Facing Targets Sputtering Technology for Thin Films in Magnetic Recording

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Sputtering is a useful technique to fabricate magnetic thin films used in magnetic recording technology because of its high performance to fabricate high quality films with relatively lower production cost. Sputtering methods, which are commonly used, may be the magnetron sputtering for high rate deposition of the metallic films and RF sputtering system for dielectric materials such as oxide thin films. However, these system has the same toporogical configuration that the target and the substrate (or the film surface) are facing each other. This configuration give rise to many problems in the quality of thin films especialy in the initial stage of the film growth. Nowadays, very thin magnetic films with nanometric size of film thickness is commonly used in the magnetic recording technology, sputtering process should be carefully selected to attain future high density magnetic recording. In this study, facing targets sputtering techniques for magnetic thin films are introduced

Figure 1 shows the schematic configuration of facing targets sputtering apparatus to explain principle of the method. Two targets are facing each other, and they will be two cathode simultaneously. The g-electrons ejected from targets go up and down between two targets to increase the plasma density. The magnetic field, which is applied perpendicularly to the targets plane, is effective to confine the discharge plasma between two targets. Then the film is deposited on the substrate located out of the plasma. This configuration is very effective to deposit films without radiation of the energetic species from the plasma. This configuration is also effective to deposit oxide films without the radiation of the high-energy negative oxygen ions, which are produced at the target's surface and accelerated in the cathode fall region as shown in Fig.2. These merits are so essential to prepare very thin films with high quality and nanometric size thickness.

Sputter-deposited oxide thin films with several nano-meter thicknesses are regarded as one of the hopeful candidates for the ultra high density magnetic recording media. It has been clarified that Facing Targets Sputtering (FTS) system is suitable for the deposition of ferrite thin films, because of the suppression of radiation damage to the growing films by the high energy negative oxygen ions accelerated by the cathode fall near the targets. It was also clarified that Pt underlayer with (111) orientation has an epitaxial effect to the most closely packed plane of oxygen lattice of the oxide films deposited on it. Pt(111) underlayers were effective to promote c-axis orientation of hexagonal ferrite films. In this study, extremely thin Ba ferrite (BaM) layers with several nano-meter thickness were deposited on Pt(111) underlayer using Facing

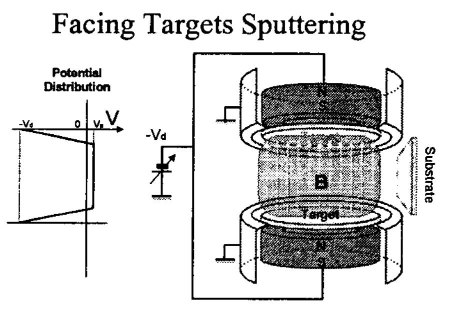

Fig.1 Schematic configuration of facing targets sputtering apparatus.

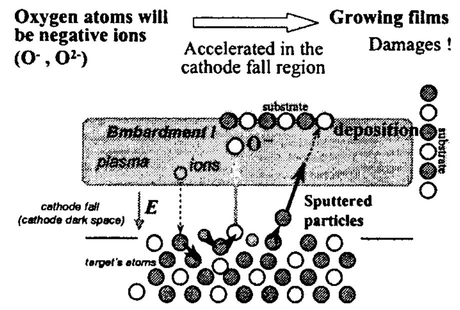

Fig.2 Phenomenon in sputter-deposition process in preparation of oxide films.

Targets Sputtering apparatus without post-annealing process.

Figure 3 shows the change of c-axis dispersion angle, $\Delta\theta_{50}$, of BaM thin films prepared by conventional DC sputtering process and FTS process as a function of substrate temperature T_{sub} at the deposition. The films prepared by conventional sputtering exhibited relatively low $\Delta\theta_{50}$ which means the crystallization and c-axis orientation above 450°C, the value of $\Delta\theta_{50}$ is still high as above 5deg. This is attributed to the effect of the radiation from the discharge plasma and the negative ions to the growing films. The kinetic energy of such energetic particles causes the crystallization at lower T_{sub} region, but the radiation also causes damage to the growing surface, because oh their large momentum. Films prepared by FTS process exhibited smaller value of $\Delta\theta_{50}$ below 2 deg. at T_{sub} above 530°C. This is regarded as the result of suppression of the energetic species to the growing surfaces.

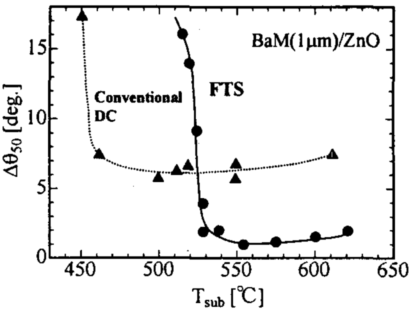

Fig.3 Phenomenon in sputter-deposition process in preparation of oxide films.

It has been succeeded to deposit BaM thin film with only 8 nm thick with apparent c-axis orientation and magnetic properties suitable to be used as recording media as shown in Fig.4. 5nm-thick Pt thin layers were also prepared to construct $[BaM/Pt]_n$ multilayered films. Facing Targets Sputtering system and Pt layers were effective to deposit very thin oxide films and $[Oxide/Pt]_n$ multilayered structure with excellent c-axis orientation and large perpendicular coercivity in the films. The $[BaM/Pt]_n$ multilayer exhibited higher perpendicular coercivity $H_{c\perp}$ even for thinner BaM layer. The large $H_{c\perp}$ seems to be originated from the large perpendicular magnetic anisotropy constant $K_\perp$ and some exchange interaction among BaM crystals in the film. Fig. 5 shows the changes of normalized remanent magnetization M_r of BaM/Pt bilayered film and $[BaM(20nm)/Pt(9nm)]_3$ multilayer as a function of logarithm of measurement time. The measurement result of M_r-decay of Co-Cr-Ta(50nm)/Pt(20nm) film was also indicated. Although M_r-decay of BaM/Pt bilayered films exhibited smaller gradient than that of Co-Cr-Ta/Pt bilayered film, M_r of $[BaM(20nm)/Pt(9nm)]_3$ multilayer was much stable than that of BaM/Pt bilayered films. These results also implied that there is some exchange interaction among the BaM crystallite grains in the $[BaM(20nm)/Pt(9nm)]_3$ multilayer.

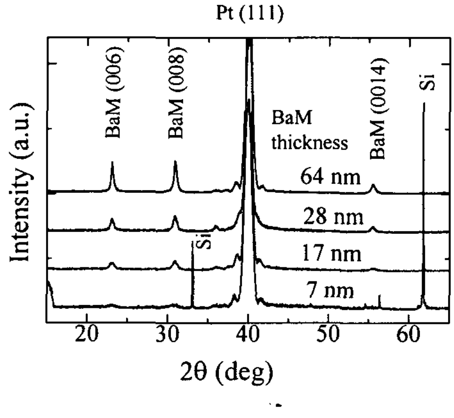

Fig.4 XRD diagrams of BaM/Pt bilayered films for various BaM layer thcikness.

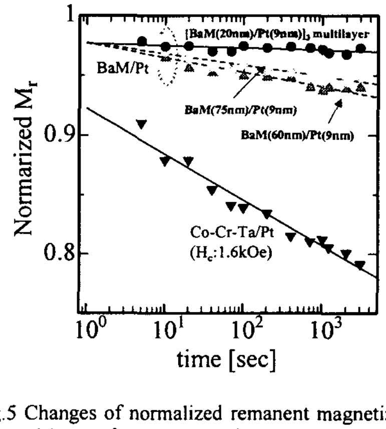

Fig.5 Changes of normalized remanent magnetization M_r of Co-Cr-Ta/Pt, BaM/Pt and $[BaM(20nm)/Pt(9nm)]_3$ multilayers as a function of measurement time.