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THE BEHAVIOR OF TIN DURING AGING OF Al-Cu-Sn ALLOYS

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Résumé.- Le spectre Mössbauer de ^{119}Sn dans l'alliage Al-Cu-Sn est enregistré pendant des recuits isothermes à différentes températures. Les effets des atomes de Sn sur le durcissement structural de l'alliage sont discutés. Il apparaît que l'étain interagit avec les atomes de cuivre pendant le vieillissement à 300 K. Au-dessus de 400 K, il y a formation d'un cluster avec des lacunes et(ou) des atomes de cuivre.

Abstract.- The Mössbauer spectrum of ^{119}Sn in the Al-Cu-Sn alloy is measured during isothermal annealing at various temperatures and effects of Sn atoms on the age hardening of the alloy are discussed. It is concluded that tin interacts with Cu atoms during aging at about 300 K. At above 400 K, it forms a cluster with vacancies and/or Cu atoms.

1. Introduction. - Trace elements such as Cd, In and Sn influence the aging process of aluminium alloys /1-3/, but the mechanism has not been clarified yet. Conventional experimental methods such as resistivity measurement are not direct enough to trace the behaviors of the minor elements in alloys. Mössbauer spectroscopy has an advantage for such studies. In the previous report the present authors showed that the change of spectrum of ^{119}Sn in the Al-Cu-Sn alloy during isochronal annealing corresponded to the change of the hardness /4/. In this report, detailed measurements of Mössbauer spectra during isothermal aging at various temperature are performed and the effects of Sn atoms on the aging process are discussed.

2. Experimentals. - Alloys were produced by melting 99.999% Al, 99.998% Cu and 80% enriched ^{119}Sn in the high purity alumina crucible. An Al-3.4%Cu-0.028%Sn alloy was used for aging experiments at above 400 K and an Al-2.0%Cu-0.028%Sn alloy was used for aging experiments below the temperature. Specimens were solution-treated in Ar atmosphere at 798 K for 3h. Isothermal annealing was performed at 303, 333 K (so-called low temperature aging) and 423, 453 K (high temperature aging). After subsequent annealing, Mössbauer spectrum was measured. For the high temperature aging experiments, Vickers hardness was also measured. For comparison, the Mössbauer spectrum of ^{119}Sn in θ phase was also measured. Obtained spectra were analyzed by single Lorentzian line using the least-squares method.

3. Results. - Figure 1 shows an example of spectra. Changes of Mössbauer parameters and Vickers hardness during the isothermal annealing are shown in figure

2 and figure 3.

Fig. 1 : Mössbauer spectra of ^{119}Sn in Al-Cu-Sn alloys. (A) quenched from 798 K; (B) annealed at 303 K for 720 minutes; (C) annealed at 423 K for 60 minutes

Line areas were normalized by that of the quenched state. Line position were measured relative to BaSnO_3 at room temperature. The spectrum of the quenched state was almost the same as that of the quenched Al-Sn alloy. Sn atoms in the quenched alloy doesn't seem to be affected by Cu atoms.

Figure 2 shows the effects of low temperature aging. During annealing at 303 K, line area, position and width increased monotonously. During annealing at 333 K, on the other hand, they kept increasing for 60 minutes and then began to decrease.

Fig. 2 : Changes in the Mössbauer spectrum parameters during aging at 303 K (—●—●) and 333 K (---○---○).

The increase of line position was caused by the growth of a new component at the higher velocity side of the spectrum. The increase in the line area showed that the recoilless fraction of the new component was larger than that of as quenched specimen. The decrease in the line area during annealing at 333 K after 90 minutes was caused by another component of the spectrum whose recoilless fraction was low.

Fig. 3 : Changes in the spectrum parameters and Vickers hardness during aging at 423 K (---●---●) and 453 K (---○---○).

Figure 3 shows the effects of the high temperature aging. The line area showed deep minimum after aging for 5 minutes at 453 K and for 60 minutes at 423 K, just before the Vickers hardness began to increase. The line position initially increased and then decreased during aging process. The large in-

crease of line position showed that nearly all of Sn atoms changed their state. The recoilless fraction of Sn atoms in this new state were lower than that of quenched state. When the Vickers hardness reached the maximum, the spectrum was almost the same as that of ^{119}Sn in θ phase. It is known that the maximum hardness is obtained when the θ' phase has precipitated. Sn atoms seem to be associated with θ' phase at this stage.

4. Discussion.— During the annealing of quenched Al-Cu-Sn alloys, two new states of Sn atoms were detected. One of them was formed during low temperature aging (called Sn(A) here after). The other was formed at high temperature aging (called Sn(B)). The state of Sn atoms formed at the later stage of 333 K annealing seems to be the initial stage of Sn(B). The line position of both states was in the higher velocity side. The recoilless fraction of Sn(A) was high and that of Sn(B) was extremely low. Sn(A) is responsible for the retardation of low temperature aging and Sn(B) for the acceleration of the high temperature aging.

In the quenched Al-Sn alloy, a state of Sn atoms bound as weak as that of Sn(B) was also formed /5/, and the line position was in high velocity side. The state of Sn was attributed to the cluster of Sn atoms and vacancies. It is supposed that Sn(B) corresponds to the cluster of Sn atoms and vacancies. However the line position of Sn(B) was somewhat different from that of Sn in the Al-Sn alloy. It may mean that the state of Sn atoms formed prior to the high temperature aging is under the direct influence of Cu atoms.

Sn(A), absent in the Al-Sn alloy, seems to be influenced by Cu atoms, suggesting the interaction between Sn and Cu atoms. During low temperature aging, Cu atoms may be associated with quenched-in vacancies and migrate. Sn atoms seem to trap the migrating Cu-vacancy aggregates and retard the age hardening.

References

- /1/ Hardy, H.K., J. Inst. Metals 80 (1951/1952)483.
- /2/ Nuyten, J.B., Acta Met. 15 (1967) 1765.
- /3/ Kimura, H. and Hasiguti, R.R., Acta Met. 9 (1961), 1076.
- /4/ Taniwaki, M., Umeyama, S., Ishida, Y. and Kato, M., Scr. Met. 11 (1977) 937.
- /5/ Umeyama, S., Taniwaki, M., Ishida, Y. and Kato, M., in this issue.