Silver – Copper – Magnesium

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Literature Data

[1943Gue] investigated three ternary alloys to determine various ranges of homo- or heterogeneity, the extension of the inter-mediate binary phases and any possible pseudobinary sections in the ternary system (clear cross method). The alloys were annealed at 400°C and X-ray analyzed at room temperature after slow cooling. $AgMg_3$ - Cu_2Mg and (Ag) - Cu_2Mg are found to be quasibinary at room temperature.
[1979She] and [1980She] reported on metallographic, X-ray and "micro-X-ray spectral analysis" as well as DTA measurements in the partial system Mg-Mg_2Cu-AgMg, stating that AgMg-Mg_2 is quasibinary [1979She].
The statements of [1943Gue] and of [1979She, 1980She] contradict one another; due to the higher number of alloys examined, the more recent results of [1979She, 1980She] are accepted here.
The present evaluation was published in the MSIT Evaluation Program earlier and reflects today's state of knowledge.

Binary Systems

The two binary systems Cu-Mg [1984Nay1] and Ag-Mg [1984Nay2] and the quasibinary AgMg-Mg_2Cu [1979She] are used as boundary systems (Fig. 1).

Solid Phases

No ternary phases have been found. The known binary phases are listed in Table 1. In the intermetallic phase $AgMg_3$ a considerable amount of Ag can be substituted by Cu (≤ 23 mass% Cu).

Pseudobinary Systems

The section AgMg-Mg_2Cu is established as quasibinary using DTA, metallography and X-ray analysis [1979She]. Unfortunately the pseudobinary eutectic is not given explicitly, only the composition of the liquid e_1 (30% Ag, 35.7% Cu and 34.3% Mg) at 530°C. The section is thus constructed and displayed in Fig. 1, using the information given in [1979She, 1980She]. Several mistakes in the liquidus surface given in [1980She] must be corrected, e.g. 550 and 540°C isotherms and the eutectic point 530°C all meet at one point; also the slope of the melting groove e_1-P is reversed.

Invariant Equilibria

Three ternary invariant equilibria are reported (Table 2), these being: maximum decomposition of liquid at 530°C, peritectic formation of $(Ag,Cu)Mg_3$ at 505°C and eutectic decomposition of liquid at 460°C. Only the composition of the liquid phases are given explicitly in [1980She] the composition of the solid phases are constructed from the three isopleths and the 400°C isothermal section of [1979She, 1980She]. The reaction scheme (Fig. 2) and a projection of the invariant equilibrium phases and the connecting lines of double saturation (Fig. 3) are presented.

Liquidus Surface

Figure 4 shows the isotherms of the liquidus surface and the melting grooves separating four areas of primary crystallization; β', γ, ε and α (refer to the section on "Pseudobinary Systems" to see the corrections needed in the liquidus surface given in [1980She]).

Isothermal Sections

Figure 5 displays the isothermal section at 400°C after [1980She] with a minor correction to meet the boundary system Ag-Mg. [1980She] reports that with decreasing temperature (300, 200°C), there is no change in the solubility for β', ε and γ, but a decrease is seen in the Ag and Cu solubilities in Mg.

Temperature-Composition Sections

Two isopleths at Ag = 20 mass% = const. and Cu = 10 mass% are given as Figs. 6 and 7; in addition [1980She] reports an isopleth at 15 mass% Ag.

Miscellaneous

[1982Miz] reports information about amorphous alloys of the type $(Ag_{0.5}Cu_{0.5})_{1-x}Mg_x$ with $0 < x < 0.8$ which are used to test the extended Ziman theory experimentally. [1984Miz, 1986Mat] measured electrical resistivity, low-temperature specific heats and thermoelectric power of Ag-Cu-Mg metallic glasses. Information about dendritic segregation of silver-rich alloys Ag-7.5Cu-0.2Mg (at.%) is reported in [1981Duk].

References

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Table 1: Crystallographic Data of Solid Phases

Phase / Temperature Range [°C]	Pearson Symbol/ Space Group/ Prototype	Lattice Parameters [pm]	Comments
(Ag)	*cF*4 $Fm\bar{3}m$ Cu	*a* = 408.61	pure Ag [P]
(Cu)	*cF*4 $Fm\bar{3}m$ Cu	*a* = 361.49	pure Cu [P]
α, (Mg)	*hP*2 $P6_3/mmc$ Mg	*a* = 320.94 *c* = 521.05	pure Mg, 25°C [P]
Ag_3Mg < 392	*cP*4 $Pm\bar{3}m$ $AuCu_3$	*a* = 411.2	25.0 at.% Mg, annealing time 2 d, [1984Nay2]
β', AgMg	*cP*2 $Pm\bar{3}m$ CsCl	*a* = 333.00 *a* = 329.80	32.26 at.% Mg, 66.71 at.% Mg, slowly cooled
ε, $AgMg_3$	*hP*8 $P6_3/mmc$ $AsNa_3$	*a* = 488.42 *c* = 778.68	25.17 at.% Mg, quenched from 440°C
γ, Mg_2Cu	*oF*48 *Fddd* Mg_2Cu	*a* = 905.0 *b* = 1824.7 *c* = 528.3	[1984Nay1]
$MgCu_2$	*cF*24 $Fd\bar{3}m$ $MgCu_2$	*a* = 699 to 708.2	[1984Nay1]

Table 2: Invariant Equilibria

Reaction	*T* [°C]	Type	Phase	Composition (at.%)		
				Ag	Cu	Mg
L + β' + γ ⇌ ε	505	P	L	9.8	15.5	74.7
			β'	36.5	6.8	56.7
			γ	<2.5	30.0	67.5>
			ε	<14.0	15.2	70.8>
L ⇌ ε + γ + α	460	E	L	7.5	10.1	82.4
			ε	14.1	13.0	72.9
			γ	1.4	29.8	68.8
			α	0.4	0.1	99.5
L ⇌ β' + γ	530	e_1(max)	L	12.4	25.0	62.7
			β'	<37.3	8.3	54.5>
			γ	< 4.0	30.6	65.3>

Composition of the liquidus P, E and e_1(max) given in [1979She] and [1980She]; other 4-phase equilibria phases constructed from isopleths; values in < > for γ, ε of P and β', γ of e_1(max) are estimated.

Fig. 1: Ag-Cu-Mg. The pseudobinary system Mg_2Cu-AgMg

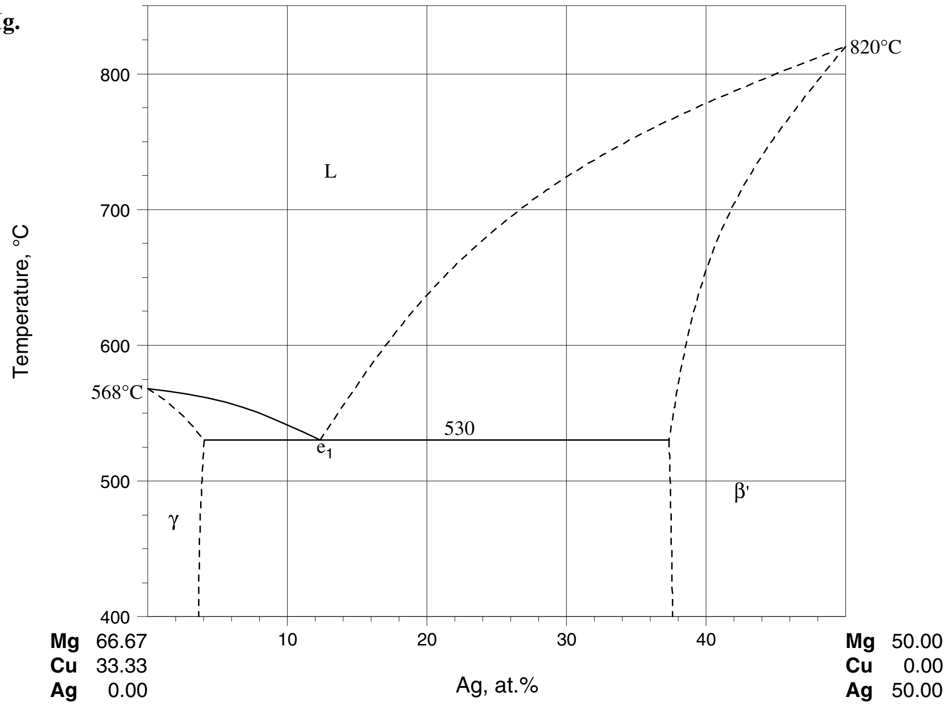

Fig. 3: Ag-Cu-Mg. Polythermal projection of four-phase equilibria and edges of double saturation

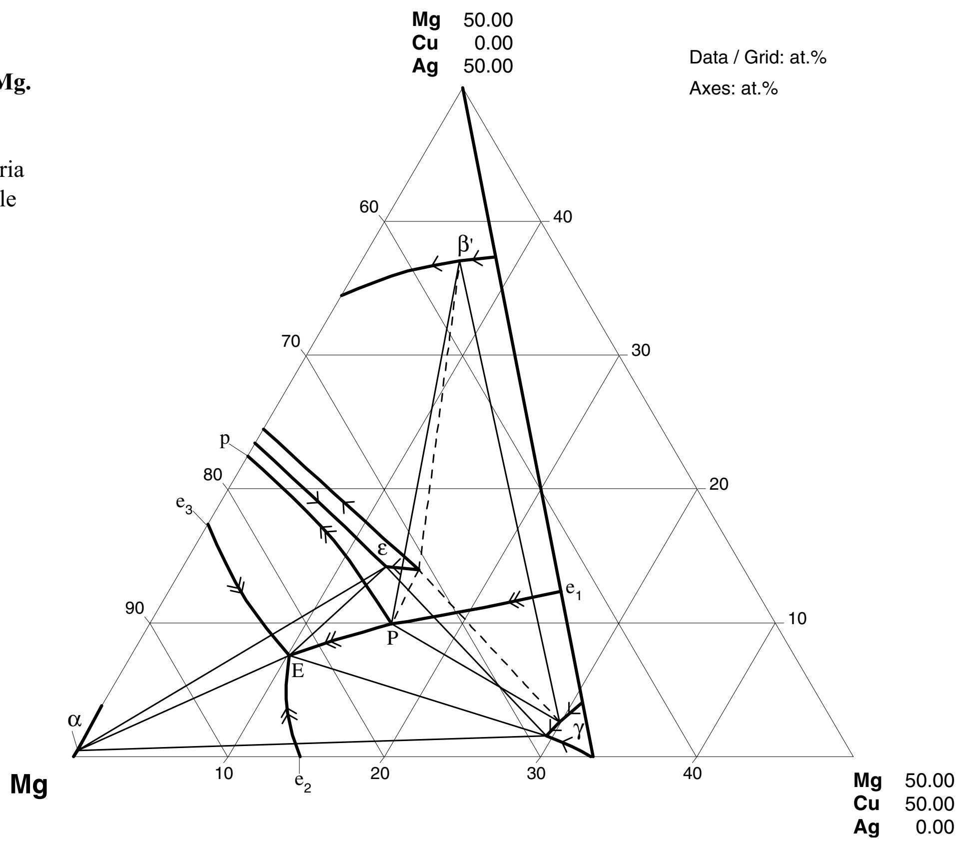

Fig. 4: Ag-Cu-Mg.
Liquidus surface

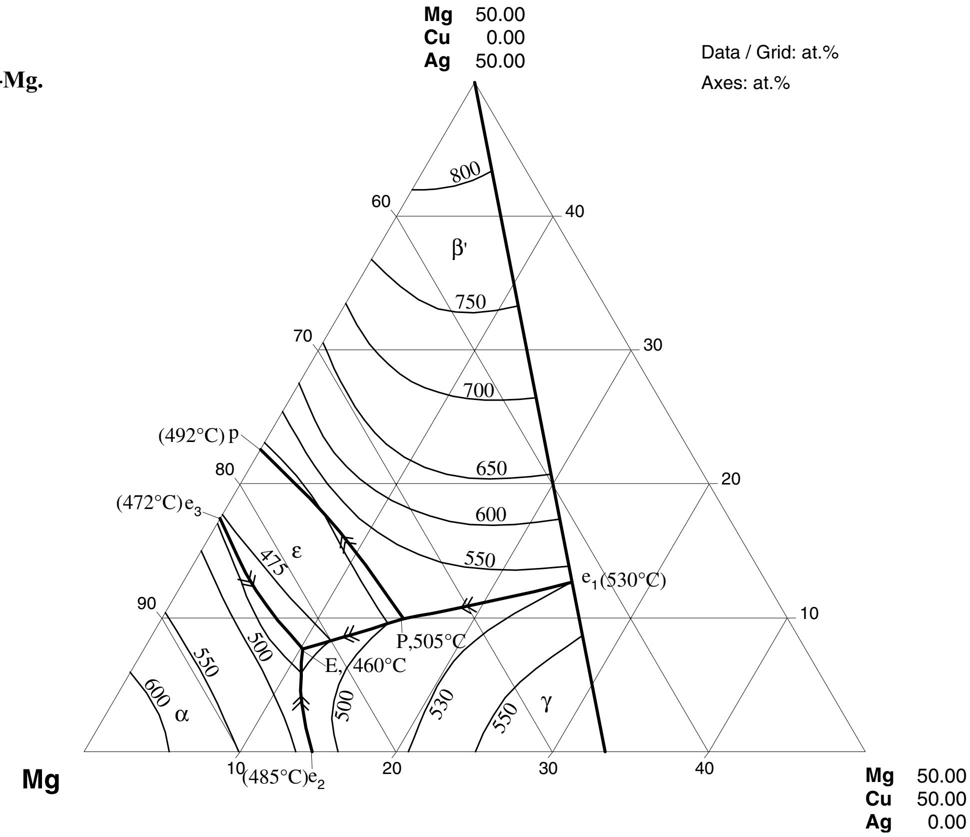

Fig. 5: Ag-Cu-Mg.
Isothermal section with some tie lines at 400°C

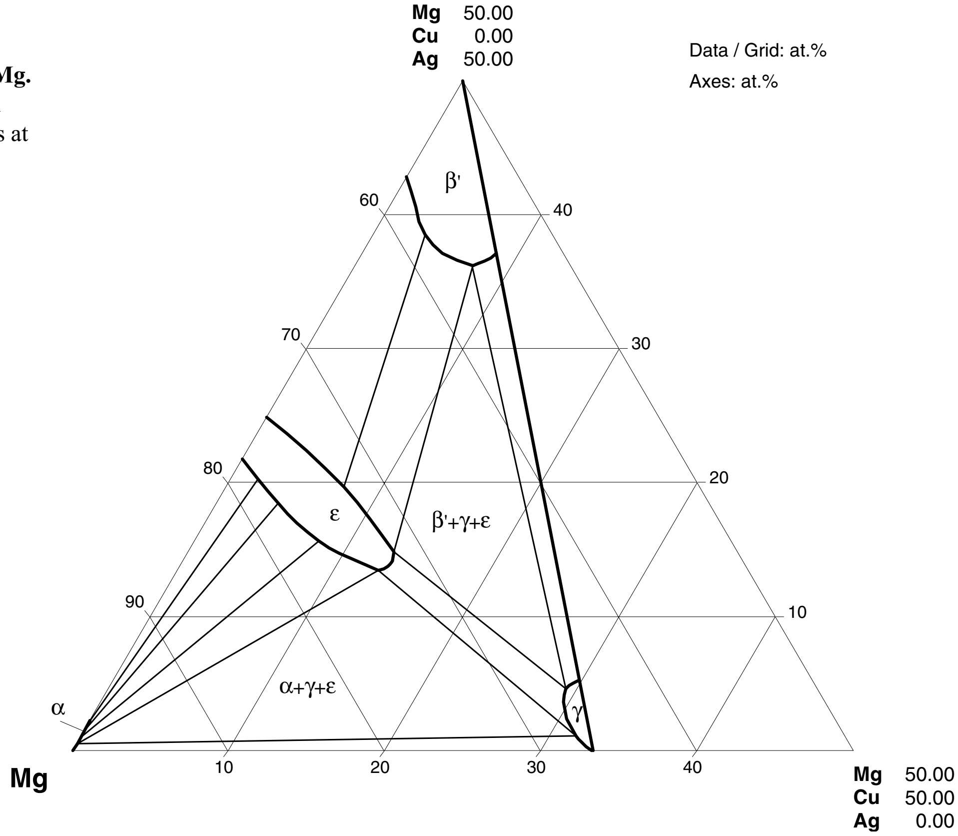

Fig. 6: Ag-Cu-Mg. Temperature - composition cut at 20 mass% Ag

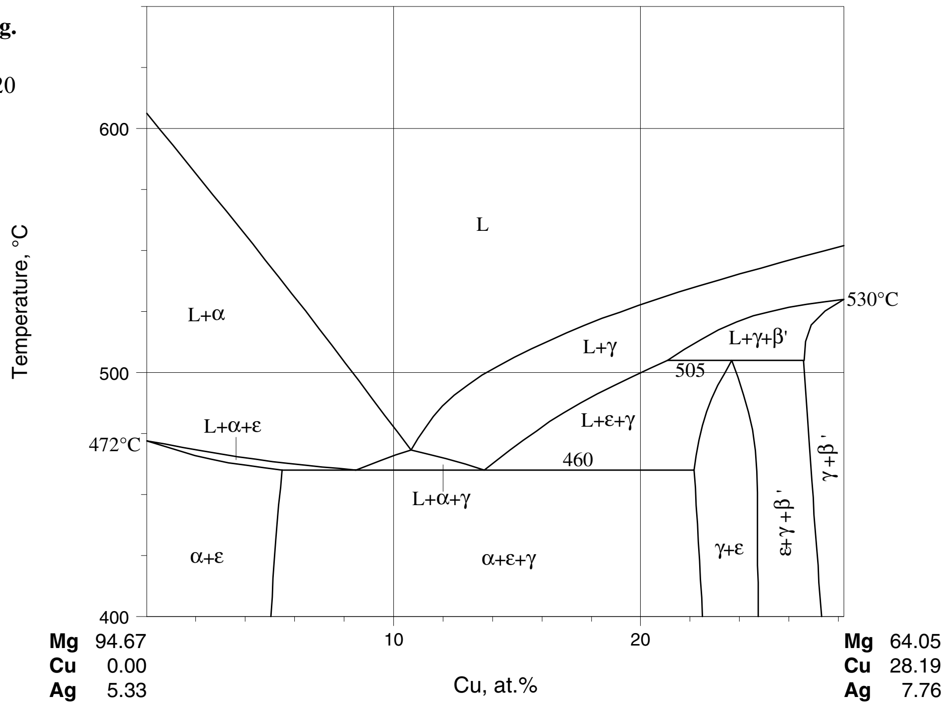

Fig. 7: Ag-Cu-Mg. Temperature - composition cut at 10 mass% Cu