Table 2 Proposed Four-Phase Equilibria in the Al-Bi-Cu System (Partial)

Reaction	Temperature, °C	Coexisting phases	Composition of phases wt.% Cu	wt.% Al	wt.% Bi
II_1: $L_1 + \sigma = L_2 + \eta$	624	L_1	57.5	42.5	...
		L_2	0.2	0.7	99.1
		σ	73.7	26.3	...
		η	71.7	28.3	...
II_2: $L_1 + \eta = L_2 + \theta$	589	L_1	53.1	46.9	...
		L_2	0.1	0.8	99.1
		η	70.5	29.5	...
		θ	53.5	46.5	...
I_1: $L_1 = L_2 + (Al) + \theta$	548	L_1	33.2	66.8	...
		L_2	0.2	1.6	98.2
		(Al)	5.7	94.3	...
		θ	52.5	47.5	...

Thermodynamic Properties

[1] used a fused-salt electrolyte electrochemical method to determine the thermodynamic properties of Al at 1073K at constant x_{Bi}/x_{Cu} ratios of 199 and 99. The relative partial molar enthalpies and entropies of Al are, within the scatter of the data, the same as for the binary system Al-Bi [Hultgren].

Y. A. Chang, Materials Engineering Department, University of Wisconsin, P.O. Box 413, Milwaukee, Wisconsin 53201, **J. P. Neumann**, U.S. Bureau of Mines, P.O. Box 70, Albany, Oregon 97321, **A. Mikula**, 1190 Vienna, Hohenauergasse 21, Austria and **D. Goldberg**, Westinghouse TAP, P.O. Box 1047, Pittsburgh, Pennsylvania 15230. From [Chang]; bibliography through 1977.

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The Al-Bi (Aluminum-Bismuth) System

26.98154 amu 208.9804 amu

The form of the diagram (Fig. 1) was reported by [1] on the basis of thermal analysis and micrographic examination; [2-5] had previously detected the existence of liquid immiscibility. The monotectic reaction is ~5 °C [1], 3.5 ± 0.5 °C [6] or 3 °C [7] below the melting point of Al; from chemical analysis of the Al-rich layer [7-9], it is 3.4 wt.% (0.45 at.%) Bi [7]. Calorimetric data [10] indicated a monotectic composition of ~1 at.% Bi. (The monotectic composition is placed at 0.45 at.% Bi in Fig. 1.) Close agreement exists between the data of [7-9, 11] for the Al-rich branch of the miscibility gap at <910 °C. At higher temperatures, [8] reported:

Temperature, °C	at.% Bi
920	3.65
968	4.48
982	4.53
1008	4.33

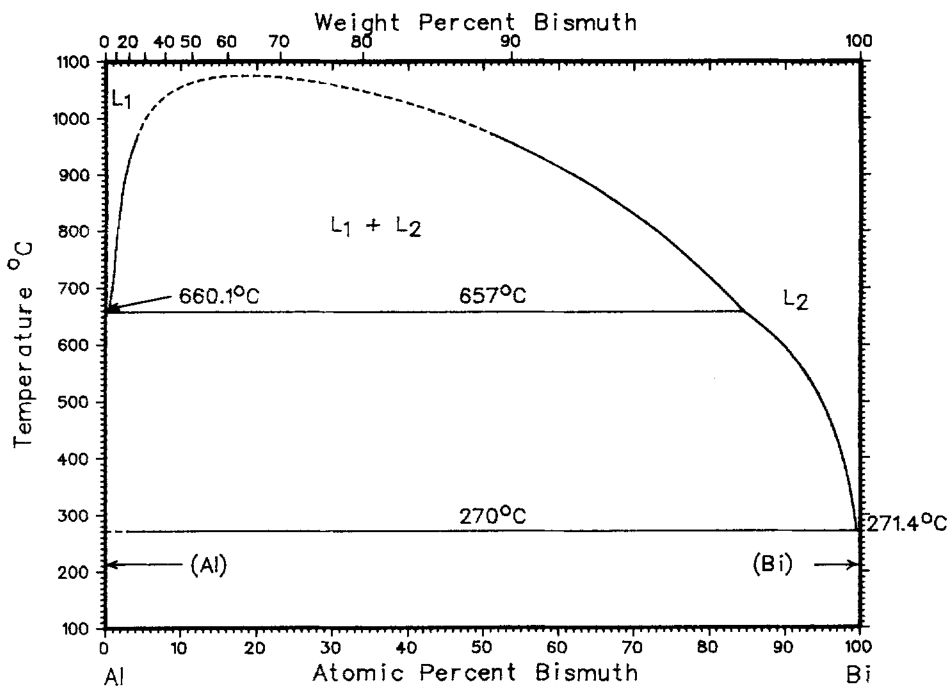
At variance, [9] reported:

Temperature, °C	wt.% Bi	at.% Bi
1018	25.1	4.15
1098	32.0	5.73
1183	41.2	8.3

For the Bi-rich branch of the miscibility gap, essential agreement exists between [8, 10-12]; the curve in Fig. 1 is based on these data. Again at variance, [9] reported:

Temperature, °C	wt.% Bi	at.% Bi
720	97.9	85.8
796	97.8	85.2
903	97.2	81.8
1018	96.1	76.1
1098	94.6	69.3
1183	89.7	52.9

Fig. 1 Al-Bi Phase Diagram



From [Elliott; IITRI] with permission.

PROVISIONAL

The data of [8, 10] indicate a monotectic terminus in the range 83.5-84.5 at.% Bi, as do liquidus data at lower temperatures (see below); [9] indicated ~88 at.% Bi. (The monotectic terminus is placed at 84.5 at.% Bi in Fig. 1.) The miscibility gap critical point was indicated as ~1060 °C, ~20 at.% Bi [8] and ~1300 °C, ~68 wt.% (~21.5 at.%) Bi [9].

The liquidus at <657 °C (for alloys in equilibrium with the Al solid solution) has been reported on the basis of emf measurements (318 to 648 °C) [8], thermal analysis (85 to 97 at.% Bi) [10] and chemical analysis of samples of the liquid (450 to 600 °C) [13] and (354 to 607 °C) [14]. The data of [8, 13, 14] are in agreement over the respective ranges investigated; those of [10] are 20 °C (at 85 at.% Bi) to 100 °C (at 97 at.% Bi) below the curve of [8, 13, 14], which is used in the diagram. The cursory investigation by [15] indicated that the liquidus decreased from 624 °C, 99.6 wt.% (97.0 at.%) Bi to 271 °C, 99.91 wt.% (99.31 at.%) Bi. The eutectic was placed at 269.75 °C, 0.56 at.% Al by [8] and at 271 °C [16]; 0.43 at.% Al by [14]. [9] reported differential thermal analysis data for six alloys in the range 0.05 to 0.50 wt.% (0.39 to 3.75 at.%) Al and concluded that the eutectic temperature was 1.8 °C below the melting point of Bi and that the eutectic composition was 0.30 wt.% (2.28 at.%) Al. According to early work [17], the liquidus temperature of a 0.13 wt.% (1.00 at.%) Al alloy was 0.25 °C below the melting point of Bi. (The eutectic composition is placed at 99.5 at.% Bi in Fig. 1.)

The solid solubility of Bi in Al at 657 °C was <0.2 wt.% (<0.03 at.%) Bi [7]. X-ray examination of vapor-deposited films [18] indicated some solubility of Bi in Al.

Rodney P. Elliott, Cleveland State University, Department of Metallurgical Engineering, Cleveland, Ohio 44115 and **Francis A. Shunk**, 3120 South Princeton, Chicago, Illinois 60616. Work done at IIT Research Institute, Chicago, Illinois, under contract to the Office of Standard Reference Data, National Bureau of Standards; bibliography through 1966.

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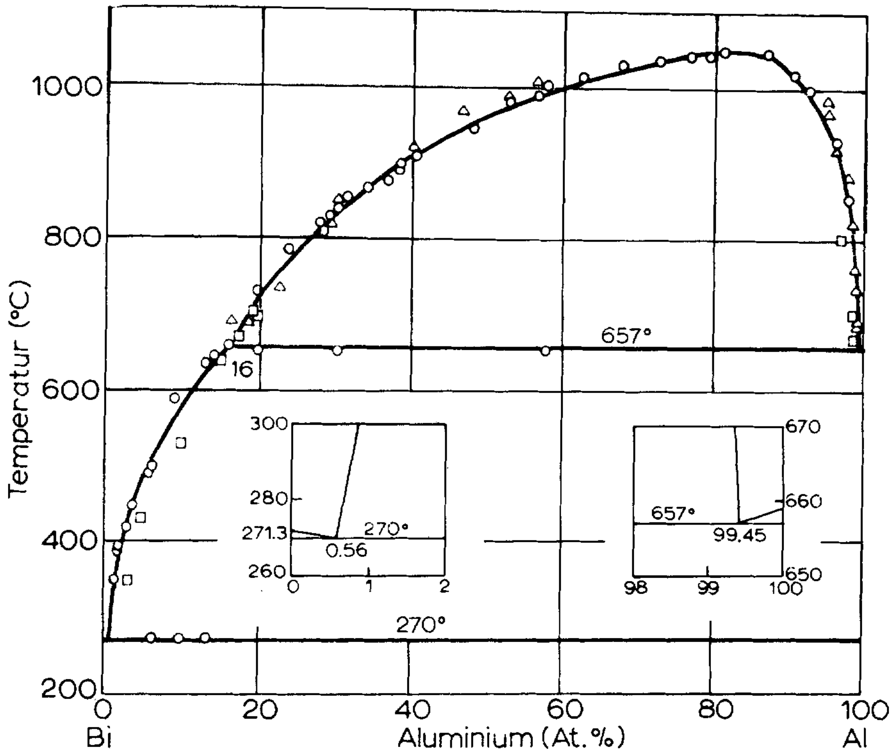
Fig. 2 Phase Diagram of Al-Bi System



From [19] with permission; Δ [8], □ [10], ○ [19].

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