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Compositional Influence on Thermo-Magnetic Properties of FeRh Thin Films

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Equiatomic FeRh undergoes a first-order transition from antiferromagnetic (AF) to ferromagnetic (F) state as heated above a transition temperature (T_{AF-F}) of about 80°C [1]. The binary $Fe_{1-x}Rh_x$ phase diagram indicates that FeRh alloys, having a Rh content between 49 and 54, are antiferromagnetic at room temperature, and there is a two phase region (B2 FeRh+fcc-type γ-FeRh) where the Rh content is greater than 54. In this study, a B2 (CsCl structure) ordered FeRh thin film (Medium A) was grown onto an MgO single crystal substrate, using sputtering at an elevated temperature of 500°C. A FeRh thin film (Medium B) with a Rh content slightly greater than 54 was prepared for comparison. A variation in the Rh content was achieved by the application of bias sputtering. As biasing increased, the Rh content increased.

In Fig. 1, XRD spectra for Media A and B are shown. A characteristic reflection of ordered B2 phase appears at an angle of 29.68°. In the case of Media B, fcc γ-FeRh (200) reflection appears at an 2θ angle of about 48° as the near-equiatomic film becomes Rh rich. In Fig. 1, the corresponding temperature dependence of magnetization (M) upon heating and successive cooling is shown as well. A magnetic field of 5kOe was applied for this measurement. The apparent AF-F transition for Medium A was observed whereas the transition for Medium B was much broader, although both displaying a thermal hysteresis, which is typically present for B2 FeRh. We further discuss compositional influence on thermo-magnetic properties of FeRh thin films.

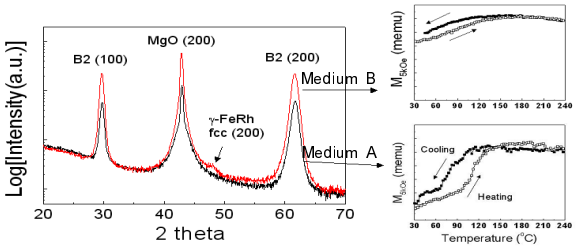

Fig. 1. XRD spectra for Media A and B. The corresponding temperature dependence of M was shown as well. The AF-F transition for Medium B was much broader due to the presence of fcc-type γ-FeRh.

[1] M. Fallot, Ann. Phys. (Paris) 10, 291 (1938).

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Effects of SiO_2 Addition in FePt on Microstructures and Magnetic Properties in Two Different MgO Substrates

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Ordered FePt films have been studied by many researchers in recent years as a candidate material for next generation recording media. However, most works are concentrated on lowering ordering temperature and grain isolation. In the present work, we report different texture formation and progress of ordering of FePt-SiO_2 on MgO(001) single crystal (A) and MgO(001) film formed on SiO2/Si (B) substrates.

$[0.24nm\ Pt/\ 0.25nm\ Fe/\ 0.21nm\ SiO_2]_{15}$ were deposited on 600°C heated substrates. The deposited films were rapidly annealed at 700°C for 12 sec and this process repeated 4 times. In each step, magnetic properties were measured by a VSM and microstructures were analyzed by X-ray and SEM. As references, $[Pt / Fe]_{15}$ on A and B substrate were prepared.

In the as-deposited state, magnetic property and microstructure of the SiO_2 added films were very different for the two different substrates. The film on B substrate showed much finer grains and much higher in-plane coercivity than that on A substrate. The higher in-plane coercivity is associated with different texture formation of FePt. Upon first cycle annealing, grain size of the film on B substrate increased rapidly and in-plane coercivity abruptly decreased while those on A substrate did not change much. FePt on A substrate showed only (002) and (001) peaks but that on B substrate showed rather strong (200) and weak (111) peaks upon annealing. The change of ordering parameter, "S" upon the repeated annealing was measured together with lattice parameter of c-axis. The S parameter of the film on B substrate increased from 0.77 to 0.86 almost linearly with 3 repeated heat cycles but that of on A substrate remained at 0.85 range, which must be associated with the different grain growth behavior. It is believed that although the activation energy for ordering transformation is high (this will be discussed in presentation), the grain growth activates atomic diffusion at lower temperature, which triggers ordering in the B substrate case. The c-axis lattice parameter of A substrate increased from 3.71 nm to 3.72nm upon 1st cycle annealing and stayed the same value upon repeated annealing but that of B substrate increased linearly from 3.69nm to 3.71nm upon 3rd cycle annealing. However, the lattice parameter was 3.71 nm in the as-deposited states of SiO_2 free films on the A and B substrates and stayed about the same with 1 hr-700°C annealing. The differences in lattice parameter upon annealing may be associated with diffusion of SiO_2 trapped in FePt although it is not clear with these data.

In the presentation, role of SiO_2 addition and the two different substrates effect will be discussed in more details.