MAGNETORESISTANCE ON POST-ANNEALED $Fe_{70}Co_{30}$-AlN SPUTTER DEPOSITED THIN FILM

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Introduction

Magnetoresistance (MR) has attracted much attention because of its applications in magnetic storage devices and sensors. The MR effect can be observed in granular type composites in which ferromagnetic (FM) grains are dispersed in an insulating (IS) matrix. The MR ratio might be affected by magnetization and coercivity of the FM grain and electrical conductivity in the composite. Most of these composites had been reported in combinations of FM metal grain and IS oxide matrix such as Al_2O_3. In our research group, AlN has been used as the IS matrix because of a possibility of stabilization in MR device. MR effects using the AlN matrix were reported in granular thin films dispersing Fe and Co metal [1,2].

In this study, granular thin films consist of AlN matrix and FM $Fe_{70}Co_{30}$ alloy having the largest magnetic moment of 2.46 μ_B among 3d transition metals were prepared by post annealing of $Fe_{70}Co_{30}$ -AlN sputter deposited thin films. Their MR effect was discussed in relation to their structure and electromagnetic property.

Experimental procedure

$Fe_{70}Co_{30}$ -Al nitride thin film was deposited by RF magnetron sputtering using the various amount of Al on $Fe_{70}Co_{30}$ alloy composite target in nitrogen pressure of 5Pa under RF power of 200W. FM particles were precipitated by their thermal annealing at 500ºC for 1-10h. Both the as-deposited and post annealed thin films were characterized using XRD and TEM. Magnetic hysteresis was studied in a field of up to ±0.5T at room temperature using a VSM. Electrical resistivity (ρ) was measured by the van der Pauw method in a magnetic field of up to ±0.5T. The MR ratio was defined by the following formula: MR= [ρ(0T) –ρ(0.5T)]/ ρ(0T).

Results and discussion

Sputter deposited $Fe_{70}Co_{30}$ nitride thin film had zinc blende type structure. It was thermally decomposed completely back to FM $Fe_{70}Co_{30}$ alloy at 500 ºC in 10h. The as deposited nitride thin films obtained in sputtering of $(Fe_{70}Co_{30})_xAl_{1-x}$ composite target were solid solutions with zinc blende ($x \geq 0.44$) or wurtzite ($x<0.5$) type structure, respectively. After post annealing at 500ºC for 10h, bcc type $Fe_{70}Co_{30}$ alloy precipitated in AlN matrix, and its saturation magnetization increased with increase in $Fe_{70}Co_{30}$ ratio on the composite target. The largest MR ratio of 0.42% was observed in the post annealed $Fe_{70}Co_{30}$ -AlN thin film at

x=0.32.

The MR ratio was studied with the annealing time on the film obtained at x=0.32. The saturation magnetization and coercivity increased with the annealing time on the post annealed thin film as shown in Fig. 1. The precipitated $Fe_{70}Co_{30}$ grains increased both in their amount and size by increasing the annealing time. The MR ratio increased with the annealing time and the largest MR ratio was 0.65% at 5h as shown in Fig. 2. Further annealed film showed a decrease in their MR ratio. Post annealed thin film having the largest MR ratio showed its electrical resistivity of ca 70Ωcm comparable to a typical semiconductor. TEM observation showed well dispersed $Fe_{70}Co_{30}$ grains of 6nm in diameter were dispersed in the AlN matrix with an interdistance of 2.5nm as represented in Fig. 3.

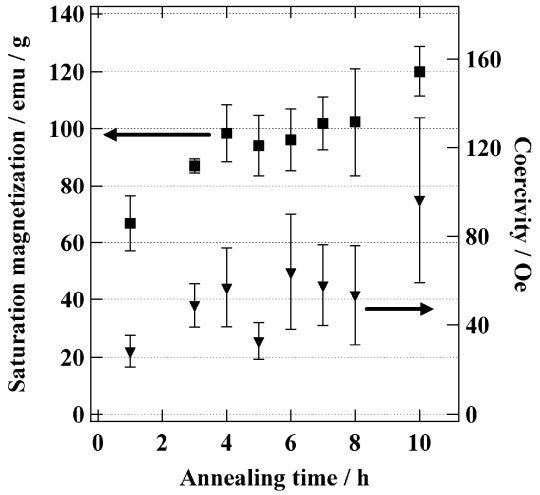

Fig. 1 Saturation magnetization and coercivity against the annealing time.

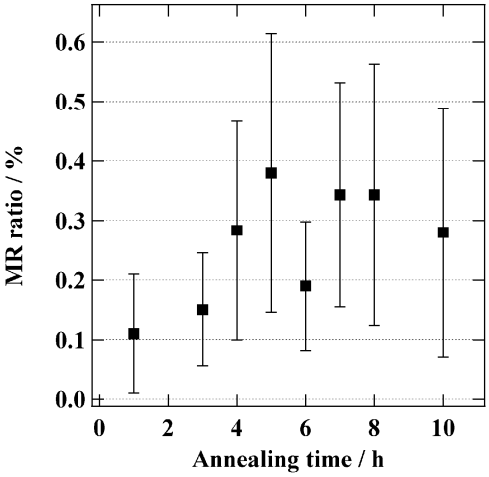

Fig. 2 MR ratio against the annealing time.

References

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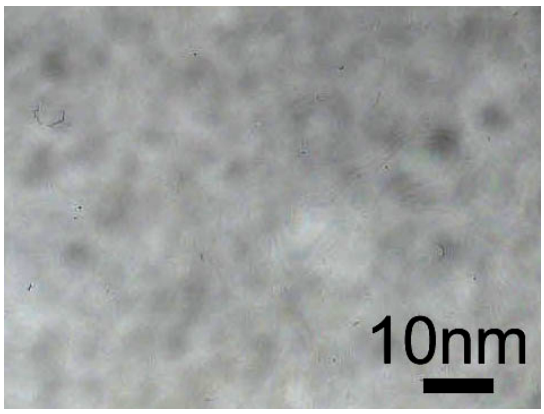

Fig. 3 TEM image of $Fe_{70}Co_{30}$-AlN granular film. Bright and dark areas correspond to AlN and $Fe_{70}Co_{30}$ alloy, respectively.