Ferromagnetism of thin films deposited from paramagnetic stainless steel targets by Facing Targets Sputtering

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The films with ferromagnetic fine particles dispersed in nonmagnetic matrix, such as Fe-SiO_2, Fe-Al_2O_3 [1] and Fe-Cu [2] have been studied for use of magnetic recording medium, optically device and sensor. Their magnetic properties depend strongly on structural parameter such as size and volume fraction of ferromagnetic particles. Fe-Cr-Ni alloy sputtered films also have microstructure with ferromagnetic - b.c.c phase and nonmagnetic f.c.c phase grains [3]. Magnetic properties of these films depend strongly on such a unique structure. These are depend on the ratio in volume of ferromagnetic particles to nonmagnetic ones V_F/V_N, the saturation magnetization Ms increased with increase of V_F/V_N. The coercivity Hc of the as-deposited films took maximum value of about 200 Oe at adequate V_F/V_N and then Ms and Squareness S were 500 emu/cc and 0.5, respectively.

The specimen Fe-Cr-Ni alloy films with thickness of 250 to 4000 Å were deposited on the substrate of silicon wafer with thermally oxidized surface layer at the Ar pressure P_{Ar} of 0.2 to 7 mtorr by using Facing Targets Sputtering(FTS) apparatus.

Figure 1 shows X-ray diffraction diagrams at various post-annealing temperature T_A. The intensity of $I_{bcc(110)}$ decreased and $I_{fcc(111)}$ increased with elevating T_A. This indicates that metastable state of b.c.c. and f.c.c. mixed phase changed to equilibrium one of only f.c.c. phase.

Figure 2 shows the dependence of magnetic properties Hc, Ms and S on T_A. Magnetic properties didn't change significantly below T_A of 250 ℃. Hc increased with elevating T_A from 300 to 400 ℃ and took maximum value of 600 Oe at T_A of 400℃. Ms and squareness S decreased with elevating T_A above 300 ℃. This semi-hard magnetism was due to isolation of ferromagnetic grains by nonmagnetic ones.

Hc of Fe-Cr-Ni alloy films were lower than that required for practical recording medium. The increase of Hc has been attempted by inducing shape anisotropy due to oblique incidence of sputtered particles to the substrate plane. The incident angle θ of sput-

tered particles was changed form 0 to 80° and slit was used for restricting the dispersion of θ.

Figure 3 shows the arrangement of targets, substrate and slit of FTS apparatus used in this study. At θ of 60°, Hc and S in direction parallel to incidence was quite different from those in direction at right angle to incidence.

Figure 4 shows M-H hysteresis loops at θ of 60° of the films post-annealed at 400°C for 1hr. Hc was 470 Oe, of which the value was almost same as that at θ of 0. Fe-Cr-Ni alloy films obliquely deposited by FTS method sputtering may have a possibility of practical use for magnetic recording.

REFERENCE

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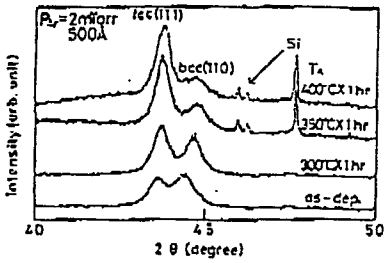
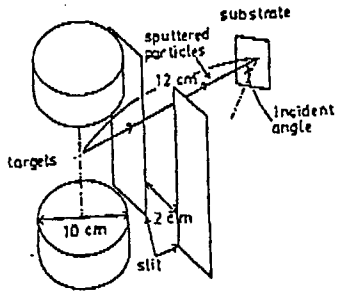


Fig.1 X-ray diffraction diagram at various post-annealing temperature T_A



Fif.3 Arrangement of targets, slit and substrate in FTS apparatus

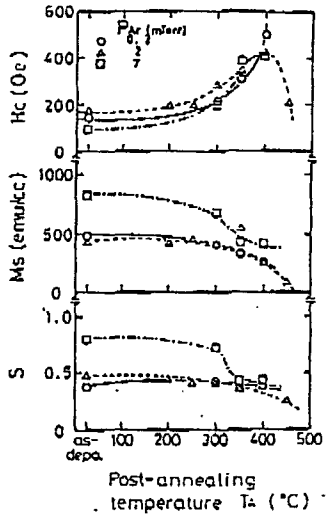


Fig.2 Dependence of magnetic properties Hc, Ms amd S on post-annealing temperature

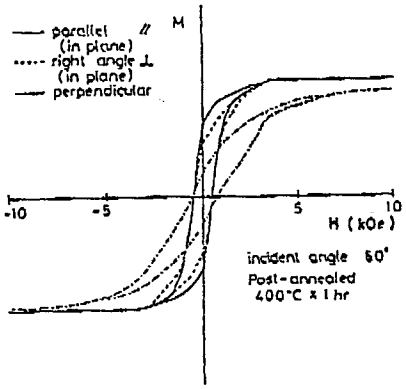


Fig.4 M-H hysteresis loops at incidence angle of films post-annealing at 400 C for 1hr