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Al-Cr-Mn (Aluminum-Chromium-Manganese)

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The experimental data on this ternary system up to 1972 were compiled by [1995Vil]. More recently, [1998Sch] clarified the phase relationships in the Al-rich region. They found a continuous solid solution μ between $CrAl_4$ and $MnAl_4$ and also identified a new ternary phase of monoclinic symmetry.

Binary Systems

The Al-Cr phase diagram depicts a number of intermediate phases with significant ranges of homogeneity: $CrAl_7$ (V_7Al_{45}-type monoclinic), Cr_2Al_{11} ($CrAl_5$-type monoclinic), $CrAl_4$ (hexagonal), Cr_2Al ($MoSi_2$-type tetragonal), and an unconfirmed low-temperature phase X at ~75 at.% Cr. Between 30 and 41 at.% Cr, five phases have been reported: αCr_4Al_9, βCr_4Al_9, γCr_4Al_9, αCr_5Al_8, and βCr_5Al_8, with no well-established phase boundaries between them [2000Mah]. The Al-Mn phase diagram [Massalski2, 1998Sch] has the following intermediate phases: $MnAl_6$ ($D2_h$-type orthorhombic), $MnAl_{4.5}$ (λ, hexagonal, space group $P6_3/m$), $MnAl_4$ (μ, hexagonal, space group $P6_3/mmc$), Mn_4A_{11} (triclinic), γ_2 (~31.4-48.5 at.% Mn, $D8_{10}$, Cr_5Al_8-type rhombohedral), γ_1 (~30-38.2 at.% Mn), γ (34.5-52 at.% Mn, body-centered cubic), and ε (55-72 at.% Mn, close-packed hexagonal).

Ternary Phase Equilibria

With starting metals of 99.99 % purity, [1998Sch] induction-melted 10 Al-rich ternary alloys under Ar atm. Differential thermal analysis was carried out at a heating/cooling rate of 5 °C/min. For isothermal studies of the liquid-solid equilibria at 800, 750, and 700 °C, the samples were equilibrated for 40 min and quenched in water. Phase compositions were determined by electron probe microanalysis. Phase structures were identified with x-ray powder diffraction, electron diffraction and high resolution imaging in a transmission electron microscope.

A ternary phase, denoted τ here and ψ by [1998Sch] with an average composition of $Al_{82}Cr_{2.3}Mn_{15.7}$, has monoclinic symmetry, space group $C2/c$ or Cc, and lattice parameters of a = 1.748 nm, b = 3.031 nm, c = 2.4695 nm, and β = 135°. The isomorphous phases $CrAl_4$ and $MnAl_4$ form a continuous hexagonal solid solution denoted μ. The lattice parameters vary from a = 2.0076 nm and c = 2.480 nm at $CrAl_4$ to a = 1.998 nm and c = 2.467 nm at $MnAl_4$. This solid solution depicts local icosahedral order, characteristic of many Al-transition metal compounds with very large cell parameters. For more structural details, see [1998Sch].

The liquidus projection for Al-rich alloys determined by [1998Sch] is shown in Fig. 1. A liquidus line starting from the Al-Cr side at 1030 °C terminates at the Al-Mn side at 923 °C. The liquidus surface on the right of this line in

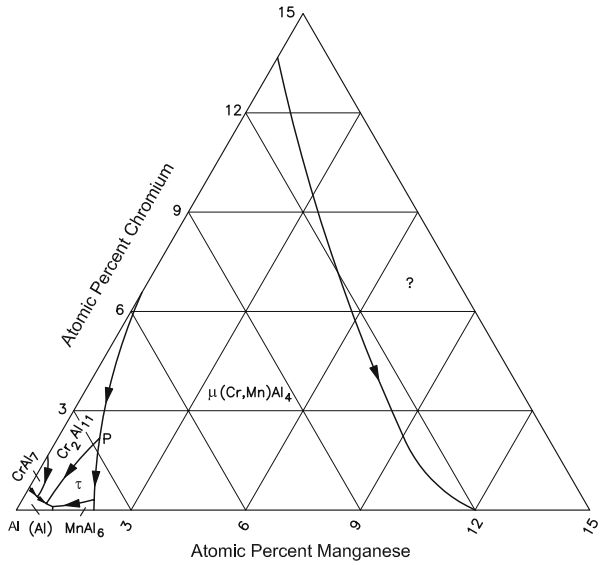

Fig. 1 Al-Cr-Mn liquidus projection for Al-rich alloys [1998Sch]

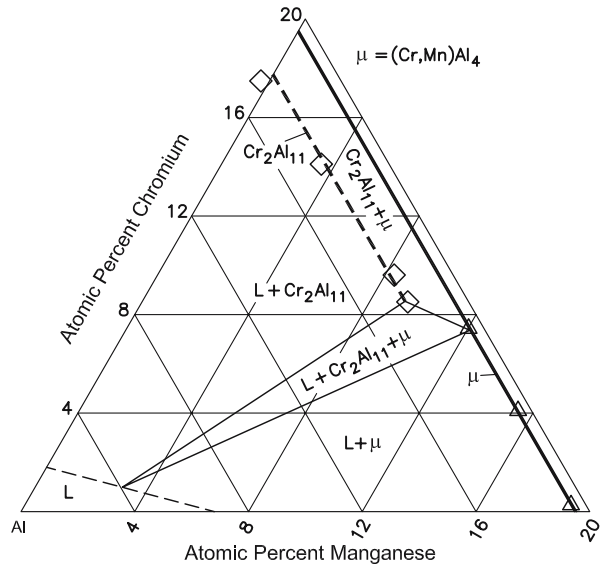

Fig. 2 Al-Cr-Mn isothermal section for Al-rich alloys at 800 °C [1998Sch]

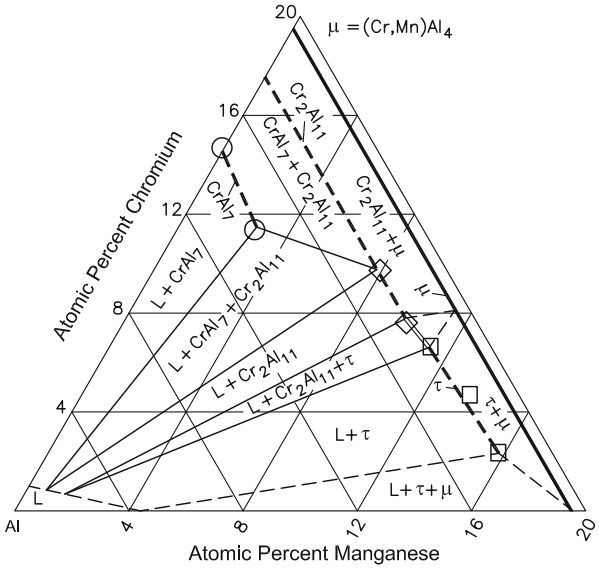

Fig. 3 Al-Cr-Mn isothermal section for Al-rich alloys at 750 °C [1998Sch]

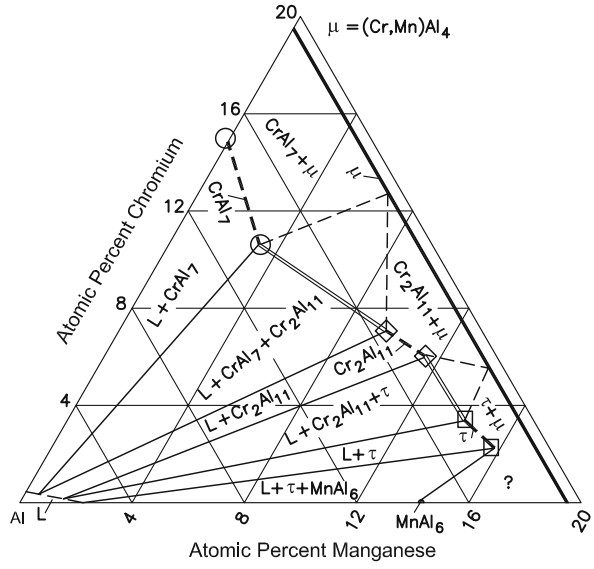

Fig. 4 Al-Cr-Mn isothermal section for Al-rich alloys at 700 °C [1998Sch]

Fig. 1 is not known. On the left, near the Al corner, several four-phase reactions occur. The primary phases are marked. The ternary phase τ (or ψ) forms probably through a ternary peritectic reaction P. The final solidification is at ~658 °C near the Al-$MnAl_6$ eutectic point. Tie-triangles and tie-lines were determined at 800, 750, and 700 °C and the co-existing compositions were listed [1998Sch]. Partial isothermal sections constructed by [1998Sch] at 800, 750, and 700 °C are shown in Fig. 2-4. Tentative phase boundaries, shown as broken lines, were added by this reviewer.

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