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Al-Cu-Zn (Aluminum-Copper-Zinc)

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The previous update on this ternary system by [2007Rag] reviewed mainly the thermodynamic assessment of [1998Lia]. Very recently, [2009Ren] determined a partial isothermal section at 360 °C for Cu-lean alloys and found that Cu stabilizes the miscibility gap of the Al-Zn fcc phase.

Binary Systems

The Al-Cu phase diagram [2004Ria] depicts the following intermediate phases: $CuAl_2$ (*C*16-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), 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-Zn phase diagram [1993Che] contains no intermediate phases. A miscibility gap occurs in the Al-based face centered cubic (fcc) solid solution below 351 °C, where the fcc phase splits into fcc_1 and fcc_2. The monotectoid reaction $fcc_2 \leftrightarrow fcc_1 + (Zn)$ follows at 277 °C. The Cu-Zn phase diagram [1993Kow, Massalski2] is characterized by a series of peritectic reactions, which yield CuZn (β, bcc), Cu_5Zn_8 (γ, $D8_2$-type cubic), $CuZn_3$ (δ, *B*2, CsCl-type cubic), and $CuZn_4$ (ε, cph). Zn (cph) has a *c*/*a* axial ratio much larger than ε and the two coexisting cph phases are modeled separately with different interaction parameters [1993Kow]. The β phase orders to a CsCl-type *B*2 phase (β′) through a second-order transition below ~460 °C.

Ternary Phases

A ternary phase with rhombohedral symmetry and with the nominal composition Al_4Cu_3Zn (denoted τ) is known in this system [Pearson3]. The homogeneity range of τ and its temperature dependence are not clearly defined. The structurally-related, low-temperature form τ′ was found to be stable by [2005Hao] between 400 °C and room temperature.

Ternary Phase Equilibria

With starting metals of 99.999% purity, [2009Ren] prepared diffusion couples of Cu-Zn master alloys with pure Al. The diffusion couples were annealed at 360 °C for 48 h and quenched in water. The coexisting phase compositions were measured by electron probe microanalysis and listed. The isothermal section at 360 °C constructed by [2009Ren] is shown in Fig. 1. In the Al-Zn system, the miscibility gap in the fcc phase closes at 351 °C. The addition of Cu stabilizes this gap, which is stable at 360 °C, even with as low as 0.1 at.% addition of Cu. The gap increases in width with increasing Cu content. In an earlier study, [2004Ren] determined tie-lines between fcc_1 and fcc_2 at 340 and 320 °C for small additions of Cu and these are shown in Fig. 2. The Cu addition shifts the $fcc_1/(fcc_1 + fcc_2)$ and $(fcc_1 + fcc_2)/fcc_2$ phase boundaries towards the Al-rich corner. Also, Cu segregates in the fcc_2 phase in preference to fcc_1.

The computed results of [2009Dai] indicate that the stabilizing effect of Cu on the Al-Zn miscibility gap increases with increasing Cu content, culminating in a metastable miscibility gap in the Al-Cu binary system. These calculations, however, ignore the intervening effect of the binary and ternary compounds.

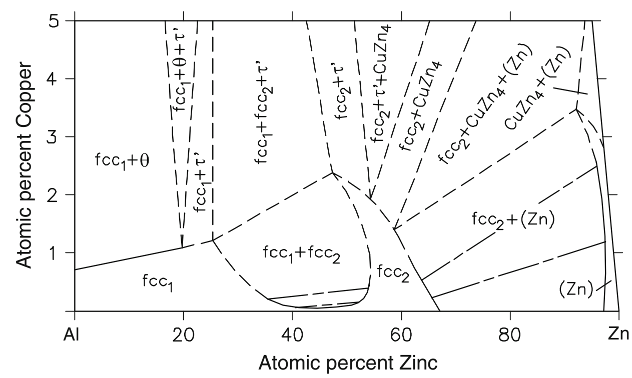

Fig. 1 Al-Cu-Zn partial isothermal section at 360 °C [2009Ren]

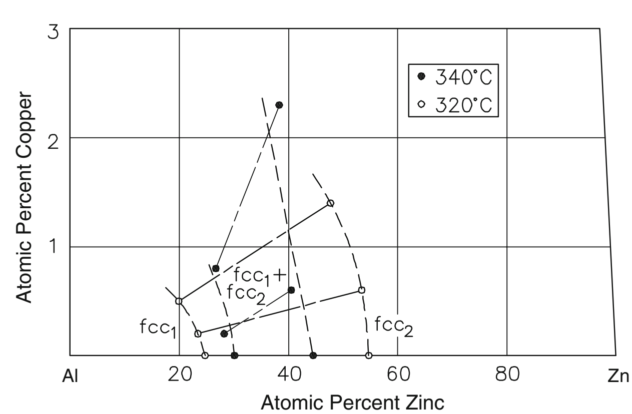

Fig. 2 Al-Cu-Zn tie-lines between fcc_1 and fcc_2 at 340 and 320 °C [2004Ren]

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