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Investigation of phase equilibria in the ternary Ti-Al-Sn

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ABSTRACT

Phase equilibria of the system Ti-Al-Sn at 900°C were investigated and are presented in form of an isothermal section. The occurrence of a ternary phase $\text{Ti}_3\text{Sn}_2\text{Al}$ having W_5Si_3 -type structure is reported.

INTRODUCTION

The ternary system Ti-Al-Sn became of interest within the action COST 507, which aims for the thermodynamic description of multicomponent light alloys. The only reference dealing with the constitution of this system reports for the vertical section $\text{Ti}_3\text{Al-Ti}_3\text{Sn}$ a complete series of solid solutions $\text{Ti}_3(\text{Al}_x\text{Sn}_{1-x})$ at temperatures below 1000°C (1). Since no information on equilibria with other phases were reported, a complete isothermal section was investigated and the results are presented here.

EXPERIMENTAL

Using powders of the elements (Ti, purity: 99%, from Johnson Matthey, Alpha Products, FRG; Al, purity: 99.8%, from Strem Chemicals, USA; and Sn purity: 99.5%, from Alpha Div., Ventron Corp., USA) 22 ternary and 4 binary alloys were prepared by arc melting the powder compacts under pure argon followed by heat treatment at 900°C for 140 hours. All alloys were water quenched and analysed by XRD (Guinier-Huber cameras, $\text{CuK}\alpha_1$ radiation). The diffraction data were handled and evaluated using the software package STRUKTUR (2).

RESULTS

ISOTHERMAL SECTION AT 900°C

The phase field partition (fig.1) is characterized by the occurrence of a ternary phase, $\text{Ti}_5\text{Sn}_2\text{Al}$, and considerable solubility of aluminium in Ti_6Sn_5 (up to 3 at% Al) as well as in Ti_5Sn_3 (up to 18 at% Al). On the other hand, in the binary phases TiAl_3 , TiAl_2 and TiAl no solubility of tin was observed. The formation of a continuous series of solid solutions between the isostructural phases Ti_3Sn and Ti_3Al is confirmed. The three-phase fields observed are:

Ti_5Sn_3 (s.s. 12.5 at% Al) + $\text{Ti}_5\text{Sn}_2\text{Al}$ + Ti_3 (Sn.96Al.04)
 TiAl (Ti rich limit) + $\text{Ti}_5\text{Sn}_2\text{Al}$ + Ti_3 (Sn.65Al.35)
 TiAl (Ti rich limit) + $\text{Ti}_5\text{Sn}_2\text{Al}$ + Ti_5Sn_3 (s.s. 12.5 at% Al)
 TiAl_2 + TiAl (Al rich limit) Ti_6Sn_5 (s.s. 16 at% Al)
 TiAl_2 + Ti_5Sn_3 (s.s. 18 at% Al) + Ti_6Sn_5 (s.s. 3 at% Al)
 TiAl_3 + TiAl_2 + Ti_6Sn_5 (s.s. 3 at% Al)

Alloys less rich in titanium than alloys along the tie line TiAl_3 + Ti_6Sn_5 contained liquid phase.

Fig.1: Isothermal section at 900°C

THE TERNARY PHASE $\text{Ti}_5\text{Sn}_2\text{Al}$

A ternary intermetallic phase with the approximate composition $\text{Ti}_5\text{Sn}_2\text{Al}$ is observed for the first time. This phase coexists with TiAl (s.s. Sn), Ti_5Sn_3 (s.s. Al) and Ti_3Sn (s.s. Al). The x-ray diffraction powder pattern (tab.1) is indexed based on a body centered tetragonal unit cell with $a = 1.0549(2)$ nm and $c = 0.5242(2)$ nm in the alloy $\text{Ti}_{62}\text{Sn}_{23}\text{Al}_{15}$, which was almost homogeneous containing only traces of Ti_5Sn_3 (s.s. Al) and TiAl . The existence of a substantial homogeneity range is indicated by the variation of the lattice parameters with the composition of the alloy, e.g. in $\text{Ti}_{62}\text{Sn}_{28}\text{Al}_{10}$ $a = 1.0564$ nm, $c = 0.5264$ nm (coexisting with Ti_5Sn_3 (s.s. Al) and Ti_3Sn (s.s. Al)). The intensities of the diffraction peaks can be described satisfactorily by a W_5Si_3 type related crystal structure with spacegroup $I4/mcm$ and 16 Ti(1) in position (16k), 4 Ti(2) in position (4b), 8 Sn in position (8h) and 4 Al in position (4a) (tab.1).

Tab.1 X-ray Powder Diffractogram of $\text{Ti}_5\text{Sn}_2\text{Al}$ in $\text{Ti}_{62}\text{Sn}_{23}\text{Al}_{15}$ ($\text{CuK}\alpha$ radiation, Ge standard, Guinier camera). Reflections having a calculated intensity < 5 are omitted.

H	K	L	$\sin^2\theta_{\text{obs}}$	$\sin^2\theta_{\text{calc}}$	Int. _{obs}	Int. _{calc}	
1	1	0	0.0107	0.0107	w	8	
2	0	0	0.0213	0.0213	w	6	
2	1	1	0.0483	0.0482	s	66	
0	0	2	0.0862	0.0864	m	28	
3	2	1	0.0909	0.0909	m	28	
3	3	0	0.0959	0.0960	m	30	
4	2	0	0.1066	0.1066	ms	24	coinc. Ti_5Sn_3
2	0	2	0.1078	0.1077	m	27	
			0.1095		vw		TiAl
4	1	1	0.1123	0.1122	vs	100	
			0.1177		w		Ti_5Sn_3
2	2	2	0.1290	0.1290	w	8	
3	1	2	0.1398	0.1397	vw	7	
4	0	2	0.1720	0.1717	w	17	
5	2	1	0.1763	0.1762	w	21	
5	3	0	0.1815	0.1813	vw	5	
3	3	2	0.1827	0.1823	w	18	
6	0	0		0.1919		8	
4	2	2	0.1925	0.1930	vw	1	
2	1	3	0.2208	0.2210	vw	9	
7	1	0		0.2666		8	
5	3	2	0.2670	0.2676	w	9	
4	1	3	0.2851	0.2849	m	27	
6	2	2	0.2997	0.2996	vw	3	
7	2	1	0.3042	0.3041	vw	3	
7	3	0	0.3089	0.3092	vw	7	
0	0	4	0.3457	0.3456	vw	8	
5	2	3	0.3492	0.3489	vw	9	
7	1	2	0.3527	0.3529	n.d.	11	coinc. Ge
6	4	2	0.3635	0.3634	w	18	
8	1	1	0.3684	0.3683	w	19	
6	6	0	0.3841	0.3840	vw	4	
7	3	2	0.3955	0.3954	vw	15	

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