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SOFT X-RAY XAFS STUDIES OF THE CHANGE IN CLUSTER STRUCTURE BY DIFFERENT AGING CONDITIONS IN Al-Mg-Si ALLOYS

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INTRODUCTION

Currently, the application of Al-Mg-Si alloys to body panel materials is accelerating to realize weight saving of automobiles. The negative effect of two-stage aging is the problem with the alloys. This is a phenomenon in which the strength increasing after the artificial aging is reduced by the natural aging after the solution treatment. For this reason, it is considered that clusters formed during natural aging interrupt the nucleation of β" phase, which is formed during artificial aging. Many studies about these clusters have been conducted, but the structure and formation process is not sufficiently clarified. Since it is considered that these clusters are very small in size and do not have long range order, it is difficult to measure by general X-ray diffraction method. Although Small-angle X-ray scattering (SAXS) method is an effective method for nano-precipitates, strong scattering intensity cannot be obtained and it is not an effective means because atomic numbers of Al, Mg, Si are close with the alloys. In this research, we investigated the constituent elements of clusters formed during natural aging of Al-Mg-Si alloys by using X-ray absorption fine structure (XAFS) method which can obtain the information on the local structure and electronic state of a specific atom.

EXPERIMENTAL PROCEDURES

The samples used in the present investigation were Al-0.55Mg-1.04Si (mass%). Solution-treated was performed at 550°C for 10 min and naturally aged in the range of 10 to 1.3×10^6 min. XAFS measurement was carried out at soft X-ray beam line BL27 SU in SPring-8 Proposal No. 2017B1772. The Si and Mg-K absorption edge energy are low, and soft X-ray having these energies hardly transmit the metal samples, so this alloy can't be measured by the transmission method. Therefore, in this study, the fluorescent X-ray intensity related to the absorption amount was measured by the fluorescence method. In order to suppress the progress of the structural change of the cluster, measurements were taken for cooling the sample with liquid nitrogen.

RESULTS AND DISCUSSION

Figure 1 shows change of the absorption edge energy (E_0) by the natural aging time. E_0 was obtained from the XANES spectrum near the Si-K absorption edge of each sample.

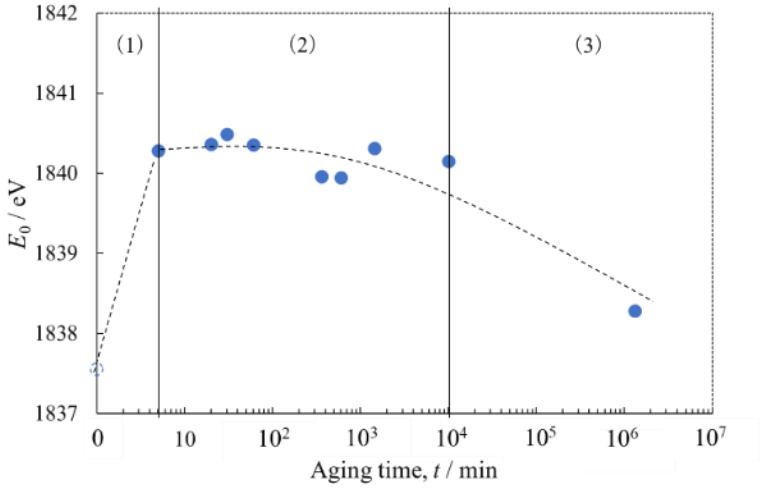

Figure 1. Relation between Si - K absorption edge energy(E_0) and natural aging time

According to the figure, E_0 change has three stages: (1) sharp increase between 0 and 5 min (2) gradual decrease between 5 and 1.0×10^4 min (3) sharp decrease after 1.0×10^4 min. From this result, it is considered that the valence of Si has a large change in each stage: (1) sharp increase (2) gradual decrease (3) sharp decrease. E_0 of Mg also showed a similar tendency to that of Si, but the change was more remarkable for Si. This change suggests that Si contributes much more than Mg when the forming cluster during natural aging.

CONCLUSIONS

The information on the constituent elements of the cluster formed during the natural aging in the Al-Mg-Si alloy could be obtained by soft X-ray XAFS measurement. Several changes occurred in E_0 of Si and Mg. This result suggested that various structural changes of Si and Mg near the respective atoms occurred during cluster formation.

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KEYWORDS

Al-Mg-Si alloy, Nano-cluster, Natural aging、Soft X-ray, XAFS