15A/2000G204

The influence of copper addition on the phase decomposition in Al-Zn-Mg alloys

Hiroki Adachi*, Junya Isogai*, Kozo Osamura*
*Department of Materials Science and Engineering, Kyoto University , Kyoto 606-8501,Japan

Introduction

Al-Zn-Mg alloys are precipitation-hardening type alloys of which hardness increases, when η' or T' metastable phase precipitates. And it is also well known that the amount of precipitation strengthening increase by addition of Cu. However, addition of Cu decreases the solubility limit of Zn and Mg. It is considered that decrease of the amount of addition of Zn and Mg reduces the volume fraction of precipitation, and also reduces the amount of precipitation strengthening. However, with the commercial Al-Zn-Mg-Cu alloy, since resistance to SCC remarkably falls by addition to the solubility limit of Zn and Mg, the amount of addition of Zn and Mg is stopped by about 70 percent of the solubility limit. However, since P/M alloy has more fine grain as compared to I/M alloy, it has high resistance to SCC. Therefore, if it adds Zn and Mg to the solubility limit, the alloy with high resistance to SCC is obtained. In this research, the change of metastable precipitate is investigated by addition of Cu into the alloy, which added Zn and Mg to the solubility limit.

Experimental

The alloys were prepared by powder metallurgy. The composition is shown in Table 1. The alloys were solution-treated at 763K for 72ks and then quenched into water. Then isothermal aging was carried out at 383K for various times (0~360ks). The SR small angle scattering measurements were carried out at BL-15A of Photon Factory in KEK. The detector is one-dimentional PSPC and the camera length is 1140mm. The hardness test was carried out for the investigating the mechanical property.

Table 1 Chemical composition of alloys (at%)

sample	Zn	Mg	Cu	Ag	Al
Cu-add	4.08	3.43	0.70	0.01	bal.
Cu-free	4.73	3.88	tr.	0.01	bal.

Result

The as-quenched hardness of Cu-free alloy and Cu-add alloy is 165 and 130, respectively. By aging, the hardness increases and show maximum at 108ks aging and then falls by overaging. Maximum hardness of Cu-free alloy and Cu-add alloy is 230 and 209, respectively. The maximum hardness of Cu-free alloy is ten percent higher than that of Cu-add alloy.

From the intensity profile of small angle scattering, the Guinier radius of the precipitate was calculated and the change by aging has been investigated. Pair correlation function with respect to spatial distribution of precipitates was calculated from the intensity profile. And the mean nearest neighbour distance among precipitates was estimated. Then the volume fraction was calculated by the Guinier radius and mean distance. The volume fraction doesn't depend on aging time and is fixed. The volume fraction of metastable phase for Cu-free alloy and Cu-add alloy are 3.8vol.% and 2.7vol.%, respectively. The volume fraction of Cu-free alloy is 40% larger than that of Cu-add alloy.

Discussion and conclusion

The increase of volume fraction by no addition of Cu is considered to be the cause of an increase of the highest hardness. However, the total solute atom, Zn, Mg and Cu, in Cu-free alloy and Cu-add alloy are 8.61at% and 8.21at%, respectively. The amount of solute increased 1.05 times. On the other hand, the volume fraction of precipitate increased 1.4 times. The quantity of solute change is not comparable to the quantity of volume fraction change. Therefore, it is considered that the reason that the volume fraction increases has a cause also besides the increase of solute atom.

The difference of electron density between matrix and precipitate can be calculated by integration intensity and volume fraction. Since the structure and composition determine the electron density, change of structure and composition can be guessed by change of the difference of electron density. The calculated difference of electron density for Cu-free alloy and Cu-add alloy is 43.0 and 56.7 a.u., respectively. This large change of difference of electron density means that the different metastable phase precipitates in these alloys. In Cu-free alloy and Cu-add alloy, it is considered that T' phase and η' phase have precipitated, respectively. Thus, since the kind of metastable phase changed with existence of Cu, the volume fraction is considered to have changed a lot in spite of a few change of quantity of solute atom.

* adachi@kumax.mtl.kyoto-u.ac.jp