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DECOMPOSITION STUDY OF Al-Sn SOLID SOLUTIONS OBTAINED BY RAPID QUENCHING FROM THE MELT

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Introduction

The equilibrium solubility of tin in aluminium is nil at room temperature. The values, indicated by Hardy (1), give a maximum solubility of 0.023 at% tin at about 610°C. Increased solid solubility of tin in aluminium and the rate of decomposition of the supersaturated solutions are reported.

Experimental Procedure

In order to obtain a supersaturated solid solutions, the rapid quenching method developed by Duwez and Willens (2) was used. The material used for the experiment was prepared from 99.997% aluminium and 99.97% tin.

The resulting quenched flakes were approximately circular (about 1 to 4 mm in dia) and from a few to 20 μm in thickness. The lattice parameter measurements were carried out exclusively with flakes thinner than 5 μm in a large Debye-Scherrer camera at room temperature. Straumains' asymmetric film position and nickel-filtered Cu K radiation were used. The lattice parameters were established through extrapolation against the Nelson-Riley function.

The heating required for the isochronal annealing examination was ensured by placing the flakes into pyrex capsules, which were put into a furnace with a nitrogen atmosphere. After each annealing the flakes were air quenched.

Results and Discussion

By very rapid quenching metastable Al-rich Al-Sn solid solutions up to 0.26 at% Sn were obtained. This value is 11 times greater than the maximum solubility in the equilibrium diagram (at 610°C). Fig. 1 shows the change in the lattice

parameter of Al-Sn solid solutions with increasing tin content. The errors in the lattice parameter measurements were equal $\pm$ 0.0002 Å.

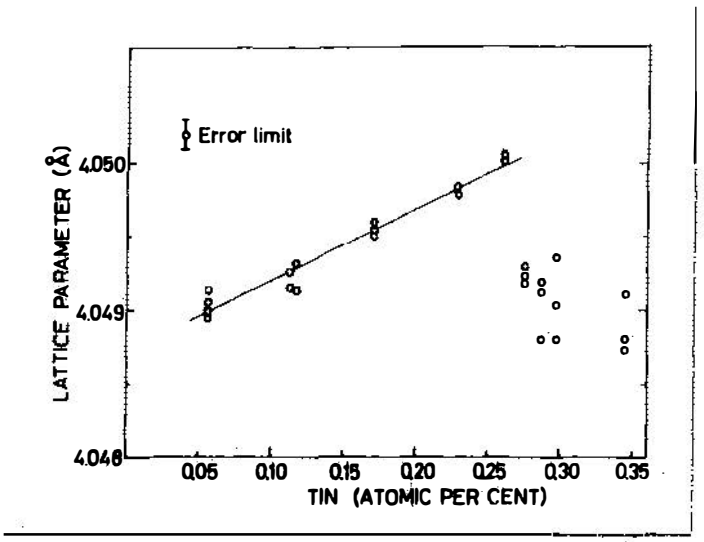

FIG. 1

Lattice parameters of aluminium-rich
Al-Sn solid solutions

As known from studies of Hardy (3) the lattice parameter of solid solutions increases with the addition of tin. In our experiments we obtained a decrease in the lattice parameter for small concentrations of tin in comparison with the parameter of pure recrystallized aluminium (4.0496 Å). This decrease is supposed to have the same origin as that of the lattice parameter in rapidly quenched flakes of pure aluminium. As reported earlier (4), the change in the lattice parameter detected in aluminium flakes rapidly cooled from the liquid state is due to vacancies condensed during the rapid quenching process. Tin is known to interact strongly with vacancies in aluminium (5,6,7). When there exists an attractive interaction between vacancies and impurities, the vacancy concentration in the alloy will be larger than in the pure metal. This may have been the reason that, although the lattice parameter of Al-Sn alloys increases with the growth of the tin content, this increase was smaller than could be expected.

After aging for two months at room temperature, none of the samples showed any change. Samples with 0.11, 0.17, 0.23 and 0.26 at% tin were then isochronally annealed at 100, 150, 200, 250, 300 and 350°C for 10 minutes at each temperature. The change of the lattice parameters of solid solutions with increasing annealing temperature is presented in Fig. 2.

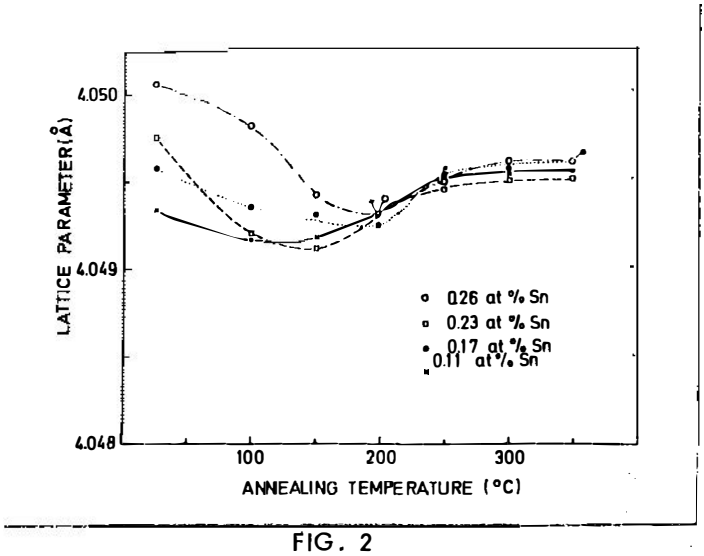

FIG. 2

The change of lattice parameters of Al-Sn solid solutions with annealing temperature after annealing for ten minutes at each temperature

With the increase of the annealing temperature up to 200°C a decrease of the lattice parameter was observed. When the annealing temperature exceeded 200°C, the lattice parameter increased to reach the value of recrystallized aluminium. The decrease of the lattice parameter in the initial period of annealing (up to 200°C) may be explained by the precipitation process. In the case of dilute binary alloys it is generally considered that the solute atoms interact with vacancies forming solute-vacancy associations. As the binding energy between a vacancy and a tin atom is estimated to be 0.42 eV (5,8), this association is so strong, that clusters of solute atoms and vacancies migrate through the lattice, until all tin is completely precipitated.

The subsequent increase of the lattice parameter may be explained by the

disappearance of excess quenched-in vacancies. The lines of tin on X-ray diffraction patterns were observed above 250°C.

Acknowledgements

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DISCUSSION

K. Mukherjee: Have you analyzed the annealing kinetics of the lattice parameter to obtain an activation energy of motion of these vacancies ? If you have, what is the value of this energy ?

A. Kirin: We have not.

A. Guinier: Did you make S.A.S. measurements on Al-Sn alloys ? Steeb (Stuttgart) reported clustering of Sn in Al-Sn in liquid state.

M. Paić: The important point is the concentration of Sn at the monotectic point, if such a point exists.

A. Bonefačić: We did not make S.A.S. measurements on Al-Sn alloys, but we did make it on pure aluminium samples quenched from the melt on the Levelut type camera. S.A.S. was observed about which Mr. Prodan will speak at this session.

R.W. Cahn: In connection with the suggestion that the anomalies found by Mrs. Kirin may be connected with compositional fluctuation in the liquid alloy, it is worth mentioning the research of Dr. Kumar in India, who in a series of elegant papers (using centrifuging away and other techniques) has presented evidence for compositional inhomogenities in various liquid alloy systems. I cannot remember whether these studies embraced the Al-Sn system.