MÖSSBAUER SPECTRUM OF 119Sn DISSOLVED IN Al

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Résumé.- Des alliages Al-Sn sont traités thermiquement et les variations correspondantes des spectres Mössbauer sont analysées. On en déduit que la raie attribuable à ^{119}Sn en solution solide dans Al se trouve à 2,32 mm/s et que la température de Debye effective est 173 K. Le spectre de ^{119}Sn dans des clusters d'atome de Sn et de lacunes est également obtenu à partir d'alliages trempés.

Abstract.- Al-Sn alloys are heat-treated and changes of Mössbauer spectrum are analyzed. It is deduced that the line position of ^{119}Sn in solid solution in Al is 2.32 mm/s and the effective Debye temperature is 173 K. The spectrum of ^{119}Sn in the clusters consisting of vacancies and Sn atoms is also deduced from the analysis of the quenched alloy.

1. Introduction.- Mössbauer spectroscopy is the useful technique for the study of point defect in metals. It provides informations of local electronic structure and lattice dynamical properties around the point defect. The concentration of point defect in metals is normally small to be detected. Most investigations use Mössbauer atoms as impurity in metals. The interaction between impurity atoms and point defects increases the concentration of latter around the Mössbauer atoms. Many studies have been reported on the interaction between $^{57}Fe/^{57}Co$ and point defect in Al. /1-5/. While few report have appeared on ^{119}Sn. Sørensen and Cotterill studied the spectrum of the ^{119}Sn in Al-Sn alloys /6/, but their results are not very conclusive. Tin impurity in Al is more interesting than Fe or Co; a large binding energy has been reported between Sn and vacancy in Al. /7/. It has been claimed that the effect of Sn impurities on the aging process of Al alloys was caused by this large binding energy /8/.

2. Experimentals.- Specimens were prepared from 99.999%Al and 80% enriched ^{119}Sn. Alloys containing $1x10^{-5}$ - $5x10^{-4}$ Sn were used for the study of concentration dependence of the spectrum. Sheet specimens 1mm thickness were air-cooled or quenched from 873 K. An annealing experiment was made up to 453 K using the quenched alloy containing $2.5x10^{-5}$ Sn. All measurements of these specimens were performed at liq.N_2 temperature. For the study of lattice dynamical properties, temperature dependence of the spectrum was measured from liq.N_2 temperature up to room temperature on the air-cooled specimen and up to 200 K on the quenched specimen. Specimen temperature was controlled using a small heater in the cryostat.

Mössbauer spectrum was measured by ordinary constant acceleration type spectrometer using the $CaSnO_3$ source at room temperature. Obtained spectra were initially analyzed by single Lorentzian line. In case that fitting was not satisfactory, superposition of lines was assumed.

3. Results and discussion.- Figure 1 shows the typical spectra, solid lines are the best fitted Lorentzian lines.

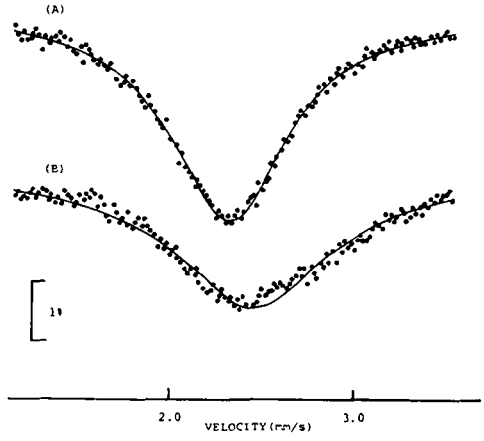

Fig. 1 : The Mössbauer spectra of ^{119}Sn in the Al-$2.5x10^{-5}$Sn alloy air-cooled(A) and quenched(B) from 873 K.

Figure 2 shows the concentration dependence of the spectra. Line position and width in figure 2 were deduced from the analysis using a single line.

For the air-cooled specimen, which Sn concentration was lower than $1x10^{-4}$, spectrum was well represented by single Lorentzian line (Fig.1(A)). Line position was constant, 2.32 mm/s, independent on the concentration. Line width was also constant and narrow, corresponding to the single state of Sn.

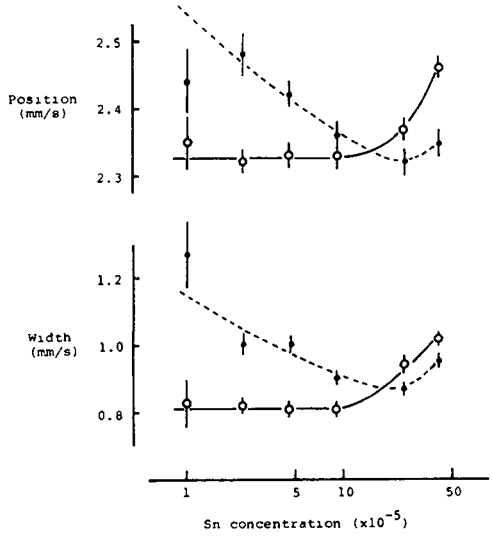

Fig. 2 : Sn concentration dependence of line position and width; O = air-cooled specimen, ● = quenched specimen.

These results showed that Sn atoms of these specimens were dissolved in the Al matrix and not influenced by lattice defects or other impurities. It was concluded that solid solution was obtained by the air-cooling of an alloy containing less than 1×10^{-4} Sn.

Figure 3 shows the temperature dependence of the line intensity and position of the air-cooled specimen containing 2.5×10^{-5}Sn. Line intensity was analyzed by simple Debye model.

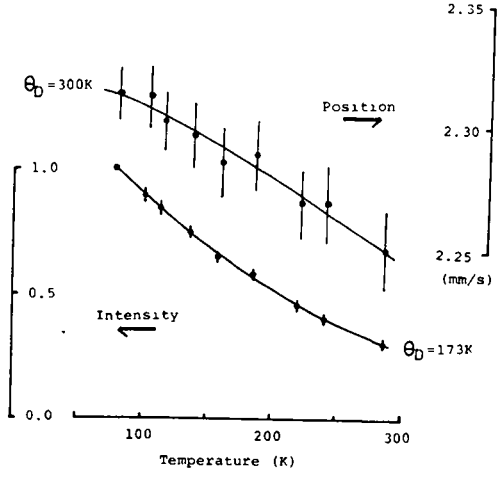

Fig. 3 : Temperature dependence of line position and intensity. Specimen was air-cooled Al-2.5×10^{-5} Sn alloy. Line intensity was normalized by that of liq.N_2 temperature.

The effective Debye temperature Θ_D was 173 K ± 10 K. In contrast, analysis of line position using the temperature approximation of the second-order Doppler shift showed that Θ_D was about 300 K. The discrepancy seems to be caused by the deviation from simple Debye model and/or temperature dependence of the isomer shift. The temperature dependent isomer shift of β-Sn /9/ suggests that the latter is more important.

Quenched specimens showed the same concentration dependence as reported by Sørensen and Cotterill /6/. The spectrum was not fitted to a single Lorentzian line (Fig. 1(B)). It was suggested that multiple state of Sn were formed by the effects of quenched-in vacancies. Figure 4 shows the analysis using two Lorentzian lines.

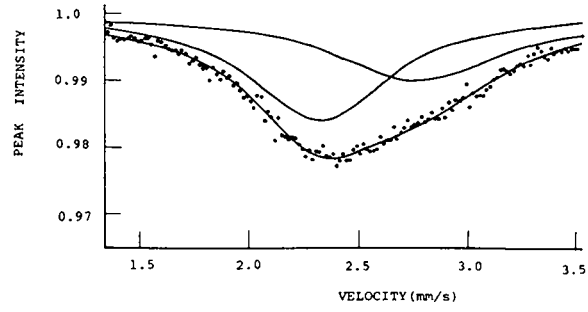

Fig. 4 : Analysis of spectrum using two Lorentzian lines. Specimen was quenched Al-2.5×10^{-5}Sn alloy.

The position of main component in the spectrum was near that of solid solution, but slight shift toward lower velocity side was observed. The position of sub-component was about 2.8 mm/s. The annealing experiment showed that the sub-component was stable up to 453 K and that the cluster of vacancies and Sn atoms. This suggestion was supported by the concentration dependence of the line position. In the low impurity concentration alloy, the fraction of impurity associated with the cluster increases and as the result, the fraction of sub-component may increase. The effective Debye temperature of the sub-component was estimated as 105 K from the temperature dependence of the line intensity. The low Debye temperature also suggested that Sn atoms associated with defects.

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