JPEDAV (2007) 28:547–548
DOI: 10.1007/s11669-007-9167-x
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Al-Cu-Gd (Aluminum-Copper-Gadolinium)

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Studies of this system by [1988Pre] gave an isothermal section at 497 °C (770 K), depicting several ternary compounds. [2001Gum] identified new ternary compounds and refined the structure of the previously known compounds. They constructed an isothermal section at 597 °C (870 K), depicting seven ternary compounds and significant solubility of the third component in several binary compounds. This system is included in the review of Al-Cu-RE systems by [2004Ria].

Binary Systems

The Al-Cu phase diagram [1998Liu] depicts a number of intermediate phases: $CuAl_2$ (*C*16-type tetragonal, denoted θ), CuAl (η_1, orthorhombic), CuAl (η_2, monoclinic), Cu_5Al_4(LT) (ζ, orthorhombic), ε_2 ($B8_2$, Ni_2In-type hexagonal), ε_1 (bcc), Cu_3Al_2 (δ, rhombohedral), Cu_9Al_4(HT) (γ_0, $D8_2$, Cu_5Zn_8-type cubic), Cu_9Al_4(LT) (γ_1, $D8_3$-type cubic), and Cu_3Al (β, bcc). In the above, HT = high-temperature and LT = low-temperature. The Al-Gd system [Massalski2] has the following intermediate phases $GdAl_3$ ($D0_{19}$, Ni_3Sn-type hexagonal), $GdAl_2$ (*C*15, $MgCu_2$-type cubic), GdAl (ErAl-type orthorhombic), Gd_3Al_2 (Zr_3Al_2-type tetragonal), and Gd_2Al (*C*23, Co_2Si-type orthorhombic). The Cu-Gd phase diagram [Massalski2, 2004Ria] depicts the following intermediate phases: $GdCu_6$, β$GdCu_5$ ($D2_d$, $CaCu_5$-type hexagonal), α$GdCu_5$ ($AuBe_5$-type cubic), Gd_2Cu_9 (monoclinic), $GdCu_2$ ($CeCu_2$-type orthorhombic), and GdCu (*B*2, CsCl-type cubic).

Ternary Phases

[2001Gum] identified four new ternary compounds in this system and refined the crystal structures of two previously known compounds. The structural details of seven compounds, numbered 1 to 7 by [2001Gum] (denoted τ_1 to τ_7 here) are given in Table 1.

Isothermal Section

With starting metals of 99.95 mass % Al, 99.95 mass % Cu, and 99.5 mass % Gd, [2001Gum] prepared 38 ternary

Table 1 Al-Cu-Gd crystal structure and lattice parameter data [2001Gum]

Phase	Composition, atomic %	Pearson symbol	Space group	Prototype	Lattice parameter, nm
$GdCu_{4.7\text{-}4.9}Al_{7.3\text{-}7.1}(\tau_1)$	56.2-54.6 Al 36.2-37.7Cu 7.7 Gd	*tI*26	*I*4/*mmm*	$ThMn_{12}$	*a* = 0.87559 *c* = 0.51445 (a)
$GdCu_{7.8}Al_{3.2}(\tau_2)$	26.7 Al 65 Cu 8.3 Gd	*tI*48	$I4_1/amd$	$BaCd_{11}$	*a* = 1.02694 *c* = 0.66054
$GdCu_{6.6}Al_{4.4}(\tau_3)$	36.7 Al 55 Cu 8.3 Gd	*oF**	*Fddd*	$Tb(Cu_{0.58}Al_{0.42})_{11}$	*a* = 1.43034 *b* = 1.49617 *c* = 0.65736
$Gd_2Cu_{9.4\text{-}6.7}Al_{7.6\text{-}10.3}(\tau_4)$	40-54.2 Al 49.5-35.3 Cu 10.5Gd	*hR*57	$R\bar{3}m$	Th_2Zn_{17}	*a* = 0.88300 *c* = 1.28568 (b)
$Gd_3Cu_{2.1}Al_{8.9}$ (τ_5)	63.6 Al 15 Cu 21.4 Gd	*oI*28	*Immm*	La_3Al_{11}	*a* = 0.42398 *b* = 1.25533 *c* = 0.99393
$GdCu_{0.9}Al_{2.1}(\tau_6)$	52.5 Al 22.5 Cu 25 Gd	*hR*36	$R\bar{3}m$	$PuNi_3$	*a* = 0.55153 *c* = 2.5519
$GdCuAl(\tau_7)$	33.3 Al 33.3 Cu 33.3 Gd	*hP*9	$P\bar{6}2m$	ZrNiAl	*a* = 0.7051 *c* = 0.4060

(a) At $GdCu_{4.7}Al_{7.3}$
(b) At $Gd_2Cu_{9.4}Al_{7.6}$

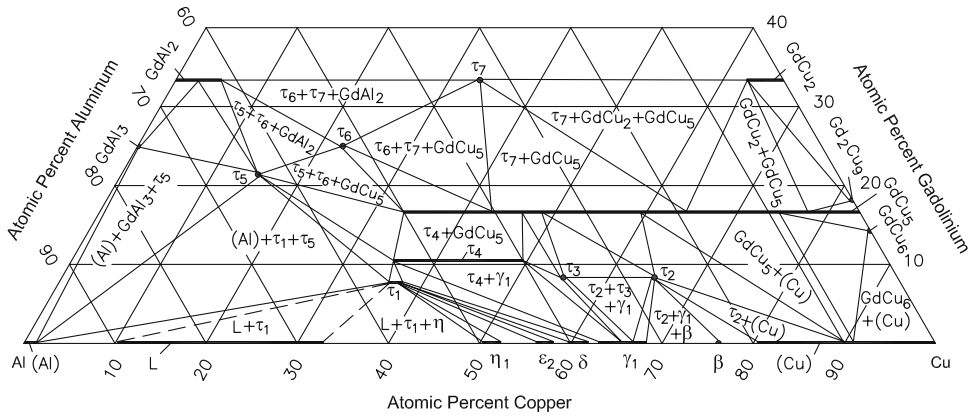

Fig. 1 Al-Cu-Gd isothermal section at 597 °C (870 K) [2001Gum]

alloys by arc-melting under Ar atm. The alloys were annealed at 597 or at 497 °C for 1000 h and quenched in water. The phase analysis was carried out with x-ray powder diffraction. The same seven ternary compounds were found at both temperatures. The ternary compound $GdCuAl_3$ reported by [1988Pre] with the Al_4Ba-type tetragonal structure was not found by [2001Gum] at 597 or 497 °C. The isothermal section at 597 °C (870 K) constructed by [2001Gum] for Gd content up to 33.3 at. % is shown in Fig. 1. Along the Al-Cu side, at this temperature, the liquid phase (L) is present instead of θ. The ternary compounds are shown at the compositions listed by [2001Gum]. The binary compound $GdCu_5$ and $GdCu_2$ dissolve up to 50 and 4 at. % Al, respectively. $GdAl_2$ dissolves up to 5 at. % Cu.

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