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LOW TEMPERATURE MAGNETIC PROPERTY OF $FeAl_{0.7}Co_{0.3}$ ALLOY

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<ABSTRACT>

Magnetic measurements of $FeAl_{0.7}Co_{0.3}$ alloys have been made at a temperature range of 2~800K. Magnetic properties of annealed and rapidly solidified $FeAl_{0.7}Co_{0.3}$ alloy showed mictomagnetic-like property, which turned out to be ferromagnetism. Crystal structures showed B2 single phase with a constant lattice parameter of ~2.91Å.

$FeAl_{0.7}Co_{0.3}$ 합금의 저온 자기특성

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<요 약>

소둔 및 급속응고한 FeAl0.7Co0.3 합금의 자기적 특성이 진동시료형 자력계를 이용하여 2~800 K 온도의 범위에서 조사되었다. 자기적 특성은 강자성의 특성을 보여주는 mictomagnetism 을 보여주었다. X-선 회절은 격자상수가 약 2.91Å인 B2 구조를 나타내었다.

INTRODUCTION

The Fe-Al system has attracted much attention as a typical example of a system which exhibits special sequence of magnetic phase transitions [1]. Ko et al. [2] showed the theoretical model for behaviors of the magnetic moments caused by the local environment in bcc Co-(Al,Fe) alloys. Also, Ko et al. reported the mictomagnetism for annealed and rapidly solidified $FeAl_{0.6}Fe_{0.4}$ and $FeAl_{0.7}Co_{0.3}$ alloys [3]. Magnetic properties of annealed and rapidly solidified $FeAl_{0.7}Co_{0.3}$ alloys have been investigated at a temperature range of 2~800K using a superconducting vibrating sample magnetometer.

EXPERIMENTAL

The master alloy was melted in an argon arc furnace with elements purer than 99.95%. The ingot was turned over and remelted 5~6 times for ensuring homogenization. Ingots with weight loss during melting less than 0.2% were taken to prepare specimens. Each ingot was sealed in a quartz tube, evacuated and filled with argon gas, further homogenized at 920℃ for 24 hours and cooled in furnace. The ingot was crushed in a steel mortar and some lumps were selected for rapidly solidified specimens. Small pieces having ~3x2mm ellipsoidal form were selected for magnetization measurement of annealed specimens and the rest was crushed into fine powder (<250 mesh) for x-ray powder diffraction measurements. These smaller pieces and powder were sealed in a quartz tube under argon atmosphere and annealed at 800℃ for 24 hours to relieve the internal stresses. The rapidly solidified specimen was obtained in the form of thin and brittle ribbons (thickness 30~70 μm, width 3~5mm) using a single roller chill block melt spinning apparatus under argon gas atmosphere. Temperatures of melt measured by an optical pyrometer was ~1500℃ and the cooling rate was estimated as ~10^5℃/sec. The ribbon was broken into small pieces for the use of both magnetic and x-ray measurements. X-ray powder diffraction was obtained for both annealed and rapidly solidified specimens at room temperature. The magnetic measurements were made using superconducting Oxford vibrating sample magnetometer (Salford/Manchester university, UK) with a maximum field of 12 T in the temperature range of 2~800K. A pure Ni specimen was used as a standard specimen and its magnetization at room temperature was taken as 55.1 (emu/g). Scanning electron microscopy (SEM, JSM-820 Jeol) and electron probe micro analyzer (EPMA-1400, Shimadzu) were used to investigate the formation of any second phases and chemical composition analyses.

RESULTS AND DISCUSSIONS

The x-ray diffraction data showed that annealed and rapidly solidified $FeAl_{0.7}Co_{0.3}$ alloy specimen were single phase having CsCl (B2) structure with a virtually constant lattice parameter ~2.91±0.01Å as shown in Fig. 1. The SEM investigation did not reveal any second phase. The chemical analyses using EPMA agreed with nominal composition within limit of instrument errors. Annealed and rapidly solidified $FeAl_{0.70}Co_{0.30}$ alloys were characterized by mictomagnetism with non-saturating σ-H isotherms showing decreasing magnetization with temperature decreasing below ~200 K. Spontaneous magnetization ($\sigma_{0,T}$) was obtained from σ- H isotherms, extrapolating linearly the high field part of the isotherms to H=0 axis. $\sigma_{0,T}$-T curve was given in Fig. 2. Ferromagnetic Curie temperature (Tc) was obtained from Arrott plots. The saturation magnetization ($\sigma_{0,0}$) was taken from extrapolating ($\sigma_{0,T}$) curve to T=0 axis. Magnetic parameters were tabulated in Table 1.

Table 1. Magnetic parameters of $FeAl_{0.7}Co_{0.3}$ alloy.

Specimen	Tc (K)	$\sigma_{0,0}$ (emu/g)	2S(B)
Annealed	519	47.3	0.78
Rapidly solidified	470	41.0	0.68

Magnetic moment per Fe atom in Bohr magnetons (2S per Fe atom) were calculated from $\sigma_{0,0}$, assuming that all the magnetic moment of the alloys is solely due to Fe atoms. Hysteresis loops for the annealed specimen as given in Fig. 3 show ferromagnetic behaviors with remanence at low temperature. It indicates that the mictomagnetism of the system belongs to ferromagnetism. Rapidly solidified specimen showed lower magnetic properties than the annealed one. It might be due to some disorder in atomic occupancy between Fe and Al sites in rapidly solidified specimens. Mictomagnetism could be possible when small ferromagnetic clusters exist within a ferromagnetic matrix and orient their moment oppositely to that of the matrix at low temperature as suggested in $FeAl_{0.60}Fe_{0.4}$ alloys [2][3].

CONCLUSIONS

Mictomagnetism appears at annealed and rapidly solidified $FeAl_{0.7}Co_{0.3}$ alloy. It could be possible when small ferromagnetic clusters exist within a ferromagnetic matrix and orient their moment oppositely to that of the matrix at low temperature.

REFERENCES

[1] R.D Shull, H. Okamoto and P.A. Beck, Solid State Commun. 20 (1976) 863

[2] K.Y. Ko and S. Yoon, J. Magn. Magn. Mater. 162 (1996) 117

[3] K.Y. Ko and S. Yoon, J. Korean Inst. Metals 27(1989) 1008

Figure captions

Figure 1. X-ray diffraction patterns of (a) annealed and (b) rapidly solidified $FeAl_{0.7}Co_{0.3}$ alloy.

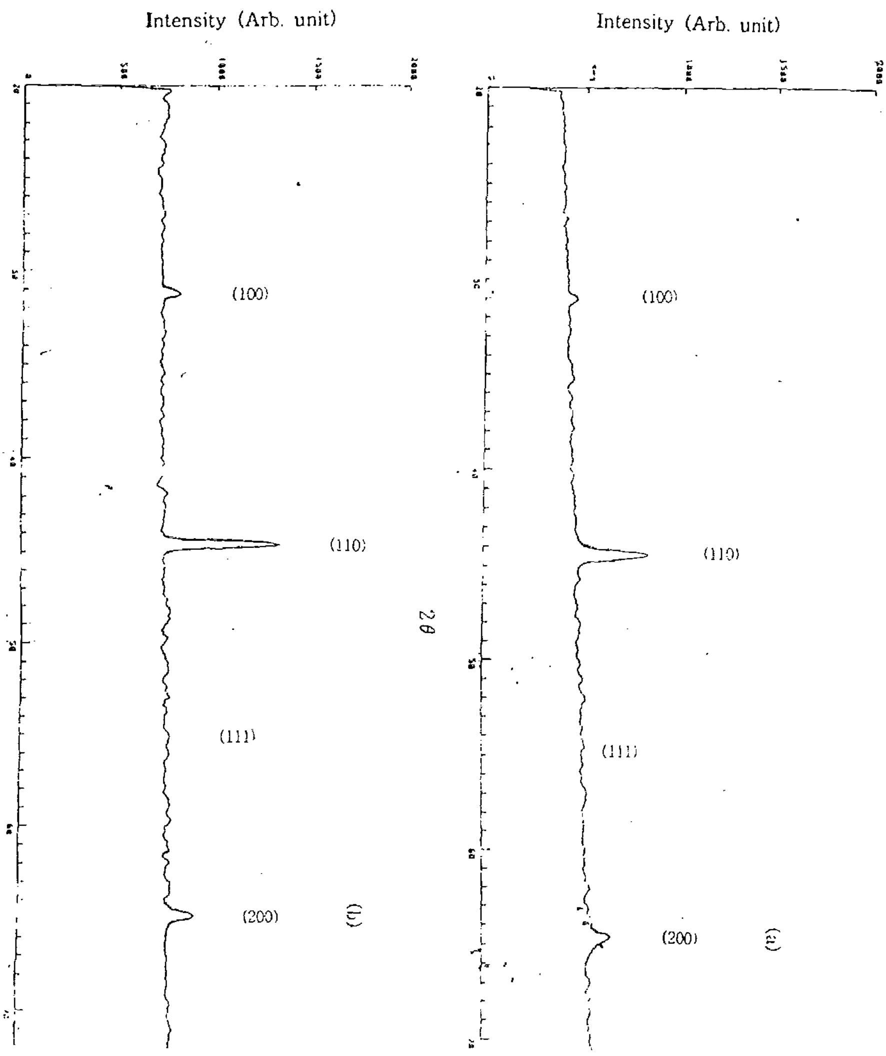


Figure 2. $\sigma_{0,T}$–T curve of annealed and rapidly solidified $FeAl_{0.7}Co_{0.3}$ alloy.

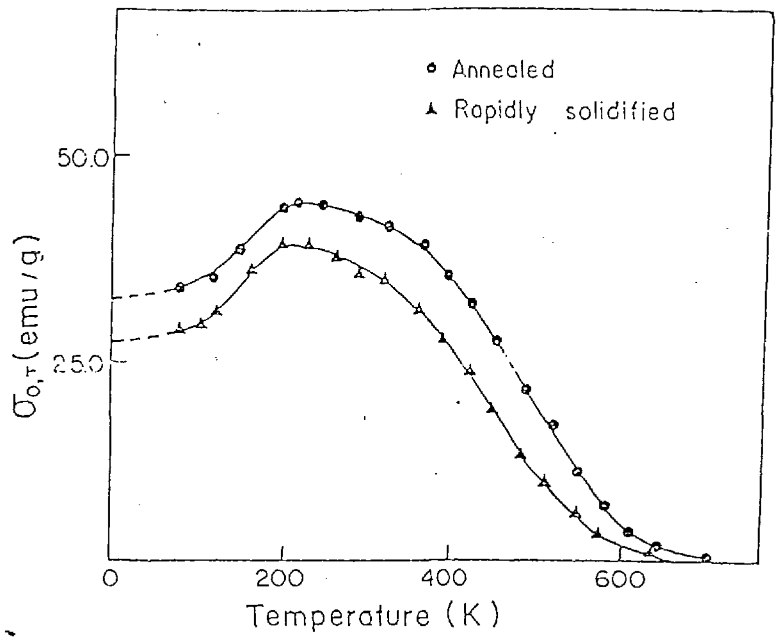
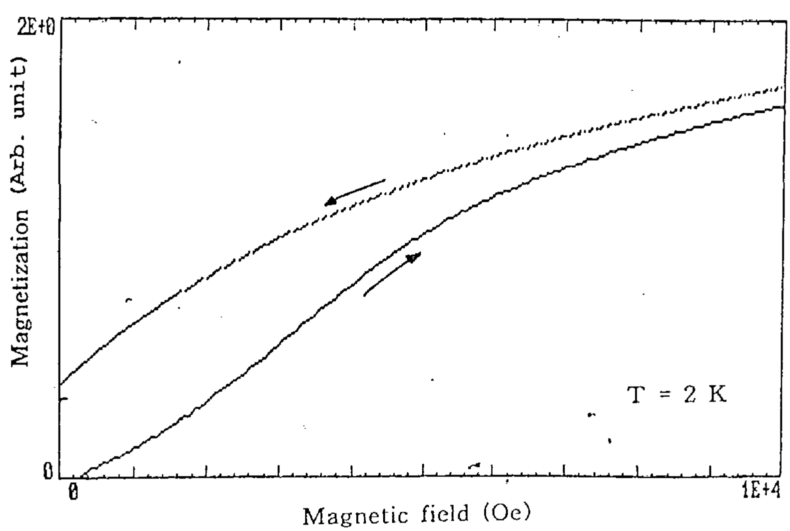
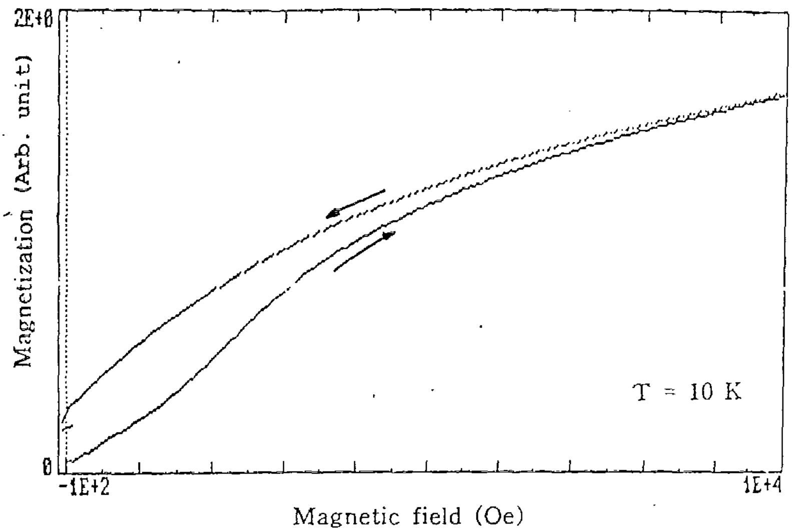
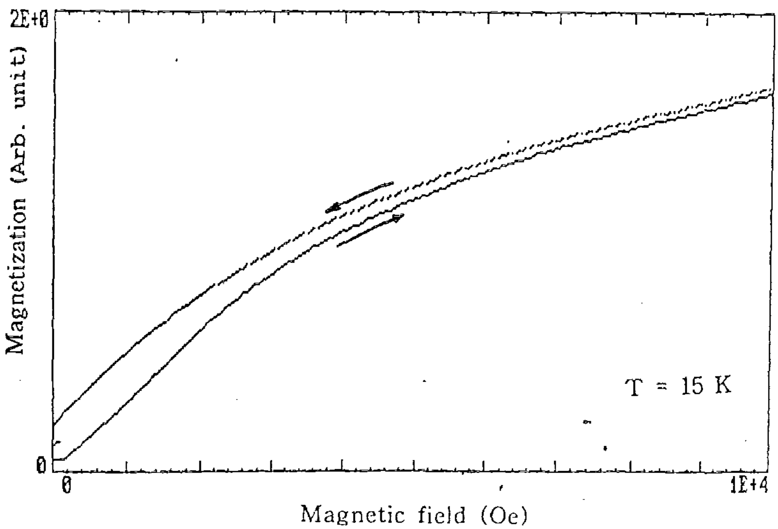
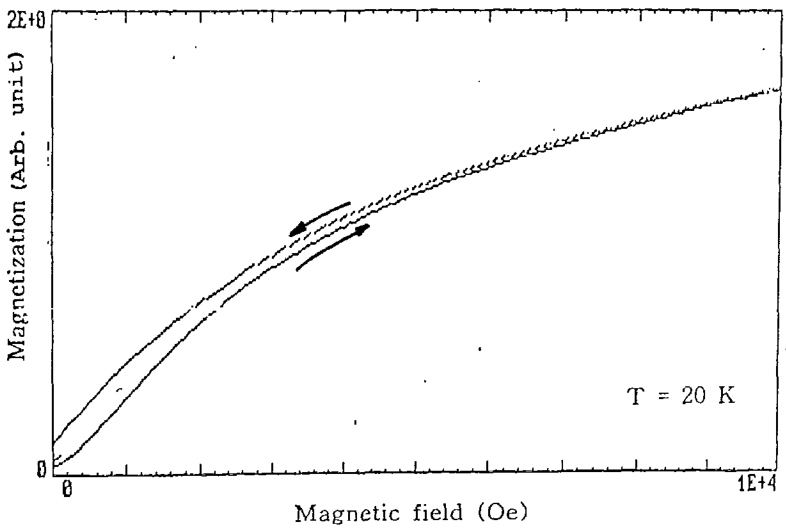


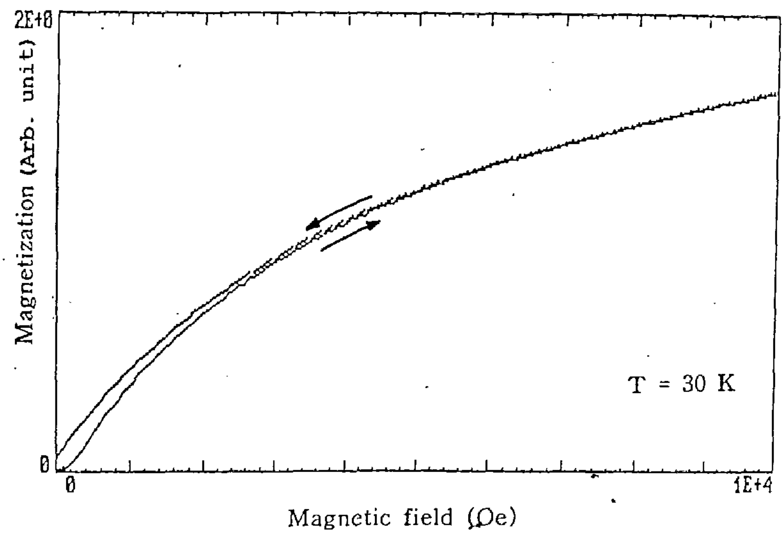
Figure 3(a)-(e). Hysteresis loops(1st quadrant) at indicated temperatures for annealed specimen.




2E+0
0
Magnetization (Arb. unit)
T = 10 K
-1E+2
1E+4
Magnetic field (Oe)


2E+0
0
Magnetization (Arb. unit)
T = 15 K
0
1E+4
Magnetic field (Oe)


2E+0
0
Magnetization (Arb. unit)
0
1E+4
Magnetic field (Oe)
T = 20 K


2E+0
0
Magnetization (Arb. unit)
0
1E+4
Magnetic field (Oe)
T = 30 K