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SEM-investigating microstructure of cast AlNiCuFeCo high entropy alloys formations a liquid-phase separation

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The $FeCoNi(CuAl)_x$ (x = 0-1.2, in molar ratios) high-entropy alloys (HEAs) has a combination of superior magnetic and mechanical properties have been investigated. The liquid-phase separation it is known that to has taken place when the undercooling is equal or greater than 100 K [1]. Crystallographic structures of $FeCoNi(CuAl)_x$ HEAs transform from single face-centered cubic (FCC) phase for $0 \le x \le 0.6$ to body-centered cubic (BCC) phase combined with minor FCC phase for $0.9 \le x \le 1.2$, whereas FCC plus BCC duplex phases are found in the range of $0.7 \le x < 0.9$. TEM images of $FeCoNi(CuAl)_{0.8}$ alloy show large numbers of the FCC Cu-rich nano-precipitates disperse in the BCC matrix [2].

The samples AlCuNiCoFe alloy of equiatomic composition were obtained by vacuum arc melting at laboratory. High purity metals, i.e., aluminum of A999 special purity grade, 99.9%, copper of the Mk00 brand (99.98%) and carbonyl iron (special purity grade, 99.98%), were applied as initial materials. The kinematic viscosity was measured using by the oscillating cylinder method during heating and subsequent cooling. A metallographic study was carried out on a Carl Zeiss Auriga CrossBeam scanning electron microscope using the function energy dispersive spectroscopy (EDS). Scanning electron microscope Auriga CrossBeam (Carl Zeiss, Germany) was equipped with the EDS system IncaEnergy (Oxford Instruments, UK) with 350 X-Max X-ray detector with spatial resolution about 1 μm and spectral resolution of 125 eV at Kα line of Mn. The SEM was used for visualization of surface morphology and structural defects in secondary electron mode with the resolution down to 2 nm. The EDS was applied for revealing of elemental composition of defects and inclusions. The EDS data collection and processing were made by means of IncaEnergy software.

The liquid-phase separation in a AlCuNiCoFe high entropy alloy of equiatomic composition has by study investigated by viscometric method. Melt overcooling before crystallization 80 K was recorded. It is interesting to note values of viscosity for studied melt during cooling were equal to or more than the corresponding values recorded by heating. The most significant increase in the viscosity at low temperatures (near liquidus).

Microstructure of ingots homogeneous over the cross section and consist of dendrites and the interdendritic layers of multi-phase composition. According to SEM-microscopy can distinguish the multiple phases in the dendrites and the interdendritic space. In ingot AlCuNiCoFe of equiatomic composition the dendrites consist of a ternary eutectic (α-Al + $CuAl_2$ + Cu_4NiAl_7) and large primary crystals isomorphic compounds $CoCu_2Al_7$ and $FeCu_2Al_7$. Interdendritic space contains small primary crystals Cu_4NiAl_7 [3]. A substantial of interdendritic porosity occurs.

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