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Letter

Crystal structure and magnetism of YbT_xGa_{4-x}, T = Zn, Cd with the $BaAl_4$-type

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Abstract

Intermetallic compounds of the composition YbT_xGa_{4-x} (T = Zn, Cd) were synthesized and their crystal structure and magnetic properties were studied. These compounds crystallize in the tetragonal $BaAl_4$ type structure with a random occupation of the 4e site by Ga, Zn(Cd). The magnetic ground state of Yb in these compounds is nonmagnetic.

Keywords: Crystal structure; Magnetism; Intermetallic compounds

1. Introduction

Recent results on the ternary $BaAl_4$-type gallides with ytterbium and transition metals such as Cu, Ag, Au, Pd, and Pt showed magnetically dipositive ytterbium for Cu, Ag, Au and Pd with a tendency towards tripositive behavior for $YbPt_{0.5}Ga_{3.5}$ [1]. An extension of this research was designed to cover the metals with a filled 3d or 4d shell, zinc and cadmium, and became the subject of the present paper.

2. Experimental

Alloys with the nominal compositions YbT_xGa_{4-x}, x at 0.10, 0.25, 0.5, 0.75 and 1.0 for T = Zn and $x = 0.5$ for T = Cd, each with a total weight of 2 g, were prepared by high frequency melting in tantalum crucibles under argon. Further details of sample preparation, heat treatment (400 °C for 500 h), X-ray powder diffraction techniques and methods of magnetic measurements in the range from 4.2 K to 300 K can be found from our earlier reports on a similar subject [1,2].

3. Results and discussion

3.1. Formation, homogeneity region and crystal structure for YbT_xGa_{4-x}

Evaluation of the X-ray powder diagrams of the two alloy systems $YbZn_xGa_{4-x}$ and $YbCd_xGa_{4-x}$ confirmed the isotypism with the crystal structure of the $BaAl_4$-type. Whereas for $YbZn_xGa_{4-x}$ an extended homogeneity region for $0.4 \leq x \leq 1.0$, was observed on the alloys annealed at 400 °C, only a very small field of existence was encountered at 400 °C for $YbCd_xGa_{4-x}$, essentially centered around $x = 0.5$. The crystallographic data for the two alloy systems are summarized in Table 1. Adopting the z-parameter for atoms in 4e, $z = 0.390$, as derived from a Rietveld refinement of $YbAu_{0.25}Ga_{3.75}$ [1], satisfactory agreement is found between observed and calculated X-ray powder intensities, assuming random Ga, Zn (Cd) atom distribution in the 4e position. Therefore, both phases belong to the $BaAl_4$ type of structure.

The unit cell volume of $YbZn_xGa_{4-x}$ vs. increasing values of x shows a monotonic decrease for $0.25 \leq x \leq 1.0$. The extrapolated value for $x = 0$ correlates nicely with the value for binary $YbGa_4$ ($V = 200.0$ Å^3 [1]). The sharp drop of the c-parameter from $x = 0.25$ to $x = 0.5$ may be seen as an increase in the covalent interatomic 4e–4e interaction, which starts to reduce again after the c-parameter passes through a minimum

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Table 1
Crystallographic and magnetic data of $YbZn_xGa_{4-x}$ and $YbCd_xGa_{4-x}$ alloys (structure type $BaAl_4$, space group *I4/mmm*)

Composition	*a*, Å	*c*, Å	*V*, Å^3	μ_{eff}/Yb μ_B	$\chi_{(5K)} \cdot 10^6$ cm^3 g^{-1}	$\chi_{(300K)} \cdot 10^7$ cm^3 g^{-1}
$YbZn_{0.25}Ga_{3.75}$	4.2428(5)	10.968(2)	197.4(1)	0.5	7.8	3.6
$YbZn_{0.5}Ga_{3.5}$	4.2290(7)	10.944(3)	195.7(1)	0.7	9.7	5.1
$YbZn_{0.75}Ga_{3.25}$	4.2141(6)	10.951(2)	194.5(1)	0.6	7.4	3.8
$YbZnGa_3$	4.2021(3)	10.955(1)	193.4(1)	0.7	9.5	5.5
$YbCd_{0.5}Ga_{3.5}$	4.2665(7)	10.965(2)	199.6(1)	0.5	2.5	7.8

(see Table 1, $0.5 < x \leq 1.0$). The importance of this interaction phenomenon has been disclosed from band structure calculations of $BaAl_4$ [3].

3.2. Magnetism

Magnetic susceptibilities of the compounds YbT_xGa_{4-x} with T = Zn, Cd have been measured in the temperature range between 4.2 to 300 K. In general, the magnetic behavior is characterized by a nonmagnetic groundstate $^1S_0$ of the ytterbium atom. However at low temperatures an upturn of the susceptibility curves (Curie-tail) is observed arising from small amounts of secondary phases. The calculated magnetic moment, according to a Curie–Weiss behaviour is smaller than 0.7 μ_B in all samples investigated. Hence less than 3% of impurity, where Yb adopts the magnetic $^2F_{7/2}$ groundstate can cause the observed weak temperature dependency of χ below 200 K.

4. Acknowledgement

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References

[1] Yu.N. Grin, M. Ellner, K. Hiebl and P. Rogl, *J. Alloys Comp.*, *196* (1993) 207.
[2] Yu.N. Grin, M. Ellner, K. Hiebl, B. Baumgartner and P. Rogl, *J. Alloys Comp.*, *221* (1995) 125–128.
[3] U. Häußermann, S. Wengert, P. Hoffmann, A. Savin, O. Jepsen and R. Nesper, *Angew. Chemie*, *106* (20) (1994) 2147.