Nanocomposites and nanomaterials

Structure and mechanical properties of Al-Cu-Fe-Ni-Si high-entropy films obtained by splat-quenching

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In recent years one kind of new alloys, high-entropy alloys (HEA) with multiple principal elements, has received more and more attentions due to its unique structure and excellent properties in hardness and wear resistance, exceptional high-temperature strength, good structural stability, radiation and corrosion resistance. Each principal element in HEA should have a concentration between 5 and 35 at.%. Because of high mixing entropy of HEAs (12- 19 J/(K·mol)), they usually consists of some simple solid solutions, instead of complex phases. Structure and mechanical properties (microhardness) of splat-quenched (SQ) films (cooling rate~10^6 K·s^{-1}) of HEAs of Al-Cu-Fe-Ni-Si system are investigated in this paper.

The XRD patterns were used to determine the phase composition, lattice parameters, parameters of the fine structure and microstresses. The results obtained are given in Table. XRD analysis allowed us to establish what SQ films of $Al_xCuFeNiSi_y$ HEAs have multiphase BCC + FCC structure. The lattice parameters shows that the BCC solid solutions are based on Fe (*a*= 0,2866 nm) and FCC – on Ni (*a*=0,3524 nm) as the elements with the highest melting points. High microhardness values of alloys can be explained by the presence of the dissimilar atoms of elements with different size, electronic structure and properties in the crystal lattice. This leads to significant distortion ($\Delta a/a$) of crystal lattice. The XRD analysis indicates that microhardness of the films is proportional to the volume fraction of the BCC phase, which is hard an brittle.

Table. Phase composition, size of coherent scattering domains (L), degree of crystall lattice distortions ($\Delta a/a$), microhardness (H_μ) and dislocation density (ρ) of $Al_xCuFeNiSi_y$ films

Alloy	Phase composition	*L*, nm	$\Delta a/a$	H_μ, MPa	ρ, cm^{-2}
$Al_{0,25}CuFeNiSi_{0,25}$	FCC (a=0,3602 nm) + BCC (a=0,2844 nm)	30±2 15±2	$1{,}7\cdot10^{-3}$ $3{,}1\cdot10^{-3}$	2500±200	$6{,}0\cdot10^{11}$ $2{,}4\cdot10^{12}$
$Al_{0,5}CuFeNiSi_{0,25}$	FCC (a=0,3619 nm) + BCC (*a*=0,2863 nm)	24±2 15±2	$1{,}6\cdot10^{-3}$ $2{,}2\cdot10^{-3}$	4300±300	$1{,}1\cdot10^{12}$ $4{,}3\cdot10^{11}$
$Al_{0,7}CuFeNi$	FCC (*a*=0,3622 nm) + BCC (a=0,2879 нм)	28±2 18±2	$2{,}0\cdot10^{-3}$ –	2400±200	$6{,}9\cdot10^{11}$ $1{,}7\cdot10^{12}$
$CuFeNiSi_{0,5}$	FCC (*a*=0,3586 nm) + BCC (*a*=0,2801 nm)	27±2 21±2	$1{,}9\cdot10^{-3}$ –	2700±200	$7{,}6\cdot10^{11}$ $1{,}3\cdot10^{12}$