JPEDAV (2006) 27:281-282
DOI: 10.1361/154770306X109827
1547-7037/$19.00 ©ASM International

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

V. Raghavan

The previous review of this system by [1992Rag] presented a liquidus projection, two isothermal sections at 1000 and 650 °C, and a reaction scheme for the Fe_2U-U-Al_2U region. [1994Gon] investigated the U-lean compositions of the general formula $U(Fe_{12-x}Al_x)$. Recently, [2005Gon] studied the entire composition range and determined an isothermal section at 850 °C, which depicts seven ternary phases.

Binary Systems

The Al-Fe phase diagram [1993Kat] depicts four intermediate phases: the high-temperature phase ε, $FeAl_2$ (triclinic), Fe_2Al_5 (orthorhombic), and $FeAl_3$ (monoclinic). The Fe-based body-centered cubic (bcc) solid solution α dissolves more than 50 at.% Al and exists also as ordered forms of the CsCl-type (*B*2) and BiF_3-type ($D0_3$). The Al-U phase diagram [Massalski2] depicts three intermediate phases: UAl_2 (*C*15, $MgCu_2$-type cubic), UAl_3 ($L1_2$, $AuCu_3$-type cubic), and $U_{0.9}Al_4$ ($D1_b$-type orthorhombic). The Fe-U phase diagram [1993Oka] has two line compounds: Fe_2U (*C*15, $MgCu_2$-type cubic) and FeU_6 ($D2_c$, MnU_6-type tetragonal).

Ternary Phases

The crystal structure data on the seven ternary phases of this system are listed in Table 1 [2005Gon]. UFe_2Al_{10} (τ_1) has the $YbFe_2Al_{10}$-type orthorhombic structure [2004Noe]. $U_2Fe_{3.6}Al_{13.4}$ (τ_2) is Th_2Ni_{17}-type hexagonal. $U_3Fe_{4+x}Al_{12-x}$ (τ_4) ($0 < x < 0.5$) is a $Gd_3Ru_4Al_{12}$-type hexagonal compound. UFe_xAl_{12-x} (τ_5) ($3 < x < 7$) is $ThMn_{12}$-type tetragonal. $U_2Fe_{17-x}Al_x$ (τ_6) ($8.5 < x < 10.3$) is Th_2Zn_{17}-type rhombohedral. $UFe_{1+x}Al_{1-x}$ (τ_7) ($\sim -0.05 < x < \sim 0.36$) is a *C*14, $MgZn_2$-type hexagonal compound at 850 °C. On annealing below 600 °C, it is stable as a ZrNiAl-type hexagonal phase. $U_2Fe_{12}Al_5$ (τ_8) is Th_2Ni_{17}-type hexagonal compound. The phases numbered 3 and 9 by [2005Gon] are extensions of two binary phases into the ternary region. UAl_2, numbered 3 by [2005Gon], dissolves up to ~12 at.% Fe at constant U content. UFe_2, numbered 9 by [2005Gon], dissolves up to ~8.3 at.% Al at constant U content.

Ternary Isothermal Section

[2005Gon] prepared 45 ternary alloy compositions by arc-melting or induction-melting under Ar atmosphere. The purity of the starting materials was not given. The samples were annealed at 850 °C for 10 days and quenched to room temperature. The phase equilibria were studied with x-ray powder diffraction and scanning electron microscopy. The compositions of the phases were determined by the energy dispersive x-ray spectroscopy. The isothermal section constructed by [2005Gon] is redrawn in Fig. 1 to agree with the accepted binary data. The composition ranges of the phases

Table 1 Al-Fe-U crystal structure and lattice parameter data

Phase	Composition, at.%	Pearson symbol	Space group	Prototype	Lattice parameter, nm
$UFe_2Al_{10}(\tau_1)$	76.9 Al	*oC*?	*Cmcm*	$YbFe_2Al_{10}$	$a = 0.89146$
	15.4 Fe				$b = 1.01986$
	7.7 U				$c = 0.90114$
$U_2Fe_{3.6}Al_{13.4}(\tau_2)$	70.5 Al	*hP*38	$P6_3/mmc$	Th_2Ni_{17}	$a = 0.88589$
	18.9 Fe				$c = 0.89824$
	10.5 U				
$U_3Fe_{4+x}Al_{12-x}(\tau_4)$	63.2-60.5 Al	*hP*?	$P6_3/mmc$	$Gd_3Ru_4Al_{12}$	$a = 0.87451$
	21.0-23.7 Fe				$c = 0.92588$(a)
	15.8 U				
$UFe_xAl_{12-x}(\tau_5)$	69.2-38.5 Al	*tI*26	*I*4/*mmm*	$ThMn_{12}$	$a = 0.8740$
	23.1-53.8 Fe				$c = 0.5036$(b)
	7.7 U				
$U_2Fe_{17-x}Al_x(\tau_6)$	44.7-54.2 Al	*hR*19	$R\bar{3}m$	Th_2Zn_{17}	$a = 0.8753$
	44.7-35.3 Fe				$c = 1.2658$(c)
	10.5 U				
$UFe_{1+x}Al_{1-x}(\tau_7)$	35.0-21.3 Al	*hP*12	$P6_3/mmc$	$MgZn_2$	$a = 0.518$
	31.7-45.3 Fe				$c = 0.808$(d)
$U_2Fe_{12}Al_5(\tau_8)$	26.3 Al	*hP*38	$P6_3/mmc$	Th_2Ni_{17}	$a = 0.8563$
	63.2 Fe				$c = 0.8438$
	10.5 U				

Lattice parameters at $x =$ (a) 0, (b) 4, (c) 9, and (d) 0.25

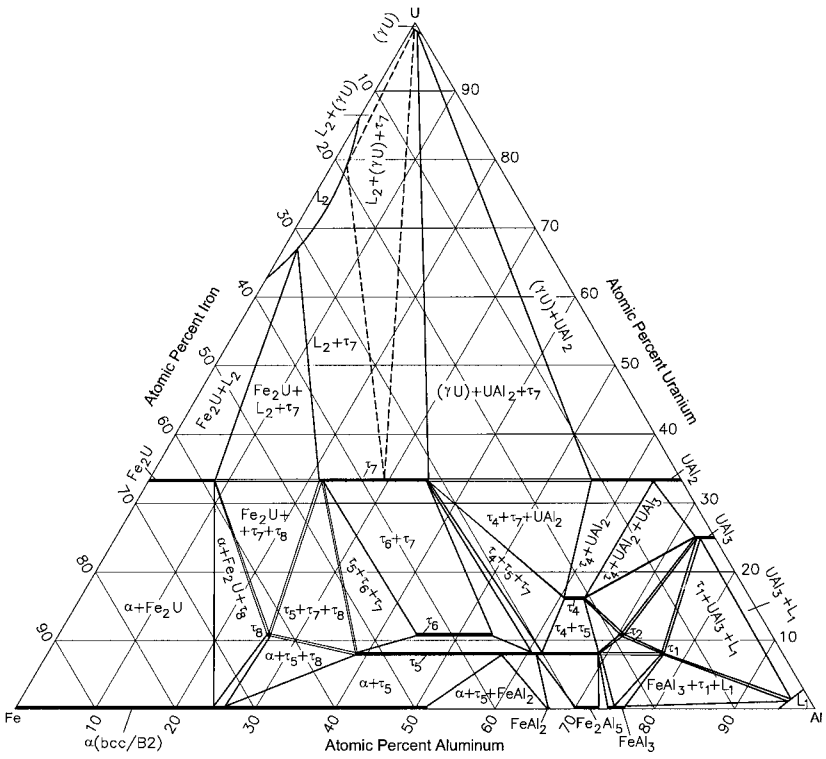

Fig. 1 Al-Fe-U isothermal section at 850 °C [2005Gon]

shown are those from the listed values. In a few cases, the listed values are significantly different from those in the figure drawn by [2005Gon]. All the ternary phases occur at or below ~33.3 at.% U. In all the compounds with a range of homogeneity, the mutual substitution is between Fe and Al at constant U content. Data are lacking on the extension of the bcc/*B*2 boundary of the Fe-Al α-phase into the ternary region.

References

1992Rag: V. Raghavan, The Al-Fe-U (Aluminum-Iron-Uranium) System, *Phase Diagrams of Ternary Iron Alloys, Part 6,* Indian Institute of Metals, Calcutta, India, 1992, p 196-203

1993Kat: U.R. Kattner and B.P. Burton, Al-Fe (Aluminum-Iron), *Phase Diagrams of Binary Iron Alloys,* H. Okamoto, Ed., ASM International, 1993, p 12-28

1993Oka: H. Okamoto, Fe-U (Iron-Uranium), *Phase Diagrams of Binary Iron Alloys,* H. Okamoto, Ed., ASM International, 1993, p 429-432

1994Gon: A.P. Goncalves, M. Almeida, C.T. Walker, J. Ray, and J.C. Spirlet, Phase Relations and Single Crystal Growth of U-Fe-M (M = Al, Si) Compounds with $ThMn_{12}$ Type Structure, *Mater. Lett.,* 1994, **19**(1-2), p 13-16

2004Noe: H. Noel, A.P. Goncalves and J.C. Waerenborgh, Characterization of Ternary UFe_2Al_{10}, *Intermetallics,* 2004, **12,** p 189-194

2005Gon: A.P. Goncalves and H. Noel, Isothermal Section at 850 °C of the U-Fe-Al Ternary System, *Intermetallics,* 2005, **13,** p 580-585