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On β-phase decomposition in the In–Sn binary system

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Abstract

Investigations have been performed on the β-phase decomposition process within 10–300 K, on the composition, structure and resistivity of In_3Sn alloy. The decomposition process was monitored by X-ray diffraction using a D5000 Siemens diffractometer equipped with a helium low temperature attachment. The X-ray investigations showed two characteristic points at 240 K and 190 K. At these points the change in resistivity is also visible. Moreover, the resistivity curve has a third characteristic point at about 285 K.

1. Introduction

Reports on the decomposition of the β-phase in the In–Sn binary system at low temperature have been published previously in refs. 1 and 2. Bartram *et al.* [1] have reported that the β-phase decomposes eutectoidally at 140 K. References 2 and 3 state that the decomposition process depends strongly on the applied temperature gradient. In this paper we present the X-ray and resistivity results obtained on a sample possessing composition 3In–Sn at a temperature within 10–300 K.

2. Experimental details

The title alloy was prepared from appropriate amounts of indium (purity 99.99%) and tin (purity 99.999%) melted together in an evacuated glass tube, followed by quenching in water. Next the ingots were converted into fillings and annealed in vacuum at 350 K for one day. The sample obtained in this way was mounted on a special holder and measured on a D5000 Siemens diffractometer equipped with a helium low temperature attachment; CuKα radiation was used. After completing the first X-ray measurement at 300 K, the temperature was lowered to the next definite point with a temperature gradient of 10 K h^{-1} and successive X-ray diffractograms were taken. After that the sample was heated back to 300 K and the X-ray diffractogram at this temperature was taken once more. It was identical with the initial one. A few selected powder diffraction diagrams are showed in Fig. 1. The lattice parameters of the phases present in 3In–Sn alloy in relation to temperature are collected in Table 1.

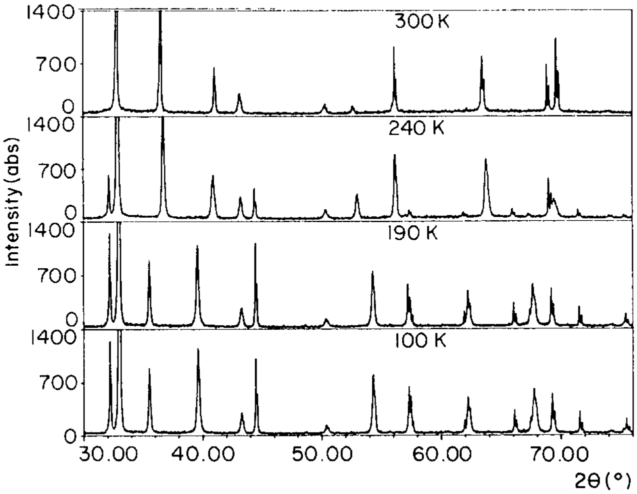

Fig. 1. Selected powder diffraction diagrams of 3In–Sn alloy.

The resistivity was measured on the same sample used for X-ray diffraction. The resistivity change in the sample *vs.* temperature is illustrated in Fig. 2. During measurement the sample was cooled with a temperature gradient of 6 K h^{-1} and heated back at 3 K h^{-1}.

3. Results and discussion

The X-ray diffraction data shows that at measurement temperatures lying above 285 K, the 3In–Sn alloy is a β-phase (in agreement with the phase diagram given in ref. 1). While cooling slowly, the γ-phase appears at 240 K. At 190 K the diffraction lines from the β-

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TABLE 1. The unit cell parameters of the phases *vs*. temperature

T (K)	β-phase *I4/mmm*		γ-phase *P6/mmm*		α-phase *I4/mmm*	
	a (Å)	*c* (Å)	*a* (Å)	*c* (Å)	*a* (Å)	*c* (Å)
300	3.4774	4.4127				
270	3.4728	4.4104				
240	3.4566	4.4097	3.2118	2.9983		
230	3.4559	4.4090	3.2110	3.9978		
220	3.4545	4.4087	3.2101	2.9977		
210	3.4533	4.4080	3.2100	2.9961		
200	3.425	4.4055	3.2073	2.9960		
190			3.2072	2.9952	3.2451	5.0485
180			3.2070	2.9948	3.2183	5.0480
140			3.2063	2.9929	3.2135	5.0470
100			3.2060	2.9920	3.2100	5.0461
30			3.1961	2.9914	3.2038	5.0452
10			3.1945	2.9910	3.2017	5.0448

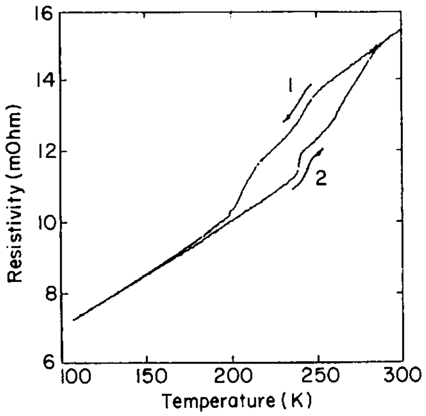

Fig. 2. Resistivity of 3In–Sn alloy *vs*. temperature. Curve 1 for sample cooled at a temperature gradient 6 K h^{-1}, curve 2 for the sample heated at a temperature gradient of 3 K h^{-1}.

phase fully vanishes, and lines from the α-phase are visible. Between 240–190 K, the β- and γ-phase and below 190 K (not 140 K as given in ref. 1) γ- and α-phase are present. The relative change in the unit cell parameters *vs*. temperature is shown in Fig. 3.

The curve 1 in Fig. 2 presents the resistivity of the sample measured during cooling. The first small inclination on curve 1 (about 240 K) is undoubtedly connected with separation of the γ-phase and the second inclination (about 190 K) is connected with simultaneous α-phase appearance and the β-phase fully vanishing.

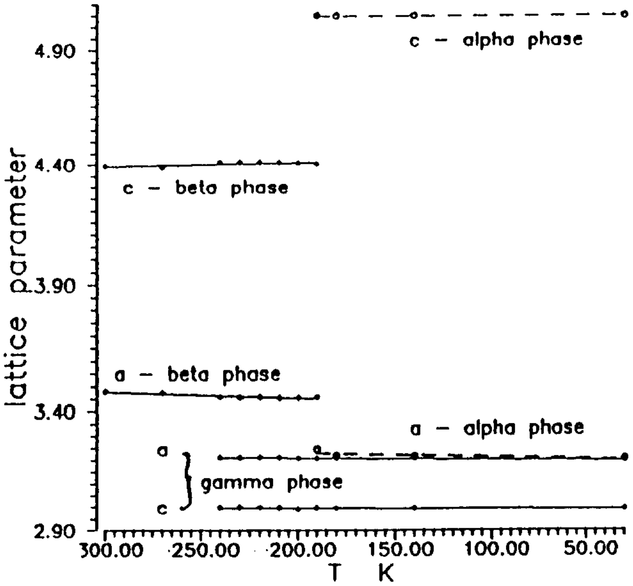

Fig. 3. Cell parameters of phases presented in 3In–Sn alloy *vs*. temperature.

Curve 2 in Fig. 2 presents the resistivity change during heating of the sample. Below 190 K and above 285 K line 1 overlaps with line 2. Between 190–285 K the hysteresis loop is observed.

On the basis of both sets of data (X-ray and resistivity measurements) we suggested that some corrections in the lower part of the In–Sn binary diagram are needed. At 240 K a remarkable change in β-phase composition and separation of the γ-phase take place. This is indicated either by the peritectic reaction or/and by the ordering process of atoms at positions randomly occupied by In and Sn atoms in the β-phase crystal lattice. A detailed discussion must be postponed until further thermodynamic and neutron diffraction experiments have been stimulated.

References

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