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

V. Raghavan

An update of the experimental results of [2002Lev] and [2003Lev] on this ternary system was presented by [2008Rag]. Recently, [2010Bha] determined an isothermal section at 750 °C and [2009Gu] studied the $A2 \leftrightarrow B2 \leftrightarrow L1_2$ ordering transitions.

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_8Al_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 [2004Ria] depicts a number of intermediate phases: CuAl_2 (θ , C16-type tetragonal), CuAl(HT) (η_1 , orthorhombic), CuAl(LT) (η_2 , monoclinic), $\text{Cu}_5\text{Al}_4(\text{HT})$ (ζ_1 , orthorhombic, space group $Fmm2$), $\text{Cu}_5\text{Al}_4(\text{LT})$ (ζ_2 , orthorhombic, space group $Imm2$), $\epsilon_1(\text{HT})$ (bcc), $\epsilon_2(\text{LT})$ ($B8_2$, Ni_2In -type hexagonal), Cu_3Al_2 (δ , rhombohedral), $\text{Cu}_9\text{Al}_4(\text{HT})$ (γ_0 , $D8_2$, Cu_5Zn_8 -type cubic), $\text{Cu}_9\text{Al}_4(\text{LT})$ (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 $\text{AuCu}_3\text{-I}$ ($L1_2$ -type cubic) are known, with formation temperatures of 240, 385 and 390 °C respectively [Massalski2].

Ternary Phase Equilibria

With starting metals of 99.99+ % Al, 99.99 % Au and 99.9 % Cu, [2010Bha] melted 14 ternary alloys in an alumina crucible under a protective layer of carbon pellets. The alloys were annealed at 750 °C and quenched in iced brine. The phase equilibria were studied with optical and scanning electron microscopy, energy dispersive spectroscopy and x-ray powder diffraction. Differential scanning calorimetry was performed at a heating rate of 10 °C/min. The isothermal section at 750 °C constructed by [2010Bha] is shown in Fig. 1. The Cu_3Al (β) bcc phase extends deep into the ternary region, dissolving more than 43 at.% Au. At 500 °C, Cu_3Al is not stable in the Al-Cu binary system. At this temperature, this phase appears within the ternary region [2002Lev]. The Cu_9Al_4 (γ_1) phase also extends up to ~40 at.% Au, with Au substituting for Cu. A large liquid field, originating from the Al-Au side, extends into the ternary region. Based on their experimental data, [2010Bha] suggested a correction to the slope of the $\beta/(\beta + \gamma_1)$ phase

Fig. 1 Al-Au-Cu isothermal section at 750 °C [2010Bha]

boundary in the vertical section at ~76 mass% Au reported by [2003Lev].

Employing electrical resistivity and internal friction measurements, [2009Gu] determined the critical transition temperatures in the $A2 \rightarrow B2$ and $B2 \rightarrow L1_2$ ordering in $(\text{Cu}, \text{Au})_3\text{Al}$ bcc alloys. The measured temperatures showed good agreement with those calculated from the Bragg-Williams-Gorski model.

References

- 2002Lev: F.C. Levey, M.B. Cortie, and L.A. Cornish, A 500 °C Isothermal Section for the Al-Au-Cu System, *Metall. Mater. Trans. A*, 2002, **33A**, p 987-993
- 2003Lev: F.C. Levey, M.B. Cortie, and L.A. Cornish, Determination of the 76 Mass Percent Au Section of the Al-Au-Cu Phase Diagram, *J. Alloys Compd.*, 2003, **354**, p 171-180
- 2004Ria: P. Riani, L. Arrighi, R. Marazza, D. Mazzone, G. Zanicchi, and R. Ferro, Ternary Rare-Earth Aluminum Systems with Copper: A Review and a Contribution to Their Assessment, *J. Phase Equilib. Diffus.*, 2004, **25**(1), p 22-52
- 2005Oka: H. Okamoto, Al-Au (Aluminum-Gold), *J. Phase Equilib. Diffus.*, 2005, **26**(4), p 391-393
- 2008Rag: V. Raghavan, Al-Au-Cu (Aluminum-Gold-Copper), *J. Phase Equilib. Diffus.*, 2008, **29**(3), p 260-261
- 2009Gu: Y. Gu, M. Jin, and X. Jin, $A2 \rightarrow B2 \rightarrow L1_2$ Ordering Transitions in Au-Cu-Al Alloys, *Intermetallics*, 2009, **17**, p 704-707
- 2010Bha: V.K. Bhatia, C.S. Kealley, R. Wuhrer, K.S. Wallwork, and M.B. Cortie, Ternary β and γ phases in the Al-Au-Cu System at 750 °C, *J. Alloys Compd.*, 2010, **488**, p 100-107