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EFFECT OF Cu ON MECHANICAL PROPERTIES AND PRECIPITATION OF Al-Zn-Mg ALLOYS WITH HIGH Zn CONCENTRATION

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INTRODUCTION

Al-Zn-Mg alloys (7xxx series alloys) are known as the strongest aluminum alloys and, have been traditionally strengthened by fine dispersed precipitates through aging treatment. The precipitation sequence is reported like [1]: S.S.S.S. -> G.P.zone -> η’ -> η ($MgZn_2$). The η' phase has been referred as the main hardening phase in Al-Zn-Mg alloys [2]. Regarding the effect of additional element, it is well known that the addition of Cu is beneficial to increase maximum hardness [3]. In this work, three alloys, with different added amounts of Cu, were prepared to compare the effect of Cu concentration on the mechanical properties, aging behaviour and precipitates.

EXPERIMENTAL PROCEDURE

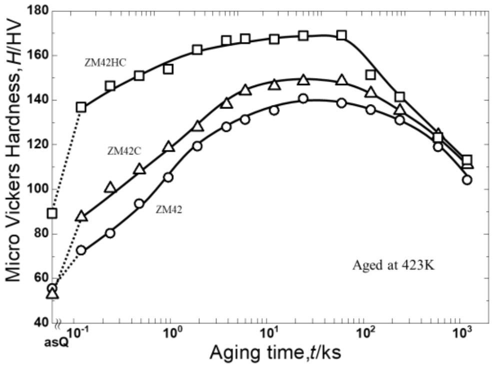
All samples with Zn/Mg ratio of 2.0, were prepared by casting. The chemical compositions of the alloys are shown in Table 1. Samples were cut from the hot extruded alloys of 1.5 mm thickness and 15 mm width and then cold rolled to sheets with 1.0 mm thickness. Solution heat treatment was conducted at 748K for 3.6 ks, and then quenched in cold water. The alloys were subjected to artificial aging at 423K in oil bath. Micro-vickers hardness was measured using Mitutoyo HM-101 (load: 0.98 N, holding time 15 s). Tensile tests were performed using peak-aged samples with the strain rate of 1.0×10^{-3} s^{-1} at room temperature using Instron type tensile machine. Fractured surfaces were observed by scanning electron microscopy (SEM, HITACHI S-3500). Transmission electron microscopy (TEM, Topcon EM-002B) observation was conducted under the accelerated voltage of 120 kV.

Table 1. Chemical composition of alloys [at.%]

	Zn	Mg	Cu	(Zn+Mg)	Zn/Mg
ZM42	3.4	1.9	-	5.3	1.8
ZM42C	3.3	1.8	0.2	5.1	1.8
ZM42HC	3.7	1.8	1.0	5.5	2.0

RESULTS AND DISCUSSION

Figure 1 shows age-hardening curves of all alloys aged at 423K. With increase of Cu addition, not only hardness increasing rate becomes higher at the initial stage of aging, but also maximum hardness level increases. Result of tensile tests (Figure 2), Ultimate tensile strength and yield strength increased with increasing concentration of Cu. While, elongation decreased with increasing concentration of Cu. In SEM observation (Figure 2b–2d), all alloy's fracture mode showed mainly transgranular fracture and a part of fractured specimen were intergranular fractured.



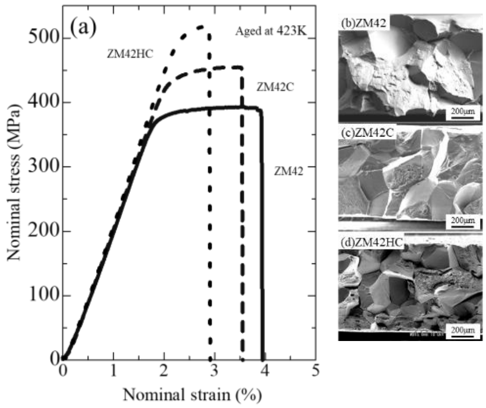


Figure 1. Age-hardening curves of alloys aged at 423K Figure 2. Tensile test for peak-aged alloys at 423K

Close inspection of TEM bright field images in under-aged (0.96ks) alloys at 423K (Figure 3a–3c), revealed that there was a fine distribution of spherical shaped precipitates in Cu free alloy. While in Cu addition alloys, rod shaped precipitates were also observed in addition to the spherical shaped ones. In selected area electron diffraction (SAED), diffraction spots from the 2nd cluster [4] were observed in all alloys. In addition, the diffraction spots of the η' phase were observed in only Cu-addition alloys.

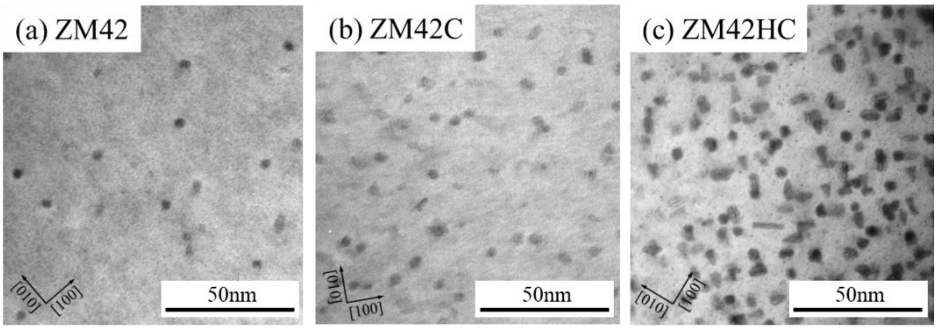


Figure 3. TEM bright field images aged 0.96 ks at 423K [0 0 1]$_{Al}$ projection

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KEYWORDS

Al-Zn-Mg alloy, Age hardening, Precipitates, TEM, Cu addition