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Al-Cu-Mg-Sc-Zn-Zr (Aluminum-Copper-Magnesium-Scandium-Zinc-Zirconium)

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Addition of Sc and Zr in small quantities (0.3 mass% or less) is known to improve the mechanical properties of commercial Al-rich Al-Cu-Mg-Zn alloys. Recently, [2004Rok] reported the effect of scandium and zirconium on the phase relationships of the Al-Cu-Mg-Zn quaternary system.

Phase Equilibria in Subsystems and the Senary System

[2004Rok] found in this system the following phases of the lower-order systems. The T phase variants $(Al,Cu)_{49}Mg_{32}$, $(Al,Zn)_{49}Mg_{32}$ and $(Al,Cu,Zn)_{49}Mg_{32}$ were treated as one phase (cubic, space group $Im\bar{3}$) and denoted as T. The Laves phases $MgZn_2$, $Mg(Cu_xAl_{1-x})_2$, and $Mg(Cu,Al,Zn)_2$ were similarly treated as one phase and denoted as M by [2004Rok]. A $ThMn_{12}$-type phase denoted W with a composition range of $ScCu_{6.6-4}Al_{5.4-8}$ in the Al-Cu-Sc ternary system was found in this six-component system. The binary phases found in the composition range investigated are $CuAl_2$ (*C*16-type tetragonal, θ), $ScAl_3$ ($AuCu_3$-type cubic) and $ZrAl_3$ (tetragonal, space group *I*4/*mmm*).

With starting metals of 99.99% Al, 99.96% Cu, 99.96% Mg, 99.975% Sc, 99.975% Zn, and 99.98% Zr, [2004Rok] melted alloys in an electrical resistance furnace, using a flux to prevent loss of Mg and Zn. The alloys were then annealed at different temperatures between 650 and 250 °C and quenched in water. The phase equilibria were studied with differential thermal analysis (DTA), light microscopy, x-ray diffraction, and x-ray local spectral analysis. The heating and cooling rate in DTA was 3 °C per min.

As the phase equilibria of several subsystems are not known, [2004Rok] investigated initially a few selected subsystems at compositions of interest in commercial Al-rich alloys. The Al-Cu-Zn-Zr system was studied with a constant Zr content of 0.3 mass% and in the range of 0-20 mass% Zn and 0-12 mass% Cu. The alloys were annealed at 500 and 250 °C for 100 and 200 h respectively. The isothermal section at 500 °C constructed by [2004Rok] is shown in Fig. 1. The binary phase $ZrAl_3$ is present in all phase fields.

Addition of Mg to Al-Cu-Zn-Zr alloys resulted in the formation of additional phases. [2004Rok] studied the Al-Cu-Mg-Zn-Zr quinary system in the temperature range of 600-400 °C and at constant contents of 8Zn, 2Cu, and 0.3Zr (in mass%) and Mg range of 0 to 8 mass%. The addition up to 1 mass% Mg did not change the phase distribution found in Al-Cu-Zn-Zr alloys. With higher Mg contents, the M and T phases appear in succession. The polythermal section at 2Cu-8Zn-0.3Zr (in mass%) constructed by [2004Rok] is shown in Fig. 2. The

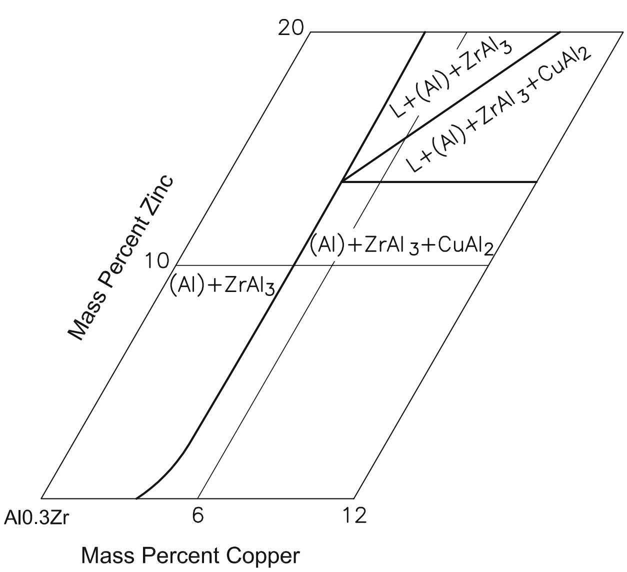

Fig. 1 Al-Cu-Zn-Zr isothermal section at 0.3 mass% Zr and 500 °C [2004Rok]

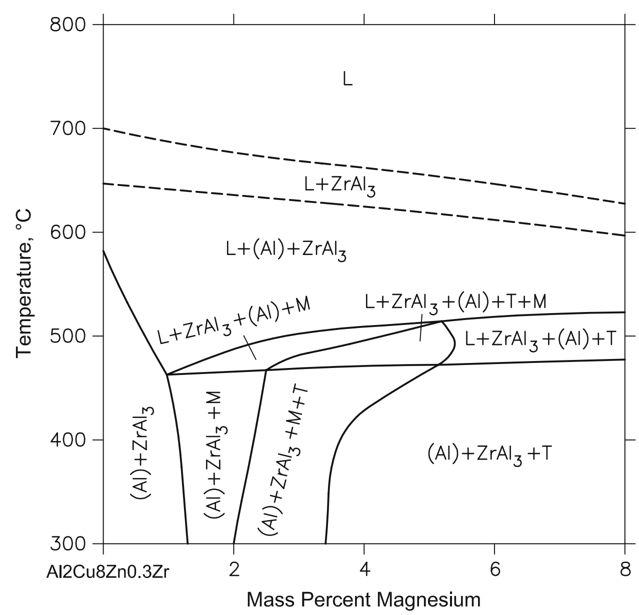

Fig. 2 Al-Cu-Mg-Zn-Zr polythermal section at 2Cu-8Zn-0.3Zr (in mass%) [2004Rok]

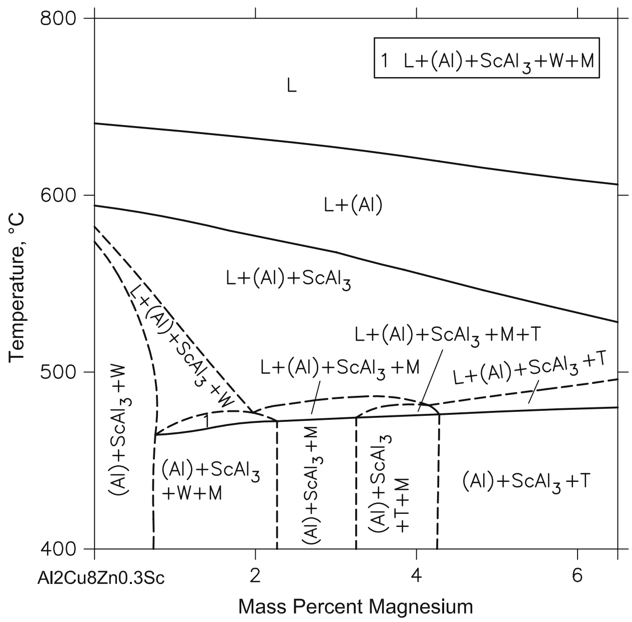

Fig. 3 Al-Cu-Mg-Sc-Zn polythermal section at 2Cu-8Zn-0.3Sc (in mass%) [2004Rok]

crystallization starts with the precipitation of $ZrAl_3$. (Al) crystallizes next, followed by M and T phases. Fig. 3 shows the polythermal section of [2004Rok] at 2Cu-8Zn-0.3 Sc (in mass%) as a function of Mg content. Here, the crystallization starts with (Al). $ScAl_3$ crystallizes next, followed by W, M and T phases. The ternary phase W ($ScCu_{6.6-4}Al_{5.4-8}$) is present at all concentrations of Mg. The M phase is present in alloys with Mg content of 1 mass% and above. The T phase forms at still higher Mg contents. There is a gradual decrease of the liquidus temperature with increasing Mg.

The six-component (senary) system was studied at 2 Cu, 8 Zn, 0.3 Sc, and 0.3 Zr (in mass%) [2004Rok]. Alloy

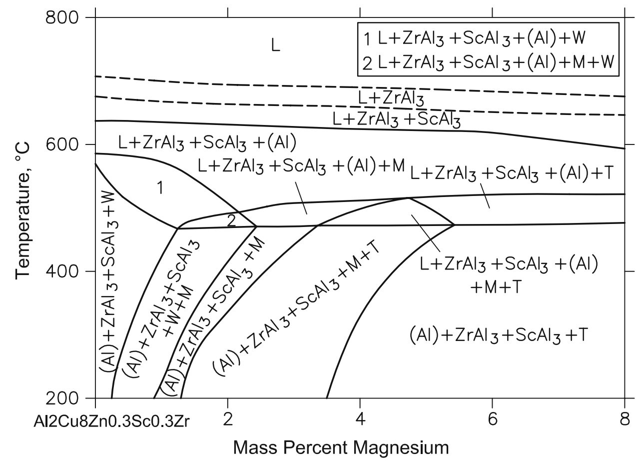

Fig. 4 Al-Cu-Mg-Sc-Zn-Zr polythermal section at 2Cu-8Zn-0.3Sc-0.3Zr (in mass%) [2004Rok]

samples were annealed at 500, 460 and 250 °C for 10, 100 and 200 h respectively, to supplement DTA results. The $ScAl_3$ and $ZrAl_3$ phases could not be distinguished by microscopy, but were identified by x-ray diffraction. In the alloy with 7 mass% Mg, Zr, and Zn dissolve up to 11 and 6 mass% respectively in $ScAl_3$. $ZrAl_3$ dissolves ~ 3 mass% Sc and 4 mass% Zn. The polythermal section at 2Cu-8Zn-0.3Sc-0.3Zr (in mass%) constructed by [2004Rok] as a function of Mg content is shown in Fig. 4.

Reference

2004Rok: L.L. Rokhlin, T.V. Dobatkina, N.R. Bochvar, and E.V. Lysova, Investigation of Phase Equilibria in Alloys of the Al-Zn-Mg-Cu-Zr-Sc System, *J. Alloys Compd*, 2004, **367**, p 10-16