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Aging in Dilute Al-Si Alloys

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SYNOPSIS

Aging behavior of Al-0.23mass%Si alloy was studied by measurements of elecrical resistivity. Resistvity maximum was observed in the aging curves at 273K after quenching from various temperatures. Appearance of maximum and its dependence on the quenching temperature were attributed to the formation of GP zones. Even in a more dilute alloy as 0.01mass%Si, the maximum of resistivity was also recognized.

1. INTRODUCTION

In many age-hardenable Al alloys such as Al-Cu and Al-Zn, formation of GP zones, which are thermodynamically metastable, precedes the precipitation of equilibrium phase. But in Al-Si alloys aged after quenching, GP zones have not been found before the precipitation of Si(1)-(4). In most of the previous works, however, composition of the alloy was more than 1mass%Si. In these alloys initial change in aging may have occurred so quickly that GP zones were likely to be missed. On the other hand, Takamura(5) suggested the presence of clusters of solute atoms in dilute Al-Si alloys, but details were not reported.

Formation of GP zones is characterized by an initial increase

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followed by the decrease of resistivity, i.e. by an appearance of maximum, during aging. On the other hand, when precipitates are formed, resistivity merely decreases monotonously. If the resistivity increases monotonously during aging, it can not necessarily be assigned to the formation of GP zones, because quasi-equilibrium ciustering of solute atoms may increase resistivity as reported previously with Al-Zn and Al-Mg alloys.(6,7)

In the present experiment aging behavior of dilute Al-Si alloys was investigated by measurements of resistivilty, which may detect a subtle change in the specimen. For a dilute alloy the amount of GP zones, if formed, are too small that X-ray and microscopic experiments are hopeless.

2. EXPERIMENT

Alloys, one the analyzed composition of which is in Table 1 and one the nominal composition of which is 0.01mass%Si, were made from

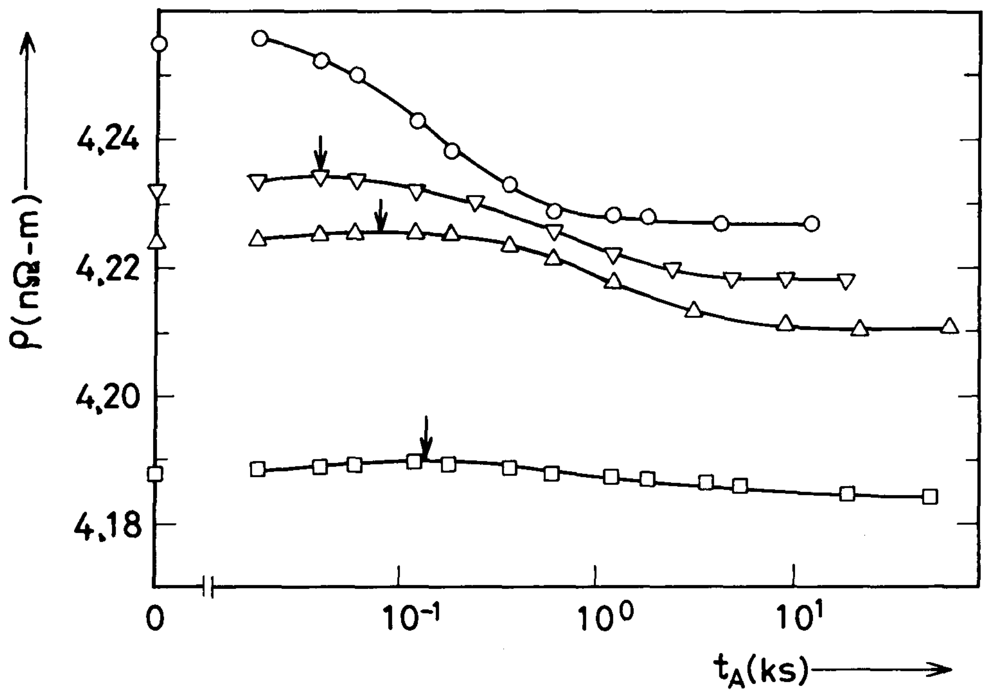

Fig.1 Aging curves in resistivity of the Al-0.23mass%Si alloy at 273K after quenching from various temperatures(T_Q); ○ 723K, ▽ 693K, △ 673K, □ 623K.

99.996%Al and 99.999%Si. They were melt in a high alumina crucible in air. Ingots of 15mm in diameter were homogenized at about 773K for 180ks, forged at about 673K to sheets of 5mm in thickness, and cold rolled to the thickness 0.4mm. The shape and size of the specimens and the method of heat treatment were identical to those used by Ohta[8]. Only one specimen was used throughout the measurement for each composition. Resistivity was measured at liquid nitrogen tem-

Table 1 Chemical analysis of Al-0.23mass%Si alloy

	Si	Mg	Fe	Cu	Al
(mass%)	0.23	<0.001	0.002	0.001	balance

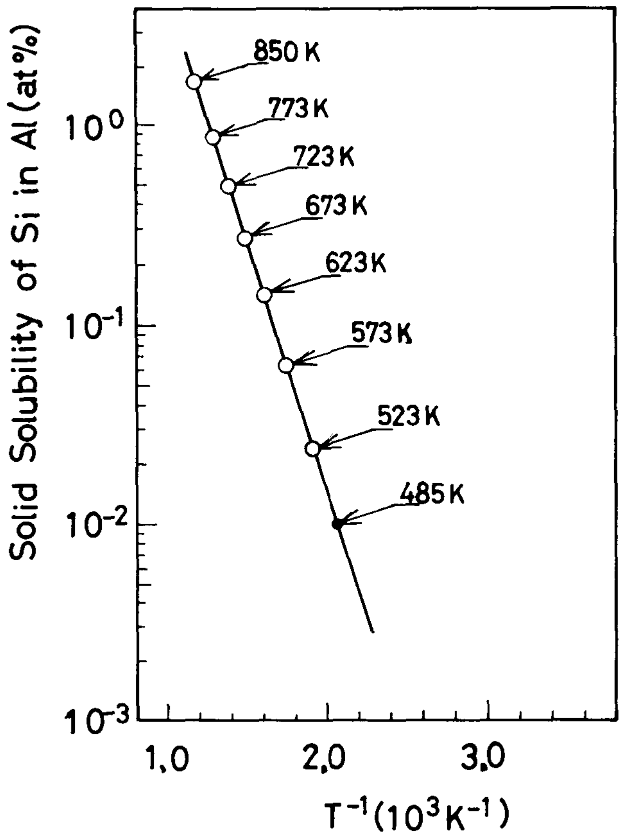

Fig.2 Solubility curve of Si in Al (Fujikawa et al.[9])

perature by a conventional potential drop method.

3. RESULTS AND DISCUSSION

Fig.1 shows aging curves of Al-0.23mass%Si alloy at 273K after quenching from various temperatures (T_Q). Quenching temperatures except for 623K are well above the solubility curve of Si in Al, as shown in Fig.2, according to the results presented by Fujikawa et al.[9]. Variation of as-quenched resistivity with T_Q is due mainly to the retained vacancies from the T_Q. As-quenched resistivity for T_Q=623K may be a little modified by the precipitation of stable Si and the composition of the matrix may be slightly lower than the others. The aging curve for T_Q=723K shows monotonous decrease in resistivity, but in the other three the distinct maximum that is marked by an arrow is observed. From the fact that the maximum shifts to shorter aging time as T_Q increases, it is reasonable to consider that in the curve for T_Q=723K also there must be the maximum

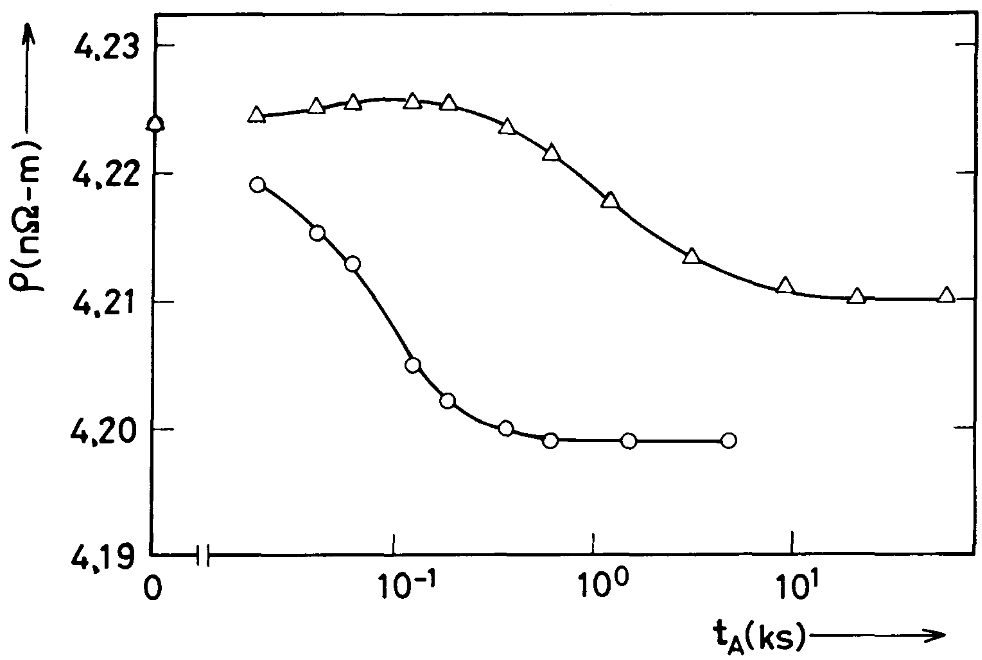

Fig.3 Aging curves of the Al-0.23mass%Si alloy at 273K(△) and 373K(○) after quenching from 673K.

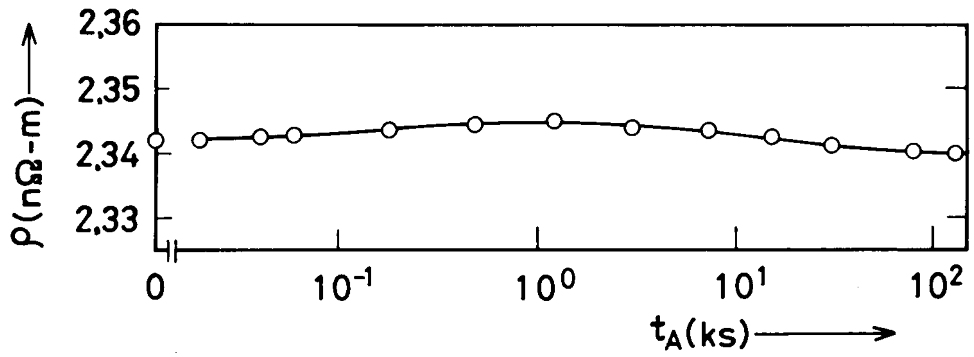

Fig.4 An aging curve of the Al-0.01mass%Si alloy at 233K after quenching from 613K.

but the time may be too short to be detected. Appearance of the maximum resistivity in the aging curve and its dependence on quenching temperature observed in Fig.1 may be corresponding to the formation of GP zones in the alloy. This maximum might also be considered as an initial increase due to short-range clustering of Si and succeeding decrease due either to vacancy decay or precipitation, but short-range clustering should have established at much shorter time of aging than the observed maximum(6). Decrease after the maximum, however, may be attributed to the precipitation superposed on the GP zone growth. Vacancies in this alloy are thought to be bound strongly to the solute Si atoms and hardly decay in the time of this experiment.

Fig.3 shows aging curves at 273K and 373K after quenching from 673K. Compared with 273K aging, the curve at 373K shows rapid decrease of resistivity. At such a high aging temperature as 373K, precipitaition becomes advantageous over GP zone formation and the rate of precipitation also becomes fast.

Fig.4 shows an aging curve of more dilute alloy at 233K after quenching from 613K. It seems interesting that even in such a dilute alloy maximum could be recognized.

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