Al-Fe-U (Aluminum-Iron-Uranium)

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The experimental data on this ternary system were updated by [2006Rag], who presented an isothermal section at 850 °C from the work of [2005Gon]. Recently, [2010Mes] determined a liquidus projection for Al-rich alloys.

Binary Phases

In the Fe-Al phase diagram [Massalski2], the solid solution γ based on face-centered cubic (fcc) Fe is restricted by a loop. The solid solution based on the body-centered cubic (bcc) Fe (α) exists in both the disordered ($A2$) and the ordered ($B2$ and $D0_3$) forms. Apart from the high temperature phase ϵ ($D8_2$, Cu_5Zn_8 -type cubic), there are three intermediate phases in the system with restricted ranges of homogeneity: FeAl_2 (triclinic), Fe_2Al_5 (orthorhombic) and $\text{Fe}_4\text{Al}_{13}$ (monoclinic). In the Al-U system [Massalski2], the intermediate phases are: UAl_2 ($C15$, MgCu_2 -type cubic), UAl_3 ($L1_2$, AuCu_3 -type cubic) and $\text{U}_{0.9}\text{Al}_4$ ($D1_b$ -type orthorhombic). The Fe-U phase diagram [Massalski2] has two compounds: Fe_2U ($C15$, MgCu_2 -cubic) and FeU_6 ($D2_c$, MnU_6 -type tetragonal).

Ternary Phases

The structural characteristics of seven known ternary phases of this system were summarized by [2006Rag]. All these phases are present in the isothermal section at 850 °C [2005Gon]. In the Al-rich alloys reviewed here, $\text{UFe}_2\text{Al}_{10}$ (denoted τ_1 by [2006Rag]) ($\text{YbFe}_2\text{Al}_{10}$ -type orthorhombic) is present. In addition, a new Al-rich compound $\text{U}_2\text{FeAl}_{20}$ (denoted τ here) is present (not listed by [2006Rag]). This phase was reported by [2008Mes] to be tetragonal, space group $I42m$ with lattice parameters $a = 1.24138$ nm and $c = 1.03014$ nm.

Liquidus Projection

With starting metals of 99.99% Al, 99.99% Fe and 99.95% U, [2010Mes] arc-melted under Ar atm six ternary alloys containing 80 to 92 at.% Al. The phase equilibria were studied with differential scanning calorimetry, x-ray powder diffraction, optical and scanning electron microscopy and energy dispersive x-ray analysis. The liquidus surface constructed by [2010Mes] for Al-rich alloys is shown in Fig. 1. $\text{UFe}_2\text{Al}_{10}$ (τ_1) forms through the ternary peritectic reaction P_1 : $L + \text{UAl}_3 + \text{Fe}_4\text{Al}_{13} \leftrightarrow \tau_1$ between 850 and 1157 °C. $\text{U}_2\text{FeAl}_{20}$ (τ) forms through the reaction

Fig. 1 Al-Fe-U tentative liquidus projection for Al-rich alloys [2010Mes]

P_2 : $L + \text{U}_{0.9}\text{Al}_4 + \tau_1 \leftrightarrow \tau$ at 639 °C. Keeping in view the binary eutectic reactions at the Al-end in the Al-Fe and Al-U systems, the final solidification is tentatively shown in Fig. 1 as a ternary eutectic reaction E.

References

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