



ELSEVIER

Journal of Alloys and Compounds 336 (2002) 187–189

Journal of  
ALLOYS  
AND COMPOUNDS

www.elsevier.com/locate/jallcom

# Phase equilibria in the Sm–Zr–Sb system at 1070 K

A.V. Morozkin\*

*Department of Chemistry, Moscow Lomonosov State University, Leninskie Gory, V-234, GSP-3, 119899 Moscow, Russia*

Received 3 August 2001; accepted 24 September 2001

## Abstract

Phase equilibria in the Sm–Zr–Sb system were investigated by X-ray powder diffraction and the isothermal cross-section at 1070 K was obtained. No ternary compounds were detected in this section. © 2002 Elsevier Science B.V. All rights reserved.

*Keywords:* Rare earths, zirconium antimonides; Sm–Zr–Sb

## 1. Introduction

Interaction between the components in the Zr–Sb and Sm–Sb binary system has been studied in Refs. [1–3] (Table 1). No compounds were detected in the Sm–Zr system [4].

## 2. Experimental detail

The present study was carried out on ~20 alloys (Fig. 1). The alloys were made in an electric arc furnace under an argon atmosphere using non-consumable tungsten electrode and a water-cooled copper tray. Antimony, samarium and zirconium (purity of each component  $\geq 99.99\%$ ) were used as starting components. Titanium was used as a getter during the melting process. The alloys were remelted three times in order to achieve complete fusion and homogeneous composition. The melted alloys were subjected to an anneal in evacuated quartz ampoules containing titanium chips as a getter. The ampoules were placed in a resistance furnace. The alloys were annealed at 1070 K for 2 weeks. The samples were quenched from 1070 K in ice cold water. The phase equilibria in the Sm–Zr–Sb system were determined using X-ray phase analysis and metallographic analysis. X-ray data were obtained on a diffractometer DRON-3.0 (Cu  $K\alpha$  radiation,  $2\theta = 20\text{--}70^\circ$ , step  $0.05^\circ$ , for 5 s per step). The diffractograms obtained were identified

by means of calculated patterns using the Rietan program [5,6] in the isotropic approximation. A Neophot microscope was employed for metallographic inspection ( $\times 250$ ,  $\times 500$ ).

## 3. Results and discussion

The results obtained were used in the construction of the isothermal cross-section of the Sm–Zr–Sb system at 1070 K, presented in Fig. 2.

ZrSb<sub>2</sub>, Zr<sub>5</sub>Sb<sub>3</sub>, Zr<sub>2</sub>Sb, Zr<sub>3</sub>Sb, Sm<sub>2</sub>Sb, Sm<sub>4</sub>Sb<sub>3</sub> and SmSb binary compounds were detected in this cross-section (Table 1). The cell parameters of Sm<sub>2</sub>Sb differ from the data of Refs. [1,2]. We have not prepared the SmSb<sub>2</sub> compound. However, it may be present in the isothermal section. We have not detected the Sm<sub>5</sub>Sb<sub>3</sub> compound.

It was found that the system contains extended regions of solid solutions for SmSb (~10% Zr) and Zr<sub>2</sub>Sb (~5 at.% Sm) (Table 1). The other binary compounds do not show any visible solubility. The Zr<sub>5</sub>Sb<sub>3</sub> compound is very unstable in air. A polycrystalline Zr<sub>5</sub>Sb<sub>3</sub> sample transformed into amorphous powder after 2–3 days.

## 4. Conclusion

We have detected no ternary compound in the isothermal cross-section of the Sm–Zr–Sb system at 1070 K although CeScSi-type RZrSb compounds were detected in

\*Fax: +7-095-932-8846.

E-mail address: morozkin@general.chem.msu.ru (A.V. Morozkin).

Table 1

Crystallographic data and temperature of the phase transition of compounds in the Sm–Zr–Sb system

	Compounds	Space group	Structure type	<i>a</i> , nm	<i>b</i> , nm	<i>c</i> , nm	<i>T</i> <sup>b</sup> , K	Refs.
1.	Zr <sup>a</sup>	<i>P6<sub>3</sub>/mmc</i>	Mg	0.32321		0.51477	1135	[1]
	Zr	<i>Im3m</i>	W	0.3616			<b>2125</b>	[1]
2.	Zr <sub>3</sub> Sb <sup>a</sup>	<i>I4</i>	Ni <sub>3</sub> P	1.135		0.565		[2]
	Zr <sub>5</sub> Sb <sup>a</sup>	<i>I4</i>	Ni <sub>3</sub> P	1.1329(3)		0.5656(1)		This work
3.	Zr <sub>2</sub> Sb <sup>a</sup>	<i>tetr</i>	–	0.652		0.790		[2]
	Zr <sub>0.67...0.62</sub> Sm <sub>0...0.05</sub>	<i>P4</i>	–	0.6497(5)...		0.7871(4)...		This work
	Sb <sub>0.33</sub> <sup>a</sup>			0.6567(7)		0.7942(7)		
4.	Zr <sub>5</sub> Sb <sub>3</sub> <sup>a</sup>	<i>P6<sub>3</sub>/mcm</i>	Mn <sub>5</sub> Si <sub>3</sub>	0.8465		0.5806		[2]
	Zr <sub>5</sub> Sb <sub>3</sub> <sup>a</sup>	<i>P6<sub>3</sub>/mcm</i>	Mn <sub>5</sub> Si <sub>3</sub>	0.8488(5)		0.5800(3)		This work
5.	ZrSb <sub>2</sub> <sup>a</sup>	<i>Pnmm</i>	ZrSb <sub>2</sub>	1.49684	0.99672	0.38813		[2]
	ZrSb <sub>2</sub> <sup>a</sup>	<i>Pnmm</i>	ZrSb <sub>2</sub>	1.4932(8)	0.9948(6)	0.3875(1)		This work
6.	Sb	<i>R3m</i>	As	0.43084		1.1247		[1]
	Sb	<i>P6<sub>3</sub>/mmc</i>	Mg	0.3369		0.533	<b>904</b>	[1]
7.	SmSb <sub>2</sub> <sup>a</sup>	<i>Cmca</i>	SmSb <sub>2</sub>	0.6171	0.6051	1.789	<b>1580</b>	[1,3]
8.	SmSb <sup>a</sup>	<i>Fm3m</i>	NaCl	0.62706			~ <b>2270</b>	[1,3]
	Sm <sub>0.50...0.40</sub> Zr <sub>0...0.10</sub> Sb <sub>0.50</sub>	<i>Fm3m</i>	NaCl	0.6263(1)...				This work
9.	Sm <sub>4</sub> Sb <sub>3</sub> <sup>a</sup>	<i>I43d</i>	Th <sub>3</sub> P <sub>4</sub>	0.9317				[1,3]
	Sm <sub>4</sub> Sb <sub>3</sub> <sup>a</sup>	<i>I43d</i>	Th <sub>3</sub> P <sub>4</sub>	0.9298(1)				This work
10.	Sm <sub>5</sub> Sb <sub>3</sub>	<i>P6<sub>3</sub>/mcm</i>	Mn <sub>5</sub> Si <sub>3</sub>	0.910		0.640		[1,3]
11.	Sm <sub>2</sub> Sb <sup>a</sup>	<i>I4/mmm</i>	La <sub>2</sub> Sb	0.4461		1.746		[1,2]
	Sm <sub>2</sub> Sb <sup>a</sup>	<i>I4/mmm</i>	La <sub>2</sub> Sb	0.4484(1)		1.8040(8)		This work
12.	Sm <sup>a</sup>	<i>R3m</i>	α-Sm	0.3621		2.625	1190	[1]
	Sm	<i>Im3m</i>	W	0.407			<b>1350</b>	[1]

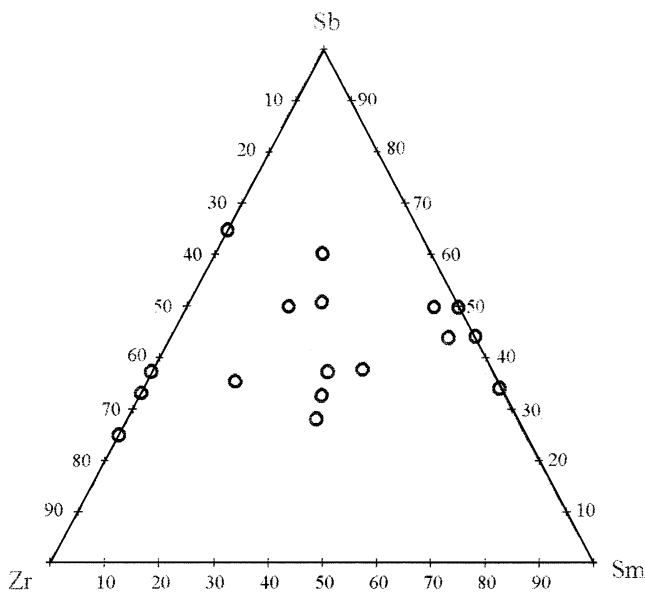
<sup>a</sup> Compounds belong to the isothermal cross-section at 1070 K.<sup>b</sup> The temperatures listed refer to a phase transition (normal font) or to the melting temperature (bold font).

Fig. 1. Composition of samples investigated in the Sm–Zr–Sb system.

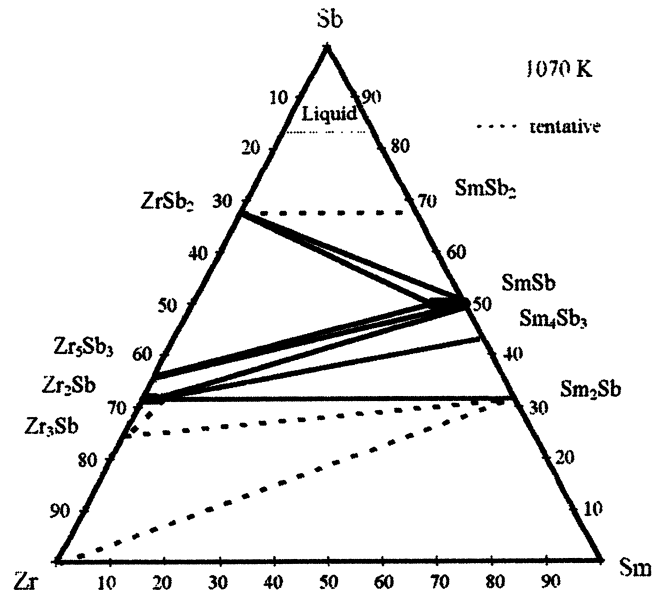


Fig. 2. Isothermal cross-section of the Sm–Zr–Sb system at 1070 K.

Ref. [7] for (R=Y, Gd–Tm, Lu). Obviously, CeScSi-type ternary {La–Sm}ZrSb compounds do not form in the {La–Sm}–Zr–Sb systems.

## References

- [1] J. Emsley, in: *The Elements*, 2nd Edition, Clarendon Press, Oxford, 1991.
- [2] *Person's Handbook of Crystallographic Data For Intermetallic Phases*, Vol. 3, American Society for Metals, Metals Park, OH, 1985, p. 3156.
- [3] G. Borzzone, A. Borsese, S. Delfino, R. Ferro, *Z. Metallkd.* 76 (3) (1985) 208–213.
- [4] E.I. Gladyshevskii, O.I. Bodak, in: *Kristallogimii intermetallicheskih soedinenii redkozemel'nyh metallov*, Vischa shkola, L'viv, 1982, p. 48, (in Russian).
- [5] F. Izumi, *Rigaku J.* 6 (1) (1989) 10–19.
- [6] F. Izumi, in: R.A. Young (Ed.), *The Rietveld Method*, Oxford University Press, Oxford, 1993, Chapter 13.
- [7] A.V. Morozkin, I.A. Sviridov, *J. Alloys Comp.* 320 (2001) L1–L2.