A R C H I V E S O F M E T A L L U R G Y A N D M A T E R I A L S
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THE AGE-PRECIPITATIONS STRUCTURE OF Al-Mg-Ge ALLOY AGED AT 473K

UMACNIANIE WYDZIELENIOWE STOPU Z Al-Mg-Ge PO STARZENIU W 473K

The Al-Mg-Ge alloy is one of the age-hardening aluminum alloy after solution heat treatment. It has been proposed that the age-precipitation behavior of Al-Mg-Ge alloy is different from that of Al-Mg-Si alloy according to our previous works about the microstructure on Al-Mg-Ge alloy over-aged at 523K. For example, The hardness of peak aged Al-1.0mass%Mg_2Ge alloy is higher than that of Al-1.0mass%Mg_2Si alloy.The precipitates in the over-aged samples have been classified as some metastable phases, such as the β'-phase and Type-A precipitates and equilibrium phase of β-Mg_2Ge by TEM observation.There a few reports about microstructure on Al-Mg-Ge alloys observed by TEM for different aging times. The age-precipitations structure of Al-Mg-Ge alloy has not been became clear. In this work, TEM observation was investigated the microstructure on Al-1.0mass%Mg_2Ge alloy for difference aging times aged at 473K.
Keywords: Al-Mg-Ge alloy, TEM, Age-precipitate, Age-precipitation sequence

Stop Al-Mg-Ge należy do grupy stopów aluminium podatnych na obróbkę cieplną w postaci przesycania prowadzącą do utwardzenia wydzieleniowego. Na podstawie wcześniejszych badań dotyczących mikrostruktury stopu Al-Mg-Ge, starzonego w temp. 523K, przyjęto założenie, że proces utwardzania wydzieleniowego będzie zachodzić inaczej niż w przypadku standardowych stopów Al-Mg-Si. Zaobserwowano, że twardość starzonego stopu Al-1,0(%mas.)Mg_2Ge jest wyższa od analogicznego stopu Al-1,0(%mas.)Mg_2Si. Jednocześnie dzięki zastosowaniu mikroskopii TEM określono skład fazowy próbek po przestarzeniu. Występujące fazy w stopie Al-Mg-Ge to m.in. faza β', wytrącenia typu A oraz faza równowagowa β-Mg_2Ge. Dodatkowo, badania mikrostruktury z użyciem mikroskopii TEM wykonano dla różnych czasów starzenia stopu Al-1,0(%mas.)Mg_2Ge, starzonego w temperaturze 473K.

1. Introduction

The Al-Mg-Ge alloys belongs to the aluminum alloys which age-harden after solution heat reatment. The hardness of peak aged Al-1.0mass%Mg_2Ge alloy is higher than that of Al-1.0mass%Mg_2Si alloy. [1] Therefore, it has been proposed that the precipitation ageing behavior of Al-Mg-Ge alloys is different from that of Al-Mg-Si alloys, according to our previous works about the microstructure on Al-Mg-Ge alloys over-aged at 523K. The precipitates in over-aged of Al-Mg-Ge alloy were classified as β' phase, Type-A precipitate, and equilibrium phase β-Mg_2Ge. On the other previous works , The Al-Mg-Ge alloy is investigated precipitates in both a high ratio and low Mg/Ge alloys. [2] However, there are a few reports about the microstructure of Al-Mg-Ge alloys observed by TEM for different aging times, and the precipitation ageing sequence of Al-Mg-Ge alloys has not been compleately cleared. In this work, TEM observations was used to investigate the microstructure on an Al-1.0mass%Mg_2Ge alloy for different aging times aged at 473K. To understand the age-precipitation sequence of Al-Mg-Ge alloys observed age-precipitates were analyzed during ageing about their types of crystal lattice.

2. Experimental procedure

The alloy of Al-1.0mass%Mg_2Ge was obtained by laboratory casting. This alloy sheet with 1.5 mm thickness and 15 mm width was made by hot extrusion. The specimens were solution heat treated at 873K for 3.6ks in an air furnace, quenched in chilled water, and subjected to electrolytic polishing by perchloric acid : ethanol=1:9 electrolyte. Vickers hardness was measured using Mitsutoyo HM-101 hardness tester (load:0.98N, holding time:15s). Aging treatment was done in oil bath at 473K. fter the aging, specimens were polished by using two type electrolyte, perchloric acid: ethanol=1:9, nitric acid: methanol=1:3 to make specimens for TEM. The microstructure was observed using a TOPCON EM-002B TEM operated at 120kV.

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3. Results and discussion

Figure 1 shows the age-hardening curves obtained for the Al-1.0mass%Mg_2Ge alloy and Al-1.0mass%Mg_2Si alloy aged at 473K. The Vickers hardness of Al-1.0mass%Mg_2Ge alloy aged at 473K is higher than that of Al-1.0mass%Mg_2Si alloy. Figure 2 shows HRTEM images obtained for Al-1.0mass%Mg_2Ge alloy aged at 473K for 600ks. The hexagonal network of the bright dots in this cross section of precipitate was observed with the spacing about 0.72nm. It is recognized as the β'-phase in Al-Mg-Ge alloy. Figure 3 shows HRTEM images obtained for Al-1.0mass%Mg_2Ge alloy aged at 473K for 600ks. The large precipitate is identified as the type-A precipitate in this alloy. It shows a rectangle network of 0.35nm and 0.68nm. This large precipitate are similar to the A-type precipitate in the Al-Mg-Si alloy with excess Si. Figure 4 shows HRTEM images obtained for Al-1.0mass%Mg_2Ge alloy aged at 473K for 2400ks. This large precipitate is supported to be the equilibrium phase of β-Mg_2Ge. It is found that the age-precipitates are β'phase, type-A precipitate and the equilibrium phase in Al-1.0mass%Mg_2Ge alloy over aged at 473K.

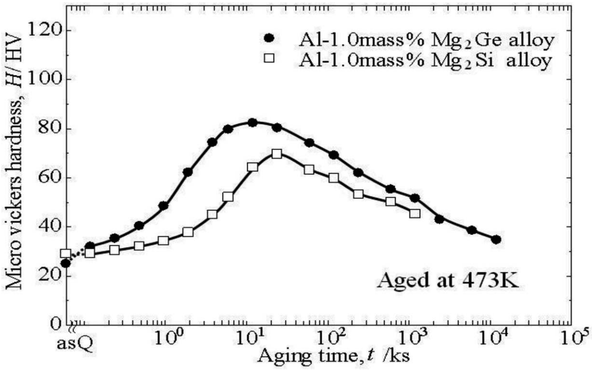

Fig. 1. Age-hardening curves of the Al-1.0mass%Mg_2Ge alloy and the Al-1.0mass%Mg_2Si alloy aged at 473K

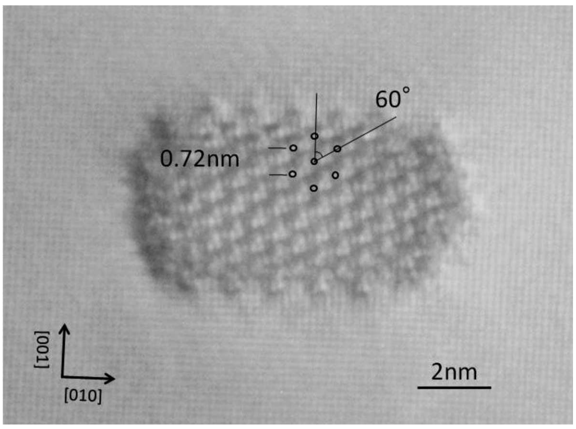

Fig. 2. HRTEM images of obtained for samples aged for 600ks: β' phase

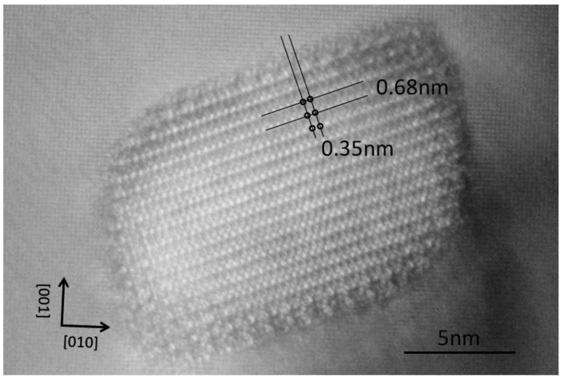

Fig. 3. HRTEM images of obtained for samples aged for 600ks: Type-A precipitate

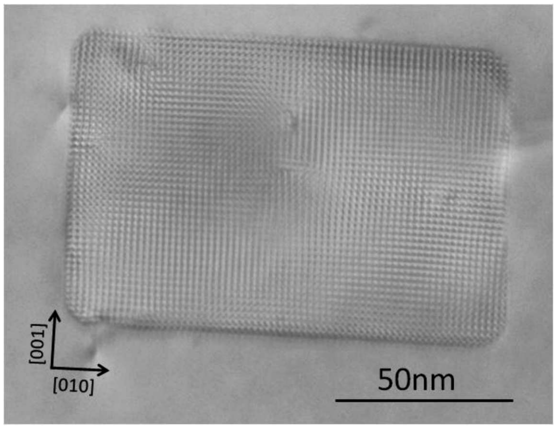

Fig. 4. HRTEM images of obtained for samples aged for 2400ks: equilibrium phase

4. Conclusions

- The Vickers hardness of Al-1.0mass%Mg_2Ge alloy aged at 473K was higher than that of Al-1.0mass%Mg_2Si alloy.
- The microstructure of Al-1.0mass%Mg_2Ge alloy aged at 473K for 600ks and 2400ks was investigated by TEM bright field images.
- The β'-phase, type-A precipitate and equilibrium phase were identified by analysis of TEM and HRTEM images.

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