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Al-Mn-Sc (Aluminum-Manganese-Scandium)

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The early results of [1984Dri] on this system presented isothermal sections at 600 and 500 °C for the Al corner and two vertical sections at 0.8 mass% Sc and at 0.8 mass% Mn respectively. Recently, [2008Rok] investigated the solubility of Sc and Mn in solid Al at 640, 600 and 400 °C.

Binary Systems

The Al-Mn phase diagram depicts a number of intermediate phases in the Al-rich region [1997Oka]: $MnAl_6$ ($D2_h$-type orthorhombic), λ (16.8-19 at.% Mn), $MnAl_4$ (hexagonal, denoted μ), Mn_4Al_{11} (orthorhombic and triclinic forms), γ (34.5-51.3 at.% Mn; bcc), γ_1 (30-38.2 at.% Mn), γ_2 (31.4-47 at.% Mn; $D8_{10}$, Cr_5Al_8-type rhombohedral), and Mn_3Al_2 (53.2-60 at.% Mn, denoted ε; close packed hexagonal). The Al-Sc phase diagram [1999Cac, Massalski2] depicts the following intermediate compounds: $ScAl_3$ ($L1_2$, $AuCu_3$-type cubic), $ScAl_2$ ($C15$, $MgCu_2$-type cubic), ScAl ($B2$, CsCl-type cubic), and Sc_2Al ($B8_2$, Ni_2In-type hexagonal). The Mn-Sc system [Massalski2] has one intermediate phase: Mn_2Sc ($C14$, $MgZn_2$-type hexagonal).

Ternary Isothermal Sections

With starting metals of 99.99% Al, 99.81+% Mn and 99.875% Sc, [2008Rok] melted in a resistor furnace or arc furnace alloys containing up to 3 at.% Sc and 2.5 at.% Mn. The alloys were given a final anneal at 640, 600, and 400 °C for 20, 30, and 100 h respectively and quenched in water. The phase equilibria were studied by optical microscope, scanning electron microscope equipped with energy dispersive x-ray analyzer, and by electrical resistivity measurements. The isothermal section at 640 °C in Al rich alloys constructed by [2008Rok] is shown in Fig. 1. The Al solid solution is in equilibrium with $MnAl_6$ and $ScAl_3$. The Sc solubility in $MnAl_6$ and Mn solubility in $ScAl_3$ were found to be less than 0.1 at.%. Figure 2 compares the phase distribution near the Al corner in samples annealed at 640, 600, and 400 °C. The decreasing solubility of Sc and Mn in Al with decreasing temperature points to the possibility of precipitation hardening in these alloys.

The phase equilibrium of alloys along the $MnAl_6$-$ScAl_3$ join at 497 °C (770 K) was studied by [1997Sok]. They arc-melted six alloys along the join and annealed them at 497 °C for 1500 h. The phase equilibrium was studied with x-ray diffraction and electron probe microanalysis. They found that there is very little mutual solubility between the

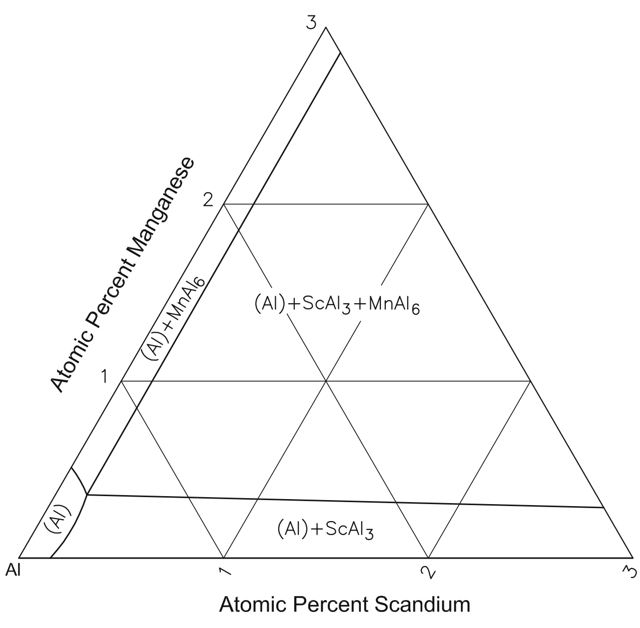

Fig. 1 Al-Mn-Sc isothermal section at 640 °C for Al-rich alloys [2008Rok]

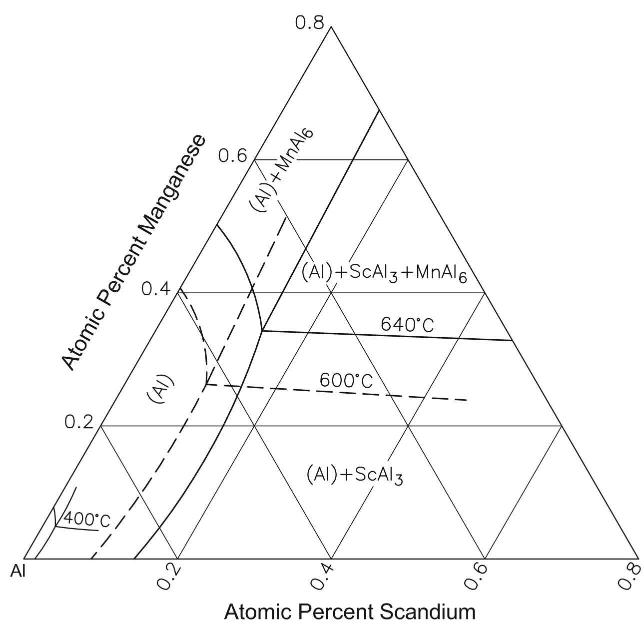

Fig. 2 Al-Mn-Sc phase distribution near the Al corner at the indicated temperatures [2008Rok]

end components. At 497 °C, $MnAl_6$ dissolves 0.4 at.% Sc and $ScAl_3$ dissolves 0.6 at.% Mn [1997Sok].

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