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Fig. 1. Microstructure of an aluminum-silicon alloy with 20% silicon, modified with lithium. 200×. Etchant—a weak aqueous solution

Figure 1: Fig. 1. Microstructure of an aluminum-silicon alloy with 20% silicon, modified with lithium. 200×. Etchant—a weak aqueous solution

Abstract

Full Text

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ON THE QUESTION OF THE MECHANISM OF MODIFICATION OF SILUMIN

(Presented by Academician I. I. Chernyaev, March 13, 1963)

In the metallurgy of light alloys, the phenomenon of modification of alloys of the silumin type is well known; it occurs when small amounts of sodium are introduced into them. Sodium sharply refines the structure of the eutectic and thereby improves the mechanical properties of the alloys, especially their ductility. The nature of this phenomenon has not yet been fully clarified and continues to remain the subject of numerous investigations.

The author of the present paper takes part in the development of a hypothesis that considers the nature of modification from the standpoint of a physicochemical analysis of the formation of a ternary eutectic from aluminum, silicon, and the ternary chemical compound (NaAlSi) in the system Al—Si—Na (1).

The aim of the present work was to obtain new data for refining the concept of the mechanism of modification of silumin. Here we consider some results of a study of alloys of the aluminum—silicon—lithium system, since lithium is the closest chemical analogue of sodium and, like sodium, modifies aluminum-silicon alloys, although less effectively.

Fig. 1. Microstructure of an aluminum-silicon alloy with 20% silicon, modified with lithium. 200×. Etchant—a weak aqueous solution.

In the modification of these alloys with lithium, a number of processes occur that are analogous to those taking place during modification with sodium, namely: a shift of the eutectic point, the appearance of three thermal effects on some cooling curves, the formation of a ternary chemical compound, and some others (2–4).

As a result, the processes occurring in aluminum-silicon-lithium alloys may to some extent serve as a convenient model for studying the mechanism of modification of silumin by sodium. Along with the similarity, there are also substantial differences here concerning the structure of the binary systems aluminum

—sodium and aluminum—lithium, since sodium has limited solubility in liquid aluminum, decreasing with decreasing temperature, whereas lithium dissolves in it without limitation and forms chemical compounds.

This indicates that the well-known adsorption-colloidal theory of silumin modification is clearly unacceptable for the alloys considered in this article. It was of interest to attempt to determine, in these alloys, what constitutes the primary cause of the refinement of silicon in the modified eutectic, since in the present case there are greater possibilities for this owing to the coarser structure of the phases composing it than in alloys of the Al—Si—Na system.

Microanalysis showed that, in aluminum-silicon-lithium alloys, there is a well-pronounced process of silicon accretion on crystals of the ternary chemical compound, probably as a result of good structural-dimensional correspondence between silicon, which has a diamond-type crystal lattice with a parameter of 5.42 kX, and the chemical compound [LiAlSi], which has the same lattice type with a parameter of 5.93 kX (5).

As an example, Fig. 1 shows the microstructure of an aluminum alloy with 20% silicon and a lithium addition, in which silicon and silicide intergrowths (indicated by the arrow) are clearly visible; these are apparently the binary eutectic Si + [LiAlSi].

Of particular interest in microanalysis is the study of the structure of the ternary eutectic Al + Si + [LiAlSi], where the manifestation of epitaxy between silicon and the silicide can be seen quite clearly; in the present case, the silicide probably also serves as a substrate for silicon.

This hinders the growth of large silicon crystals and causes a change of the phase "leading" the crystallization of the ternary eutectic, as a result of which a dispersed silicon structure is formed (6).

Thus, the observations presented above are additional evidence of the correctness of the viewpoint on the nature of the modification of silumin by sodium set forth at the beginning of the present article.

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