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SYNTHESIS OF CU-NB ALLOYS BY LOW ENERGY HIGH CURRENT ELECTRON BEAM

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Copper-niobium alloys are of great interest in the fields of high deformability, high conductivity, strain hardening and superconducting alloys [1, 2]. Niobium, due to the very limited solubility in copper, exhibits strong tendency towards segregation, leading to the impossibility of proper production of single-phase Cu-Nb alloys via traditional methods [2]. On the other hand, Low Energy High Current Electron Beam (LEHCEB) gives the possibility to deliver enough energy in the form of electron beam pulses of microseconds, that allow melting and solidifying, at extremely high cooling rates layers, of few micrometres layers [3].

By combining in this way, elements are mixed together at the liquid state and the rapid solidification brings to the formation of non-equilibrium alloys [4]. This is an innovative route for vacuum surface treatment of materials. Coatings result being strongly adherent to substrates [5].

Cu-Nb surface alloys were realized by magnetron sputtering niobium thin films (thicknesses from 100 to 500 nm) onto commercially pure copper. Samples were then irradiated with three electron beam pulses at different accelerating voltages (from 15 to 30 kV, resulting in energy density between 1.64 and 5.56 J/cm^2). X-Ray Diffraction (XRD), surface topography and micro indentation data were used for characterization. Diffraction spectra highlighted non-equilibrium FCC solid solutions with 29.7 and 80.2 at % of copper, as well as BCC solid solutions with 77.3 and 47.4at% of niobium. Microhardness of Cu-Nb surface reached up to 450 HV, with a large increment with respect to copper substrate (120 HV).

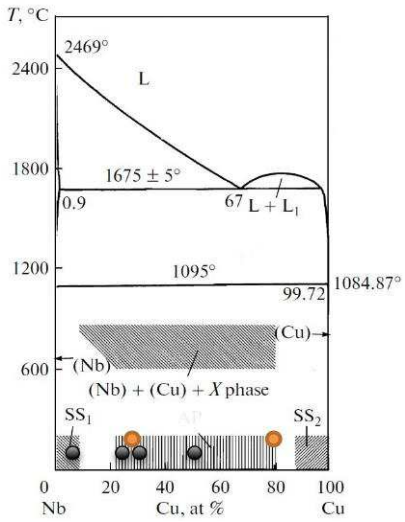

Fig.1. Non-equilibrium phase diagram of the niobium-copper system. At room temperature: SS1, solid solution of copper in niobium; SS2, solid solution of niobium in copper; central part, amorphous phase [6].

Superimposed: phases obtained via LEHCEB. Black dot for BCC Nb-based and orange dot for FCC Cu-based alloys.

REFERENCES

[1] C. C. Tsuei, Superconducting composite of copper and niobium - a metallurgical approach, Journal of Applied Physics, 1974, 45, pp. 1385 – 1388.

[2] R. Roberge, J. L. Fihey, Origin of Superconductivity in copper niobium alloys, Journal of Applied Physics, 1977, 48, pp. 1327 – 1331.

[3] V. Rotshtein, Y. Ivanov, A. Markov, Surface Treatment of Materials with Low-Energy High-Current Electron Beams in Materials Surface Processing by Direct Energy Techniques, Elsevier, 2006, pp. 205 – 240.

[4] C. Zhang et al., The microstructure and properties of tungsten alloying layer on copper by high-current pulse electron beam, Applied Surface Science, 2017, 422, pp. 582 – 590.

[5] A. B. Markov, E. V. Yakovlev, V. Petrov, Electron-Beam Technique for Forming HighConductivity and High-Adhesion Surface Alloy for Application in Microelectronics, Proceedings of 28th International Symposium on Discharges and Electrical Insulation in Vacuum, Greifswald, Germany, September 23 - 28, 2018, pp. 717 – 720.

[6] V. N. Volodin, Yu. Zh. Tuleushev, E. A. Zhakanbaev, Structure and Phase Composition of Niobium-Copper Deposited Films, X-Ray Synchrotron and Neutron Techniques in Journal of Surface Investigation, 2015, 9, 1, pp. 178 – 183.