S-1

MAGNETIC FILED TREATMENT of Sm-Co/Co SUPERLATTICE

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1. Introduction

Sm-Co thin films are widely studied due to their potential application for a high-density hard disk magnetic recording media and designing a micro-device. Eric E. Fullerton et al [1] study the structure and magnetic properties of epitaxial Sm-Co/Co superlattices prepared by magnetron sputtering. J.P. Liu et al [2] and R. Andreescu et al [3] study the magnetic hardening in $SmCo_x$-Co multilayers. In this article we report the structure and magnetic properties of $SmCo_5$/Co superlattices by combining superlattice technique and magnetic field heat treatment. Layered structure provides convenient model systems for studying the magnetic properties since the deposition process can control individual layer thickness. The magnetic field heat treatment may further improve the magnetic structure.

2. Experimental procedure

Our films utilize Si substrate and Ta buffer and capping layers. A series of superlattices in the form of Si/Ta/[Sm-Co(20nm)/Co(15nm)]^{10}/Ta were prepared with a multiple-gun rf-sputtering system by sputtering the target onto silicon substrate. By compressing the powder of $SmCo_5$ alloys and sintering the Sm-Co target was made. Ta and Co targets were made by alloying pure elements (>99.9/%). Flowing high-purity argon gas at 10 mTorr was used and base pressure of sputtering system is better than 2×10^{-6}Torr. The as-deposited films were then annealed in a furnace at vacuum 5×10^{-6}Torr under a 4.5 kGs field in plane direction or without the field. X-ray diffraction was carried out using a Ni filter to select both the Cu $K_{\alpha1}$ and Cu $K_{\alpha2}$ sources. Magnetic properties were measured at room temperature by VSM and AGM.

3. Results and Discussions

As-deposited films were confirmed to be amorphous with some $SmCo_5$ crystals of $CaCu_5$ structure with

(301) preferred texture. All films have obviously preferred texture. The main phase is Th_2Zn_{17} phase of preferred texture (211) with a trace of $SmCo_5$ after annealed at 630°C. For our films textures are obtained by annealing as-deposited films.

The depth profiling of films, by using Auger electron spectra, shows that annealing can change distribution of elements along the depth of films. The Ta and Co elements are preferential to inter-diffuse each other. The Ta elements reject the diffusion of Sm elements. So the interdiffusion of Ta and Co affects the diffusion of Sm element. When annealed at 630°C without field, the depth of hard and soft layer coexistence decrease which is about the depth of Sm element. This is due to Sm exclusion from the inter-diffusion of Co and Ta elements. When applying a magnetic field during annealing along the plane of films, the depth of hard and soft layer coexistence increase again. It means that the applied field dominantly activates the diffusion of Co. Consequently it affects the inter-diffusion of Co and Ta, so does Sm element. From the results of Auger electron spectra, Si diffusion in the films can be ignored. These are firstly reported detailed by Auger electron spectra for magnetic superlattices.

4. Conclusions

Magnetic measurement shows that the magnetic field heat treatment is helpful to improve the properties of SmCo/Co superlattice. All films exhibit the remanence enhancement. When applying the magnetic field heat treatment, especially for those annealed at 630°C, coercivity increases largely. It indicates that a uniform structure could be obtained by applying a magnetic field during annealing. By Auger electron spectra, the depth profiling of films clearly shows the changes of layer composition. It indicates the Ta elements reject the diffusion of Sm elements.

5. References

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