BL-9C, 12C/ 2012G033

Structural phase transformation of intermetallic compound $GdMn_2$ by milling

Ikuo Nakai* Ken Inui, Yuhji Yamao
[1]Tottori Univ., Tottori 680-8552, Japan

We report XAFS study on the structural phase transformation of C15 Laves phase intermetallic compound $GdMn_2$ by mechanical milling. Milling transforms $GdMn_2$ into the $GdMn_{12}$ phase for 40 h; subsequent milling grows the Gd_6Mn_{23} compound at 150 h.

1 Introduction

Gd-Mn alloying system has a variety of intermetallic compounds such as $GdMn_2$, Gd_6Mn_{23} and $GdMn_{12}$. The C15 Laves phase $GdMn_2$ (space group *Fd-3m*) has a Néel temperature of 110 K and becomes ferromagnetic below 40 K with the Mn moment of $1.6\mu_B$ [1]. Mechanical milling is a technique to introduce a lattice defect and to induce a structural phase transformation. We report here an example of the structural phase transformation of $GdMn_2$ by milling.

2 Experiment

The ingot of $GdMn_2$ was prepared from Mn (99.99%) and Gd (99.9%) metals by arc melting. It was ground in a mortar. Milling was made upto 1000 h with a vibratory ball mill in an argon atmosphere. The weight ratio of the powdered $GdMn_2$ to balls was 1:7. Although x-ray diffraction with rotating Cu anticathode was measured as shown in Fig. 1, reflection peaks disappeared after 15 h milling because of reduced crystallite size.

3 Results and Discussion

Figure 2 shows the radial structure functions for the Mn K edge of milled $GdMn_2$ at a typical milling time. As indicated by the arrow, the first peak around 2.3 Å corresponds to Mn-Mn pairs and the shoulder around 3.0 Å comes from Mn-Gd ones. These peaks at 5 h milling are exactly the same as those of no milling. The interatomic distance between Mn atoms is 2.74 Å at 5 h milling. This is the same as that of $GdMn_2$. Therefore milling for 5 h does not affect $GdMn_2$ with the *Fd-3m* structure. After 10 h the first peak does not change, while the shoulder shrinks abruptly. This means that $GdMn_2$ with the *Fd-3m* structure is transformed gradually into $GdMn_{12}$ (space group *I4/mmm*) because Mn atoms has a much smaller number of Gd neighbor in $GdMn_{12}$ than that of $GdMn_2$. At 40 h milling the phase transformation has been almost completed and the atomic distance of Mn-Mn pairs is 2.39 Å. Milling after 40 h till 100 h activates no phase transformation. After 100 h another phase transformation occurs and a new phase of Gd_6Mn_{23} (space group *Fm-3m*) appears. At 120 h the distance between Mn-Mn neighbors becomes 2.58 Å which is longer than that of $GdMn_{12}$. As the Mn coordination number of Gd_6Mn_{23} is about twice larger than that of $GdMn_{12}$, the first peak grows. X-ray diffraction is a powerful technique to complement these prediction about the structural phase transformation. We will plan a synchrotron x-ray diffraction measurement.

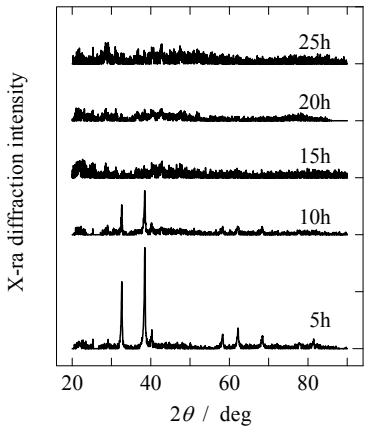

Fig. 1: X-ray diffraction patterns of $GdMn_2$ at typical milling time.

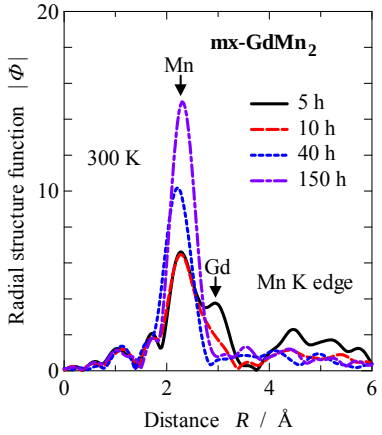

Fig. 2: The radial structure function of $GdMn_2$ at typical milling time for the Mn K edge at 300 K.

Acknowledgement

We thank Professor Y. Makihara for preparing a part of the samples.

References

[1] Y. Makihara *et al.*, *J. Phys. Soc. Jpn.* **52**, 629 (1983).

* nakai@ele.tottori-u.ac.jp