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Al-Cu-Ti (Aluminum-Copper-Titanium)

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The previous review of this system by [1992Ran] presented a liquidus surface, a reaction scheme, three isothermal sections at 800, 540, and 500 °C, and two vertical sections at 10 wt.% Cu and 10 wt.% Al, respectively. These were based mainly on the studies of [1971Vir] and [1973Mar]. This update presents an isothermal section at 850 °C from [1997Dur] and three partial sections at 1300, 1200, and 1000 °C from [2000Kai].

Binary Systems

The Al-Cu phase diagram [Massalski2] depicts a number of intermediate phases. $CuAl_2$ (θ) is a *C*16-type tetragonal phase. CuAl (η) has two crystal modifications, the high-temperature orthorhombic and the low-temperature monoclinic forms. The two forms of the ζ phase occur in the composition range of 55.2-59.8 at.% Cu and are stable below 590 °C. Two modifications of the ε phase occur around the composition Cu_3Al_2 and are stable above 560 °C. The structures of the phases, δ, γ_1 (Cu_9Al_4), and γ_0, which are stable between 58 and 70 at.% Cu, are based on the γ-brass structure. The β phase (70.6-82 at.% Cu) is body-centered cubic (bcc) and is stable above 567 °C. The updated version of the Al-Ti phase diagram [2005Rag] depicts a number of intermediate phases: $TiAl_3$ ($D0_{22}$-type tetragonal), Ti_5Al_{11} (tetragonal), $TiAl_2$ ($HfGa_2$-type tetragonal), $Ti_{1-x}Al_{1+x}$ (AuCu-type tetragonal), Ti_3Al_5 (tetragonal), TiAl (γ) (AuCu-type tetragonal), and Ti_3Al (α_2), ($D0_{19}$, Ni_3Sn-type hexagonal). The Cu-Ti phase diagram [2002Oka] depicts a number of intermediate phases: Cu_4Ti (Au_4Zr-type orthorhombic) possibly with a low-temperature tetragonal modification, Cu_2Ti (Au_2V-type orthorhombic, stable between ~900-880 °C), Cu_3Ti_2 (tetragonal), Cu_4Ti_3 (tetragonal), CuTi (*B*11-type tetragonal), $CuTi_2$ ($MoSi_2$-type tetragonal), and $CuTi_3$ (orthorhombic).

Ternary Phases

The three established ternary phases [1992Ran] of this system are: TiCuAl (*C*14, $MgZn_2$-type hexagonal), $TiCu_2Al$ ($L2_1$, $MnCu_2Al$-type cubic), and Ti_2CuAl_5 ($L1_2$, $AuCu_3$-type cubic). All these phases have significant homogeneity ranges in the temperature range investigated (850-500 °C). Ti_2CuAl_5 ($L1_2$) was shown by [1992Ran] to have a homogeneity range along a constant Ti content of ~27 at.%. [1989Maz] showed that, at 1200 °C, the $L1_2$ phase has a

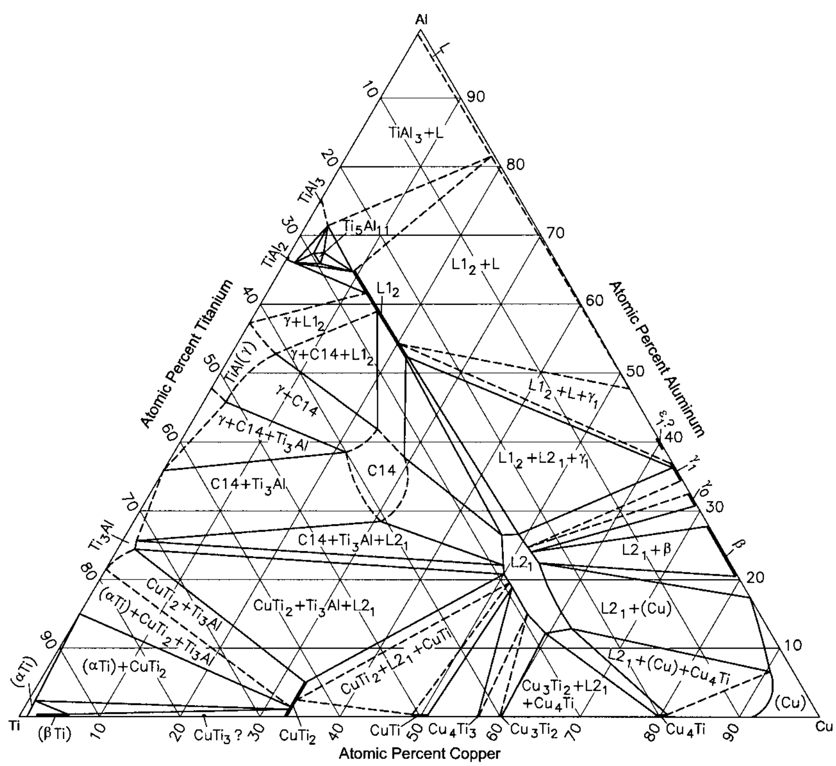

Fig. 1 Al-Cu-Ti isothermal section at 850 °C [1997Dur]

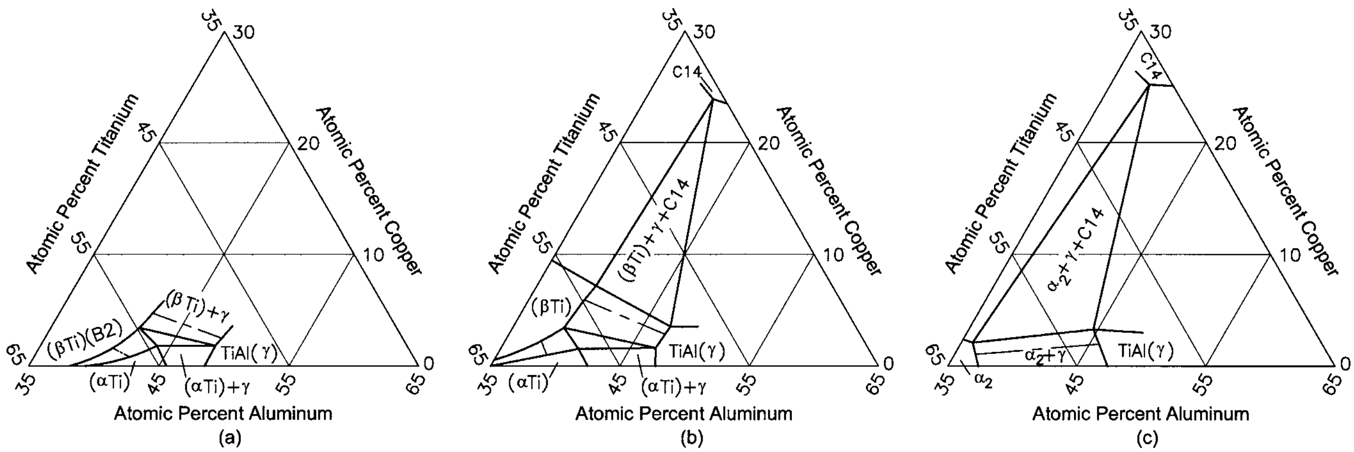

Fig. 2 Al-Cu-Ti partial isothermal sections near the Ti-Al side at (a) 1300 °C, (b) 1200 °C, and (c) 1000 °C [2000Kai]

"geometric center" of Al-27 at.% Ti-12 at.% Cu and a homogeneity range of ~11.5 at.% in the Al-Cu direction and ~3-4 at.% in the Al-Ti direction. The phase remains ordered up to at least 1200 °C [1989Maz].

Isothermal Sections

[1997Dur] performed a few critical experiments at 850 °C to resolve the disagreement between [1971Vir] and [1973Mar] about a tie-line. The results of [1997Dur] favor the conclusion of [1973Mar] that the tie-line is between Ti_3Al (α_2) and $TiCu_2Al$ ($L2_1$) and not between TiCuAl ($C14$) and $CuTi_2$, as found by [1971Vir] at 800 °C and as recommended by [1992Ran]. A transition-type reaction: $Ti_3Al + TiCu_2Al \leftrightarrow TiCuAl + CuTi_2$ is necessary just above 800 °C to reconcile the two viewpoints. The isothermal section of [1997Dur] at 850 °C is redrawn in Fig. 1 to agree with the binary data accepted here. Ti_5Al_{11} is apparently stabilized at this temperature by the addition of a few percent of Cu.

Partial isothermal sections determined by [2000Kai] at 1300, 1200, and 1000 °C depicting the relationships between (αTi), (βTi), Ti_3Al (α_2), and TiAl (γ) are redrawn in Fig. 2. [2001Liu] determined the distribution coefficient K of Ti at 800 and 700 °C and found that $K^{(\alpha Ti)/(\beta Ti)} = 0.9$ and 1.2, respectively, and that $K^{\gamma/(\beta Ti)} = 0.97$ and 0.985, respectively.

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