MAGNETIC PROPERTIES OF $UFe_{10}Si_2B_x$ (x= 0.1, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 2)*

Akihiro Kimura, Kaoru Yokoyama, Shinji Takeda, and Shinichi Kodama

Ningyo-toge Enviromental Engineering Center
Japan Nuclear Cycle Development Institute
Kamisaibara-son 1550 Tomata-gun,708-0698 Okayama, Japan

(Received July 10, 2002)

The boron interstitial solid solutions $UFe_{10}Si_2B_x$ (x= 0.1, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 2) were synthesized with the arc furnace and the structural analysis was performed by X-ray diffraction. The magnetic hysteresis in room temperature and the temperature dependence of the magnetization from room temperature to 800°C were measured. From these measurements, the saturated magnetization and the Curie point were clarified, respectively.

PACS numbers: 75.50.Dd, 75.30.Cr, 61.10.Nz

1. Introduction

Since the uranium atom develops the f electron-shell like the rare earth elements used as the permanent magnet materials, such as neodymium and samarium, we are examining whether the uranium compound can also be used as the materials of the permanent magnet. It is required that they have large saturated magnetization, high Curie point and strong uniaxial magnetic anisotropy for the substance used as the permanent magnet materials. It is thought that $UFe_{10}Si_2$ which crystalizes in $ThMn_{12}$ type structure as shown in Fig. 1 is most satisfing for these conditions among the uranium compounds known until now [1-5]. However, this compound has only small saturated magnetization as compared with the rare earth permanent magnet materials. This is thought because the f and d electron hybridization is so strong that the magnetic moment of the uranium and the iron decrease greatly. Then, we tried interstitial of the boron for the purpose of turning a magnetic moment stably, and observed how the saturated magnetization would change.

* Presented at the International Conference on Strongly Correlated Electron Systems, (SCES 02), Cracow, Poland, July 10–13, 2002.

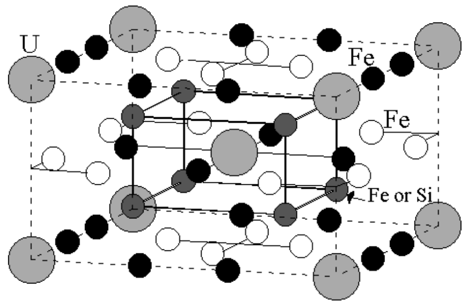

Fig. 1. Crystal structure of $UFe_{10}Si_2$.

2. Experimental details

The compounds were obtained by melting the elements with an arc furnace under an argon atmosphere. In order to check the composition and the existence of impurities, the powder X-ray diffraction examination was performed. The magnetic hysteresis was measured in external magnetic field between –15kOe and 15kOe at room temperature with Vibrating Sample Magnetometer (VSM). The curve of the temperature dependence of the magnetization was measured by the magnetic balance in the vacuum. The measurement temperature range is from room temperature to 800°C.

3. Results and discussion

It is considered that all the samples show $ThMn_{12}$ structure from the obtained X-ray diffraction profile, and we calculated the lattice parameters. The variation of these values is shown in Fig. 2. Large change of the lattice parameter was not seen with the increase in boron content. The diffraction pattern considered to be based on the iron was observed in the sample of x = 1, 1.25, 1.5, and 2. It is necessary to take notice in the influence of these impurities to the physical properties.

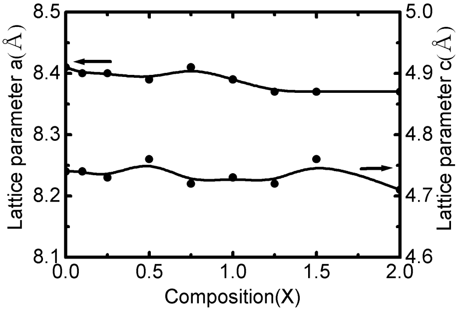

Fig. 2. Composition dependences of the lattice parameters.

The variation of the saturated magnetization is shown in Fig. 3. Since the magnetization was saturated for almost all samples in the magnetic field of 15kOe from the measurement of the magnetic hysteresis loop, the magnetization at this time was considered as the saturated magnetization. However, since the magnetization was not completely saturated with the sample of $x= 0.5$, it is necessary to apply more stronger magnetic field. The saturated magnetization increased gradually from $18.6\mu_B$/f.u. of $x = 0$ to 19.4 μ_B/f.u. of $x = 0.1$ and 20.4 μ_B/f.u. of $x=0.25$, but it started to decrease at $x = 0.5$.

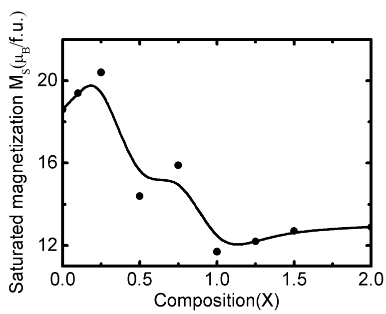

Fig. 3. Composition dependences of the saturated magnetization.

The variation of the Curie point and the curve of the temperature dependence of the magnetization is shown in Fig. 4 and Fig. 5, respectively. Although the Curie point was observed near 370°C and the change was hardly seen as compared with that of $UFe_{10}Si_2$ for the samples of $x = 0.1$ to 0.75, another Curie point came to be independently observed near 260°C, and the degree of the change of the magnetization at this Curie point became superior with the increase of the composition x for the samples after $x = 1$. And the Curie point near 360°C was no longer observed at all in $x = 2$. Moreover, according to the increase in boron content, the change of the magnetization came to be greatly observed above 700 °C. Since this temperature is mostly in agreement with iron Curie point, the result of the X-ray diffraction is also simultaneously taken into consideration, this is imagined to be a phenomenon depended on the influence of iron.

In above examinations, it was observed that the saturated magnetization increased for the samples of $x = 0.1$ and 0.25 as compared with $UFe_{10}Si_2$. It is thought that this is because the strength of $5f$–$3d$ hybridization changed with the boron interstitial. However, in order to clarify influence of this hybridization, more detailed examination is required.

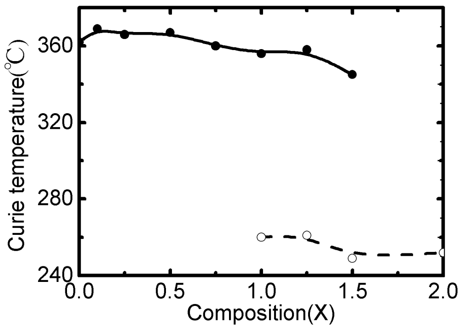

Fig. 4. Composition dependences of the Curie temperature.

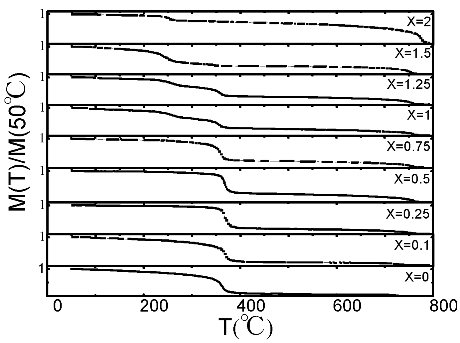

Fig. 5. Curves of the temperature dependence of the magnetization.

REFERENCES

[1] W. Suski, A. Baran, T. Mydlarz, *Phys. Lett.* **A136**, 89 (1989).

[2] T. Berlureau, B. Chevalier, L. Fournes, J. Etourneau, *Mater. Lett.* **9**, 21 (1989).

[3] A.V. Andreev, W. Suski, N.V. Baranov, *J. Alloy. Compd.* **187**, 293 (1992).

[4] P. Estrela, M. Godinho, A.P. Gonçalves, M. Almeida, J.C. Spirlet, *J. Alloy. Compd.* **230**, 35 (1995) .

[5] W. Suski, in: *Handbook on the Physics and Chemistry of Rare Earths*, K.A. Gschneidner and L.Eyring (eds.) Vol.22, North-Holland, Amsterdam 1996, Chap.149, p.143.