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Al-Au-Cu (Aluminum-Gold-Copper)

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Recently, [2002Lev] and [2003Lev] investigated the phase equilibria in this system and presented an isothermal section at 500 °C and a vertical section at 76 mass% Au.

Binary Systems

The Al-Au system [2005Oka] depicts the following intermediate phases: $AuAl_2$($C1$, CaF_2-type cubic), AuAl (AuAl-type monoclinic), Au_2Al (α, β, and γ modifications with $MoSi_2$-type or related structures), Au_8 Al_3 (rhombohedral, space group $R\bar{3}c$), Au_4Al (cubic, space group $P2_13$), and β (80-81.2 at.% Au; bcc). The Al-Cu phase diagram [1998Liu] depicts a number of intermediate phases: $CuAl_2$ (θ, $C16$-type tetragonal), CuAl (η_1,orthorhombic), CuAl (η_2, monoclinic), Cu_5Al_4(LT) (ζ_2, orthorhombic), ε_1(bcc), ε_2 ($B8_2$, Ni_2In-type hexagonal), 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. Au and Cu form a continuous face-centered cubic (fcc) solid solution at high temperatures. At lower temperatures, at least three ordered structures Au_3Cu ($L1_2$, $AuCu_3$-type cubic), AuCu-I ($L1_0$, AuCu-type tetragonal), and $AuCu_3$-I ($L1_2$-type cubic) are known with formation temperatures of 240, 385 and 390 °C respectively [Massalski2].

Ternary Phase Equilibria

With starting metals of at least 99.9% purity, [2002Lev] arc-melted or air-melted about 50 alloys. The alloys were annealed at 500 °C for 2 h and quenched in ice-water or ice-brine mixture. [2002Lev] pointed out that the annealing time of 2 h corresponds to the cast-and-solution-anneal kind of treatment and may or may not have produced the equilibrium structures. The isothermal section at 500 °C constructed by [2002Lev] is shown in Fig. 1. A ternary phase labeled β with the nominal formula $AlAu_2Cu$ with the $B2$-type of ordered bcc structure is stable below about 800 °C in an approximately-triangular region having the coordinates of $Al_{1.08}Au_{1.96}Cu_{0.96}$, $Al_{0.68}Au_{2.12}Cu_{0.80}$, and $Al_{1.0}Au_{1.0}Cu_2$ [2002Lev]. The ternary phase β, the binary phaseAu_4Al (labeled as β by [2002Lev]) and the binary phase Cu_3Al (also labeled β, stable only above 567 °C) all lie approximately along the 25 at.% Al line, suggesting the

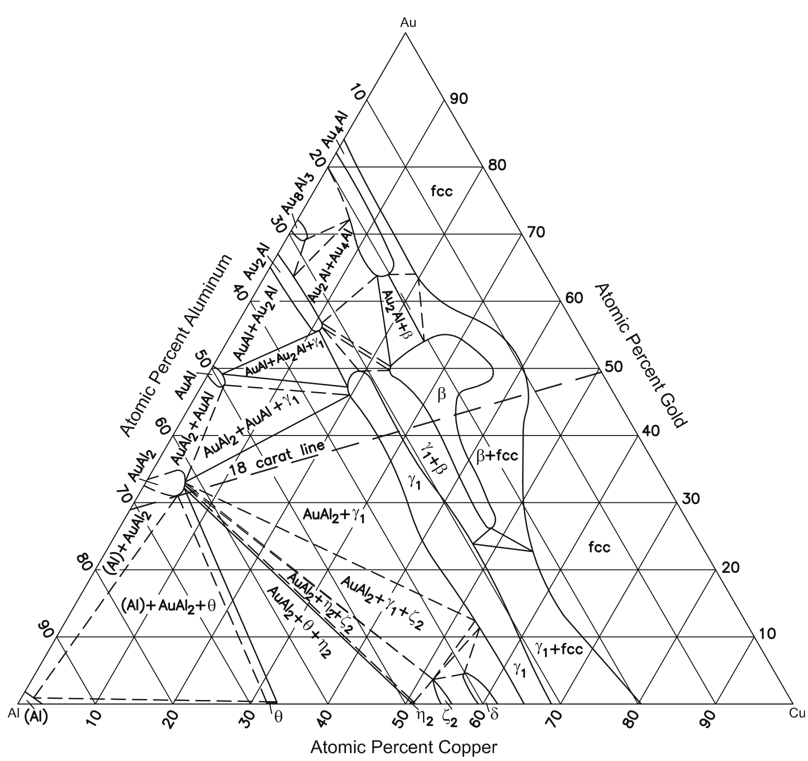

Fig. 1 Al-Au-Cu isothermal section at 500 °C [2002Lev]

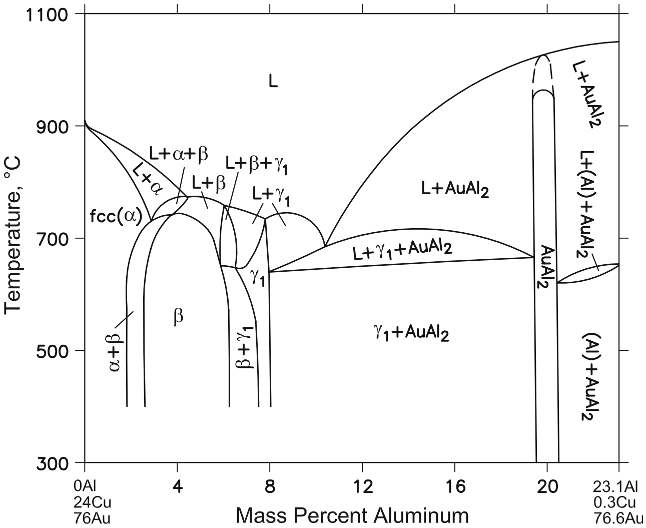

Fig. 2 Al-Au-Cu vertical section at ~76 mass% Au [2003Lev]

possibility of a continuous solid solution between them at higher temperatures. Cu_9Al_4(LT) (γ_1) dissolves a large amount of Au, which substitutes for Cu at constant Al content. [2002Lev] found some evidence for the ternary ordering of Au and Cu atoms in the γ_1-based solid solution. The line corresponding to 75 mass% Au (the 18-carat line) (Fig. 1) passes through the single-phase regions of the ternary β and the γ_1-based solid solution.

[2003Lev] used about half of the samples prepared by [2002Lev], which had an approximate Au content of 76 mass%. Differential thermal analysis and differential scanning calorimetry were employed at a heating/cooling rate of 5-10 °C per min to identify the thermal arrests. Samples were also annealed at 700, 600, 500, and 400 °C for 2-4 h, followed by ice-brine quenching. The phase equilibria were studied with optical microscopy, x-ray powder diffraction, and energy dispersive spectral analysis. The vertical section constructed by [2003Lev] at ~76 mass% Au is redrawn in Fig. 2.

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