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Al-Fe-Mn (Aluminum-Iron-Manganese)

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The previous review of this system by [1988Ray] presented liquidus and solidus projections for Fe-rich alloys and for compositions near the Al corner, and partial isothermal sections at 1200, 1000, and 760 °C for Fe-rich alloys and at 600 °C for the Al-rich region. An update by [1994Rag] added two more computed isothermal sections for Fe-rich alloys at 1400 and 1100 °C from the work of [1993Liu]. [1996Liu] reported experimental isothermal sections at 1300, 1200, 900, and 800 °C for Al-poor alloys. [1997Mul] presented a partial isothermal section at 700 °C near the Mn-Al side.

Binary Systems

The Al-Fe phase diagram [1993Kat] shows that the face-centered cubic (fcc) solid solution based on Fe is restricted by a γ loop. The body-centered cubic (bcc) solid solution α exists in the disordered *A*2 form, as well as the ordered *B*2 and $D0_3$ forms. Apart from the high-temperature phase ε, there are three other intermediate phases in the system: $FeAl_2$ (triclinic), Fe_2Al_5 (orthorhombic), and $FeAl_3$ (monoclinic). The Al-Mn phase diagram [Massalski2] has a number of intermediate phases: Al_6Mn ($D2_h$-type orthorhombic), two hexagonal phases around the composition Al_4Mn, (denoted λ and μ in [Massalski2]), $Al_{11}Mn_4$ (orthorhombic at high temperatures and triclinic at low temperatures), γ (35 to 51 at.% Mn, unknown structure), γ_1 (30 to 38 at.% Mn, unknown structure), γ_2 (31 to 47 at.% Mn, Al_8Cr_5-type rhombohedral), and ε (close-packed hexagonal, or cph). For a thermodynamic assessment of the Al-Mn phase diagram, see [1999Liu]. The Fe-Mn phase diagram [1993Oka] contains no intermediate phases. It depicts a wide range of mutual solid solubility between face-centered cubic (fcc) Fe and γMn.

Ternary Isothermal Sections

Using starting metals of purity 99.99% Al, 99.9% Fe, and 99.9% Mn, [1996Liu] melted alloy compositions in the Al-poor region in an arc furnace under an Ar atmosphere. The phase equilibria were studied by the diffusion couple technique and differential thermal analysis (DTA). The compositions of the coexisting phases were measured by the electron probe microanalysis and listed. The partial isothermal sections constructed by [1996Liu] at 1300, 1200, 900, and 800 °C are redrawn in Fig. 1 to 4. The sections show satisfactory agreement with the computed sections by the same authors [1993Liu], except at 1300 °C. Using the thermal arrests obtained from DTA and the isothermal sections as a guide, [1996Liu] constructed two vertical sections at 4 and 8 wt.% Al, respectively.

Using starting metals of purity >99.9 %, [1997Mul] arc-melted (in Ar atmosphere) a series of ternary alloy compositions, with Fe replacing Mn in the basic composition of 55Mn45Al (at.%). The phase equilibria were studied by high-temperature x-ray diffraction and electron probe microanalysis. The partial isothermal section constructed by [1997Mul] at 700 °C is redrawn in Fig. 5. The γ_2-(βMn) two-phase equilibrium extends from the Al-Mn side into the ternary region. At Fe > 10 at.%, a ternary phase κ is present. Iron was found to have no stabilizing effect on the metastable, magnetic Al-Mn phase τ (AuCu-type tetragonal).

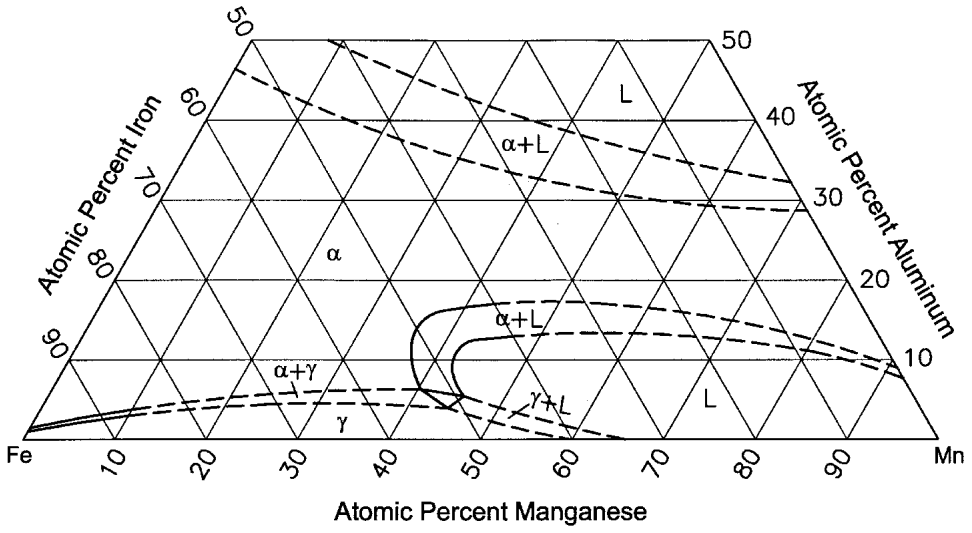

Fig. 1 Al-Fe-Mn isothermal section at 1300 °C [1996Liu]

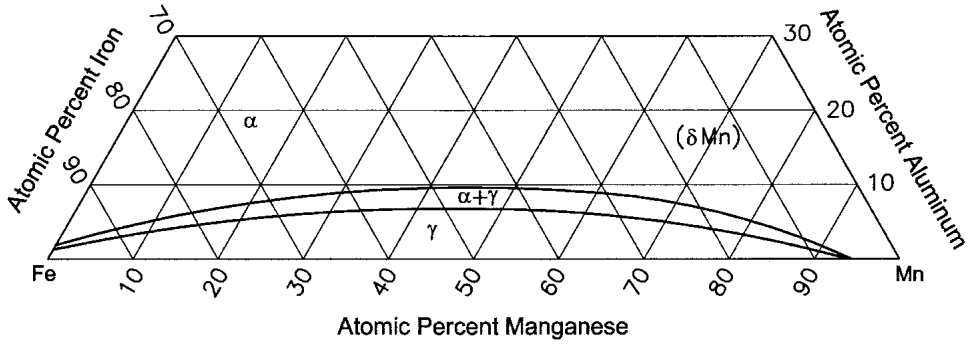

Fig. 2 Al-Fe-Mn isothermal section at 1200 °C [1996Liu]

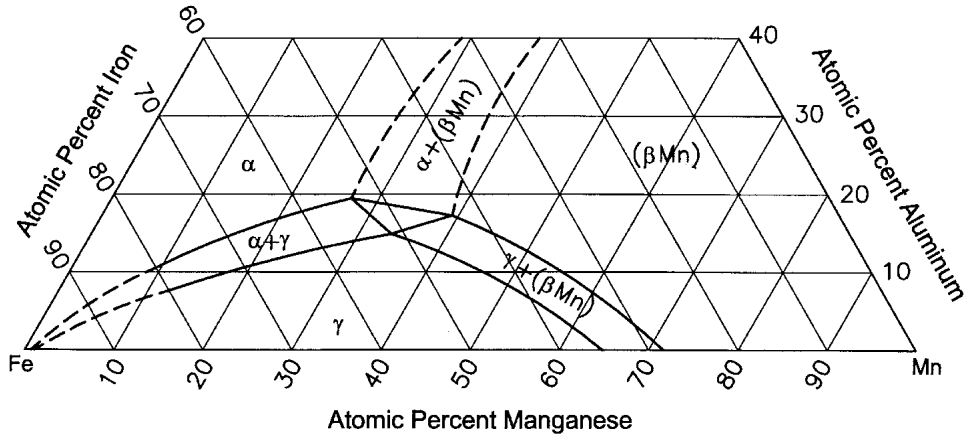

Fig. 3 Al-Fe-Mn isothermal section at 900 °C [1996Liu]

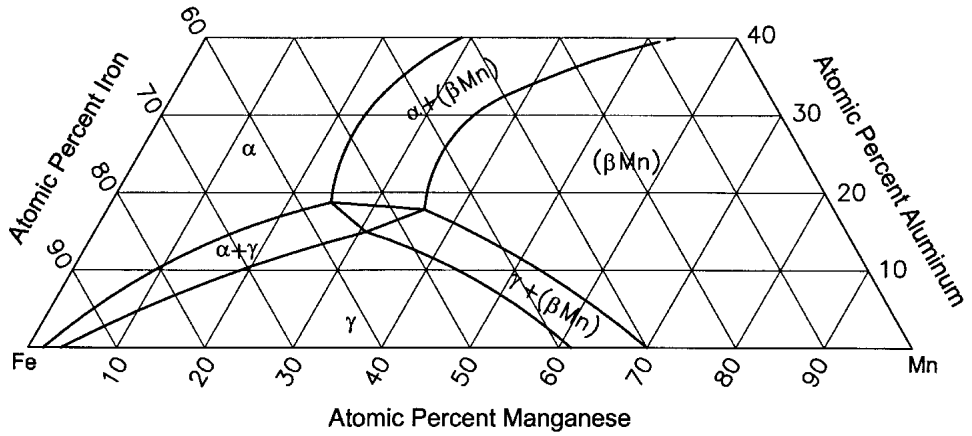

Fig. 4 Al-Fe-Mn isothermal section at 800 °C [1996Liu]

Using starting metals of purity 99.99% Al, 99.9% Fe, and 99.9% Mn, [1997Wei] arc-melted alloy buttons, which were given a final anneal at 550 °C for up to 1500 h and were quenched in water. The phase equilibria were studied by optical microscopy, x-ray powder diffraction, and electron probe microanalysis. The binary compound Al_6Mn dissolves Fe up to 8.6 at.%. $Al_{4.15}Mn$ (λ) dissolves 1.5 at.% Fe, Al_4Mn (μ) shows no solubility for Fe, and $Al_{11}Mn_4$ dissolves 2.9 at.% Fe. $FeAl_3$ (denoted Fe_4Al_{13} by [1997Wei]) dissolves 9.5 at.% Mn, and Fe_2Al_5 dissolves 6 at.% Mn. [1997Wei] reported four ternary phases: τ_1 (80 Al, 2-4 Fe) of unknown structure, τ_2 (76.5 Al, 9-10 Fe) with orthorhombic symmetry, τ_3 (76.9 Al, 5 Fe) of hexagonal structure, and τ_4 (64.5 Al, 7.5 Fe) with Cr_5Al_8-type rhombohedral structure. Pending further confirmation of the stability, structure, and composition of these ternary phases, the par-

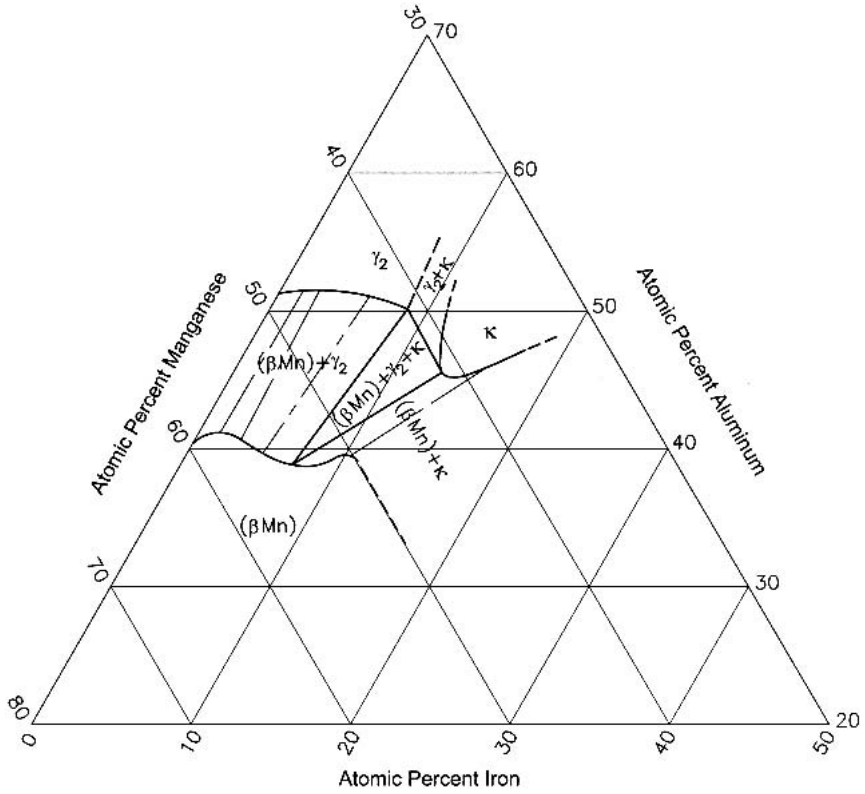

Fig. 5 Al-Fe-Mn partial isothermal section at 700 °C [1997Mul]

tial isothermal section drawn by [1997Wei] at 550 °C is not given here.

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