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Co-Cu-Fe (Cobalt-Copper-Iron)

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The previous review of this ternary system by [1995Vil] presented a liquidus projection and five vertical sections from the early work of [1936Jel] and four computed isothermal sections near the Fe corner between 950 and 650 °C by [1989Har], showing the face-centered cubic (fcc)-body-centered cubic (bcc) equilibrium. Recently, attention has been focused on the metastable liquid miscibility gap in this system [2005Cao, 2006Pal, 2008Cur].

Binary Systems

There are no intermediate phases in any of the three binary subsystems. The metastable liquid miscibility gap has been experimentally measured in the Fe-Cu system (see, for example, [1997Wil]) and the Co-Cu system (e.g. [2002Cao]). Both stable phase diagrams depict a relatively-flat liquidus line.

Ternary Phase Equilibria

With starting metals of 99.998% Co, 99.999% Cu, and 99.99% Fe, [2005Cao] arc-melted about 20 samples, as three series with Co:Fe atom ratio of 1:3, 1:1, and 3:1, respectively, and the Cu content varying between 10 and 84 at.%. The samples were remelted in alumina crucibles under a cover of crushed Durand glass, which acts as a denucleant and fluxing agent and promotes the undercooling of the liquid. Figure 1 shows the metastable miscibility gap determined by [2005Cao] for the three series of alloys. For comparison, the metastable liquid miscibility gaps of the Fe-Cu binary system [1997Wil] and the Co-Cu system [2002Cao] are shown. The critical points in the ternary alloys are all near the mid-composition at 1366, 1343, and 1320 °C for Fe:Co = 3:1, 1:1, and 1:3, respectively. The gap shifts to lower temperatures, as Fe is replaced with Co in the alloys. In their recent work, [2008Cur] employed differential scanning calorimetry to measure the arrest temperatures, as compared to the differential thermal analysis technique used by [2005Cao].

In their thermodynamic analysis of this ternary system, [2006Pal] made their own assessment of the Co-Cu binary system, listing the optimized parameters. The calculated metastable liquid miscibility gap in this binary system was compared with the available experimental results. They showed excellent agreement with the data of [2002Cao]. [2006Pal] used the previous thermodynamic descriptions for the Cu-Fe and Co-Fe systems. Selected experimental data on the ternary phase equilibria (including the new results of [2005Cao]) and on thermochemical properties from the literature were used in the optimization. The magnetic contribution to the Gibbs energy was taken into account. The subregular solution model was used for the liquid, face-centered cubic (fcc), body-centered cubic (bcc), and close-packed hexagonal (cph) phases. The ternary interaction parameters were evaluated and listed. There are no binary or ternary compounds in this system.

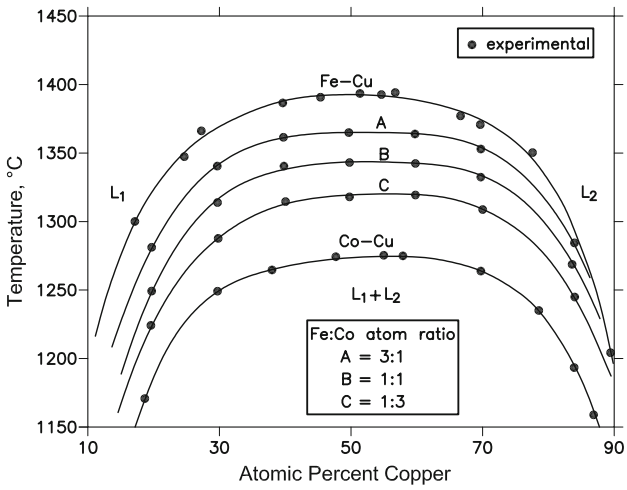

Fig. 1 Co-Cu-Fe metastable miscibility gaps in binary and ternary alloys [2005Cao]

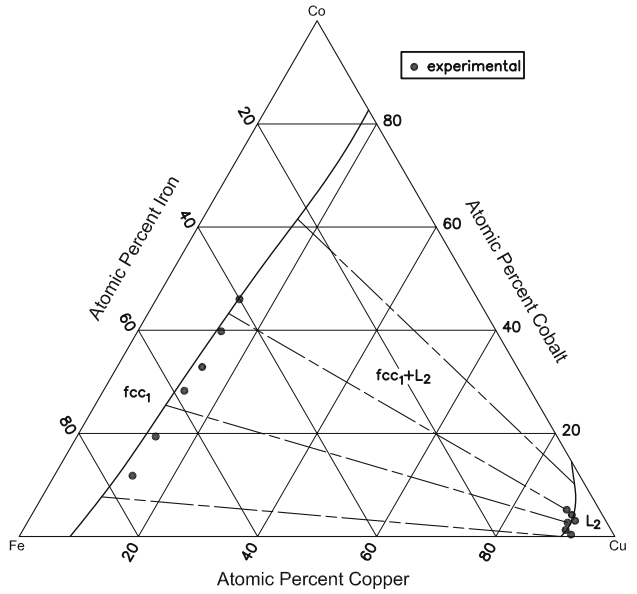

Fig. 2 Co-Cu-Fe computed isothermal section at 1300 °C [2006Pal]

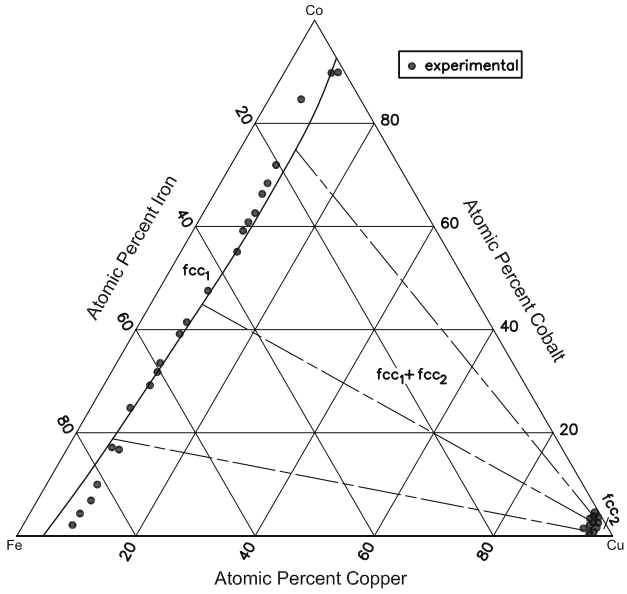

Fig. 3 Co-Cu-Fe computed isothermal section at 1000 °C [2006Pal]

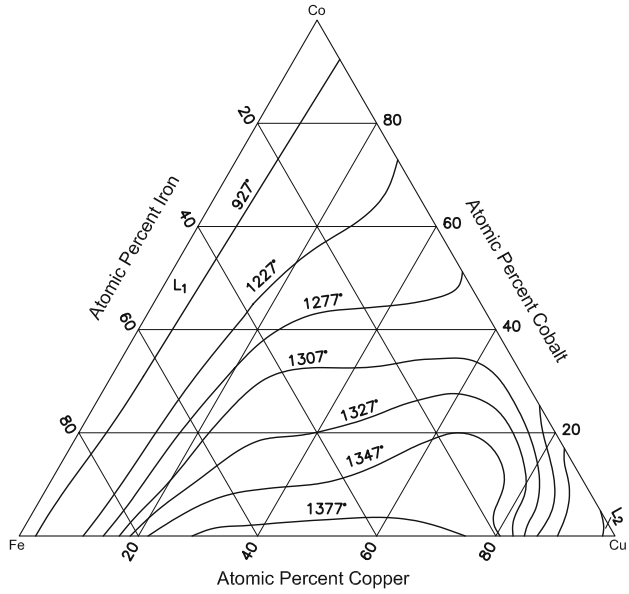

Fig. 5 Co-Cu-Fe computed metastable liquid miscibility gap at indicated temperatures (°C) [2006Pal]

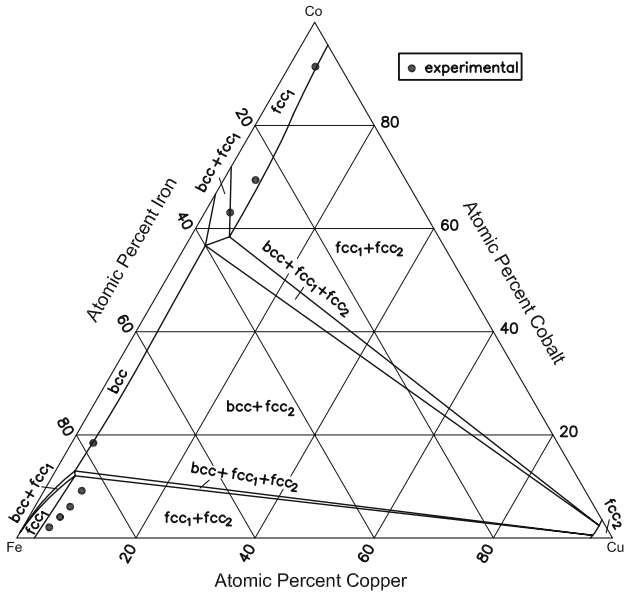

Fig. 4 Co-Cu-Fe computed isothermal section at 900 °C [2006Pal]

Five isothermal sections were computed by [2006Pal] for stale equilibrium at 1300, 1127, 1000, 900, and 800 °C. Three of these at 1300, 1000, and 900 °C are shown in Fig. 2-4. The continuous face-centered cubic (fcc) solid solution between Fe and Co is labeled fcc_1 and the Cu-rich fcc phase is labeled fcc_2. At 900 °C (Fig. 4), the Fe-Co continuous solid solution is interrupted by the bcc phase. Comparison with the experimental results from different sources indicates good agreement. Three vertical sections at Fe:Co atom ratios of 1:1, 1:3, and 3:1 were computed by [2006Pal] for stable and metastable equilbria and were compared mainly with the data of [2005Cao]. The agreement was good. The computed metastable liquid miscibility gaps at 1377, 1347, 1327, 1307, 1277, 1227, and 927 °C are shown in Fig. 5 [2006Pal].

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