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ИСМАН

ADVANCED HIGH ENTROPY MATERIALS

Abstracts of the IV International Conference and School of Young Scientists "Advanced High Entropy Materials"

Chernogolovka, Russia,
September 26-30, 2022

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Editors-in-Chief

Salishchev G.A. *– Doctor of Technical Sciences, Professor, Head of the laboratory of the Belgorod State University;*

Tikhonova M.S. *– Ph.D., senior researcher of the laboratory of the Belgorod State University;*

Povolyaeva E.A. *– Junior Researcher, Belgorod State University.*

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Lecturer of the Young Scientists School

THE EFFECT OF HIGH-CURRENT PULSED ELECTRON BEAM TREATMENT ON THE ELEMENTAL DISTRIBUTION IN AL-CO-CR-FE-NI HIGH-ENTROPY ALLOY

Osintsev K.A.[1,2], Konovalov S.V.[1,2*], Gromov V.E.[1], Ivanov Yu.F.[1,3], Pashkova D.D.[1], Panchenko I.A.[1]

[1]Siberian State Industrial University, Novokuznetsk, Russia
[2]Samara National Research University, Samara, Russia
[3]Institute of High Current Electronics SB RAS, Tomsk, Russia
*konovalov@sibsiu.ru

High-entropy alloys consist of at least five principal elements in equal or close to equal atomic ratios. Due to the high entropy effect, severe lattice distortion and sluggish diffusion the innovative concept of HEAs results in a significant number of alloys with extraordinary properties. In this study we fabricated Al-Co-Cr-Fe-Ni high-entropy alloy by wire-arc additive manufacturing using cable-type feeding wire composed of three different filaments: pure Al wire (99.95 wt. % Al), Cr-Ni wire (20 wt. % Cr, 80 wt. % Ni), and Fe-Ni-Co wire (17 wt. % Co, 29 wt. % Ni, Fe – balanced). High-entropy alloy was layer-by-layer deposited on an AISI 1020 steel in Ar (99.99%) atmosphere. The operation parameters were constant: a wire feed speed – 8 m/min, voltage – 17 V, a torch travel speed – 0.3 m/min, a gas supply speed (Ar) – 14 L/min. Then samples were irradiated by a high-current pulsed electron beam: the energy of accelerated electrons 18 keV, the density of an electron beam (10, 20, 30) J/cm^2, the duration of a beam pulse 50 μs, the pulse repetition frequency 0.3 s^{-1}, a number of irradiation pulses 3. TEM analysis demonstrated that the initial HEA sample has dendritic microstructure. The dendrites are enriched with Al, Ni, and Fe, while the interdendritic areas mostly contain Cr. The most liquating element of the alloy is Cr, whose liquation coefficient is δ = 27.5, while the least liquating element is Co (δ = 5.9). A modification of the surface by high-current pulsed electron beams remelts the dendrites and forms a cellular structure. The processes of fast melting and crystallization that proceeds at the rates of 10^5–10^6 K/s induces the homogenization of the elemental distribution. An energy beam of 10 J/cm^2 reduces the range of the Cr liquation from 27.5 to 4.6, while the most liquation element is Al (δ = 10.4). Further increase in the energy of electron beam up to 20 J/cm^2 leads to an increase the homogeneity of distribution of Al content (δ = 2.7). The most liquating element in this case is Cr (δ = 5.4) and the least liquating element is Co (δ = 1.9). When input of an energy density of electron beam rises up to 30 J/cm^2 the temperature gradients also increase, that leads to excessive evaporation of some elements and deteriorates homogeneity of the elemental distribution.

To sum up, the modification of Al-Co-Cr-Fe-Ni high-entropy alloy fabricated by wire-arc additive manufacturing with high-current electron beams leads to the homogenization of the element's distribution in the modified layer. The highest homogenization degree of chemical elements obtained when the energy density of an electron beam was set 20 J/cm^2.

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