EFFECT OF BORON ON THE MICROSTRUCTURE AND MECHANICAL PROPERTIES OF HIGH-ENTROPY $AlNiCoFeCrTiB_x$ COATINGS

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Modern technology develops new requirements for the parts of machines and mechanisms operating in extreme conditions of exploitation. One of the effective methods for improving the physical, mechanical and operational properties of traditional materials (steels and alloys) is the application of protective reinforcement coatings from new materials. These materials include high-enthropy alloys (HEA) [1, 2]. Multi-component high-entropy alloys related to the newest class of metal composite materials Complex Metallic Alloys (CMAs) with complex crystallographic structure [2]. The high entropy of mixing various metal elements with a concentration close to equiatomic can significantly reduce the free energy of Gibbs and stabilize solid solutions with a simple crystalline structure and a good combination of properties. [1,2]. By controlling the composition at certain combinations of elements and their concentration, it is possible to achieve high hardness, wear resistance, corrosion resistance, resistance to oxidation, other characteristics [1]. Considering HEA's tendency to form simple structures, fabricating HEA coating by electron beam cladding process is of great significance and potential for extensive use. Until now this novel method for preparing HEA coatings has just been reported by any organizations.

The purpose of this work was to study the effect of boron content on the phase composition, structure and microhardness of multicomponent high-entropy AlCoNiFeCrTiBx coatings obtained by the method of electron-beam surfacing on a steel substrate.

Coatings with a nominal composition of AlCoNiFeCrTiBx (x = 0; 0.25; 0.5 and 1.0 mol) were prepared from a mixture of the starting components of Al, Co, Ni, Fe, Cr, Ti and B with a purity greater than 99.9% by weight . and the particle size about 50 microns. All the elements except B are equiatomic. The microstructure, chemical composition, and constituent phases of the synthesized coatings were characterized by SEM, EDX, and X-ray diffraction (XRD) analysis. Microhardness HV was also evaluated.

Experimental results demonstrate that the AlCoNiFeCrTi, $AlCoNiFeCrTiB_{0,25}$, $AlCoNiFeCrTiB_{0,5}$ coatings consist of 2 solid solutions with the BCC structure, which contain all components of the initial powder mixtures and differ in periods of crystalline lattices. As the content of boron increases to x = 1, the phase composition changes and in AlCoNiFeCrTiB coatings formation of one BCC solid solution and Cr_2B; TiB_2; $BCr_{0,2}Fe_{1,8}$ borides is observed due to the excess of boron atoms that do not dissolve in interstitial position of BCC solid solution.

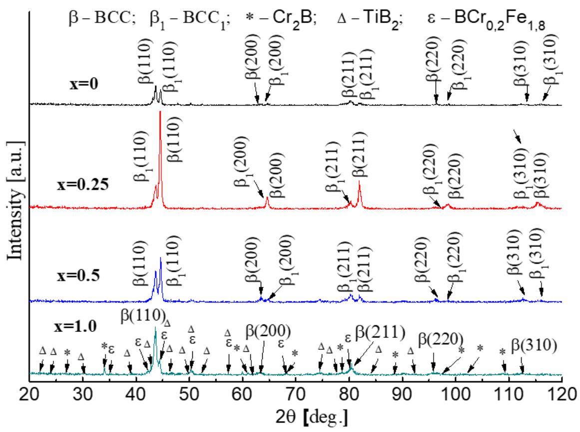

Fig. 1. XRD patterns of $AlNiCoFeCrTiB_x$ HEA coatings resulted from electron beam cladding.

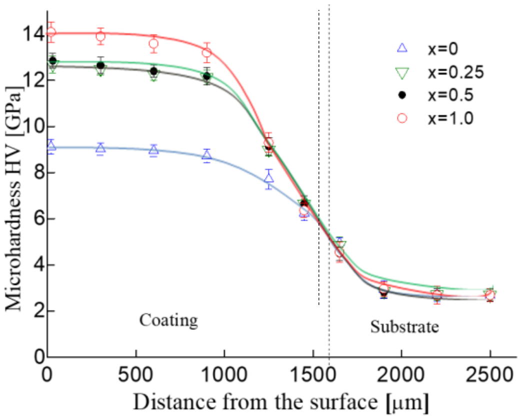

Fig. 2. Hardness of $AlNiCoFeCrTiB_x$ HEA coatings received from electron beam cladding.

The addition of boron (0,25; 0,5; 1) to original mixture AlNiCoFeCrTi leads to distortion of the crystal lattice and increase in hardness from 8,7 GPa to 12.8 GPa and then with a maximum content in AlNiCoFeCrTiB coating due to appearance of borides. Boron in solid solution as an interstitial atom, distorts the crystal lattice of BCC solid solution. Also we can indicate that increasing the proportion of boron to one mole leads to the formation of borides, which greatly increases the microhardness of the coatings. The hardness of high entropy $AlNiCoFeCrTiB_X$ coatings is much higher than that of the initial components and than the one of the steel substrate, and is much higher than that of the similar alloys prepared by laser cladding. It is shown that yield strength increases from 2,94 GPa to 4,54 GPa due to boron addition. Testing of coatings on the fracture toughness by loading on the indenter from 2 N to 10 N shows no cracks. That indicates the ability of the coating to counteract brittle fracture, namely, to inhibit the development of fragile cracks.

[1] *Yeh J.-W., Chen Y.-L., Lin S.-J., Chen S.-K.* // Materials Science Forum. – 2007. – V. **560**. – P.1- 9.

[2] *Yurkova A.I., Chernyavskii V.V., Gorban V.F.* Powder Metallurgy and Metal Ceramics. – July 2016. – Vol. 55. – Issue 3. – P. 152–163.