Journal of Alloys and Compounds 854 (2021) 156982

Contents lists available at ScienceDirect

Journal of Alloys and Compounds

journal homepage: http://www.elsevier.com/locate/jalcom

Magnetic properties and electronic structure of $CeFe_{2-x}Mn_x$ and $CeFe_2Mn_x$ compounds

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ARTICLE INFO

Article history:
Received 30 June 2020
Received in revised form
12 August 2020
Accepted 31 August 2020
Available online 16 September 2020

Keywords:
Laves phases
Magnetization
Exchange interactions
Mössbauer spectroscopy
X-ray photoelectron spectroscopy
Crystal structure
Mixed valence

ABSTRACT

The effect of manganese alloying on the structure and magnetic properties of $CeFe_2$ has been studied on two isostructural series: quasibinary $CeFe_{2-x}Mn_x$ and nonstoichiometric $CeFe_2Mn_x$ alloys. The single-phase *bcc* $MgCu_2$-type structure is formed at $x \leq 0.5$ in both systems. At $x = 0.5$, the lattice parameter is increased by ~0.3%. The Mn alloying leads to a nonmonotonic variation of magnetic moment and gradual decrease in the Curie temperature from 230 K to 150 K and 167 K for $CeFe_{1.5}Mn_{0.5}$ and $CeFe_2Mn_{0.5}$, respectively. For $x \geq 0.3$, the magnetization data indicate the formation of noncollinear magnetic structure. The binary $CeFe_2$ and nonstoichiometric $CeFe_2Mn_{0.15}$ have been studied using Mössbauer effect and X-ray photoelectron spectroscopy. The Ce valence state remains unchanged upon the Mn alloying. The parameters of hyperfine interactions have been determined in paramagnetic state at room temperature and in magnetically ordered state at 78 K. The Mössbauer data revealed a difference in the quadrupole coupling constants of $CeFe_2$ and $CeFe_2Mn_{0.15}$, which is associated with the difference in the local distortions of the lattice.

1. Introduction

Intermetallic compounds of rare earth and 3*d* transition metals attract interest of researchers in view of their wide practical applications as magnetic materials. Localized magnetic moments of rare earth elements provide high magnetic anisotropy of such materials and vast variety of magnetic structures (from ordinary collinear to "canted" and helicoidal). Strong exchange interactions in the 3*d* sublattice yield enhanced temperatures of magnetic ordering. The compounds RT_2 (*R* is rare earth, *T* is 3*d* transition metal) with a structure of the $MgCu_2$-type Laves phase have intensively been studied in view of their giant magnetistriction and high magnetocaloric effect [1–3]. Deviations in the stoichiometry of these compounds typically lead to appearance of foreign phases. However, in 2006, Wang et al. [4] showed that RNi_2Mn with heavy *R* elements possess the $MgCu_2$-type structure. In these alloys, Mn atoms substitute for both Ni atoms at 16*d* sites and *R* atoms at 8*a* sites. Our publications [5,6] reported a successful synthesis of nonstoichiometric compounds RNi_2Mn_x with heavy *R* in which concentration *x* of alloying manganese was varied in wide limits, the single-phase cubic structure being preserved up to $x = 2$ [7]. The studies showed that their magnetic properties significantly differed from those of parent RNi_2 and RMn_2 compounds. Later, the cobalt-based nonstoichiometric compounds RCo_2Mn_x and RCo_2Ni_x with heavy rare earths were synthesized as well [8,9]. However, data on nonstoichiometric Laves phases with light *R*, as well as those with Fe as a transition metal, are unavailable in literature. Since Ce has the smallest atomic radius among the light rare earth elements, it seemed reasonable to synthesize nonstoichiometric compounds of the $CeFe_2Mn_x$ series.

The compound $CeFe_2$ has lately been in the focus of studies dealing with its unusual properties. Its lattice parameter is beyond the conventional tendency for the RFe_2 compounds [10], so-called lantanoid compression. Besides, it possesses the minimal Curie temperature over the whole RFe_2 series [11] and is not featured by giant magnetostriction. Magnetic moments of rare earth and iron in

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https://doi.org/10.1016/j.jallcom.2020.156982
0925-8388/