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A Study on magnetic properties of Fe-Ni alloys thin films deposited on Si(111)

한양대학교 물리학과, 김정기, 한경훈, 김현중, 장지영
인하대학교 물리학과, 이석목

1. Introduction

The face centered cubic (fcc) Fe-Ni system is the most extensively studied of the 3d metallic alloys because of their practical applicability in modern industrial technology. The purpose of the present study is to understand experimentally the changes in the magnetic properties for Fe-Ni films deposited without and with additional constant bias field (H_{bias}). The experimental method of choice that allows determining the spin wave stiffness constant is the Brillouin light scattering (BLS) and magnetization measurements[1]. In addition, the knowledge of the temperature dependence of coercivity is very important, because it mediates an insight into the properties of the domain wall pinning. In order to confirm the difference of the Fe-Ni films deposited without and with constant bias we further are investigated the wall pinning based on Gaunt's strong pinning theory[2].

2. Experiment

DC magnetron sputtering system was used in sample fabrication, together with a hybrid target consisting of Ni chips placed on a 99.9 % Fe disc covering 9.9 % of the disc surface. The size of deposit plane is approximately 8 mm in diameter on a Si(111) of square-type of 10 x 10 mm. The sputtering was carried out at an Ar gas pressure of 1mTorr and DC Power of 50 W. The substrate temperature was held at approximately 240 °C throughout the experiment. During deposition an additional constant bias field of 500 G was applied to the film parallel to the plan in order to introduced uniaxial anisotropy. The films without the bias magnetic field are called as F1 and otherwise F2. The crystal structure was investigated by using an X-ray diffraction with *Cu-Kα* radiation in θ-2θ geometry. The film composition deduced from Energy Dispersive X-ray Spectrometer. Magnetic properties were measured by vibration sample magnetometer in maximum magnetic field of 100G at room temperature. The spin waves were studied by Brillouin light scattering (BLS) and SQUID.

3. Result and Discussion

The BLS spectrum of the films is attributed as the spin wave due to the bulk standing spin wave mode and surface localized wave known as Damon-Eshbach (DE) mode, as displayed in Fig. 1. The peaks labeled Bulk and DE.

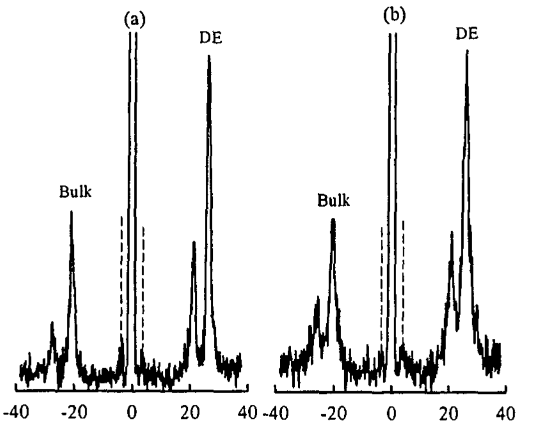

Fig. 1. A typical BLS spectrum for the F1(a) and F2(b) film with thickness 40 nm in the presence of H = 2.6 G magnetic field.

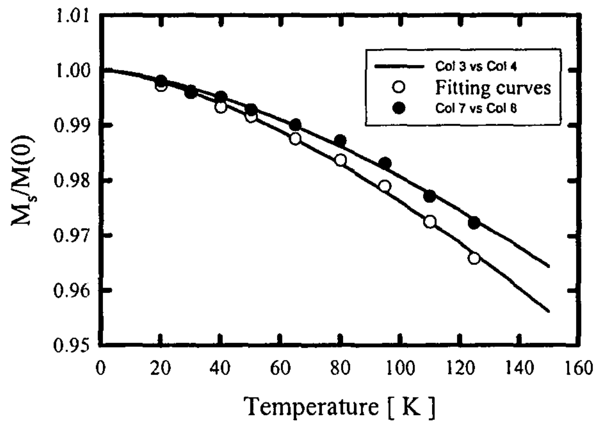

Fig. 2. The temperature dependence of reduced magnetization for the F1(a) and F2(b) film with thickness of 40 nm. The solid lines denote the theoretical results by using spin-wave theory

The width of DE spin wave peaks for anti-Stoke region as shown in Fig 1 is found to be 1.35 GHz for the F1(a) and 2.54 GHz for the F2(b). Figure 2 shows the temperature dependence of the magnetization for the films F1 and F2 with thickness of 40 nm. The temperature dependence of magnetization is described by the Bloch relation, $M(T) = M(0)(1 - \beta T^{3/2} - \gamma T^{5/2})$. The spin wave stiffness constants were calculated from the values of $M(0), \beta$, and the spectroscopic splitting g factor obtained by the BLS. The spin wave stiffness constants were determined 93.4 meVÅ^2 for the film without a bias field and 95.4 meVÅ^2 for the film with a bias field.

4. Conclusions

In conclusion, Ni concentration in the $Fe_{1-x}Ni_x$ films was increased by effect of constant magnetic bias field and determined to be x = 41 at% for the film without a bias field and 44 at% for the film with a bias field. The spin-wave spectrum using BLS measurements showed bulk and DE mode. The spin wave stiffness constant for the film without a bias field was determined from the Bulk mode as 93.1 meVÅ^2, which was 1.08 as small as that of the film with a bias field. The reduced stiffness constant for the film without a bias field is due to the separation of the between the grain and grain. The pinning effect was investigated to the statistical theory of domain wall pinning aided by thermal activation. The domain wall pinning is a little larger than that of the film without a bias field.

5. Acknowledgments

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6. References

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