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Magnetic and magneto-optical properties of FeRh thin films

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ABSTRACT

The magnetic and magneto-optical properties of FeRh thin films epitaxially deposited onto MgO(1 0 0) substrates by RF sputter-deposition system have been investigated in conjunction with the structure. An intriguing virgin effect has been found in the *M–T* curves of the as-deposited FeRh thin films, which is presumably interpreted in term of a change in structural phase when heating. Also, a (negative) maximum peak of Kerr rotation at around 3.8 eV has been observed when FeRh thin films are in ferromagnetic state. The polar Kerr rotation angle is found to increase at temperatures above 100 °C, which corresponds to the antiferromagnet (AF)–ferromagnet (FM) transition of FeRh thin films.

1. Introduction

Thin films of FeRh known to possess a peculiar first-order phase transition from antiferromagnet (AF) to ferromagnet (FM) [1] upon heating have recently received much renewed interest because of their potential applications in heat-assisted magnetic recording media [2], MEMS devices [3] and spin valve-based devices [4]. Although extensively studied, the physical origin of this magnetic phase transition in FeRh thin films is still controversial as it is accompanied by a volume expansion [5], a reduction in resistivity [6] and a large change in entropy [7]. Despite the fact that there is a lot of research on FeRh materials [8], there has been little work in the literature reported about the magneto-optical properties of FeRh thin films, especially at around the transition temperature. This work is therefore motivated to examine the magneto-optical and magnetic properties of FeRh thin films in conjunction with the structure.

2. Experimental

Thin films of FeRh were deposited onto MgO (1 0 0) substrates using a $Fe_{50}Rh_{50}$ alloy target by DC magnetron sputtering at an ambient temperature with the deposition pressure of 0.6 mTorr. The base pressure of the chamber was less than 5×10^{-8} Torr. The thickness of the films is fixed at around 150 nm. The composition of the films, analyzed by an energy dispersion fluorescence X-ray spectrometer (EDX), is about $Fe_{49}Rh_{51}$. The as-deposited thin films were annealed for 2 h at temperatures between 200 and 700 °C in a high vacuum better than 10^{-7} Torr. The crystallographic structure and microstructure of the films were characterized by an X-ray diffractometer (XRD) using Cu Kα radiation. A vibrating sample magnetometer (VSM) with a maximum applied field of 15 kOe was used to measure the magnetic properties of the films in the range from $T = -196$ to 350 °C. A homemade ultra-wide band magneto-optical Kerr effect (MOKE) apparatus [9] with a maximum applied field of 20 kOe was employed to characterize the magneto-optical properties of the samples at varied temperatures from $T = 25$ to 200 °C.

3. Results and discussion

Shown in Fig. 1 are the XRD patterns of FeRh thin films annealed at different temperatures. Strong (0 0 1) and (0 0 2) peaks and full-width at half-maximum (FWHM) values of rocking curves of (0 0 1) peaks shown in the insets, indicate that the (0 0 1)-oriented FeRh thin films were obtained onto MgO (1 0 0) substrate after annealed beyond 300 °C. The FWHM of rocking curves of FeRh (0 0 1) decreases with increasing annealing temperature and the sample annealed at 700 °C presents a small FWHM value of 1.1°. These results indicate a narrow orientation distribution of FeRh lattice and also supports better epitaxial growth of FeRh on MgO (1 0 0) substrate after high-temperature annealing. It is also found that (0 0 1) and (0 0 2) peaks of bcc FeRh

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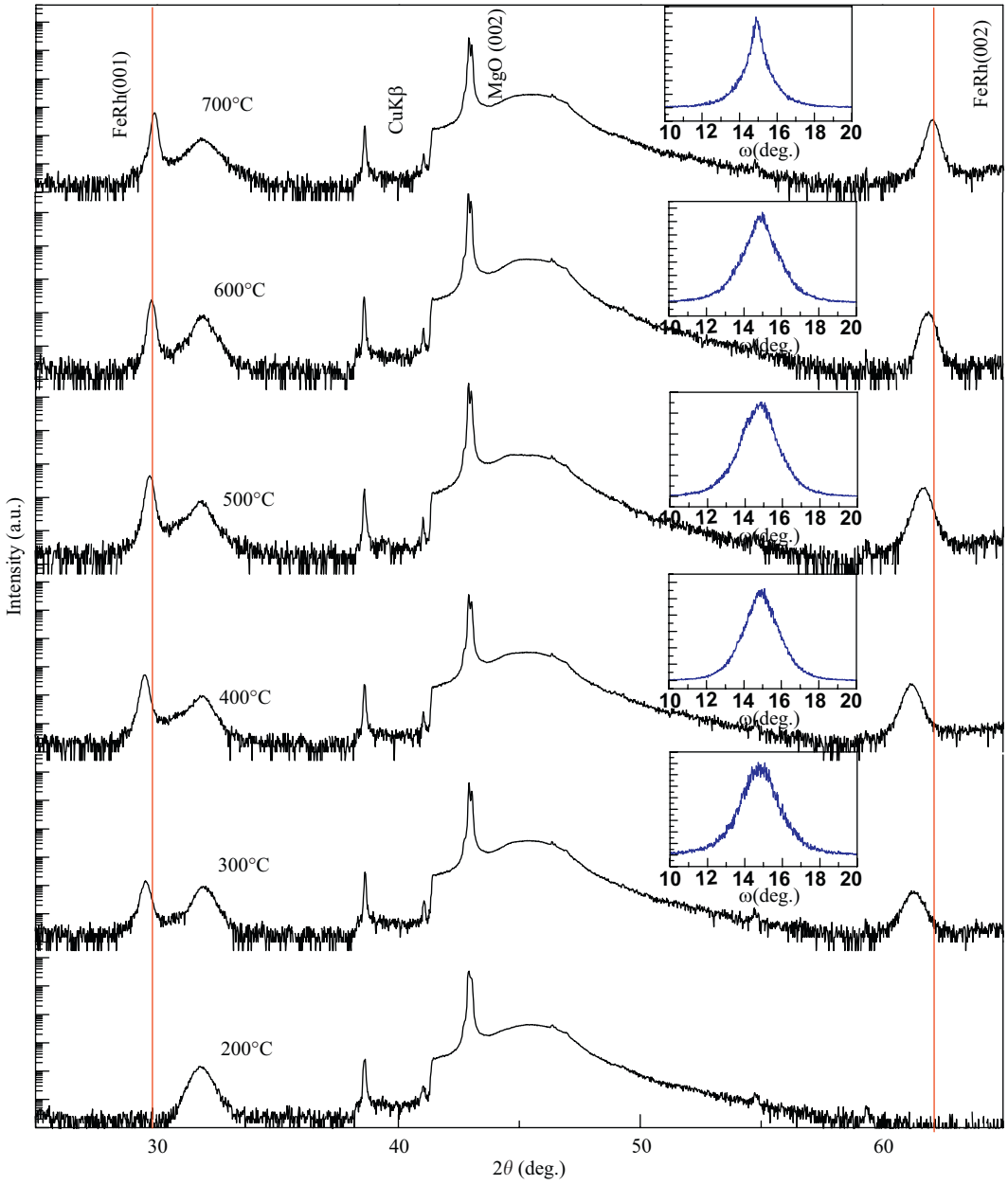

Fig. 1. X-ray diffraction patterns for FeRh thin films annealed at various temperatures. Insets are the rocking curves at FeRh (0 0 2) peaks.

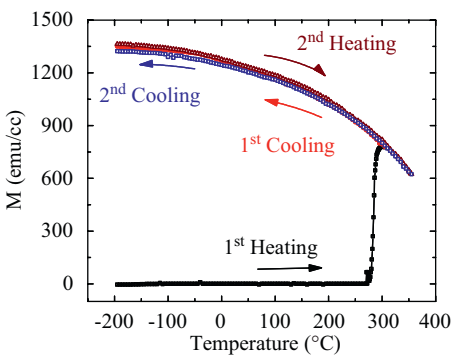

Fig. 2. *M* vs. *T* curves for an as-deposited FeRh sample with 2 cycles of measurement indicated in the arrows.

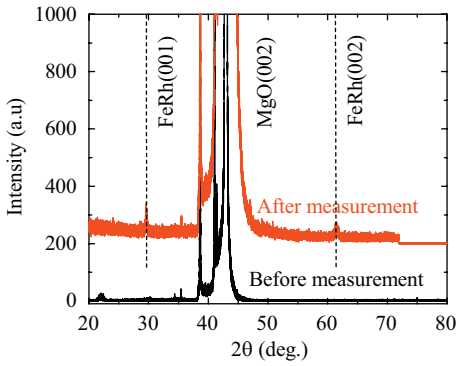

Fig. 3. X-ray diffraction profiles for an as-deposited FeRh sample before and after the *M* vs. *T* measurement shown in Fig. 2.