Copper – Palladium – Tin

Viktor Kuznetsov

Introduction

The Cu-Pd-Sn system gained interest in the search for new lead free solders because the performance of Pd-coated components with lead-free alloys is equivalent to, or better than SnPb. This is due to the slightly greater dissolution rates of Pd in high tin alloys. Generally, lead-free alloys perform adequately on OSP (Organic Solderability Preservatives) coated boards, but have improved solderability on metallic coatings such as Sn, Ag or Pd.
The intermetallics of the system occur in nature as mineral species. The natural specimens have also varying content of Pt (5% and more) as well as admixtures of Ni, Sb and Pb (see reviews in [1970Yus], [1973Ras]).
The only experimental investigation of the system [1980Evs] (Table 1) is performed for rationalization of phase relations and compositions of those minerals. The samples were prepared from powders of components of special purity, melted in the ampoules (material not specified) and subjected to DTA. After that the samples were studied by optical microscopy, X-ray analysis and EPMA. The transition temperatures in the solid state were determined by high-temperature X-ray analysis. X-ray patterns were taken at room temperature before and after the experiment and 100°C below solidus after 1 h annealing. During heating and cooling with 10°C·min^{-1} rate the changes of the diffraction patterns were monitored in the 2θ region of 35 to 42°. In addition, a separate samples with several compositions were synthesized by hydrothermal method (300 to 700°C, $p(H_2O)$ = 1 kbar) in presence of HCl. Authors noticed that phase relations in the Pd-Sn-Cu-HCl system differ from those in dry Cu-Pd-Sn system, so these results are not included here; for further details see original work [1980Evs].

Solid Phases

At higher temperatures the solid solution of Cu in the Pd_3Sn phase extends for all the compositions studied (till ~30 at.% Cu). Six ternary phases are claimed to exist in the low-temperature part; they were characterized mainly by optical properties (color, bireflexivity, anisotropy of reflexivity). In particular, the latter was taken as evidence for symmetry lowering as compared to Pd_3Sn compound. X-ray patterns for ternary phases are tabulated, but no structural information seems to be extracted, except qualitative observation of splitting of some lines of Cu_3Au structure; in particular, no *hkl* are ascribed to the lines in the table. A suggested scheme of ordering of the high-temperature Pd_3Sn based phase seems to be purely speculative.
The phases of the studied part of the Pd_3Sn-Cu_3Sn section are listed in Table 2.

Temperature – Composition Sections

The partial Pd_3Sn-Cu_3Sn section is presented in Fig. 1. This is based on the data of [1980Evs], but with some modifications. First, the spurious two-phase region in declared field of stability of the solid solution of Cu in Pd_3Sn, is removed; the reasons of its appearing in the figure are quite unclear from the text. Second, the congruent maximum of formation of the "Pd_5Sn_2Cu" phase is tentatively added at 550°C instead of a peritectoid reaction, given in the original figure, where two participating phases would be the same. Finally, the liquidus and solidus lines are adjusted to meet the accepted melting temperature of Pd_3Sn (Table 1).
The low-temperature part of the section can not be considered firmly established and seems to need more detailed investigations, in particular for invariant reactions shown in the figure.

References

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Copper-Nickel Ores of Talnakh and Norilsk Fields" in "*Mineralogicheskiye Issledovaniya (Mineralogical Studies)*", (2), Moscow, Nauka, 58-69 (1972) (Review, 8)

[1973Ras] Rasin L.V., Begazov V.D., Meshchankina V.I., "Notes about Mineralogy of Platinoid Metals in Talnakh Field" (in Russian), in "*Trudy ZNIGRI*", (108), 96-151 (1973) (Review, 15)

[1980Evs] Evstigneeva, T.L., Nekrasov, I.Ya., "Conditions of Synthesis of Phases and Phase Relations in Pd_3Sn-Cu_3Sn and Pd-Sn-Cu-HCl Systems" (in Russian), *Ocherki Fiz.-Khim. Petrol.*, **9**, 20-35 (1980) (Phase Relations, Experimental, 11)

Table 1: Investigations of the Cu-Pd-Sn Phase Relations, Structures and Thermodynamics

Reference	Method/Experimental Technique	Temperature/Composition/Phase Range Studied
[1980Evs]	DTA, optical microscopy, X-ray analysis, EPMA	Pd_3Sn-Cu_3Sn section, 0 to 66 mol.% of Cu_3Sn

Table 2: Crystallographic Data of Solid Phases of the Pd_3Sn-Cu_3Sn Section

Phase/ Temperature Range [°C]	Pearson Symbol/ Space Group/ Prototype	Lattice Parameters [pm]	Comments/References
$(Pd,Cu)_3Sn$	*cP*4 $Fm\bar{3}m$ $AuCu_3$	*a* = 398	at 16.7 mol.% Cu_3Sn, 1040°C [1980Evs]
		a = 394	at 25.0 mol.% Cu_3Sn, 1004°C [1980Evs]
		a = 390	at 33.3 mol.% Cu_3Sn, 1000°C [1980Evs]
		a = 388	at 40.0 mol.% Cu_3Sn, 1000°C [1980Evs]
		a = 385	at 50.0 mol.% Cu_3Sn, 890°C [1980Evs]
Pd_3Sn < 1326		*a* = 397.6	[V-C2, Mas2]
Cu_3Sn < 676	*oC*80 *Cmcm* Cu_3Sn	*a* = 552.9	[V-C2, Mas2]
* Pd_5Sn_2Cu < 550	-	-	[1980Evs]
* $Pd_9Sn_4Cu_3$ < 320	-	-	[1980Evs]
* Pd_2SnCu < 198	-	-	[1980Evs]
* $Pd_9Sn_5Cu_6$ < 100	-	-	[1980Evs]
* $Pd_3Sn_2Cu_3$ < 100	-	-	[1980Evs]
* $PdSnCu_2$	-	-	[1980Evs]

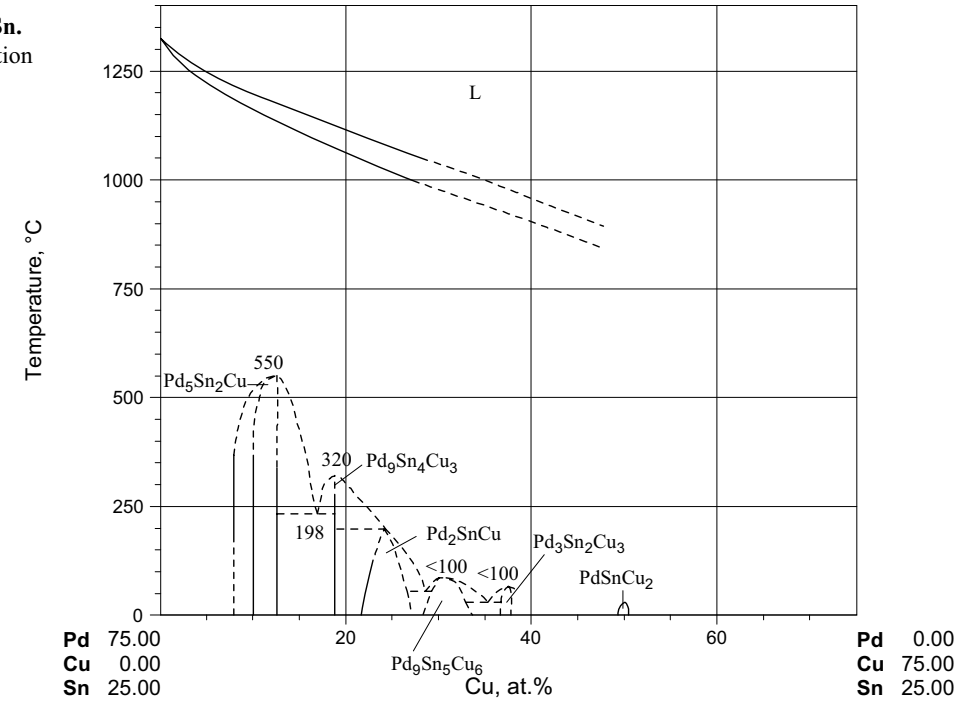

Fig. 1: Cu-Pd-Sn. Partial vertical section Pd_3Sn-Cu_3Sn