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Letter

DTA investigation of the $(Ni_2Cu)_{1-x}Sn_x$ system

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Abstract

Alloys of the system $(Ni_2Cu)_{1-x}Sn_x$ with $x \leq 0.3$ were investigated by means of DTA between 850 °C and 1400 °C at heating velocity 10 K min^{-1}. They confirmed the form of the liquidus curve reported in the literature and, for the first time, bring information concerning the solidus and solvus lines.

Keywords: Differential thermal analysis; Arc melting

1. Introduction

Mechanical properties of alloys depend on their phase composition and stability. A study of the Ni_2CuSn alloy, reported in Ref. [1], has initiated a search for literature data concerning the equilibrium phase diagram of the system. Apart from the well-known binary phase diagrams of the Ni–Cu, Ni–Sn and Cu–Sn systems (see e.g. Refs. [2,3]) important data concerning the Ni_3Sn–Cu_3Sn section were found in [4,5,6]; isothermal sections of the liquidus surface are reported in Refs. [7,8]. The single-phase regions along the Ni_3Sn–Cu_3Sn section have the form of a thin wall. We found it necessary to investigate the phase stability of the Ni–Cu–Sn system along the $(Ni_2Cu)_{1-x}Sn_x$ section for $x \leq 0.3$ for which the published data deliver the form of the liquidus curve and some contradictory assertions concerning the stability regions of the solid phases with DO_3, DO_{19} and 2H structure. Here we present data obtained in DTA measurements. The results of parallel resistometric and X-ray investigations will be published elsewhere [9,10].

2. Experimental part

The alloys $(Ni_2Cu)_{1-x}Sn_x$ with $x = 0; 3; 5; 7; 10; 15; 17; 21; 22.5; 25; 27; 30$ at% were prepared by the arc melting of appropriate amounts of Ni 99.9+, Cu 99.995 and Sn 99.995 under argon atmosphere. The melt was chill solidified on a water-cooled copper plate; the ingots were of lenticular shape, approx. 2 cm in diameter, from which the samples for DTA investigation were spark cut. Prior to proper measurements each specimen was heated within the measuring device (with $v = 10$ K min^{-1}) up to the liquid state and then immediately cooled down (with the same v) back to room temperature.

The experiments were done in the 404/406 Netzsch apparatus. The samples with mass of about 100 mg were put on a small alumina (AL23) crucible; annealed kaolin was used as the reference sample. All measurements were done under static argon atmosphere. The PtRh10–Pt thermocouples, properly calibrated by means of the set of pure metals, were used. The typical heating and cooling velocity was 10 K min^{-1}.

The performance of the experimental set-up and evaluation procedure was checked by measuring the melting and solidification of a set of Ni–Cu alloys (prepared in the same way as those mentioned above). Endothermic melting peak (with one mean and sometimes another one side maximum) was observed upon heating, an exothermic solidification peak upon cooling, both done $v = 10$ K min^{-1}. The melting peak data were evaluated according to the ICTA convention (see e.g. Ref. [11]) and compared with data extracted (with an estimated ±4 °C error) from the phase diagram given in Ref. [3]. The temperature T_0 of the onset of the melting peak was found to correspond to the reported solidus temperature T_s (with maximum de-

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Table 1
Characteristic temperatures of the melting peak observed in the $(Ni_2Cu)_{1-x}Sn_x$ alloys for heating velocity $v = 10\,K\,min^{-1}$

x[at% Sn] (nomin.)	$T_0 \approx T_s$ [°C]	$T_m \approx T_{lq}$ [°C]	T_{lq}^{lit} [°C]
0	1325	1367	1370
3	1172	1328	
5	1124	1294	1291
7	1086	1256	
10	1020	1191	1197
13	1023	1128	1134
15	1028	1101	1102
17	1013	1058	
20	995	1087	1088
21	1009	1095	
22.5	1001	1103	
25	1053	1111	1091
27	1037	1101	1088
30	1004	1130	1127

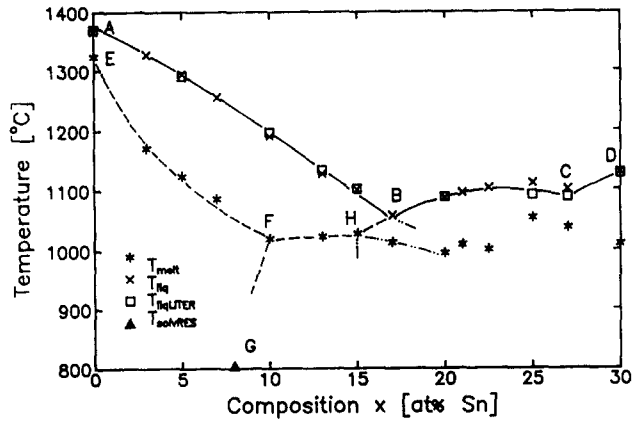

Fig. 1. The proposed form of isopleth phase diagram of the $(Ni_2Cu)_{1-x}Sn_x$ system.

viation of 6 °C), the temperature T_m of the high temperature maximum to correspond (with maximum deviation of 8 °C) to the liquidus temperature T_{lq}.

In the $(Ni_2Cu)_{1-x}Sn_x$ alloys the melting and the solidification peaks were more complicated. As we were unable to discover any regular effect of prior heat treatment, velocity v of temperature change or composition on their form, we decided to adopt strictly the same evaluation procedure as in the case of Ni_2Cu alloys, i.e. to take into account the $v = 10\,K\,min^{-1}$ heating curves only, and to find the temperature T_0 of the onset of the peak and the temperature T_m of the high temperature maximum. These values are summarized in the second and third column of Table 1; the fourth column contains the liquidus temperatures derived from a figure published in Ref. [8]. Solidus temperature of 1334 °C can be found for the $x = 0$ alloy in Ref. [2].

The estimated error of determination of the T_{lq}^{lit} and the T_{lq} temperature is ±5 °C and ±10 °C, respectively. Although we expect the error of the T_s values to be also of the order of ±10 °C, these values are supposed to be less precise than those of T_{lq}. This is especially true for the alloys with 3 and 5 at% Sn where we suspect the T_s to be too low.

3. Discussion and conclusions

The data given in Table 1 are plotted in Fig. 1. The solid guide-for-eye curve ABCD takes into account the overall form of the liquidus surface of the system as presented in Fig. 2 of [8] and fits reasonably well both our experimental data and those given in the literature. Therefore we take it for the equilibrium liquidus line. It is worth mentioning that the starting temperatures of the first DTA peak observed upon cooling with $v = 10\,K\,min^{-1}$ follow its AB part well, whereas some seemingly chaotic discrepancies exist along the BC part.

As for the rest of our measurements we lack the possibility of direct comparison with literature. The proposed form of the curves EFHB and FG is supported by their analogy to the Ni–Sn phase diagram on the one hand and by the information concerning the approximate solubility limit at 800°C – point G – on the other hand (see Ref. [10]). The dash–double dot parts starting at H and B were sketched in accordance with the general rules concerning the phase state of neighbouring fields in the equilibrium state diagram (see e.g. Ref. [12]); their precise position and actual extent, however, remained uncertain.

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References

[1] P. Kratochvíl, W. Biegel, B. Sprušil and B. Chalupa, *Phys. Stat. Sol. (A), 131* (1992) 321.
[2] M. Hansen and K. Anderko, *Constitution of Binary Alloys*, 2nd Edition, McGraw Hill, New York, 1965.
[3] T.B. Massalski (ed.), *Binary Alloys Phase Diagrams*, ASM International, 1990, pp. 1442, 1481, 2863.
[4] Y. Watanabe, Y. Murakami and S. Kachi, *J. Japn. Inst. Metals, 45* (1981) 551.
[5] J.S. Lee Pak, K. Mukherjee, O.T. Inal and H.R. Pak, *Mater. Sci. Eng., A117* (1989) 167.
[6] J.S. Lee Pak, K. Mukherjee, O.T. Inal and H.R. Pak, *Mater. Sci. Eng., A130* (1990) 83.

[7] M. Miki and Y. Ogino, *J. Japn. Inst. Metals 47* (1983) 602.
[8] E. Wachtel and E. Bayer, *Z. Metallkd. 75* (1984) 602.
[9] P. Kratochvíl, to be published.
[10] B. Sprušil, to be published.
[11] G. Lombardi, *For Better Thermal Analysis*, Instituto di mineralogia e petrografia dell'Universita di Roma, Rome 1977, p. 22.
[12] F.N. Rhines, *Phase Diagrams in Metallurgy*, McGraw-Hill Book Comp., New York, 1956.