Synthesis of intermetallic compounds in the surface layer of eutectic silumin by dense plasma impact

Nikolai Cherenda, Natalya Bibik, Vladimir Uglov, Valentin Astashynski, Anton Kuzmitski

1Belarusian State University, Minsk, Belarus 2Institute of Physics, Minsk, Belarus

cherenda@bsu.by

Multicomponent Al–Si casting alloys are widely used in engineering, e.g. automotive industry. The improvement of these alloys microstructure is still a topical task. In this work the samples of the eutectic silumin alloy (12,9 Si; 3 Mg; 0,7 Cu; 0,4 Ni; 0,1 Fe; at.%, Al - balance) with a Ti coating (2.5 and 5 micrometers) were treated by compression plasma flows generated by a gas-discharge magneto-plasma compressor of compact geometry. The velocity of particles in the plasma flow amounts to $10^7$ cm/s, their concentration – up to $10^{18}$ cm$^{-3}$, discharge time – 100 μs. Such an approach allows to form a deep (a few tens of micrometers) composite layer alloyed with titanium and containing submicron Al-Ti intermetallicides providing silumin alloy surface properties enhancement. Ti concentration in the alloyed layer as well as phase composition of the layer can be controlled by the change of Ti coating thickness and plasma parameters. The investigation of the Al-Ti and Al-Ti-Si phases composition and morphology as well as of the surface layer microstructure was the main aim of this work. The findings showed that plasma impact led to melting of the Ti/silumin system, liquid phase mixing of components, subsequent fast cooling and as a result - the formation of a composite layer (containing synthesized intermetallicides) with the thickness up to 60 μm. The formation of the dispersed AlTi$_3$ phase was found at the energy absorbed by the surface layer (Q) of 16 J/cm$^2$. The increase of Q up to 21 J/cm$^2$ resulted in additional formation of a (Al,Si)$_3$Ti compound. At Q=27 J/cm$^2$ the surface layer contains only the (Al,Si)$_3$Ti compound. The size of intermetallicide precipitates (mainly dendritic-like) varied in the range of 0.2 – 1 μm depending on plasma parameters. Plasma treatment also resulted in aluminium grain size refinement, dissolution of silicon primary crystals and formation of a Al(Si) supersaturated substitutional solid solution.

Keywords compression plasma flows alloying silumin intermetallic compounds