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Al-Cu-Dy (Aluminum-Copper-Dysprosium)

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An isothermal section for this ternary system at 500 °C was determined by [1989Kuz] and was reviewed by [2004Ria]. Recently, [2009Zha] did a thermodynamic assessment of this system and computed three isothermal sections 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 *Fmm*2), Cu_5Al_4(LT) (ζ_2, orthorhombic, space group *Imm*2), ε_1(HT) (cubic?), ε_2(LT) ($B8_1$, 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-Dy phase diagram [2009Zha] depicts the following intermediate compounds: αAl_3Dy ($D0_{24}$, Ni_3Ti-type hexagonal), βAl_3Dy (Al_3Ho-type rhombohedral), Al_2Dy ($C15$, $MgCu_2$-type cubic), AlDy (AlEr-type orthorhombic), Al_2Dy_3 (Al_2Zr_3-type tetragonal), and $AlDy_2$ ($C23$, Co_2Si-type orthorhombic). The Cu-Dy phase diagram [2009Zha] has the following intermediate phases: Cu_7Dy (Cu_7Tb-type hexagonal), Cu_5Dy(LT) ($AuBe_5$-type cubic), Cu_5Dy(HT) ($CaCu_5$-type hexagonal), Cu_9Dy_2, Cu_7Dy_2, Cu_2Dy ($CeCu_2$-type orthorhombic) and CuDy (CsCl-type cubic). Computed phase diagrams of the above binaries were given by [2009Zha].

Ternary Compounds

Seven ternary compounds are known in this system [1989Kuz, 2004Ria]. The structural characteristics of these are listed in Table 1, as updated by [2009Zha]. The compounds Al_8Cu_4Dy (τ_1), Al_3CuDy (τ_4), $Al_{11}Cu_4Dy_4$ (τ_5) and AlCuDy (τ_7) are of fixed composition. The compounds with a range of homogeneity are: $(Al_xCu_{1-x})_{17}Dy_2$ (τ_2) (x = 0.39-0.59 at 500 °C) and $(Al_xCu_{1-x})_5Dy$ (τ_3) (x = 0.24-0.74 at 500 °C). The compound $Al_9Cu_5Dy_5$ (τ_6) shows a small homogeneity range around the nominal composition [2009Zha]. An additional compound $Al_7Cu_{16}Dy_6$ (see Table 1) with the $Mn_{23}Th_6$-type of cubic structure was listed by [2004Ria]. This compound was not considered by [2009Zha] in their assessment.

Table 1 Al-Cu-Dy crystal structure and lattice parameter data [2009Zha]

Phase	Composition, at.%	Pearson symbol	Space group	Prototype	Lattice parameter, nm
Al_8Cu_4Dy (τ_1)	61.5 Al 30.8 Cu 7.7 Dy	*tI*26	*I*4/*mmm*	$Mn_{12}Th$	a = 0.8725 c = 0.5137
$(Al,Cu)_{17}Dy_2$ (τ_2)	34.9-52.8 Al 54.6-36.7 Cu 10.5 Dy	*hR*57	$R\bar{3}m$	Th_2Zn_{17}	a = 0.8716-0.8812 c = 1.2735-1.2844
$(Al,Cu)_5Dy$ (τ_3)	20-45 Al 63.3-38.3 Cu 16.7 Dy	*hP*6	*P*6/*mmm*	$CaCu_5$	a = 0.5063-0.5257 c = 0.4140-0.4079
Al_3CuDy (τ_4)	60 Al 20 Cu 20 Dy	*oI*10	*Immm*	Al_4Ba	a = 0.4184 b = 0.4112 c = 0.9773
$Al_{11}Cu_4Dy_4$ (τ_5)	57.9 Al 21.05 Cu 21.05 Dy	…	…	…	…
$Al_9Cu_5Dy_5$ (τ_6)	45 Al 30 Cu 25 Dy	*hR*36	$R\bar{3}m$	Ni_3Pu	a = 0.5457 c = 2.5317
AlCuDy (τ_7)	33.3 Al 33.3 Cu 33.3 Dy	*hP*9	$P\bar{6}2m$	AlNiZr	a = 0.7015 c = 0.4024
$Al_7Cu_{16}Dy_6$	24.1 Al 55.2 Cu 20.7 Dy	*cF*116	$Pm\bar{3}m$	$Mn_{23}Th_6$	…

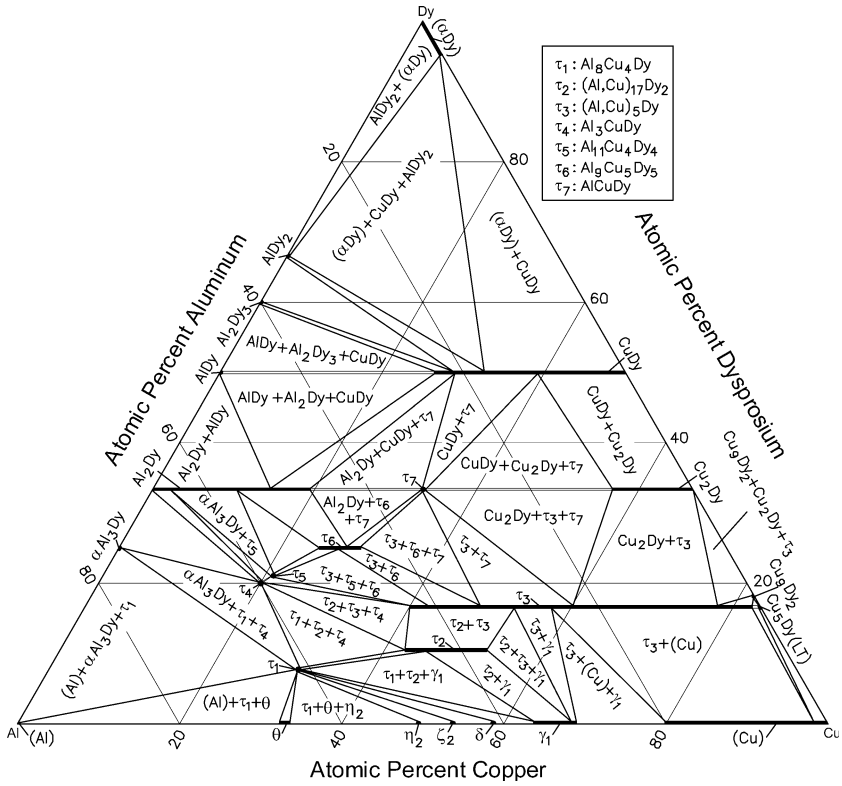

Fig. 1 Al-Cu-Dy computed isothermal section at 500 °C [2009Zha]. Narrow two-phase regions are omitted

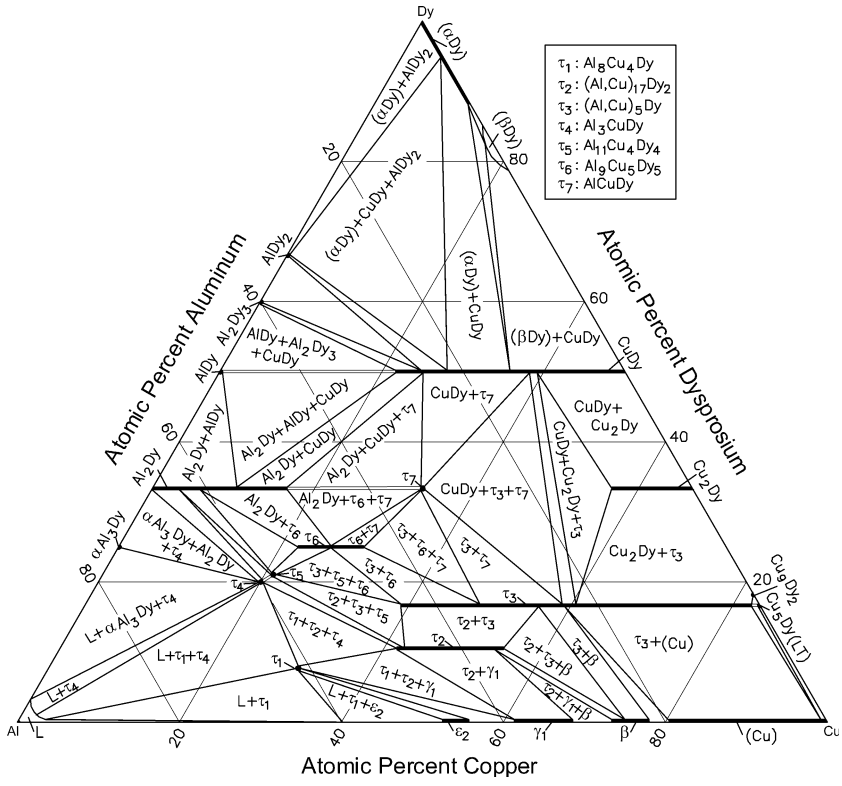

Fig. 2 Al-Cu-Dy computed isothermal section at 700 °C [2009Zha]. Narrow two-phase regions are omitted

Computed Isothermal Sections

In the thermodynamic modeling, [2009Zha] used the binary descriptions from the literature. The liquid, fcc and cph phases were treated as substitutional solutions and the ternary interaction parameters were set to zero. The binary compounds were described by two sublattice models, providing for ternary solubility. The ternary compounds of fixed composition were modeled as stoichiometric phases. The ternary phases with a homogeneity range were modeled with two sublattices, providing for substitution between Al and Cu in the first sublattice, with Dy solely occupying the second sublattice. The optimized parameters were listed.

[2009Zha] computed three isothermal sections at 700, 500 and 300 °C and a liquidus projection. The isothermal section at 500 °C (Fig. 1) shows reasonable agreement with the results of [1989Kuz], with some deviation regarding the homogeneity ranges of the ternary compounds. The triangulation near the Al corner agrees with that found by [1997Sok] at 400 °C. The isothermal section at 700 °C (Fig. 2) has no experimental support. Besides the changes in the stability of the binary phases, two solid-state U-type transition reactions occur between 700 and 500 °C: CuDy + $\tau_3 \leftrightarrow Cu_2Dy + \tau_7$ and τ_4 + (Al) (or L) $\leftrightarrow \alpha Al_3Dy + \tau_1$.

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