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Al-Fe-Mo (Aluminum-Iron-Molybdenum)

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The early review of this system by [1992Rag] presented two isothermal sections at 1050 and 800 °C from the work of [1970Mar]. An update by [2005Rag] reviewed the isothermal section at 1000 °C determined by [1999Eum]. Extending this work, [2008Eum1, 2008Eum2] made a detailed investigation of the isothermal sections at 1150, 1000, and 800 °C.

Binary Systems

The Al-Fe phase diagram [1993Kat] shows a gamma 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 ($D8_2$, Cu_5Zn_8-type cubic; stable between 1232 and 1102 °C), there are three intermediate phases in the system: $FeAl_2$ (triclinic, space group $P\bar{1}$), Fe_2Al_5 (orthorhombic, space group *Cmcm*), and Fe_4Al_{13} (or $FeAl_3$; monoclinic, space group *C*2/*m*). The Al-Mo phase diagram [2008Eum1] depicts the following intermediate phases: $MoAl_{12}$ ($Al_{12}W$-type cubic), $MoAl_5$ (r) (rhombohedral, space group $R\bar{3}c$), $MoAl_5$ (h′) (hexagonal, *P*321), $MoAl_5$ (h) (hexagonal, $P6_322$), Mo_5Al_{22} (orthorhombic, *Fdd*2), Mo_4Al_{17} (monoclinic, *C*2), $MoAl_4$ (monoclinic, *Cm*), $MoAl_3$ (monoclinic, *C*2/*m*), Mo_3Al_8 (monoclinic, *Cm*), $Al_{63}Mo_{37}$, MoAl (bcc), and Mo_3Al (*A*15, Cr_3Si-type cubic). In the Fe-Mo phase diagram [Massalski2], the σ phase ($D8_b$-type tetragonal) and the *R* phase (rhombohedral) form through peritectic reactions and decompose above 1200 °C. Fe_7Mo_6 (denoted μ; $D8_5$-type rhombohedral) and Fe_2Mo (*C*14, $MgZn_2$-type hexagonal) form in the solid state. The iron-based bcc phase α and (Mo) show significant mutual solubility.

Ternary Phases

Two ternary phases are known in this system: Al_8FeMo_3 (τ_1) has the $D0_{22}$, αTiAl_3-type of tetragonal structure with lattice parameters of a = 0.3745 nm and c = 0.8390 nm. It forms at a temperature above 1150 °C and decomposes eutectoidally at ~850 °C. It has a small homogeneity range

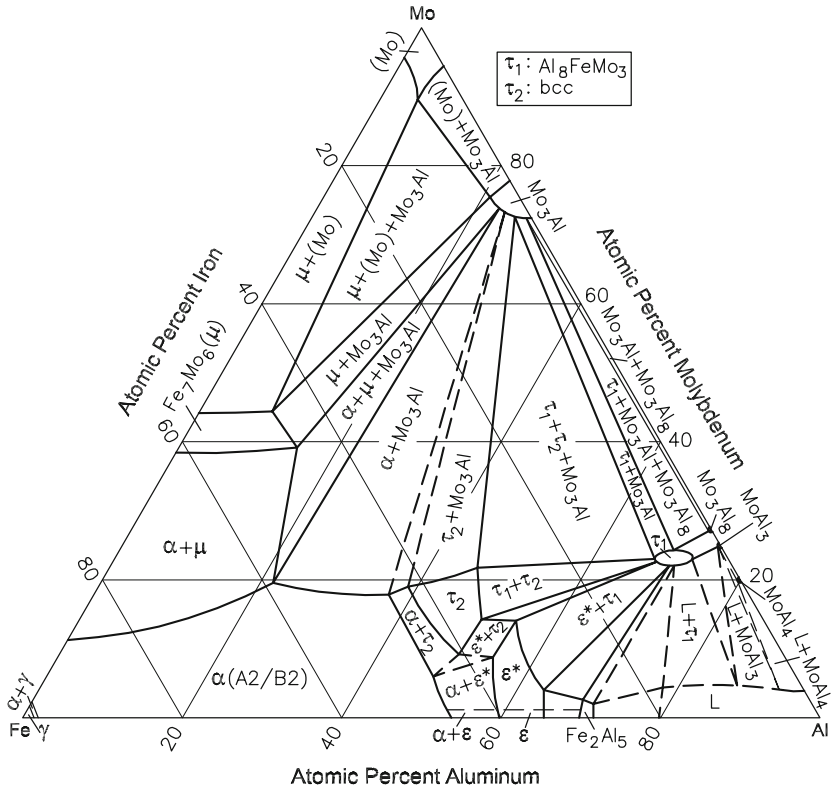

Fig. 1 Al-Fe-Mo isothermal section at 1150 °C [2008Eum2]

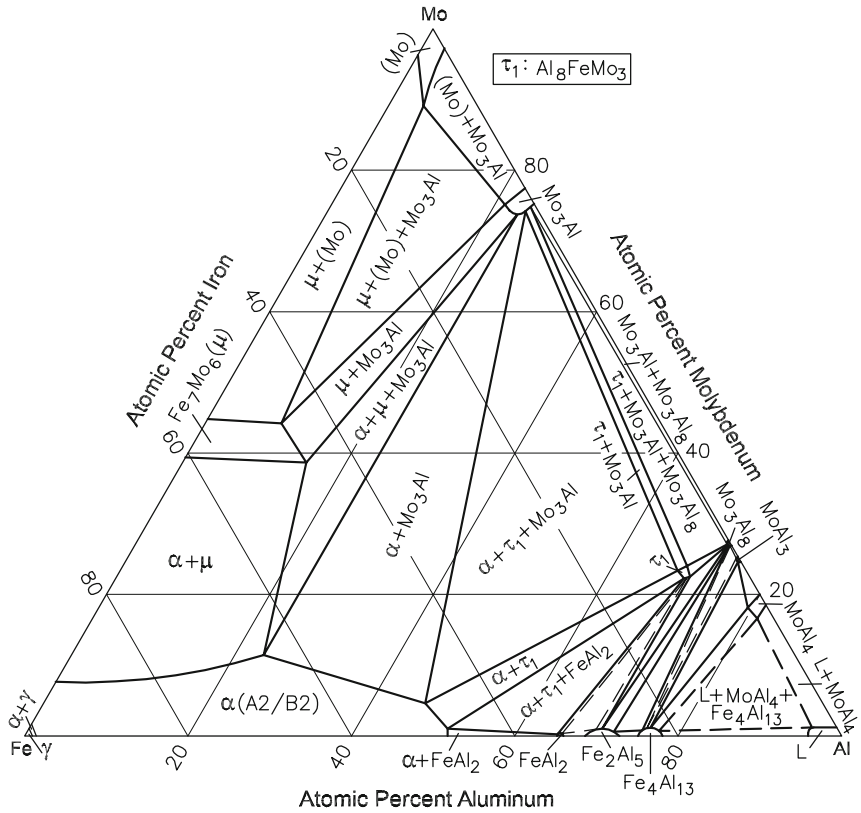

Fig. 2 Al-Fe-Mo isothermal section at 1000 °C [2008Eum2, 1999Eum]

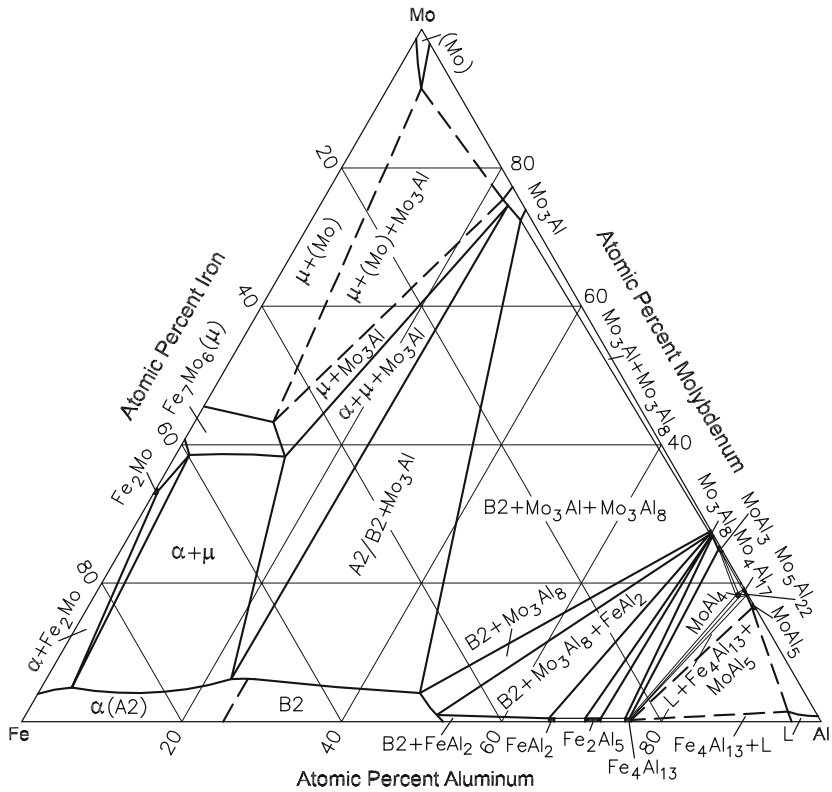

Fig. 3 Al-Fe-Mo isothermal section at 800 °C [2008Eum1]

of 67.9-69.6 at.% Al and 22.0-24.2 at.% Mo at 1000 °C and 67.7-71.6 at.% Al and 22.1-24.4 at.% Mo at 1150 °C [2008Eum2]. The other phase τ_2 also forms above 1150 °C, has a homogeneity range and decomposes eutectoidally between 1071 and 1095 °C. It has the *A*2-type bcc structure and a lattice parameter range of 0.296-0.313 nm. On addition of Mo, the high-temperature Fe-Al phase ε, which possesses a $D8_2$, Cu_5Zn_8-type cubic structure, undergoes a transition to ε* with $D8_{10}$, Cr_5Al_8-type rhombohedral structure [2008Eum2].

With starting metals of 99.999% Al, 99.95% Fe and 99.95% Mo, [2008Eum1, 2008Eum2] melted 13 binary and 54 ternary alloys by levitation melting under Ar atm. The alloys were annealed at 1150, 1000 and 800 °C for 200, 500 and 1000 h respectively and were quenched in iced brine. The phase equilibria were studied with the diffusion couple technique, optical and scanning/transmission electron microscopy, electron probe microanalysis, x-ray powder diffraction and differential thermal analysis. The isothermal sections constructed by [2008Eum2] at 1150, 1000 and 800 °C are shown in Fig. 1-3. At 1150 °C (Fig. 1), both ternary phases τ_1 and τ_2 are present. The τ_2 phase has an extended homogeneity range with the concentration of the three elements varying about 10 at.% each. The transition in the ε phase to the ε* modification is indicated by a dotted line inside this phase region, which extends up to ~ 14 at.% Mo. The binary phases $FeAl_2$ and Fe_4Al_{13} were not detected by [2008Eum2] at 1150 °C.

At 1000 °C (Fig. 2) [2008Eum2, 1999Eum], τ_2 and ε/ε* phases are not stable and only τ_1 is present. At 800 °C (Fig. 3) [2008Eum1], none of the ternary phases are present. The binary phase Al_4Mo, stabilized by a small amount of Fe, is present in the ternary region at 800 °C.

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