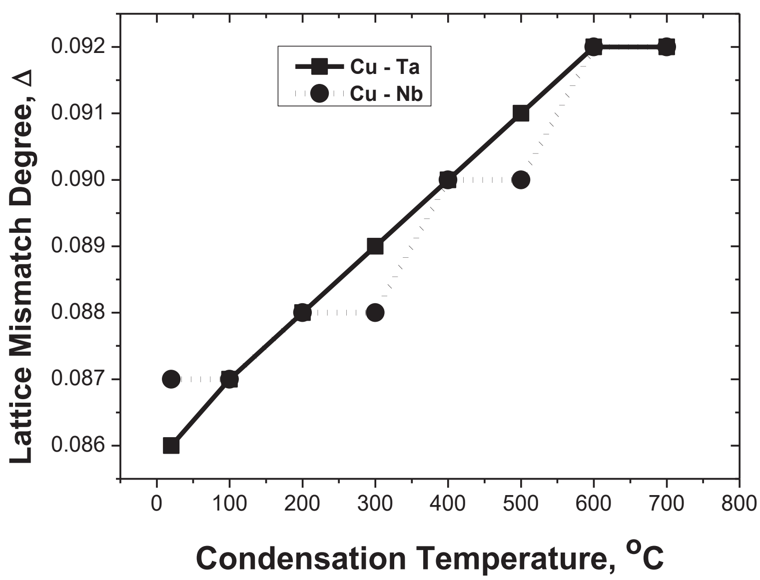


Fig. 2 - The degree of incompatibility between the crystal lattices of copper substrate and the niobium and tantalum condensates depending on temperature

According to the diagrams, based on the experimental data, (Figure 2), the degree of lattice mismatch between the copper substrate and the tantalum (niobium) deposits depends on the condensation temperature; the lower the condensation temperature, the less is the lattice mismatch degree. Consequently, accumulation of significant residual stresses is excluded ensuring a satisfactory adhesion between the substrate and the coating.

When the crystal lattices are not completely identical but slightly different from each other, in the initial stage of condensed film formation the discrepancy between the periods of the crystal lattices is partially compensated at the expense of some elastic (coherent) deformation of the crystal lattices of adjacent phases; it will facilitate the matching of the lattices. The magnitude of the elastic energy induced under such conditions depends mainly on the degree of mismatch between the atomic distances and the elastic constants of the lattices.

Because copper substrate has higher plasticity than those of tantalum (niobium), the development of a pseudomorphism phenomenon is not ruled out, which will significantly reduce the stress caused by the elastic deformation at the phase boundary.

4. Conclusion

As a result of studies it was ascertained:

1. X-ray structural analysis also revealed following intermediate compounds between the substrate and condensate transition zones: Ta_2CuO_6 and $Cu_7Ta_{15}O_{41}$- as a result of tantalum condensation on the copper substrate; $CuNbO_3$, $CuNb_2O_3$ and $Cu_3Nb_2O_6$.- as a result of niobium condensation on the copper substrate.

2. Experimentally established positive effect of the deposition tantalum (niobium) onto the copper substrates in the ranges of 600–750°C and 300–500°C respectively must be promoted by the coherent link between the substrate and coating phase interface, which is maintained at the room temperature. The degree of satisfactory adhesion between the substrate and the condensate is also determined by the fact that no structural or phase transformations take place in the composite during the cooling process.

5. Acknowledgements

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ЛЕСНЫЕ МАШИНЫ «АМКОДОР». ТЕКУЩЕЕ СОСТОЯНИЕ И ПЕРСПЕКТИВЫ РАЗВИТИЯ

На сегодняшний день холдинг Амкодор по праву является ведущим производителем лесопромышленных машин на территории стран СНГ имея в своем составе 19 заводов со списочным количеством сотрудников более 6800 человек и производящим более 120 моделей специальной техники. Более 70% деталей, узлов и агрегатов машин холдинга – собственного производства. В линейке модельном ряду лесопромышленных машин насчитывается более 18 моделей и модификаций. Холдинг обладает собственными развитыми сетями сервисного обслуживания и учебных центров. За последние годы более 1000 лесопромышленных машин холдинга реализуются в 9 странах мира.

Холдинг ведет постоянную работу по созданию новой конкурентоспособной лесной техники в кооперации с Белорусским государственным технологическим университетом. При конструкторском