In-situ Synchrotron X-ray Diffraction Measurement of Epitaxial FeRh thin Films

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ABSTRACT

The magnetic properties and structure of FeRh thin film epitaxially grown onto MgO(001) substrate were studied by MPMS(Magnetic Properties Measure System) and in-situ temperature synchrotron XRD(X-ray Diffraction). The transition temperature of FeRh thin films was around 380K. Both M-T curve and d-spacing changes correspond to each other very closely.

BACKGROUND

First-order antiferromagnetic(AFM)-ferromagnetic(FM) phase transition in ordered FeRh thin films with CsCl structure[1],[2] have attracted much attention due to its fundamental scientific interest and potential applications, such as heat assisted magnetic recording media[3], spin valve based devices[4] and highly sensitive magnetic sensors. Ordered FeRh alloy thin films in chemical equilibrium exhibit a first-order phase transition from antiferromagnetic to ferromagnetic phase around 380K. The magnetic phase transition in FeRh alloy thin films is quite complicated because of their sensitivity to composition, heat treatment, magnetic field, and pressure.

It is popular belief that antiferromagnetic to ferromagnetic transition is caused by an isotropic lattice expansion effects[5],[6] of the reduced dimensions in thin film samples such as substrate effects, strain introduced during growth and, in poly-crystalline films, grain boundary effects can be expected to play a significant role in the temperature-dependent magnetic properties. However, there are not sufficient experimental results to fully understand this phenomenon, especially at around the transition temperature.

In this paper, the structural and magnetic phase transition in FeRh thin films were studied by in-situ synchrotron XRD to yield a better understanding of the transition.

RESULTS AND DISCUSSIONS

Fig. 1(a), shows the temperature dependence of magnetization of Fe48Rh52. The film clearly exhibits the AFM-FM phase transition around 380K. A magnetic field of 1.5T in magnitude was continually applied during heating and cooling. In Fig. 1(b), the temperature dependence of lattice constants is shown for the same sample. Notice that the d(001)-spacing increases by about 0.6 % over a temperature range from 370-390K which corresponds to the transition temperature range. This can be seen for both the heating and cooling processes. Also, the hysteresis of lattice constants can be observed for heating and cooling processes similar to that of shown in the M-T curve in Fig.

1(a).

Fig. 2 shows the peak shift as a function of temperature, analyzed by in-situ temperature synchrotron XRD. The d-spacing increases by about 0.5%. This phenomenon is very similar to those reported for volume expansion of bulk FeRh alloys[6]. Notably, a discontinuous peak shift is observed. The peak shift occurs rapidly around 380K. Both peak is separated into peaks, which can be thought of as local change in lattice parameter. This separation might be related the fist-order transition(M-T curve). Also, notable (002) peak shift occurs at temperatures 5K lower than that of (001) peak shift. Since (200) peak shows diffraction between the antiferromagnetic planes, when FeRh thin films was heated by enough thermal energy, the magnetic properties changed from antiferromagnetism to ferromagnetism. And lattice expansion of (200) plane was proceed Consequently, the net lattice of (100) plane was expanded.

ACKNOWLEDGMENT

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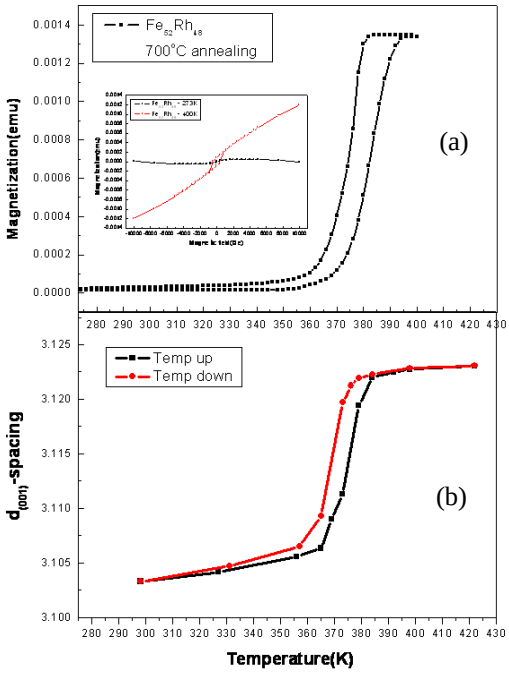

figure 1

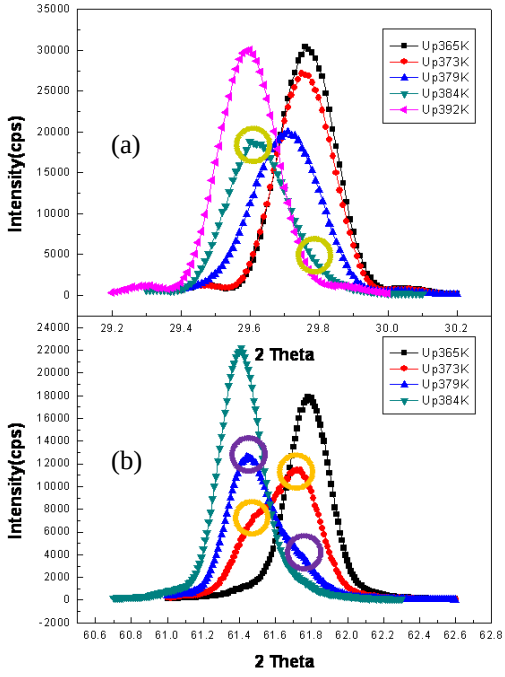

figure 2