SITE OCCUPANCY OF Fe ATOM IN RFe$_{4+x}$Al$_{8-x}$ ($R = \text{Gd, Er, Y}$) AND THEIR MAGNETIC PROPERTIES


To cite this version:

T. Kamimori, W. Liu, H. Kadomatsu, M. Goto, H. Fujiwara. SITE OCCUPANCY OF Fe ATOM IN RFe$_{4+x}$Al$_{8-x}$ ($R = \text{Gd, Er, Y}$) AND THEIR MAGNETIC PROPERTIES. Journal de Physique Colloques, 1988, 49 (C8), pp.C8-381-C8-382. <10.1051/jphyscol:19888172>. <jpa-00228325>

HAL Id: jpa-00228325
https://hal.archives-ouvertes.fr/jpa-00228325
Submitted on 1 Jan 1988

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
SITE OCCUPANCY OF Fe ATOM IN $RFe_{4+x}Al_{8-x}$ ($R = \text{Gd, Er, Y}$) AND THEIR MAGNETIC PROPERTIES

T. Kamimori (1) W. L. Liu (2), H. Kadomatsu (2), M. Goto (1) and H. Fujiwara (2)

(1) Faculty of Science, Ehime University, Matsuyama 790, Japan
(2) Faculty of Science, Hiroshima University, Hiroshima 790, Japan

Abstract. - The compound systems $RFe_{4+x}Al_{8-x}$ with ThMn$_{12}$ type structure have been studied from the Mössbauer effect and a.c. susceptibility in the range of $0 \leq x \leq 2$ for $R = \text{Gd, Er and Y}$. In these compound systems, site occupancy of Fe atom is different from each other and this fact causes the differences in magnetic properties.

1. Introduction

The Mössbauer effect and magnetic studies have been made on the ternary ThMn$_{12}$ type intermetallic compound systems $RFe_{4+x}Al_{8-x}$ ($R =$ rare earths) [1-7]. In these compound systems, rare earth atom always occupies (a) site, and at $x = 0$ Fe and Al atoms mainly occupy (f) and (i, j) sites, respectively. In the previous work for $R =$ Gd [1], we pointed out that $x$ dependence of site occupancy of Fe atom is divided into 3 regions and they correspond to 3 regions in magnetic phase diagram.

In the present work, measurement was carried out on $R =$ Er and the results were compared with the previous result ($R =$ Gd) [1] and with the result for $R =$ Y reported by Felner and Nowik [7].

2. Experimental

The samples were prepared by arc melting in an argon atmosphere and annealed at 800°C. X-ray analysis was done to verify the crystal structure. The measurement of $^{57}$Fe Mössbauer effect was carried out at room temperature by transmission method. The spectra obtained were analysed by the least squares fitting to some doublets or sextets of Lorentzian lines in the paramagnetic and ferromagnetic regions, respectively. a.c. magnetic susceptibility $X_{\text{ac}}$ was measured by means of Hartshorn bridge in the temperature range from 4.2 to 400 K.

3. Results and discussion

Figures 1a and b show the Mössbauer spectra of $\text{GdFe}_4\text{Al}_8$ (a: $R =$ Gd, $x = 0$) and $\text{ErFe}_4\text{Al}_8$ (b: $R =$ Er, $x = 0$) measured at room temperature in arbitrary scale. The absorber thickness is about 0.3 mg/cm$^2$ $^{57}$Fe.

1. Mössbauer spectra of $\text{GdFe}_4\text{Al}_8$ (a: $R =$ Gd, $x = 0$) and $\text{ErFe}_4\text{Al}_8$ (b: $R =$ Er, $x = 0$) measured at room temperature in arbitrary scale. The absorber thickness is about 0.3 mg/cm$^2$ $^{57}$Fe.

1 Present address: Dept. of Material Science and Engineering, University of Illinois, Urbana, IL 61801, U.S.A.
Fig. 2. - Site occupancy of Fe atoms in (f) site (Fig. 2a) and (i, j) site (Fig. 2b) per formula unit, as a function of x. (•) R = Gd (Ref. [1]), (●) R = Er (present), (▲) R = Y (Ref. [7]).

with Fe atom for R = Gd as described above, but not for R = Er and Y. For RF6Al6 (x = 2), 60% of Fe atoms (3.6/f.u.) remain at (f) site for R = Gd but only 33% (2.0/f.u.) for R = Er and almost no Fe atoms for R = Y. These facts show that occupancy of Fe atom at (f) site strongly depends on the kind of R atom at (a) site: (1) for R = Gd : Fe atom occupies (f) site completely in small x region but partially above x = 0.25. Then another regularity is found above x = 0.75 as follows; number of Fe atoms at (f) site is always 60% of the whole number of Fe atoms; (2) for R = Er : the occupancy of Fe atom at (f) site at x = 0 is lower than that for R = Gd and the preferential site is (i, j) above x = 1; (3) for R = Y : the occupancy at x = 0 is the lowest among these three. Fe atom at (f) site decreases remarkably as x increases.

In figure 3 is shown the magnetic phase diagram of ErFe4+xAl8-x obtained from measurements of a.c. susceptibility. At x = 0, magnetic coupling of Er-Er and Fe-Fe are ferromagnetic and Er-Fe is antiferromagnetic below TC1 (FR in the Fig.) and Fe-Fe is antiferromagnetic between TC1 and TN (A) [4, 5]. Another transition TC2 was observed at x = 0.25 and 0.5. Small spontaneous magnetization and large high field susceptibility were observed between TC1 and TC2 (FR'). In this phase, ferromagnetic cluster may exist in the antiferromagnetic matrix.

The FR region develops with increasing x. This is due to the increment of Fe(f)-Fe(i, j) and Fe(i, j)-Fe(i, j) pair and the decrement of Fe(f)-Fe(f) pair. Therefore Fe(f)-Fe(i, j) and Fe(i, j)-Fe(i, j) couplings are thought to be ferromagnetic. The magnetic coupling of Fe(f)-Fe(f) is antiferromagnetic at x = 0. The ferromagnetic cluster in the antiferromagnetic matrix at the FR' region, mentioned above, is understandable as a mixed state of antiferromagnetic coupling of Fe-Fe pair at x = 0 and ferromagnetic one above x = 0.75.

Felner and Nowik [7] reported on YFe4+xAl8-x that Y has no moment and magnetic coupling of Fe-Fe is antiferromagnetic at x = 0, ferromagnetic at x = 2 and spinglass at around x = 1.

The difference in Fe-Fe coupling among R = Gd [1], R = Er [present] and R = Y [7] is originated from the number of Fe-Fe pairs; Fe(f)-Fe(f), Fe(i, j)-Fe(i, j) and Fe(f)-Fe(i, j), that is the difference in site occupancy of Fe atom among these compound systems.