

Journal of ALLOYS AND COMPOUNDS

Journal of Alloys and Compounds 377 (2004) L4-L6

www.elsevier.com/locate/jallcom

Letter

The Dy–Cr–Si and Dy–Sc–Si systems at 1200 K

A.V. Morozkin*

Department of Chemistry, Moscow State University, Leninskie Gory, House 1, Building 3, GSP-2, Moscow 119992, Russia

Received 10 October 2003; received in revised form 22 January 2004; accepted 22 January 2004

Abstract

Phase equilibria in the Dy–Cr–Si and Dy–Sc–Si systems were investigated by X-ray powder diffraction, local X-ray spectral analysis and the isothermal sections at 1200 K were obtained. The CeGa₂Al₂-type (space group I4/mmm, No.139) DyCr₂Si₂ compound has been confirmed in the Dy–Cr–Si system. Extended solid solution regions were found in the Dy–Sc–Si system for AlB₂-type Dy_{1-x}Sc_xSi₂, CrB-type Dy_{1-x}Sc_xSi, Sm₅Ge₄-type Dy_{5-x}Sc_xSi₄ and Mn₅Si₃-type Dy_{5-x}Sc_xSi₃ solid solutions.

© 2004 Elsevier B.V. All rights reserved.

Keywords: Lanthanide chromium silicides; Lanthanide scandium silicides; Ternary compounds; Dy-Cr-Si; Dy-Sc-Si

The interaction between the components in the Dy–Si, Sc–Si, and Cr–Si binary systems have been studied in references [1–3]. No binary compounds were detected in the Dy–Cr and Dy–Sc systems [2,3]. It is obvious, Mg-type $Dy_{1-x}Sc_x$ solid solution forms in the Dy–Sc system (x = 0, ..., 1), like in the (Y, Gd, Er)–Sc systems [3]. CeGa₂Al₂-type DyCr₂Si₂ [2] and Sm₅Ge₄-type Dy₂Sc₃Si₄ ternary compounds are known [4] (Tables 1 and 2). In the present work we have completed the series of the Dy–T–Si systems (T: Sc, Ti, V, Cr) [5,6].

The alloys (Figs. 1 and 2) were made in an electric arc furnace under an argon atmosphere using a non-consumable tungsten electrode and a water-cooled copper tray. Silicon (purity 99.99%), chromium (purity 99.99%), scandium (purity 99.8%) and disprosium (purity 99.8%) were used as starting components. Zirconium was used as an O_2 getter during the melting process. The alloys were re-melted 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 an O_2 getter. The ampoules were placed in a resistance furnace. The alloys were annealed at 1200 K for 2 weeks. The samples were quenched from 1200 K in ice-cold water. The phase equilibria in the

0925-8388/\$ – see front matter @ 2004 Elsevier B.V. All rights reserved. doi:10.1016/j.jallcom.2004.01.050

Dy–Cr–Si and Dy–Sc–Si systems were determined from X-ray phase analysis and local X-ray spectral analysis. Powder X-ray data were obtained on a DRON-3.0 diffractometer (Cu K α radiation, $2\Theta = 20-70^\circ$, step 0.05°, for 5 s per step).

The powder X-ray diffractograms obtained were identified by means of calculated patterns using the Rietan-program [7,8] in the isotropic approximation.

A "Camebax" microanalyser was employed to perform local X-ray spectral analysis of the samples.

The results obtained were used in the construction of the isothermal sections of the Dy–Cr–Si and Dy–Sc–Si systems at 1200 K, presented in Figs. 1 and 2, respectively.

The CeGa₂Al₂-type $DyCr_2Si_2$ compound [2] has been confirmed. We have not found another ternary compounds in the Dy–Cr–Si system. The binary compounds in the Dy–Cr–Si system do not show any visible solubility.

Extended solid solutions regions were found in the Dy–Sc–Si system for AlB₂-type $Dy_{1-x}Sc_xSi_2$, CrB-type $Dy_{1-x}Sc_xSi$, Sm₅Ge₄-type $Dy_{5-x}Sc_xSi_4$ and Mn₅Si₃-type $Dy_{5-x}Sc_xSi_3$ (Table 2).

So, up to now the systems Dy–(Sc, Ti, V, Cr)–Si were investigated. The Dy–Fe–Si system at 520 °C is known also [9]. We plan to complete the series of the Dy–T–Si systems with T = Sc–Cu to estimate the influence of the nature of the transition metal on the structure of the ternary compounds in the Dy–T–Si systems.

^{*} Fax: +7-95-932-8846.

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

Table 1 Crystallographic data of binary compounds in the Dy-Cr-Si and Dy-Sc-Si systems

N	Compound	Space group	Structure type	<i>a</i> (nm)	<i>b</i> (nm)	<i>c</i> (nm)	R _F (%)	References
1	Si ^a	Fd3m	С	0.54307				[1,2]
2	Cr ^a Cr ^a	Im3m Im3m	W W	0.28846 0.2887(1)			8.7	[1,2] This work ^b
3	Sc (LT) Sc (HT)	P6 ₃ /mmc Im3m	Mg W	0.3309		0.5273		[1,2] [1,2]
4	Dy (LT1) Dy (LT2) ^a Dy (LT2) ^a Dy (HT)	Cmcm P6 ₃ /mmc P6 ₃ /mmc Im3m	Mg Mg W	0.3595 0.35903 0.3595(2) 0.398	0.6183	0.5677 0.56475 0.5655(4)	6.0	[1,2] [1,2] This work ^b [1,2]
5	Cr ₃ Si ^a Cr ₃ Si ^a	Pm3n Pm3n	Cr ₃ Si Cr ₃ Si	0.4558 0.4568(3)			4.5	[2] This work ^b
6	$\begin{array}{c} Cr_5Si_3{}^a\\ Cr_5Si_3{}^a\\ Cr_5Si_3\end{array}$	I4/mcm I4/mcm P6 ₃ /mcm	$\begin{array}{l} W_5Si_3\\ W_5Si_3\\ Mn_5Si_3 \end{array}$	0.9170 0.9172(4) 0.6993		0.4636 0.4645(2) 0.4726	10.6	[2] This work ^b [2]
7	CrSi ^a CrSi ^a	P2 ₁ 3 P2 ₁ 3	FeSi FeSi	0.4620 0.4625(3)			9.5	[2] This work ^b
8	$CrSi_2^a$ $CrSi_2^a$	P6 ₂ 22 P6 ₂ 22	CrSi ₂ CrSi ₂	0.4428 0.4423(9)		0.6363 0.6363(3)	10.9	[2] This work ^b
9	Sc ₅ Si ₃	P63/mcm	Mn ₅ Si ₃	0.7861		0.5812		[2,3]
10 11	ScSi ScSi _{1.67}	Cmcm P6/mmm	CrB AlB ₂	0.3958 0.366	0.9882	0.3659 0.387		[2,3] [2,3]
12	$\begin{array}{c} Dy_5 Si_3{}^a \\ Dy_5 Si_3{}^a \end{array}$	P6 ₃ /mcm P6 ₃ /mcm	$\begin{array}{l} Mn_5Si_3\\ Mn_5Si_3 \end{array}$	0.837 0.8380(5)		0.626 0.6367(4)	11.1	[2,3] This work ^b
13	$\begin{array}{c} Dy_5 Si_4{}^a \\ Dy_5 Si_4{}^a \end{array}$	Pnma Pnma	Sm_5Ge_4 Sm_5Ge_4	0.736 0.7372(4)	1.448 1.4562(8)	0.765 0.7665(4)	11.0	[2,3] This work ^b
14	DySi (HT) DySi (LT) ^a DySi (LT) ^a	Pnma Cmcm Cmcm	FeB CrB CrB	0.787 0.4237 0.4234(3)	0.380 1.0494 1.0488(7)	0.565 0.3818 0.3808(3)	11.3	[2,3] [2,3] This work ^b
15	$\begin{array}{c} \text{DySi}_{1.67}{}^{\text{a}} \\ \text{DySi}_{1.67}{}^{\text{a}} \end{array}$	P6/mmm P6/mmm	AlB ₂ AlB ₂	0.383 0.3818(2)		0.411 0.4117(2)	10.0	[2,3] This work ^b
16	$\begin{array}{c} DySi_2 \ (HT) \\ DySi_2 \ (LT)^a \\ DySi_2 \ (LT)^a \end{array}$	I4 ₁ /amd Imma Imma	$\begin{array}{c} ThSi_2\\ GdSi_2\\ GdSi_2 \end{array}$	0.403 0.404	0.394	1.338 1.334		[2,3] [2,3] This work ^b

The reliability factors are $R_{\rm F} = 100 \left(\sum_{k} |(I_k^{\rm obs})^{1/2} - (I_k^{\rm cal})^{1/2}| \right) / \sum_{k} |(I_k^{\rm obs})^{1/2}|$) is the integrated intensity evaluated from a summation of the contributions of the *k*th peaks to the net observed intensity, $I_k^{\rm cal}$ is the integrated intensity calculated from the refined structural parameters).

^a Compounds belongs to the isothermal cross-section at 1200 K.

^b Data for compounds from X-ray phase analysis of the three-component samples.

Table 2 Crystallographic data of ternary compounds in the Dy-Cr-Si and Dy-Sc-Si systems

N	Compound	Space group	Structure type	a (nm)	b (nm)	<i>c</i> (nm)	<i>R</i> _F (%)	References
1	DyCr ₂ Si ₂	I4/mmm	CeGa ₂ Al ₂					[2]
	DyCr ₂ Si ₂	I4/mmm	CeGa ₂ Al ₂	0.3911(1)		1.0648(1)	10.0	
2	Dy15Sc47Si38	P63/mcm	Mn ₅ Si ₃	0.8012(3)		0.5912(2)	7.1	
	Dy32Sc30Si38	P6 ₃ /mcm	Mn ₅ Si ₃	0.8163(1)		0.6029(1)	3.0	
	Dy37Sc26Si37	P6 ₃ /mcm	Mn_5Si_3	0.8183(4)		0.6009(2)	4.9	
3	Dy2Sc3Si4	Pnma	Sm5Ge4	0.7060	1.3951	0.7380		[4]
	Dy22Sc33Si44	Pnma	Ce ₂ Sc ₃ Si ₄	0.7064(2)	1.3948(5)	0.7380(2)	3.1	
	Dy34Sc22Si44	Pnma	Sm5Ge4	0.7148(2)	1.4165(4)	0.7486(2)	5.2	
	$Dy_{51}Sc_5Si_{44} \\$	Pnma	Sm5Ge4	0.7311(2)	1.4453(5)	0.7625(2)	6.9	
4	Dy25Sc25Si50	Cmcm	CrB	0.4123(1)	1.0194(2)	0.3736(1)	6.2	
	Dy35Sc15Si50	Cmcm	CrB	0.4169(1)	1.0313(3)	0.3766(1)	9.4	
	$Dy_{48}Sc_2Si_{50}$	Cmcm	CrB	0.4244(1)	1.0478(3)	0.3815(1)	5.6	
5	Dy32Sc8Si60	P6/mmm	AlB ₂	0.3790(2)		0.4071(2)	8.6	
	$Dy_{22}Sc_{17}Si_{61}$	P6/mmm	AlB ₂	0.3729(2)		0.4006(2)	9.3	

The reliability factors are $R_{\rm F} = 100 \left(\sum_{k} |(I_k^{\rm obs})^{1/2} - (I_k^{\rm cal})^{1/2}| \right) / \sum_{k} |(I_k^{\rm obs})^{1/2}|$ % $(I_k^{\rm obs})^{\rm is}$ is the integrated intensity evaluated from a summation of the contributions of the *k*th peaks to the net observed intensity, $I_k^{\rm cal}$ is the integrated intensity calculated from the refined structural parameters).



Fig. 2. Isothermal section of the Dy-Sc-Si system at 1200 K.

References

- J. Emsley, in: The elements, second ed., Clarendon Press, Oxford, 1991.
- [2] Pearson's Handbook of Crystallographic Data for Intermetallic Phases, American Society for Metals, vol. 2–3, Metals Park, OH 44073, 1985.
- [3] E.I. Gladyshevskii, O.I. Bodak, Kristallohimia intermetallicheskih soedinenii redkozemel'nyh metallov, L'viv, Vischa shkola, 1982, 24, 44, 48, 50 (in Russian).
- [4] A.V. Morozkin, Yu.D. Seropegin, V.K. Portnoy, A.V. Leonov, I.A. Sviridov, J. Alloys Compd. 281 (1998) L1–L2.
- [5] A.V. Morozkin, J. Alloys Compd. 346 (1-2) (2002) L4-L6.
- [6] A.V. Morozkin, J. Alloys Compd. 345 (1-2) (2002) 155-157.
- [7] F. Izumi, RIGAKU J. 6 (1) (1989) 10-19.
- [8] F. Izumi, in: R.A. Young (Ed.), The Rietveld Method, Oxford University Press, Oxford, 1993 (Chapter 13).
- [9] Z. Yinghong, Y. Yiqiang, Z. Huaiying, Q. Wen, J. Alloys Compd. 268 (1998) 137–140.