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PHASE TRANSFORMATIONS UNDER THERMAL TREATMENT IN Al-12%Si-Zr SYSTEM WITH METASTABLE STRUCTURE SYNTHESIZED BY COMPRESSION PLASMA FLOWS IMPACT

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Mixing of a "coating/substrate" system by ion, electron, plasma and laser beams allows alloying the substrate material with the coating elements. This process is of special interest in producing nonequilibrium, immiscible and metastable compounds. The use of such a technique for materials treatment leads to formation of surface layers with improved properties. At the same time metastable structure of the modified layer may be not effective for materials working at the high temperature. Thus, investigation of the effect of thermal treatment on the structure, phase composition and properties of Al-12%Si alloy surface layer alloyed with Zr atoms under compression plasma flows impact on Zr/Al-12%Si system was the main aim of this work.

Al-12%Si alloy was the research object. Before compression plasma flows (CPF) treatment Zr coating with the thickness of 2 μm was deposited on the alloy surface using the vacuum arc vapor deposition technique. CPF were obtained in nitrogen atmosphere using a gas-discharge magneto-plasma compressor of compact geometry. Structure, element and phase composition of the surface layer were characterized by the X-ray diffraction analysis, scanning electron microscopy and energy-dispersive X-ray microanalysis. Vickers microhardness measurement was also carried out. Annealing in air in the temperature range of 450-550^{o}C and period of 0.5-10 hours was carried out to investigate modified layers structure and properties stability.

The findings showed that CPF treatment of the Zr/Al-12%Si system led to the formation of surface Al-Si layer with the thickness up to 65 μm containing metastable $(Al,Si)_3Zr$ compound with a tetragonal $D0_{22}$ crystal lattice (so called τ_1 phase in Al-Si-Zr system). The minimal size of τ_1 phase precipitates was 200 nm. The lattice parameters of τ_1 phase were decreasing with the growth of the energy absorbed (Q) by the surface layer during plasma impact: from a=0,3890 nm and c=0,8806 nm at Q=15 J/cm^2 to a=0,3873nm and c=0,8791 nm at Q= 35 J/cm^2 (a=0,3903 nm and c=0,9008 nm - in Al_2SiZr standard). Besides that formation of supersaturated Al(Si, Zr) solid solution was observed.

Annealing of alloyed sample at 450^{o}C resulted in partial disintegration of supersaturated Al(Si,Zr) solid solution and formation of Al_3Zr (after 0.5 annealing hour) and $ZrSi_2$ (after 2 annealing hours) phases. Increase of annealing time at this temperature also led to Si atoms release from τ_1 phase precipitates and increase of τ_1 lattice parameters up to a=0,3890nm and c=0,8931 nm (after 10 annealing hours).

Further increase of annealing temperature up to 500^{o}C led to the change of τ_1 precipitates shape from dendritic-like to equiaxial.

Increase of annealing temperature up to 550^{o}C provided more substantial phase transformations in the alloyed layer just after 0.5 hour. In particular, dissolution of most of τ_1 phase precipitates and formation of plate-like $ZrSi_2$ precipitates was observed.

Increase of annealing temperature and time was accompanied by microhardness decrease.

The mechanisms and the reasons of the observed effects are discussed.