JPEDAV (2010) 31:285–287
DOI: 10.1007/s11669-010-9680-1
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Al-Cu-Er (Aluminum-Copper-Erbium)

V. Raghavan

An isothermal section for this ternary system at 600 °C was determined by [1989Kuz] and reviewed by [2004Ria]. Recently, [2008Zha] did a thermodynamic assessment of this system and presented an isothermal section at 600 °C and a liquidus projection.

Binary Systems

The Al-Cu phase diagram [2004Ria] depicts the following intermediate phases: $CuAl_2$ ($C16$-type tetragonal, denoted θ), CuAl(HT) (η_1, orthorhombic), CuAl(LT) (η_2, monoclinic), Cu_5Al_4(HT) (ζ_1, orthorhombic, space group $Fmm2$), Cu_5Al_4(LT) (ζ_2, orthorhombic, space group $Imm2$), ε_1(HT) (cubic?), ε_2(HT) ($B8_1$, NiAs-type hexagonal), Cu_3Al_2 (rhombohedral, denoted δ), Cu_9Al_4(HT) (γ_0, $D8_2$, Cu_5Zn_8-type cubic), Cu_9Al_4(LT) (γ_1, $D8_3$, Cu_9Al_4-type cubic), and Cu_3Al(β, bcc). The Al-Er phase diagram [2002Cac] has the following intermediate phases: Al_3Er ($L1_2$, $AuCu_3$-type cubic), Al_2Er ($C15$, $MgCu_2$-type cubic), AlEr (AlEr-type orthorhombic), Al_2Er_3 (Al_2Zr_3-type tetragonal) and $AlEr_2$ ($C23$, Co_2Si-type orthorhombic). The Cu-Er system [2008Zha] depicts the following compounds: Cu_5Er ($AuBe_5$-type cubic), Cu_9Er_2, Cu_7Er_2, Cu_2Er ($CeCu_2$-type orthorhombic) and CuEr ($B2$, CsCl-type cubic).

Ternary Compounds

Seven ternary compounds are known in this system [1989Kuz, 2004Ria]. The structural characteristics of these compounds are listed in Table 1 [2008Zha]. Al_8Cu_4Er (τ_1), Al_3CuEr (τ_4), $Al_5Cu_3Er_2$ (τ_5), $Al_9Cu_6Er_5$ (τ_6) and AlCuEr (τ_7) are compounds of fixed composition. $(Al,Cu)_{17}Er_2$ (τ_2) and $(Al,Cu)_5Er$ (τ_3) have a range of homogeneity at a constant Er content.

Computed Ternary Phase Equilibria

In the thermodynamic modeling, [2008Zha] used the binary descriptions of [2004Wit] for Al-Cu and [2002Cac] for Al-Er. [2004Wit] did not consider the high temperature forms of η, ε and ζ phases of the Al-Cu system. For the Cu-Er system, [2008Zha] made their own assessment. The liquid, fcc and cph phases were treated as substitutional solutions and the ternary interaction parameters were set

Table 1 Al-Cu-Er crystal structure and lattice parameter data [2008Zha]

Phase	Composition, at.%	Pearson symbol	Space group	Prototype	Lattice parameter, nm
Al_8Cu_4Er (τ_1)	61.5 Al 30.8 Cu 7.7 Er	*tI*26	*I*4/*mmm*	$Mn_{12}Th$	*a* = 0.8712 *c* = 0.5130
$(Al,Cu)_{17}Er_2$ (τ_2)	47.8-39.2 Al 41.7-50.3 Cu 10.5 Er	*hR*19	$R\bar{3}m$	Th_2Zn_{17}	*a* = 0.8630 *c* = 0.5029
$(Al,Cu)_5Er$ (τ_3)	20.1-51.9 Al 63.2-31.4 Cu 16.7 Er	*hP*6	*P*6/*mmm*	$CaCu_5$	*a* = 0.5029 *c* = 0.4139
Al_3CuEr (τ_4)	60 Al 20 Cu 20 Er	*oI*10	*Immm*	Al_3CuHo	*a* = 0.4184 *b* = 0.4112 *c* = 0.9773
$Al_5Cu_3Er_2$ (τ_5)	50 Al 30Cu 20 Er	…	…	…	…
$Al_9Cu_6Er_5$ (τ_6)	45 Al 30 Cu 25 Er	…	…	…	…
AlCuEr (τ_7)	33.3 Al 33.3 Cu 33.3 Er	*hP*9	$P\bar{6}2m$	Fe_2P	*a* = 0.6975 *c* = 0.4003

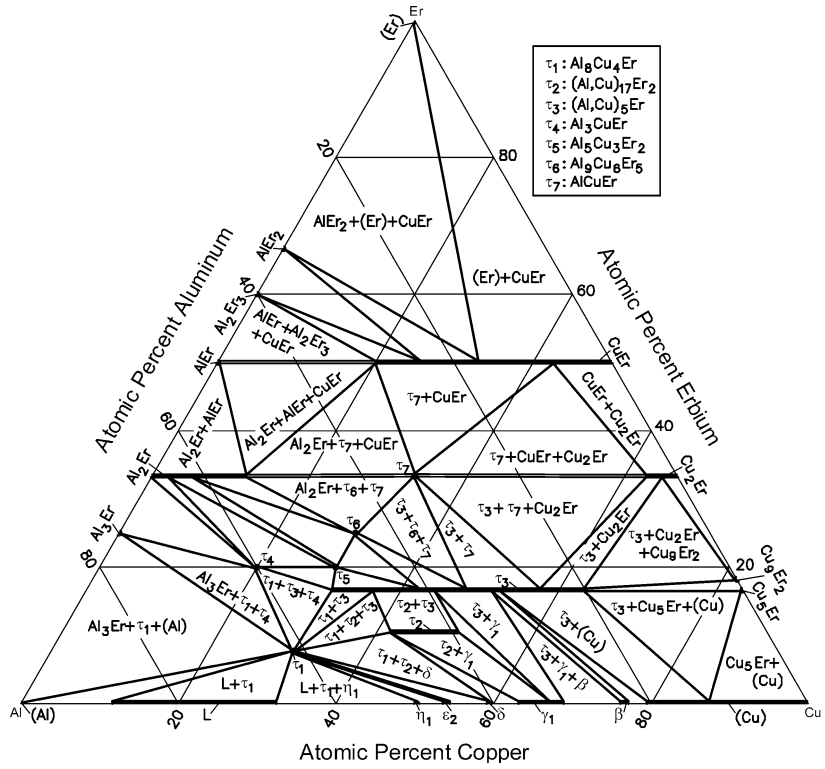

Fig. 1 Al-Cu-Er computed isothermal section at 600 °C [2008Zha]. Narrow two-phase regions are omitted

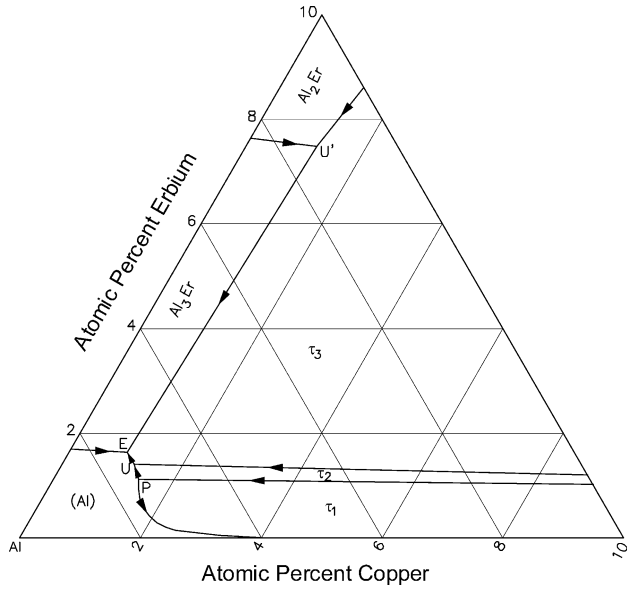

Fig. 2 Al-Cu-Er computed liquidus projection for Al-rich alloys [2008Zha]

to zero. The binary compounds were described by two sublattice models, providing for ternary solubility. The stoichiometric ternary compounds were modeled as phases with fixed composition. The ternary phases with a homogeneity range at a constant Er content were modeled with two sublattices, providing for substitution between Al and Cu in the first sublattice, with Er occupying the second sublattice. The optimized parameters were listed.

[2008Zha] computed an isothermal section at 600 °C and a liquidus projection. The invariant reactions occurring on the liquidus surface and the corresponding temperatures were listed. The computed isothermal section at 600 °C is shown in Fig. 1. It is in satisfactory agreement with the experimental section of [1989Kuz]. The seven ternary compounds listed in Table 1 are present. The computed (experimental) ternary solubilities in Al_2Er, Cu_2Er and CuEr were found to be 12 (13) at.% Cu, 3.9 (3) at.% Al and 29 (25) at.% Al respectively. There are no experimental results to compare with the computed liquidus projection. Figure 2 gives the computed liquidus projection near the Al corner. (Al) forms through a ternary peritectic reaction P at 644 °C, followed by a transition reaction U at 643 °C. The final solidification is through a ternary eutectic reaction E at 642 °C: $L \leftrightarrow (Al) + \tau_3 + Al_3Er$ [2008Zha].

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