

Excellent Crystallinity of Ba Ferrite Layers Deposited on Pt(111) Underlayers

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A magnetoplumbite type of Ba ferrite(BaM) layers were deposited on Pt(111) and Pt(200) layers, and their c-axis orientation and magnetic characteristics were compared each other. The as-deposited BaM layer on Pt(111) one at the substrate temperature T_s above 500°C revealed remarkable c-axis orientation. The saturation magnetization $4\pi M_s$ and the perpendicular coercivity $H_{c\perp}$ of the films as-deposited at T_s of 600°C were 4.0 kG and 2.5 kOe, respectively. On the other hand, BaM ferrite layer deposited on Pt(200) layer at T_s as relatively low as 500°C also revealed weak c-axis orientation as well as (107) one and the films as-deposited at T_s of 600°C exhibited $4\pi M_s$ and $H_{c\perp}$ of 2.8 kG and 2.5 kOe, respectively. It was suggested that although chemical activity of Pt surface was effective for the formation of BaM crystallites, the lattice matching was also important for obtaining BaM layer with good c-axis orientation and large perpendicular anisotropy.

Key words: Ba ferrite layer, C-axis orientation, Pt(111) layer, Pt(200) layer, Perpendicular anisotropy

I. Introduction

A magnetoplumbite type of Barium ferrite(BaM) films with c-axis orientation perpendicular to film plane seem to be superior candidates for perpendicular recording layer with ultra-high density. Since BaM films deposited directly on amorphous substrates revealed no preferential orientation, several underlayers with small misfitting such as ZnO(001), Pt(111), amorphous Ba ferrite layer and so on, were studied for their epitaxial growth.¹⁻³⁾ Among these underlayers, Pt one seems to be the most hopeful because of little interdiffusion between BaM and underlayer even at high substrate temperature T_s of above 500°C which is necessary for c-axis orientation of BaM crystallites. In addition to the misfitting of 7.6% between the most closely packed plane of oxygen of BaM layer and that of Pt(111) layer, chemical activity of Pt underlayer seems to promote the formation of BaM crystallites. Pt surface, in which the dissociation of oxygen molecules and the adsorption of their atoms are expected, seems useful for the formation of the most closely packed plane of oxygen atoms which is base structure of BaM crystallites.

In this study, BaM layers were deposited on Pt(111) and Pt(200) layers and their c-axis orientation and magnetic characteristics were investigated to clarify the effect of Pt underlayers.

II. Experiment Procedure

All specimen films were deposited using the "damage-free" facing targets sputtering(FTS) apparatus. The deposi-

Table 1. Deposition Conditions of Pt(111), Pt(100) and BaM layers

	Pt(111) layer	Pt(100) layer	BaM layer
target	pure Pt 99.99%	pure Pt 99.99%	sintered BaFe ₁₂ O _{19-y}
substrate	SiO ₂ (600 nm)/Si	Si(100)	Pt(111) or Pt(100)
sputtering gas	Ar(1.125 mTorr)	Xe(0.375 mTorr)	Ar(1.125 mTorr)
		Xe(0.375 mTorr)	Ar(0.735 mTorr)
			Xe(0.75 mTorr)
			O ₂ (0.015 mTorr)
substrate temp.	300°C	300°C	100-600°C
discharge current	0.05 A	0.05 A	0.1 A
discharge voltage	970-1020 V	970-1020 V	610-630 V

tion conditions of Pt(111), Pt(200) and BaM layers were shown in Table 1. Layer thickness of Pt and BaM layers was set at 24 and 250 nm constant, respectively. The mixture of Ar and Xe(and O₂) was used for the deposition of Pt and BaM layers to reduce the energy and number of particles recoiled from target surface during deposition.⁴⁾ Crystal orientation was analyzed by X-ray diffraction diagram(XRD), and the saturation magnetization $4\pi M_s$ and the in-plane and perpendicular coercivities $H_{c\parallel}$ and $H_{c\perp}$ were measured using a vibrating sample magnetometer(VSM).

III. Results and Discussions

The Pt layer deposited on Si wafers with thermal oxidized

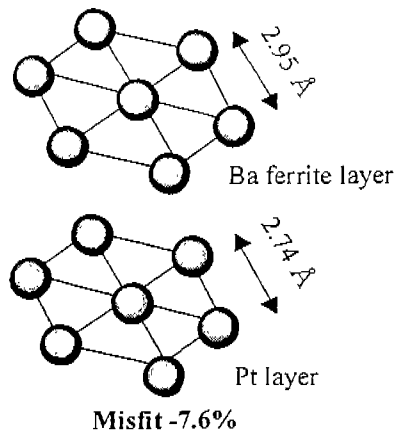


Fig. 1. Schematic Illustration of the epitaxial growth of Ba ferrite and Pt(111) layer.

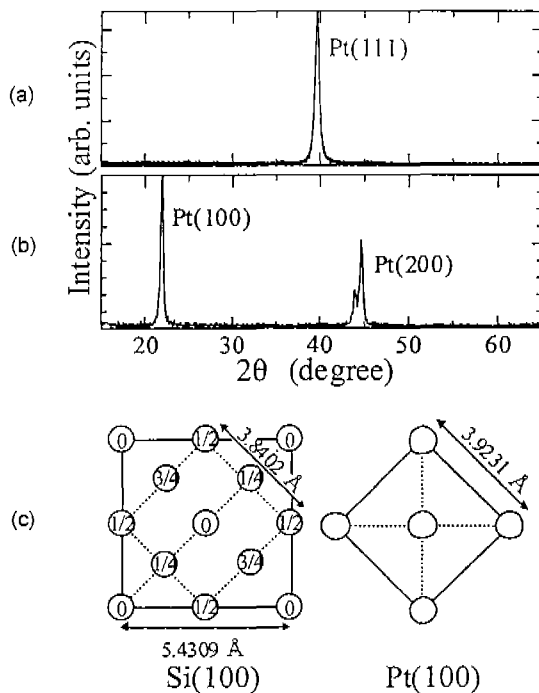


Fig. 2. XRD diagram of (a) Pt(111) and (b) Pt(100) films and (c) schematic illustration of epitaxial growth of Pt(100) layer on Si(100) substrate.

surface layer(SiO₂/Si) revealed (111) orientation in X-ray diffraction diagram(XRD) as shown in Fig. 2(a). That is because that the sputter-deposited films on amorphous substrates tend to form the most closely packed structure. On the other hand, the Pt layer deposited on Si(100) wafer, of which oxidized surface layer was removed by HF solution, revealed (100) orientation as shown in Fig. 2(b). It seemed to be attributed to the small misfitting between Pt(100) and Si(100) plane as shown Fig. 2(c).

Fig. 3 shows XRD diagram of (a) BaM/Pt(111) film and (b) BaM/Pt(100) film as-deposited at T_s in the range from 450 to 600°C, where absolute intensity of (a) is 10 times larger

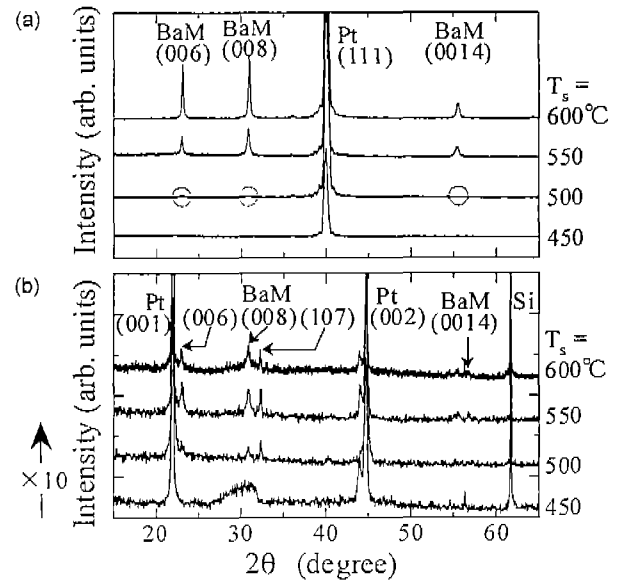


Fig. 3. XRD diagram of (a) BaM/Pt(111) and (b) BaM/Pt(100) films, where absolute intensity of (a) is 10 times larger than that of (b).

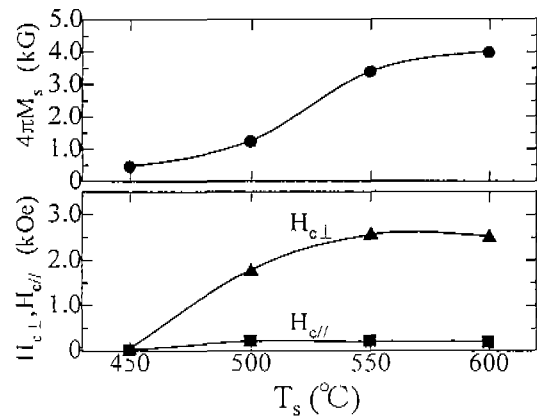


Fig. 4. T_s dependence of $4\pi M_s$, $H_{c\perp}$ and $H_{c//}$ of BaM/Pt(111) films.

than that of (b). In (a), BaM(006), BaM(008) and BaM(0014) peaks which correspond to c-axis orientation of BaM crystallites were observed at T_s above 500°C and their peak intensity became larger at higher T_s . On the other hand, small BaM(107) peak was also observed as well as c-axis orientation in (b) and they were also visible even at low T_s of 500°C. Since there is larger misfitting between the c-plane of BaM layer and Pt(100) plane, c-axis orientation was not as good as that in (a). Although their absolute peak intensities were quite small even at relatively high T_s of 600°C, it was suggested that the formation of BaM crystallites was promoted by chemical activity of Pt surface.

Fig. 4 and 5 show the T_s dependence of saturation magnetization $4\pi M_s$, perpendicular and in-plane coercivities $H_{c\perp}$ and $H_{c//}$ of BaM layers deposited on Pt(111) and Pt(100) underlayers. The $4\pi M_s$ increased with the increase of T_s

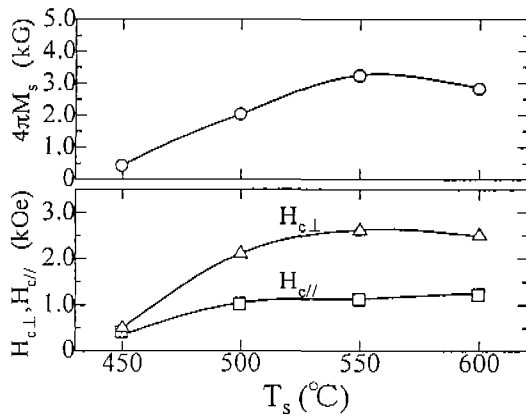


Fig. 5. T_s dependence of $4\pi M_s$, $H_{c\perp}$ and $H_{c//}$ of BaM/Pt(111) films.

and the maximum value of about 4.0 kG was attained at T_s 600°C for the BaM/Pt(111) films. The values of $H_{c\perp}$ was about ten times higher than those of $H_{c//}$ as seen in Fig. 4, and it corresponds to the large perpendicular magnetic anisotropy. Almost the same result was obtained for BaM layer with excellent c-axis orientation deposited on ZnO(001) underlayer.⁴⁾

On the other hand, although the $4\pi M_s$ increased with the increase of T_s and relative large value of 3.2 kG was attained at T_s of 550°C as shown in Fig. 5, $H_{c//}$ took relatively high values of about 1.0 kOe at T_s higher than 500°C. They were 40% and above of $H_{c\perp}$, and it suggested that perpendicular anisotropy was not so good in these films. The difference of perpendicular anisotropy as seen in Fig. 4 and

Fig. 5 seemed to be attributed to their crystal orientation as seen in Fig. 3. Since crystallites with (107) orientation also possess in-plane magnetization components, $H_{c//}$ took relatively high value as shown in Fig. 5.

III. Conclusions

BaM layers were deposited on Pt(111) and Pt(200) layer using FTS apparatus in the mixture of Ar, Xe and O_2 , and their crystal orientation and magnetic characteristics were compared each other. BaM layer deposited on Pt(111) underlayer revealed better c-axis orientation and exhibited larger perpendicular anisotropy than that deposited on Pt(100) underlayer. It was suggested that although chemical activity of Pt surface, i.e. the dissociation of oxygen molecules and the adsorption of oxygen atoms, was effective for the formation of BaM crystallites, the lattice matching was also important for obtaining BaM layer with good c-axis orientation and large perpendicular anisotropy.

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