Silver – Copper – Manganese

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Introduction

Based on the binary systems related to the ternary Ag-Cu-Mn system, [1909Jae] supposed the liquidus surface in this system with a minimum at about centre of the concentration triangle. This feature of the phase diagram was not still confirmed completely by the experiments.
The only one experimental investigation was made by [1931Kei] who studied the ternary Ag-Cu-Mn system using mainly metallography supported by thermal analysis. [1931Kei] established extension of the liquid miscibility gap from the binary Ag-Mn system into the ternary system. Its boundaries were determined by chemical analysis. Besides, [1931Kei] assumed existence of a three-phase monovariant equilibrium in the Ag-Cu-Mn system which changed from the peritectic equilibrium in the Ag-Mn system to eutectic one in the Ag-Cu system. However, in the work [1931Kei] the reactions between the liquid phase and different allotropic forms of Mn in the Ag-Mn system were not taken into consideration. These reactions were shown later in the review of the Ag-Cu-Mn system [1977Cha].
[2002Jac] measured the melting temperature of the only 70Cu-25Mn-5Ag (mass%) alloy by differential thermal analysis. This temperature turned out between 800 and 830°C in agreement with [1931Kei].
[1949Jae, 1979Dri, 1980Bra] presented the reviews of the ternary Ag-Cu-Mn system basing on [1931Kei] without critical analysis.

Binary Systems

The binary Ag-Cu, Ag-Mn and Cu-Mn systems are accepted from [2002Rom], [2002Maz] and [2005Tur], respectively.

Solid Phases

No ternary compounds have been observed in the Ag-Cu-Mn system. The crystal structure and lattice parameters of the unary and binary phases of the system are presented in Table 1.

Liquidus Surface

On the liquidus surface the boundary of the miscibility gap $L_1 + L_2$ was determined only experimentally. It is shown in Fig. 1 after the publication [1977Cha], with some corrections of the compositions and temperatures of the invariant reactions taking into account the accepted binary Ag-Cu, Ag-Mn and Cu-Mn systems. The binary Ag-Mn liquid miscibility gap extends into the ternary phase diagram to a maximum at about 32 mass% Cu (~35 at.% Cu) at an unspecified temperature. Other features of liquidus surface were not established.

Notes on Materials Properties and Applications

Commercial alloy “Hi-Temp 095” with the nominal composition of 9.5Ag-52.5Cu-38Mn is used as high strength filler metal for joining carbides, steels and heat resistant alloys. Its liquidus temperature is 926°C, its solidus temperature is 879°C.
Ag-Cu-Mn alloys are the part of the commercial alloy “WB850” (65Ag-28Cu-5Mn-2Ni) used for electronic packaging.
[1942And] investigated a series of the Ag-Cu-Mn alloys aiming to substitute nickel in the present 5 cent coin. The resistivity, color, density and resistance to corrosion were determined for Cu rich alloys with Mn and Ag from 4 to 50 mass%. The diagrams characterizing dependence of the properties on the alloy compositions were presented.

[1931Kei] measured the hardness of Ag based alloys with 2, 3, 4 mass% Cu and 15, 10, 5 mass% Mn after homogenization at 750°C, quenching and ageing at 280°C for 2, 5, 10 and 20 h. The maximum of hardness was reached on 91Ag-4Cu-5Mn (mass%) alloy after ageing at 280°C for 5 h. The increase of Mn content led to decrease of hardness.
[2002Jac] investigated the properties of the 70Cu-25Mn-5Ag (mass%) alloy. The values of hardness 130 H_V and tensile strengths of 150 to 230 MPa were obtained.

Miscellaneous

[1969Gue] considered the ternary Ag-Cu-Mn system introduced by [1931Kei] and gave some comments on it. According to [1969Gue] the Mn corner of the system is scientifically interesting owing to the polymorphism of Mn and to its very different dissolving power for Ag and Cu atoms. Formation between Cu and Mn an ultimate series of the solid solutions in a definite temperature range might display special properties in presence of Ag in the alloys. Such properties could be brightness, color of copper, patina and chemical behavior.

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/References
(Ag) < 961.93	*cF*4 $Fm\bar{3}m$ Cu	*a* = 408.57	pure Ag at 25°C [Mas2] dissolves up to 14.1 at.% Cu at 779.1°C [2002Rom] and 43.6 at.% Mn at 989°C [2002Maz]
(δMn) 1246 - 1138	*cI*2 $Im\bar{3}m$ W	*a* = 308.0	pure δMn at >1138°C [Mas2] dissolves up to 13 at.% Cu at 1097°C [2005Tur] and 1.2 at.% Ag at 1207°C [2002Maz]
(γMn,Cu)	*cF*4 $Fm\bar{3}m$ Cu		
(γMn) 1138 - 1087		*a* = 386.0	pure γMn [Mas2] dissolves up to 100 at.% Cu [2005Tur] and 0.7 at.% Ag at 1128°C [2002Maz]
(Cu) < 1084.62		*a* = 361.46	pure Cu at 25°C [Mas2] dissolves up to 5 at.% Ag at 779.1°C [2002Rom] and up to 100 at.% Mn [2005Tur]
(βMn) 1087 - 707	*cP*20 $P4_132$ βMn	*a* = 631.52	pure βMn [Mas2] dissolves up to 2 at.% Cu at 706°C [2005Tur] and 0.4 at.% Ag at 1069°C [2002Maz]
(αMn) < 707	*cI*58 $I\bar{4}3m$ αMn	*a* = 891.26	pure αMn at 25°C [Mas2] dissolves up to 2 at.% Cu at 706°C [2005Tur]
γ_3 (Cu-Mn) ≤ 700	*c**	-	[2005Tur]
γ_2, $MnCu_3$ ≤ 450	*c***	-	[2005Tur]
γ_3 (Cu-Mn) ≤ 410	*c***	-	[2005Tur]

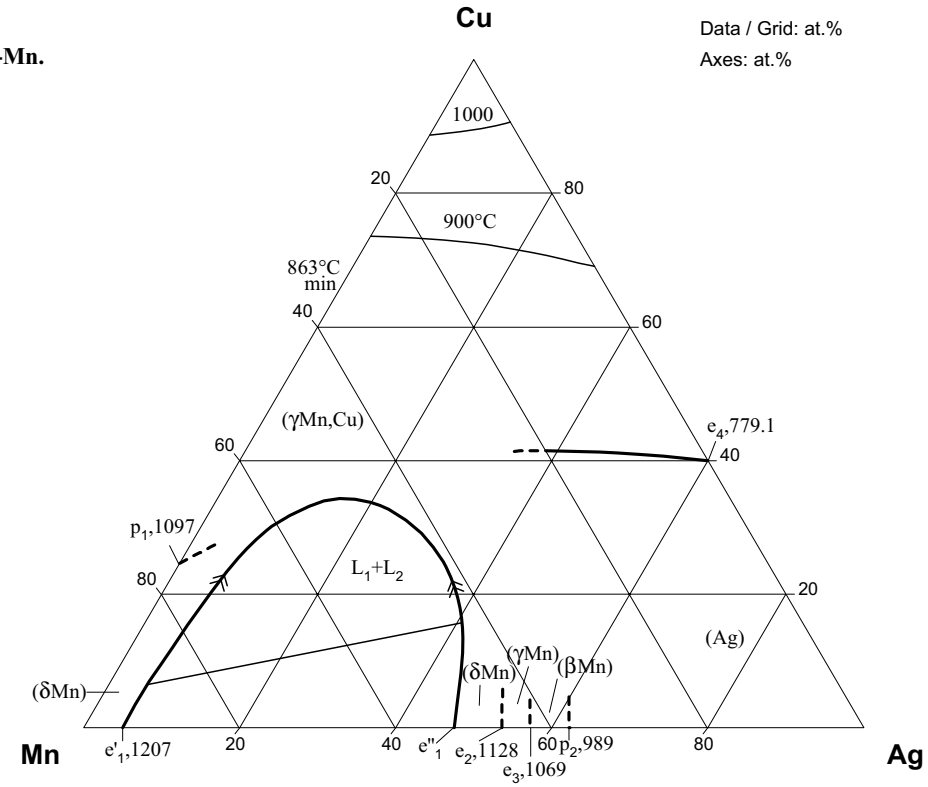

Fig. 1: Ag-Cu-Mn. Liquidus surface projection