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Al-Bi-Zn (Aluminum-Bismuth-Zinc)

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Ternary alloys having a four-phase monotectic reaction can produce interesting microstructures with two different solidified liquids. These offer possibilities of applications such as self-lubricating bearings. Recently, [2005Gro] computed the phase equilibria of this system, using new experimental results from selected ternary alloys.

Binary Systems

In this ternary system, none of the three binaries has an intermediate phase. In the Al-Bi system, a liquid miscibility gap is present. A monotectic reaction takes place at 658 °C, where the Al-rich liquid L′ transforms to (Al) and a Bi-rich liquid L″. L″ solidifies through a eutectic reaction at 270 °C into (Al) and (Bi). In the Al-Zn system, solidification occurs through a eutectic reaction at 381 °C yielding (Zn) and (Al). On solidification, (Al) has more than 60 at.% of dissolved Zn. At lower temperatures, this solid solution exhibits a miscibility gap, with a monotectoid reaction at 277 °C: (Al)′↔ (Al) + (Zn). In the Bi-Zn system, a liquid miscibility gap is present and a monotectic reaction occurs, where the Zn-rich liquid L′ transforms to (Zn) and L″. The final solidification is through the eutectic reaction: L″ ↔ (Zn) + (Bi). Calculated phase diagrams of the above three binaries were given by [2005Gro].

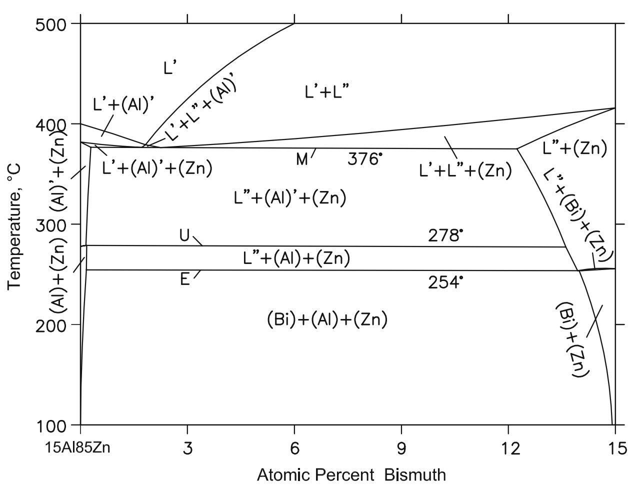

Fig. 1 Al-Bi-Zn computed vertical section at 85 at.% Zn [2005Gro]

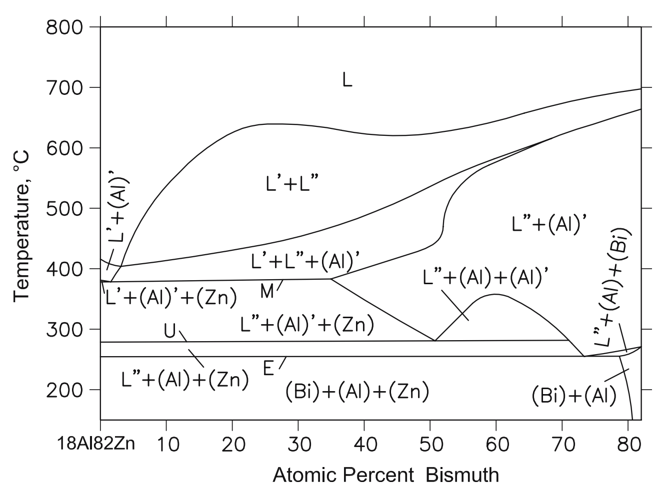

Fig. 2 Al-Bi-Zn computed vertical section at 18 at.% Al [2005Gro]

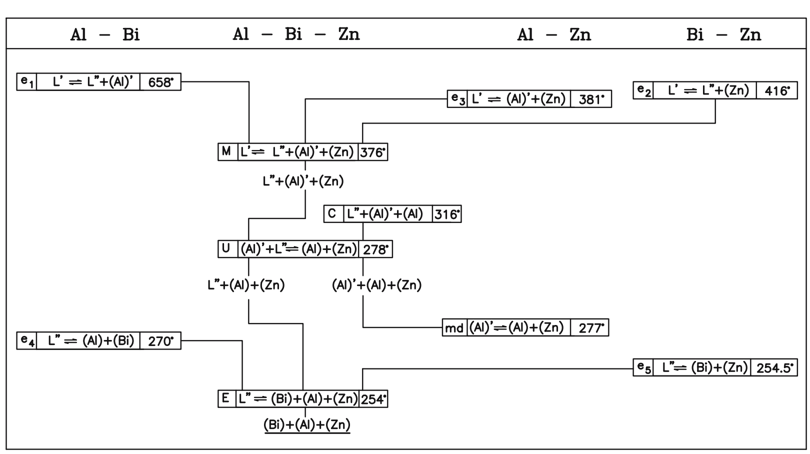

Fig. 3 Al-Bi-Zn reaction sequence during solidification [2005Gro]

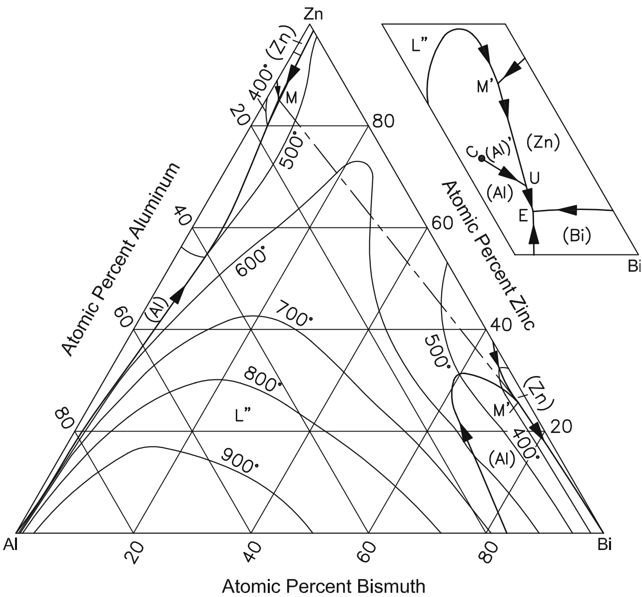

Fig. 4 Al-Bi-Zn computed liquidus projection [2005Gro]. The details at the Bi corner are shown schematically

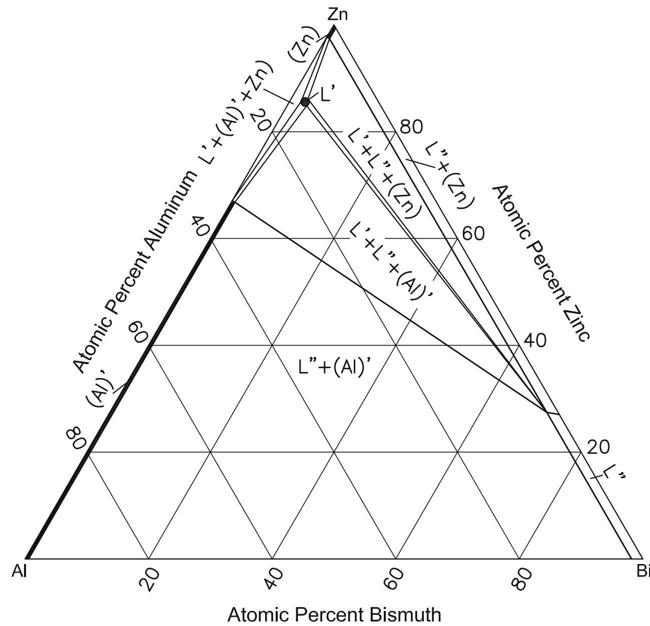

Fig. 5 Al-Bi-Zn computed isothermal section at 377 °C [2005Gro]

Ternary Phase Equilibria

With starting metals of 99.997% Al, 99.999% Bi, and 99.99% Zn, five ternary alloys rich in Zn or Bi were melted in Ta capsules to minimize Zn evaporation. Differential scanning calorimetry was performed at heating/cooling rates of 1-5 °C/min. The phase equilibria were studied with optical and scanning electron microscopy. The local phase compositions were determined with energy dispersive x-ray analysis. The experimental arrest temperatures and their interpretation were listed.

The thermodynamic parameters for the binary systems were taken from [1984McA] (Al-Bi), [1993Mey] (Al-Zn), and [2000Mal] (Bi-Zn). Only one ternary interaction parameter was found necessary for the liquid phase. Two calculated vertical sections at 85 at.% Zn and 18 at.% Al respectively are shown in Fig. 1 and 2. In both the figures, three invariant horizontals are seen. They correspond to the four-phase invariant reactions M, U and E in Fig. 3, which shows the reaction sequence during solidification [2005Gro]. The computed liquidus projection is shown in Fig. 4. The details at the Bi corner are shown schematically. Figure 5 shows the computed isothermal section at 377 °C (which is 1° above the temperature of the monotectic reaction M).

References

1984McA: A.J. McAlister, The Al-Bi (Aluminum-Bismuth) System, *Bull. Alloy Phase Diagrams*, 1984, **5**(3), p 247-250

1993Mey: S. An Mey, Reevaluation of the Al-Zn System, *Z. Metallkd.*, 1993, **84**(7), p 451-455

2000Mal: D.V. Malakov, Thermodynamic Assessment of the Bi-Zn System, *CALPHAD*, 2000, **24**(1), p 1-14

2005Gro: J. Grobner, D. Mirkovic, and R. Schmid-Fetzer, Monotectic Four-Phase Reaction in Al-Bi-Zn Alloys, *Acta Mater.*, 2005, **53**, p 3271-3280