Probe microscopy in the study of the surface of aluminum alloys

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The work is devoted to the study of the surface of antifriction aluminum alloys. The effect of heat treatment on topography and electrical properties of the surface was investigated. The studies were carried out using a set of different methods of microscopy: topography, spreading currents and Kelvin-mode.

Aluminum alloys have the widest range of applications. One of the fields of their application is the use as bearing materials in mechanical engineering - they are cheap and have high operational properties [1]. One of the stages of their fabrication is heat treatment (HT). The most important control parameter of such samples is their surface properties: topography and elemental composition, as well as electrical properties. In the present work, alloys of the composition Al-5% Si-4% Cu-4% Sn, with additives (0.5% each) Bi, Pb and Cd were studied. It was shown that the optimal mode of treatment for such alloys is heating up to 500°C, followed by cooling in water.

How does such HT affect the alloy surface? To answer this question, a complex of microscopic studies was carried out. SEM studies were performed on a Quanta-650 microscope with an X-ray spectral microanalyzer EDAX (accelerating voltage 25 kV). For SPM studies, Smart SPM-TM (AIST-NT) and Ntegra Prima (NT-MDT) instruments (tapping regime, cantilevers of the fpN10 series, NSC18/Pt) were used. The results of microscopic studies of the surface are shown in Figure 1.

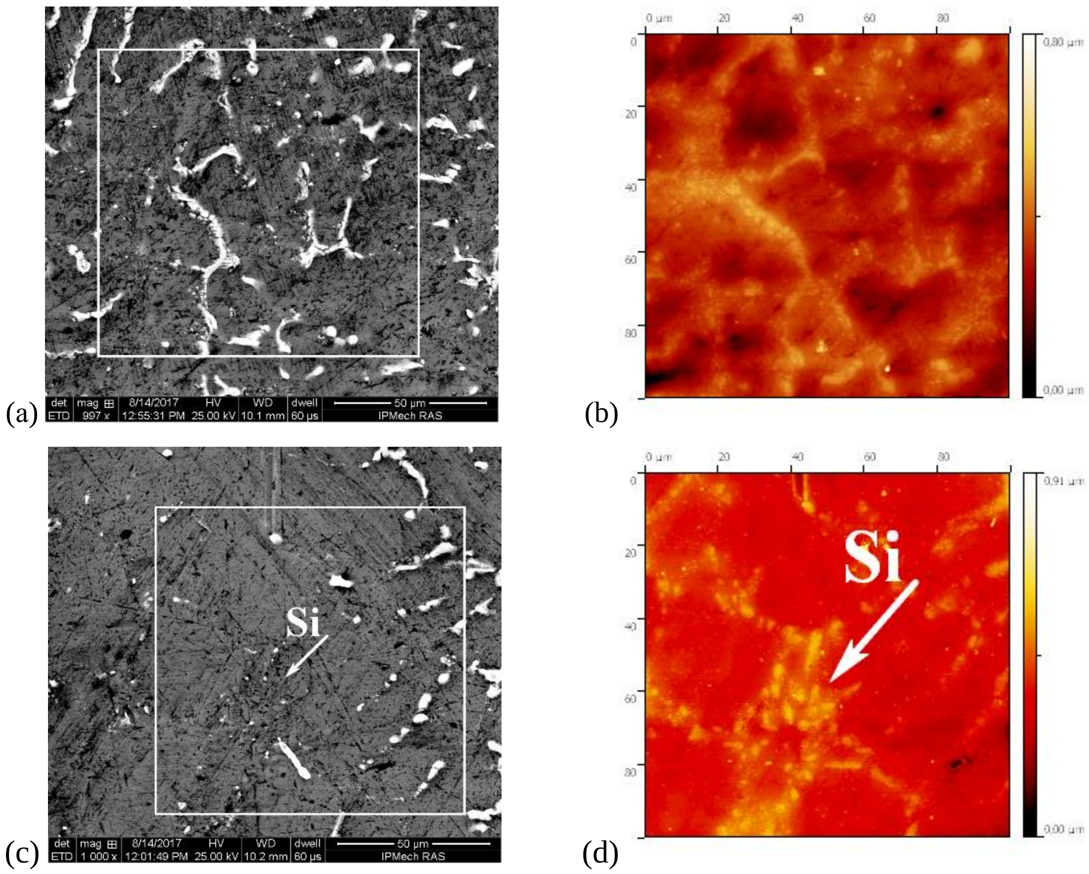

Figure 1. The image of the surface of the alloy: (a, b) cast sample, (c, d) heat-treated sample. (a, c) SEM (squares indicate the areas of SPM research), (b, d) SPM.

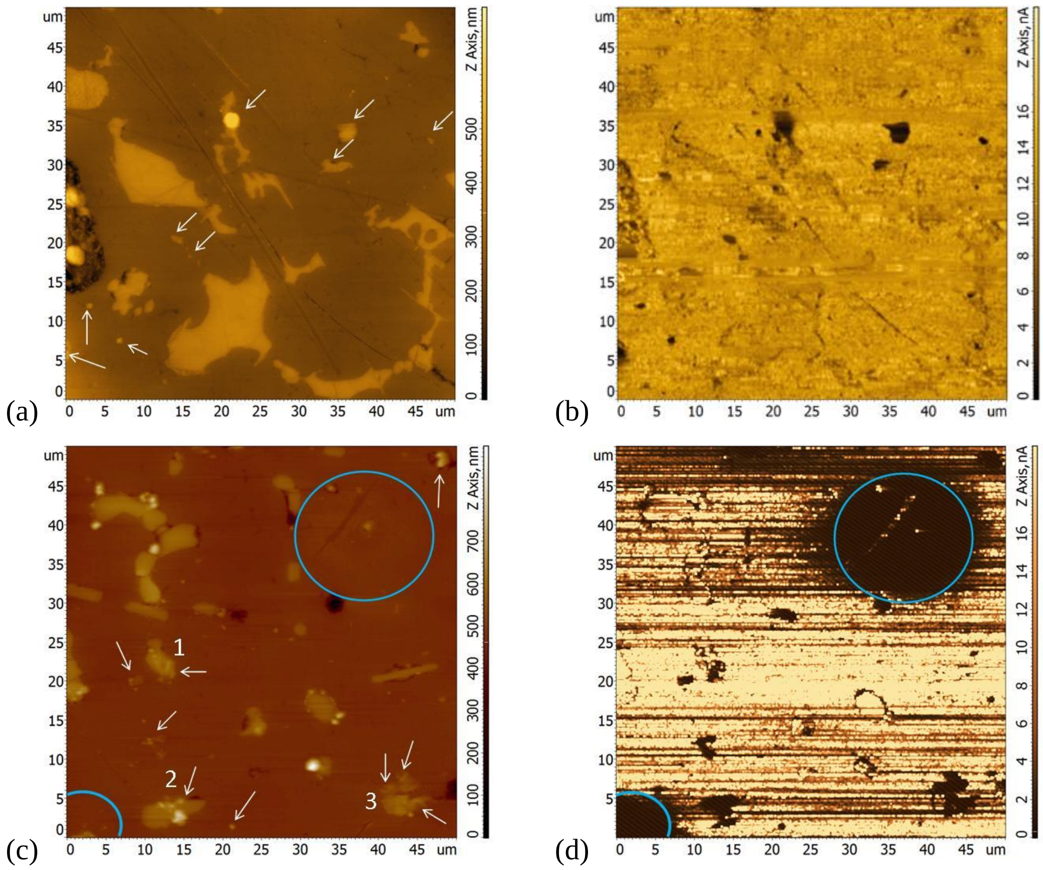

Figure 2. The image of the surface of the alloy: (a, b) cast sample, (c, d) heat-treated sample. (a, c) SPM image and (b, d) flow currents.

It can be seen that HT leads to spheroidization of the particles (the phase constituents of the alloy). The methods used complemented each other: SPM allowed to visualize elements that are difficult to distinguish on SEM images (due to the proximity of atomic numbers). It also allows to estimate the spatial geometry of individual phase components [2]. For example, silicon, which is actually indistinguishable in the aluminum matrix (according to SEM), is clearly visible in the SPM image.

The electrical properties of the surface were also measured: it is known that the electrical conductivity directly correlates with the thermal conductivity. The latter is the most important operational parameter, but it is difficult to measure it directly. The obtained results are shown in Figure 2.

It can be seen that after the HT the picture of the spreading currents has changed: big areas with a significantly lower electrical conductivity appeared, although in general the electrical conductivity has changed insignificantly. At the same time, it can be assumed that if, according to the SEM and SPM (topography), the HT leads to homogenization and homogeneity of the alloy. The flow current pattern, on the contrary, indicates the differentiation of different regions.

The picture of the surface potential correlates with the measured flow currents (measurements in the Kelvin mode). All these results indicate the prospectivity of the application of electrical methods for studying the surface properties of alloys.

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