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Comparison of the interaction of components in the La–Co–Zn and Ce–Co–Zn ternary systems at 470 K

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Abstract

Interaction of the components in the La–Co–Zn and Ce–Co–Zn ternary systems has been investigated by means of X-ray analysis. The isothermal sections of the phase diagrams have been determined over the entire composition range at 470 K. Seven new ternary compounds have been found in each system and the crystal structure has been determined for most of them.

Keywords: Phase diagram; Crystal structure; Intermetallic compound

1. Introduction

R–M–Zn (R, rare-earth metal; M, transition metal) ternary systems are very interesting due to the structure and magnetic properties of their compounds. At present the alloys of the R–M–Zn systems are being intensively investigated for hydrogen storage purposes [1,2]. For systems containing Co, mainly the La–Co–Zn system has been studied in order to investigate the existence of intermetallic compounds. Such ternary phases as $LaCeZn_{12}$ ($BaCd_{11}$ structure type), $LaCo_6Zn_7$ (Th_2Zn_{17} structure type) and $LaCo_9Zn_4$ ($NaZn_{13}$ structure type) have been found by the authors of Ref. [3]. In this contribution we present our results concerning the isothermal sections of both systems (La–Co–Zn and Ce–Co–Zn) at 470 K and data on new ternary compounds and solid solutions.

The binary systems La–Co, Ce–Co, La–Zn, Ce–Zn and Co–Zn have been accepted as given in Refs. [4,5].

2. Experimental

Isothermal sections of the La–Co–Zn and Ce–Co–Zn systems have been determined by X-ray phase analysis of 108 and 61 alloys, respectively, prepared by arc melting in argon atmosphere at 100 kPa. The alloys were annealed in quartz ampoules under vacuum at 470 K for 1500 h. The purity of the starting metals was better than 99.9%. Powder patterns of alloys were obtained by powder diffractometers DRON-2.0 (Fe K_α-radiation, 2°/min speed of scanning) and SIEMENS (Co K_α-radiation, with 2θ steps of 0.02° and step times of 8–10 s). Lattice parameters and crystal structure refinement were calculated by LATCON and RIETVELD ANALYSIS programs [6].

3. Results and discussion

The phase diagrams of the La–Co–Zn and Ce–Co–Zn systems at 470 K are shown in Figs. 1 and 2. There are seven ternary compounds in each system. Their crystallographic characteristics are listed in Table 1.

$LaCo_{4.4}Zn_{0.6}$ and $CeCo_{4.4}Zn_{0.6}$ crystallise in the $AuBe_5$ structure type. La or Ce occupy positions of Au and statistic mixture (Co+Zn) in the positions of Be. $La_3Co_{1-x}Zn_x$ and $Ce_3Co_{1-x}Zn_x$ belong to the $AuCu_3$ structure type. La or Ce are in the positions of Cu and statistic mixture (Co+Zn) in the positions of Au. $CeCo_{2.6}Zn_{2.4}$ crystallises in the $CaCu_5$ structure. Ce are in the positions of Ca and the statistic mixture (Co+Zn) in the positions of Cu. $La_2Co_2Zn_{15}$, $Ce_2Co_2Zn_{15}$ is isostructural with $Ce_2Al_2Co_{15}$, $La_2Co_5Zn_2$ and $Ce_2Co_5Zn_2$ — in the $Ce_2Ni_5Zn_2$ structure type, $LaCo_2Zn$ and $CeCo_2Zn$ — in the YRh_2Si one, respectively. The structures of $\sim La_{16.5}Co_{63.5}Zn_{20}$, $\sim La_{25}Co_{35}Zn_{40}$ and $\sim Ce_{24}Co_{24}Zn_{52}$ compounds have not been determined yet.

The solid solutions based on the binary compounds La–Co, La–Zn, Ce–Co and Ce–Zn systems are formed in these ternary systems. The solubility of Co in LaZn is

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Table 1
The crystallographic data of the compounds of the La–Co–Zn and Ce–Co–Zn systems

Compound	Structure type	Space group	Lattice parameters, nm		
			a	*b*	*c*
$LaCo_{4.4}Zn_{0.6}$	$AuBe_5$	$F\bar{4}3m$	0.7115(2)		
$La_2Co_2Zn_{15}$	$Ce_2Al_2Co_{15}$	$R\bar{3}m$	0.9080(1)		1.3316(4)
$La_2Co_5Zn_2$	$Ce_2Ni_5Zn_2$	$R\bar{3}m$	0.5055(2)		3.6325(7)
$LaCo_2Zn$	YRh_2Si	$P6_3/mmc$	0.5023(1)		1.6371(2)
$La_3Co_{0.40-0.52}Zn_{0.60-0.48}$	$AuCu_3$	$Pm\bar{3}m$	0.5305(3)		
$CeCo_{4.4}Zn_{0.6}$	$AuBe_5$	$F\bar{4}3m$	0.7058(4)		
$Ce_2Co_2Zn_{15}$	$Ce_2Al_2Co_{15}$	$R\bar{3}m$	0.9006(3)		1.3468(7)
$Ce_2Co_5Zn_2$	$Ce_2Ni_5Zn_2$	$R\bar{3}m$	0.4947(3)		3.6167(2)
$CeCo_2Zn$	YRh_2Si	$P6_3/mmc$	0.5044(4)		1.639(2)
$Ce_3Co_{0.40-0.52}Zn_{0.60-0.48}$	$AuCu_3$	$Pm\bar{3}m$	0.5381(5)		
$CeCo_{2.6}Zn_{2.4}$	$CaCu_5$	$P6/mmm$	0.4945(3)		0.4026(6)
$\sim La_{16.5}Co_{63.5}Zn_{20}$	Structures are not determined				
$\sim La_{25}Co_{35}Zn_{40}$					
$\sim Ce_{24}Co_{24}Zn_{52}$					

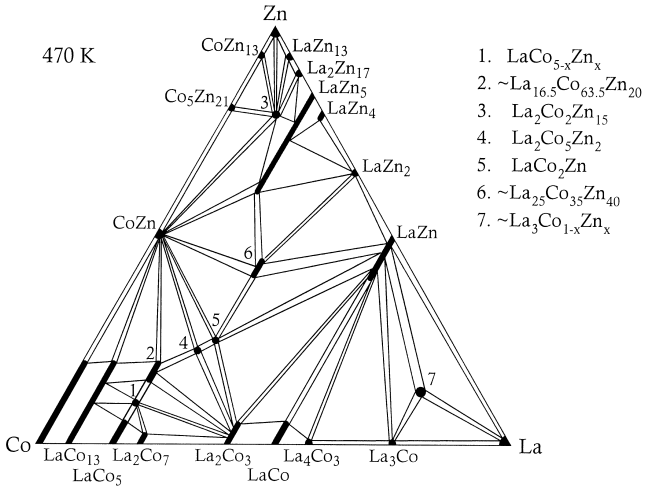

Fig. 1. Isothermal section of the La–Co–Zn ternary system at 470 K.

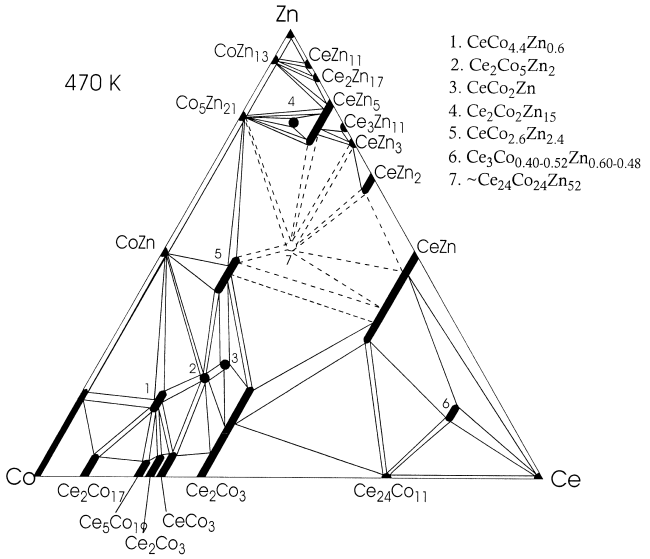

Fig. 2. Isothermal section of the Ce–Co–Zn ternary system at 470 K.

about 10 at.%, in CeZn about 20 at.%, in $LaCo_5$ about 5% and in $CeZn_5$ about 15 at.%. The solubility of Zn in La_2Co_3, LaCo and in Ce_2Co_{17}, Ce_5Co_{19}, Ce_2Co_7, $CeCo_3$ is about 5 at.%. The largest solubility of Zn is about 20 at.% in $LaCo_{13}$ and in $CeCo_2$.

These ternary systems are close to the earlier investigated R–M–Zn ternary systems such as Ce–Ni–Zn [7], Ce–Fe–Zn [7], La–Ni–Zn [8]. The formation of compounds with composition such as $R_2M_2Zn_{15}$ ($Ce_2Al_2Co_{15}$ structure type), RM_2Zn (YRh_2Si structure type) and $R_2M_5Zn_2$ ($Ce_2Ni_5Zn_2$ structure type) is characteristic of this type of system. Besides two isostructural compounds are formed only in these ternary systems: $RCo_{4.4}Zn_{0.6}$ ($AuBe_5$ structure type) and $R_3Co_{0.40-0.52}Zn_{0.60-0.48}$ ($AuCu_3$ structure type). This fact indicates a more similar interaction of the components in the La–Co–Zn and Ce–Co–Zn systems.

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