

MAGNETIC ALLOY SPUTTERING TARGET AND RECORDING LAYER FOR MAGNETIC RECORDING MEDIA

1. Field of the Invention

The present invention relates to a magnetic alloy sputtering target and a recording layer for magnetic recording media.

2. Description of the Prior Art(s)

Cobalt-platinum based (CoPt-based) alloy is usually used in recording layers of perpendicular magnetic recording media. Said cobalt provides the magnetic force to induce the magnetization of magnetic recording media, and platinum is useful for enhancing the magnetocrystalline anisotropy and coercivity (H_c) of the material, thereby improving the data storage capabilities of the magnetic recording media.

However, the magnetic exchange coupling effect induced between the adjacent magnetic cobalt-based (Co-based) grains of the CoPt-based alloy lowers the signal to noise ratio (SNR) of magnetic recording media, and thus deteriorates the read/write reliability of magnetic recording media.

To improve the read/write reliability of magnetic recording media, a CoPt-oxide composite comprising a non-magnetic oxide, such as silicon dioxide (SiO_2), tantalum pentoxide (Ta_2O_5), titanium dioxide (TiO_2), aluminum oxide (Al_2O_3), magnesium oxide (MgO), thorium dioxide (ThO_2), zirconium dioxide (ZrO_2), cerium dioxide (CeO_2), manganese oxide (MnO), and diyttrium trioxide (Y_2O_3), is provided, such that the recording layer made of the CoPt-oxide composite comprises a magnetic phase composed of Co and Pt grains and a non-magnetic oxide phase located between two grains of the

magnetic phase to impede the magnetic exchange coupling effect among the grains.

However, the grains of the magnetic phase are not fully covered by the non-magnetic phase, thereby failing to achieve the desired magnetocrystalline anisotropy, H_c , and SNR of the high-density magnetic recording media.

To overcome the shortcomings, the present invention provides a magnetic alloy sputtering target and a recording layer for magnetic recording media to mitigate or obviate the aforementioned problems.

The objective of the present invention is to provide a magnetic alloy sputtering target and a recording layer for magnetic recording media to improve the magnetocrystalline anisotropy, H_c , and SNR of magnetic recording media and meet the demands of high-density magnetic recording media.

The magnetic alloy sputtering target in accordance with the present invention comprises a magnetic phase and an amorphous phase. The amorphous phase comprises a first oxide selected from the group consisting of: MgB_4O_7 , $Mg_2B_2O_5$, $Mg_3B_2O_6$, $Al_{18}B_4O_{33}$, $Al_4B_2O_9$, and any combination thereof.

Preferably, the amount of the first oxide of the magnetic alloy sputtering target ranges from 0.1 molar percent (mol.%) to 8.0 mol.% based on the amount of the magnetic alloy sputtering target.

More preferably, the first oxide of the amorphous phase is selected from the group consisting of: MgB_4O_7 , $Mg_2B_2O_5$, $Mg_3B_2O_6$, and any combination thereof, and the amount of the first oxide ranges from 1.5 mol.% to 8.0 mol.%; much preferably, ranges from 3.0 mol.% to 6.0 mol.%, based on

the amount of the magnetic alloy sputtering target.

More preferably, the first oxide of the amorphous phase is selected from the group consisting of: $\text{Al}_{18}\text{B}_4\text{O}_{33}$, $\text{Al}_4\text{B}_2\text{O}_9$, and their combination. The amount of the first oxide ranges from 0.1 mol.% to 4.0 mol.%; much more preferably ranges from 0.2 mol.% to 3.0 mol.%; moreover preferably, ranges from 0.3 mol.% to 2.0 mol.%, based on the amount of the magnetic alloy sputtering target.

Further preferably, the first oxide of the amorphous phase is $\text{Al}_{18}\text{B}_4\text{O}_{33}$, and the amount of the first oxide ranges from 0.1 mol.% to 1.5 mol.%; furthermore preferably ranges from 0.2 mol.% to 1.0 mol.%; still furthermore preferably ranges from 0.3 mol.% to 0.7 mol.%, based on the amount of the magnetic alloy sputtering target.

Further preferably, the first oxide of the amorphous phase is $\text{Al}_4\text{B}_2\text{O}_9$, and the amount of the first oxide ranges from 0.3 mol.% to 4.0 mol.%; furthermore preferably, ranges from 0.7 mol.% to 3.5 mol.%; still furthermore preferably, ranges from 1.0 mol.% to 2.0 mol.%, based on the amount of the magnetic alloy sputtering target.

Preferably, the amount of the first oxide of the magnetic alloy sputtering target ranges from 4 volume percent (vol.%) to 45 vol.% based on the amount of the magnetic alloy sputtering target.

More preferably, the first oxide of the amorphous phase is selected from the group consisting of: MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, and any combination thereof, and the amount of the first oxide ranges from 10 vol.% to 35 vol.% based on the amount of the magnetic alloy sputtering target.

More preferably, the first oxide of the amorphous phase is selected from the group consisting of: $\text{Al}_{18}\text{B}_4\text{O}_{33}$, $\text{Al}_4\text{B}_2\text{O}_9$, and their combination, and the amount of the first oxide ranges from 4.0 vol.% to 45 vol.%; much more preferably, ranges from 9 vol.% to 36 vol.%; moreover preferably, ranges from 14 vol.% to 25.0 vol.%, based on the amount of the magnetic alloy sputtering target.

Preferably, the magnetic phase of the magnetic alloy sputtering target comprises at least one magnetic component, such as cobalt (Co), iron (Fe), and their alloy materials. More preferably, the metal matrix phase of the magnetic alloy sputtering target is selected from the group consisting of: CoPt alloy, CoPtX alloy, FePt alloy, FePtX alloy, and any combination thereof, wherein X is denoted as any one of chromium (Cr), boron (B), molybdenum (Mo), titanium (Ti), silicon (Si), tantalum (Ta), and manganese (Mn).

Preferably, the magnetic alloy sputtering target further comprises a second oxide differentiated from the foresaid first oxide, i.e., MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, $\text{Al}_{18}\text{B}_4\text{O}_{33}$, $\text{Al}_4\text{B}_2\text{O}_9$, and/or any combination thereof. Said second oxide comprises at least one metal element selected from the group consisting of: aluminum (Al), titanium (Ti), silicon (Si), chromium (Cr), gallium (Ga), magnesium (Mg), molybdenum (Mo), manganese (Mn), yttrium (Y), zirconium (Zr), tantalum (Ta), and iron (Fe).

More preferably, the amount of the second oxide of the magnetic alloy sputtering target ranges from 0.1 mol.% to 9 mol.%; much more preferably, ranges from 0.1 mol.% to 6 mol.%, based on the amount of the magnetic alloy sputtering target.

According to metallographic analysis, the magnetic alloy sputtering target produced from vacuum hot-pressed sintering process can stably comprise the amorphous phase even at high temperature. Since the grains of the amorphous phase are still fine and uniformly distributed after thermal treatment, undesired arcing formed during sputtering the magnetic alloy sputtering target can be effectively avoided, thereby enhancing the sputtering stability and the product yield.

With such an amorphous phase of the magnetic alloy sputtering target, a recording layer sputtered from the target also comprises an amorphous phase to effectively prevent the magnetic exchange coupling effect between two grains of the magnetic phase of the recording layer, such that the magnetocrystalline anisotropy, H_c , and SNR of a magnetic recording media comprising the recording layer are improved to meet the demands of the high-density magnetic recording media.

The recording layer for magnetic recording media in accordance with the present invention comprises a magnetic phase and an amorphous phase. The amorphous phase of the recording layer comprises a first oxide selected from the group consisting of: MgB_4O_7 , $Mg_2B_2O_5$, $Mg_3B_2O_6$, $Al_{18}B_4O_{33}$, $Al_4B_2O_9$, and any combination thereof.

Since the recording layer comprises the amorphous phase, the magnetic exchange coupling effect between two grains of the magnetic phase of the recording layer is effectively impeded, and the magnetocrystalline anisotropy, H_c , and SNR of the magnetic recording media are improved to meet the demands of high-density magnetic recording media.

Preferably, the amount of the first oxide of the recording layer ranges from 0.1 mol.% to 8 mol.% based on the amount of the recording layer.

More preferably, the first oxide of the amorphous phase is selected from the group consisting of: MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, and any combination thereof, and the amount of the first oxide ranges from 3.0 mol.% to 6.0 mol.% based on the amount of the recording layer.

More preferably, the first oxide of the amorphous phase is selected from the group consisting of: $\text{Al}_{18}\text{B}_4\text{O}_{33}$, $\text{Al}_4\text{B}_2\text{O}_9$, and a combination thereof, and the amount of the first oxide ranges from 0.1 mol.% to 4.0 mol.%; much more preferably, ranges from 0.2 mol.% to 3.0 mol.%; further more preferably, ranges from 0.3 mol.% to 2.0 mol.%, based on the amount of the recording layer.

Further preferably, the first oxide of the amorphous phase is $\text{Al}_{18}\text{B}_4\text{O}_{33}$, and the amount of the first oxide of the recording layer ranges from 0.1 mol.% to 1.5 mol.%; furthermore preferably, ranges from 0.2 mol.% to 1.0 mol.%; still furthermore preferably, ranges from 0.3 mol.% to 0.7 mol.%, based on the amount of the recording layer.

Further preferably, the first oxide of the amorphous phase is $\text{Al}_4\text{B}_2\text{O}_9$, and the amount of the first oxide of the recording layer ranges from 0.3 mol.% to 4.0 mol.%; furthermore preferably, ranges from 0.7 mol.% to 3.5 mol.%; still furthermore preferably, ranges from 1.0 mol.% to 2.0 mol.%, based on the amount of the recording layer.

Preferably, the amount of the first oxide of the recording layer ranges from 4 vol.% to 45 vol.% based on the amount of the recording layer.

More preferably, the first oxide of the amorphous phase is selected from the group consisting of: MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, and any combination thereof, and the amount of the first oxide of the recording layer ranges from 10 vol.% to 35 vol.% based on the amount of the recording layer.

More preferably, the first oxide of the amorphous phase of the recording layer is selected from the group consisting of: $\text{Al}_{18}\text{B}_4\text{O}_{33}$, $\text{Al}_4\text{B}_2\text{O}_9$, and their combination, and the amount of the first oxide ranges from 4.0 vol.% to 45 vol.%; much more preferably, ranges from 9 vol.% to 36.0 vol.%; moreover, ranges from 14.0 vol.% to 25.0 vol.%, based on the amount of the recording layer.

By controlling the amount of the first oxide in the recording layer, the magnetic exchange coupling effect between two grains of the magnetic phase of the recording layer is decreased; meanwhile, the amount of grains of the magnetic phase in the recording layer is controlled to optimize the magnetocrystalline anisotropy, H_c , and SNR of the magnetic recording media.

Preferably, the metal matrix phase of the recording layer comprises at least one magnetic component, such as Co, Fe and their alloy materials. More preferably, the magnetic phase of the recording layer is selected from the group consisting of: CoPt alloy, CoPtX alloy, FePt alloy, FePtX alloy, and any combination thereof, wherein X is denoted as one of Cr, B, Mo, Ti, Si, Ta, and Mn.

Preferably, the recording layer further comprises a second oxide differentiated from the foresaid first oxide, i.e., MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, $\text{Al}_{18}\text{B}_4\text{O}_{33}$, $\text{Al}_4\text{B}_2\text{O}_9$, and/or any combination thereof. Said second oxide

comprises at least one metal element selected from the group consisting of: Al, Ti, Si, Cr, Ga, Mg, Mo, Mn, Y, Zr, Ta, and Fe. With the addition of the second oxide, the magnetic exchange coupling effect between two grains of the magnetic phase of the recording layer is decreased and the magnetocrystalline anisotropy, H_c , and SNR of the magnetic recording media having the recording layer are enhanced.

More preferably, the amount of the second oxide of the recording layer ranges from 0.1 mol.% to 9 mol.%; much more preferably, ranges from 0.1 mol.% to 6 mol.%, based on the amount of the recording layer, so as to optimize the magnetocrystalline anisotropy, H_c , and SNR of the magnetic recording media having the recording layer.

Preferably, the recording layer is formed by sputtering the magnetic alloy sputtering target. The sputtering process may be, but is not limited to, magnetron sputtering, plasma sputtering, or ion beam sputtering. Accordingly, the recording layer formed by sputtering the magnetic alloy sputtering target with high sputtering stability has good yield, and comprises the amorphous phase. Therefore, the magnetic exchange coupling effect between two grains of the magnetic phase of the recording layer is well impeded, and the magnetocrystalline anisotropy, H_c , and SNR of the magnetic recording media are well improved, so as to meet the demands of high-density magnetic recording media.

Other objectives, advantages, and novel features of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

IN THE DRAWINGS

Fig.1 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 1 of the present invention;

Fig.2 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 2 of the present invention;

Fig.3 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 3 of the present invention;

Fig.4 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 4 of the present invention;

Fig.5 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 5 of the present invention;

Fig.6 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 6 of the present invention;

Fig.7 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 7 of the present invention;

Fig.8 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 8 of the present invention;

Fig.9 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 9 of the present invention;

Fig.10 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 10 of the present invention;

Fig.11 is a metallograph of the magnetic alloy sputtering target taken by SEM in experimental example 11 of the present invention;

Fig. 12 is an X-ray diffraction spectrum of the magnetic alloy

sputtering target in the experimental example 1 of the present invention;

Fig. 13 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the experimental example 2 of the present invention;

Fig. 14 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the experimental example 3 of the present invention;

Fig. 15 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the experimental example 4 of the present invention;

Fig. 16 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the experimental example 5 of the present invention;

Fig. 17 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the experimental example 6 of the present invention;

Fig. 18 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the experimental example 7 of the present invention;

Fig. 19 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the experimental example 8 of the present invention;

Fig. 20 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the experimental example 9 of the present invention;

Fig. 21 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the experimental example 10 of the present invention;

Fig. 22 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the experimental example 11 of the present invention;

Fig.23 is a metallograph of the magnetic alloy sputtering target taken by TEM in experimental example 2 of the present invention;

Fig.24is an enlarged view of Fig. 23;

Fig.25 is a metallograph of the magnetic alloy sputtering target taken by TEM in experimental example 9 of the present invention;

Fig.26 is an enlarged view of Fig. 25;

Fig.27 is a metallograph of the magnetic alloy sputtering target taken by TEM in experimental example 11 of the present invention;

Fig.28 is an enlarged view of Fig. 27;

Fig.29 is a metallograph of the magnetic alloy sputtering target taken by SEM in comparative example 1 of the present invention;

Fig. 30 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the comparative example 1 of the present invention;

Fig. 31 is a metallograph of the magnetic alloy sputtering target taken by SEM in comparative example 2 of the present invention;

Fig. 32 is an X-ray diffraction spectrum of the magnetic alloy sputtering target in the comparative example 2 of the present invention;

Fig.33 is a metallograph of the magnetic alloy sputtering target taken by TEM in comparative example 2 of the present invention;

Fig.34 is an enlarged view of Fig. 33.

Experimental examples 1 to 11: Making and analyzing magnetic alloy sputtering target

In each of the experimental examples 1 to 11, a magnetic alloy sputtering target was made as follows:

A magnetic substance and a first oxide were mixed and ball milled to form a powder mixture. Then, the powder mixture was reduced with hydrogen around 650°C and under 760 bar for 2 hours to form a reduction powder. After

mixing by a high-energy mixing machine for 2 hours, the reduction powder was charged into a graphite mold and entered into a hydraulic press under a pressing pressure of 300 psi to form a green compact. The graphite mold with the green compact was put into a hot-pressing furnace and the green compact was sintered at a sintering temperature around 950°C to 1100°C under a sintering pressure of 500 bar for 2 hours to 3 hours to obtain the magnetic alloy sputtering target.

The component of the magnetic substance, the component of the first oxide, the molar and volume ratios of the magnetic substance relative to the first oxide, the sintering temperature, and sintering duration of each of the experimental examples 1 to 11 were shown in Table 1. Note that the magnetic substance and the first oxide of experimental experiment 8 were further mixed with a second oxide; then the magnetic substance, the first oxide, and the second oxide were ball mixed to form the powder mixture of experimental experiment 8. The composition of the second oxide comprised the powders of Cr_2O_3 and TiO_2 . The molar ratio of the magnetic substance to the first oxide to the powder of Cr_2O_3 and to the powder of TiO_2 of experimental experiment 8 was 80:6:5:9.

The concentration of Mg, Al, and B in the magnetic alloy sputtering target of each of the experimental examples 1 to 11 was analyzed by an inductively coupled plasma spectrometer (Perkin Elmer 5300 DV ICP) and the analysis results were shown in Table 2.

The metallograph of the magnetic alloy sputtering target of each of the experimental examples 1 to 11 was taken by scanning electronic microscopy

(Hitachi 3400 N SEM) under an accelerating voltage of 15 kilovolts (kV) at a working distance of 3 millimeters (mm). As shown in Figs. 1 to 11, a light phase and a dark phase were observed in the metallograph of the magnetic alloy sputtering target of each of the experimental examples 1 to 11. A successive analysis for the magnetic alloy sputtering target of each of the experimental examples 1 to 7 and 9 to 11 by the energy dispersive spectrometer (EDS) further proved that the light phase of the target of each of the experimental examples 1 to 7 and 9 to 11 was a magnetic phase consisted of the magnetic substance and the dark phase of the same was a first oxide phase consisted of the first oxide. The results of the EDS analysis were shown in Table 3.

Table 1 the related fabrication parameters of each of the experimental and comparative examples

		Component of Magnetic Substance	Component of First Oxide	Amount Ratio of Magnetic Substance to First Oxide		Sintering Temperature	Sintering Period
				Molar Ratio	Volume Ratio		
Experimental Example No.	1	Co powder	Mg ₂ B ₂ O ₅	92.00:8.00	60:40	1100°C	3 hr
	2	Co powder	Mg ₂ B ₂ O ₅	94.00:6.00	66.79:33.21	1100°C	3 hr
	3	Co powder	Mg ₂ B ₂ O ₅	98.50:1.50	89.4:10.6	1100°C	3 hr
	4	Co powder	Mg ₃ B ₂ O ₆	95.50:4.50	69.16:30.84	1100°C	2 hr
	5	Co powder	MgB ₄ O ₇	96.00:4.00	69.14:30.86	950°C	2 hr
	6	Fe and Pt powders (Fe : Pt = 1 mole :1 mole)	Mg ₂ B ₂ O ₅	93.60:6.40	62.53:37.47	1100°C	2 hr
	7	Co, Cr, and Pt powders (Co: Cr: Pt = 75 mole :4 mole: 21 mole)	Mg ₂ B ₂ O ₅	94.00:6.00	68.5:31.5	1100°C	3 hr
	8	Co, Cr, and Pt powders (Co: Cr: Pt = 72 mole:12 mole: 16 mole)	Mg ₂ B ₂ O ₅	80.00:20.00	74.1:25.9	950°C	2 hr
	9	Co, Cr, and Pt powders (Co: Cr: Pt = 85 mole :4 mole: 11 mole)	Al ₁₈ B ₄ O ₃₃	99.68: 0.32	85.43:14.57	1100°C	3 hr
	10	Co, Cr, and Pt powders (Co: Cr: Pt = 84 mole :4 mole: 12 mole)	Al ₁₈ B ₄ O ₃₃	99.36:0.64	74.50:25.50	1100°C	3 hr
	11	Co, Cr, and Pt powders (Co: Cr: Pt = 83 mole :5 mole: 12 mole)	Al ₄ B ₂ O ₉	98.50:1.50	83.01:16.99	1100°C	3 hr
Comparative Example No.	1	Co powder	B ₂ O ₃	94.00:6.00	79.16:20.84	1100°C	3 hr
	2	Co powder	MgO and TiO ₂ powders (MgO:TiO ₂ =4 mole:2mole)	94.00:6.00	88.19:21.81	1100°C	3 hr

Table 2 the results of ICP analysis

		Mg	Al	B	Cr	Ti
Experimental Example No.	1	5.80 wt% (59.0 ppm)	0.00 wt%	2.65 wt% (26.5 ppm)	0.00 wt%	0.00 wt%
	2	4.60 wt%	0.00 wt%	2.00 wt%	0.00 wt%	0.00 wt%
	3	1.5 wt%	0.00 wt%	0.54 wt%	0.00 wt%	0.00 wt%
	4	5.06 wt%	0.00 wt%	1.50 wt%	0.00 wt%	0.00 wt%
	5	1.50 wt%	0.00 wt%	2.70 wt%	0.00 wt%	0.00 wt%
	6	2.45 wt%	0.00 wt%	1.09 wt%	0.00 wt%	0.00 wt%
	7	3.20 wt%	0.00 wt%	1.40 wt%	0.00 wt%	0.00 wt%
	8	3.50 wt%	0.00 wt%	1.60 wt%	6.30 wt%	5.20 wt%
	9	0.00wt%	2.02 wt%	0.18wt%	2.70 wt%	0.00 wt%
	10	0.00 wt%	3.82 wt%	0.03 wt%	2.54 wt%	0.00 wt%
	11	0.00 wt%	2.08 wt%	0.42 wt%	3.29 wt%	0.00 wt%
Comparative Example No.	1	0.00 wt%	0.00 wt%	2.15 wt%	0.00 wt%	0.00 wt%
	2	1.66wt%	0.00 wt%	0.00 wt%	0.00 wt%	1.69 wt%

Table 3 the results of the EDS analysis

		Magnetic Phase (100 at%)				First Oxide Phase (100 at%)				
		Co	Cr	Pt	Fe	Mg	Al	B	Ti	O
Experimental Example No.	1	100.00 at%	0.00 at%	0.00 at%	0.00 at%	22.30 at%	0.00 at%	22.00 at%	0.00 at%	55.70 at%
	2	100.00 at%	0.00 at%	0.00 at%	0.00 at%	22.00 at%	0.00 at%	22.40 at%	0.00 at%	55.60 at%
	3	100.00 at%	0.00 at%	0.00 at%	0.00 at%	22.50 at%	0.00 at%	22.10 at%	0.00 at%	55.40 at%
	4	100.00 at%	0.00 at%	0.00 at%	0.00 at%	27.30 at%	0.00 at%	18.00 at%	0.00 at%	54.70 at%
	5	100.00 at%	0.00 at%	0.00 at%	0.00 at%	8.10 at%	0.00 at%	33.70 at%	0.00 at%	58.20 at%
	6	50.90 at%	0.00 at%	0.00 at%	49.10 at%	22.00 at%	0.00 at%	22.60 at%	0.00 at%	55.40 at%
	7	74.60 at%	4.20 at%	21.20 at%	0.00 at%	22.5 at%	0.00 at%	22.00 at%	0.00 at%	55.50 at%
	8	72.24at%	11.59at%	16.17at%	0.00 at%	22.5 at%	0.00 at%	22.00 at%	0.00 at%	55.5 at%
	9	84.46 at%	3.79 at%	11.75 at%	0.00 at%	0.00 at%	27.15 at%	0.87 at%	0.00 at%	71.98 at%
	10	83.41 at%	3.88 at%	12.71 at%	0.00 at%	0.00 at%	28.81 at%	0.98 at%	0.00 at%	70.21 at%
	11	82.24 at%	4.98 at%	12.78 at%	0.00 at%	0.00 at%	40.12 at%	6.21 at%	0.00 at%	53.67 at%
Comparative Example No.	1	100.00 at%	0.00 at%	0.00 at%	0.00 at%	0.00 at%	0.00 at%	40.2 at%	0.00 at%	59.80 at%
	2	100.00 at%	0.00 at%	0.00 at%	0.00 at%	14.30 at%	0.00 at%	0.00 at%	28.60 at%	57.10 at%

Also, an analysis for the magnetic alloy sputtering target of each of the experimental example 8 by the EDS proved the light phase of the target of the experimental example 8 was a magnetic phase consisted of the magnetic substance and the dark phase of the same comprised a first oxide phase consisted of the first oxide and a second oxide phase consisted of the second oxide. The results of the EDS analysis was shown in Table 3.

Referring to Figs. 1 to 11, the solid dissolution of Mg, B, and Al were not observed in the magnetic phase. Referring to Figs. 1 to 7 and 9 to 11, the solid dissolution of Co, Cr, Pt, and Fe atoms were not observed in the first oxide phase. Besides, as shown in Table 2, the signals of Mg, B, and Al atoms were not detected from the magnetic phase by EDS, and the signals of Co, Cr, Pt, and Fe atoms were not detected from the first oxide phase by EDS. Therefore, the first oxide of the magnetic alloy sputtering target of each of the experimental examples 1 to 12 was proved to be stable, and the first oxide of the magnetic alloy sputtering target of each of the experimental examples 1 to 12 were not dissolved in the magnetic phase of the same.

Further, observed from Figs. 1 to 11, the dark phases of the magnetic alloy sputtering targets of experimental experiments 1 to 11 were fine and uniformly distributed; therefore, each of the magnetic alloy sputtering targets are capable of preventing arcing in sputtering processes, enhancing sputtering stability, and increasing the yield of a recording layer formed by sputtering of each of the targets.

The X-ray diffraction spectrum of the magnetic alloy sputtering target of each of the experimental examples 1 to 11 was measured by X-ray

diffractometer (Rigaku Ultima IV) under the scanning of Cu K α radiation through 20° to 80° of 2 θ angles with a scanning rate of 6 degrees per minute (°/min) and was compared with the powder diffraction files (PDF) of Joint Committee on Powder Diffraction Standards (JCPDS). The results of the XRD analysis were shown in Figs. 12 to 22.

Regarding to Figs. 12 to 22, the characteristic peaks in the X-ray diffraction spectrum of the magnetic alloy sputtering target of each of the experimental examples 1 to 11 did not match the characteristic peaks of the crystalline of MgB₄O₇, Mg₂B₂O₅, Mg₃B₂O₆, Al₁₈B₄O₃₃, and Al₄B₂O₉, but the characteristic peaks of the magnetic alloy sputtering target of each of the experimental examples 1 to 7 and 9 to 11 and one part of the characteristic peaks of the magnetic alloy sputtering target of the experimental example 8 matched the characteristic peaks of the crystalline of one or some of Co, FePt, Cr, and Pt, depending on the composition of the magnetic substance of each of the experimental examples. The other part of the characteristic peaks of the magnetic alloy sputtering target of the experimental example 8 matched the characteristic peaks of the crystalline of Cr₂O₃ and TiO₂. Also, with reference to Table 3 and Figs. 1 to 7 and 9 to 11, according to the results of the SEM and EDS analysis mentioned above, each of the magnetic alloy sputtering targets comprises the magnetic phase consisted of Co (experimental examples 1 to 5), FePt (experimental example 6), or CoCrPt (experimental example 7), and the first oxide phase consisted of MgB₄O₇, Mg₂B₂O₅, Mg₃B₂O₆, Al₁₈B₄O₃₃, or Al₄B₂O₉. Accordingly, it was known that the crystalline structures of MgB₄O₇, Mg₂B₂O₅, Mg₃B₂O₆, Al₁₈B₄O₃₃, and Al₄B₂O₉ in the magnetic alloy sputtering

targets were amorphous after sintering; that was, the first oxide phase of the magnetic alloy sputtering target of each of the experimental examples 1 to 11 were amorphous phase after sintering. As concluded, the magnetic alloy sputtering target of each of the experimental examples 1 to 11 comprised the magnetic phase consisted of Co, FePt, or CoCrPt, and the amorphous phase consisted of MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, $\text{Al}_{18}\text{B}_4\text{O}_{33}$, or $\text{Al}_4\text{B}_2\text{O}_9$. The magnetic alloy sputtering target of the experimental example 8 further comprised an oxide crystalline phase consisted of Cr_2O_3 and TiO_2 . Since the magnetic alloy sputtering target of each of the experimental examples 1 to 11 comprised the magnetic phase consisted of Co, FePt, or CoCrPt, and the first oxide phase consisted of MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, $\text{Al}_{18}\text{B}_4\text{O}_{33}$, or $\text{Al}_4\text{B}_2\text{O}_9$ after sintering, a recording layer formed by sputtering the magnetic alloy sputtering target of each of the experimental examples 1 to 11 would comprise an amorphous phase consisted of MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, $\text{Al}_{18}\text{B}_4\text{O}_{33}$, or $\text{Al}_4\text{B}_2\text{O}_9$ and a magnetic phase consisted of Co, FePt, or CoCrPt. Since the amorphous phase had good wettability, the amorphous phase of the recording layer formed by each of the magnetic alloy sputtering targets was beneficial for surrounding a grain of the magnetic phase, such as that the magnetic exchange coupling effect between two grains of the magnetic phase of the recording layer was well impeded.

The metallograph of the recording layer formed by the sputtering of the magnetic alloy sputtering target of each of the experimental examples 2, 9, and 11 was taken by transmitting electronic microscopy (TEM). As shown in Figs. 23 to 28, the amorphous phase 10, which is consisted of $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Al}_{18}\text{B}_4\text{O}_{33}$,

or $\text{Al}_4\text{B}_2\text{O}_9$ of each of the recording layers, was located between two adjacent grains of the magnetic phase 20 of each of the recording layers; that is, located on the grain boundary between the adjacent grains of the magnetic phase 20. Besides, as the contour of each of the adjacent grains of the magnetic phase 20 was clear and obvious, the amorphous phase 10 of each of the recording layers surrounded each grain of the magnetic phase 20 well. Accordingly, the magnetic exchange coupling effect between two grains of the magnetic phase of each of the recording layers was proved to be well impeded by the amorphous phase consisted of $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Al}_{18}\text{B}_4\text{O}_{33}$, or $\text{Al}_4\text{B}_2\text{O}_9$.

Comparative example 1: Making and analyzing magnetic alloy sputtering target

The magnetic alloy sputtering target of the present comparative example was made by the same steps as each of the experimental examples 1 to 11. The composition of the magnetic substance, the composition of the first oxide, the molar ratio of the magnetic substance relative to the first oxide, to the sintering temperature, and to sintering duration of the present comparative example was shown in Table 1. Also, the magnetic alloy sputtering target of the present comparative example was also analyzed under the same SEM, EDS, and XRD analysis as each of the experimental examples 1 to 11. Besides, the composition of the magnetic phase and the first oxide phase of the target of the present comparative example represented in volume percentage was further shown in Table 4.

The metallograph of the magnetic alloy sputtering target of the present comparative example was shown in Fig. 29. Referring to Fig. 29, a light phase

and a dark phase were observed in the metallograph of the present comparative example. With reference to Tables 1 and 2, the light phase of the present comparative example was proved to be a magnetic phase consisted of the magnetic substance, and the dark phase of the present comparative example was proved to be a first oxide phase consisted of B_2O_3 .

In addition, referring to Fig. 29, the solid dissolution of B atoms were not observed in the magnetic phase of the present comparative example, and the solid dissolution of Co atoms were not observed in the first oxide phase of the present comparative example. Besides, as shown in Table 2, the signals of B atoms were not detected from the magnetic phase of the present comparative example by EDS, and the signals of Co atoms were not detected from the first oxide phase of the present comparative example by EDS. Therefore, the boron oxide of the magnetic alloy sputtering target of the present comparative example was not dissolved in the magnetic phase of the same.

Referring to Fig. 30, the characteristic peaks in the X-ray diffraction spectrum of the magnetic alloy sputtering target of the present comparative example did not match the characteristic peaks of the crystalline of B_2O_3 , but only matched the characteristic peaks of the crystalline of Co. Accordingly, the crystalline structures of B_2O_3 in the magnetic alloy sputtering target of the present comparative example was amorphous.

Referring to Figs. 1 to 11 and 29, after the identical vacuum hot-pressed sintering process, the average grain size of the first oxide phase of the present comparative example was obviously larger than that of each of the experimental examples 1 to 11. The average grain size of the first oxide phase

of each of the experimental examples 1 to 11 was larger than 1 micrometer (μm); the average grain size of the first oxide phase of the present comparative example was larger than 5 μm . That was, the grain size of the first oxide phase of the present comparative example was coarsening, and the high temperature stability of the first oxide phase of the present comparative example was worse than that of each of the experimental examples 1 to 11. Thus, the magnetic alloy sputtering target of the present comparative example hardly prevented arcing in sputtering processes, causing a bad performance on sputtering stability and product yield.

Comparative example 2: Making and analyzing magnetic alloy sputtering target

The magnetic alloy sputtering target of the present comparative example was made by the same steps as each of the experimental examples 1 to 11. The composition of the magnetic substance, the composition of the first oxide, the molar ratio of the magnetic substance to the first oxide, the sintering temperature, and sintering duration of the present comparative example were shown in Table 1. Also, the magnetic alloy sputtering target of the present comparative example was also analyzed under the same SEM, EDS, and XRD analysis as each of the experimental examples 1 to 11. Besides, the composition of the magnetic phase and the first oxide phase of the target of the present comparative example represented in volume percentage was further shown in Table 4.

The metallograph of the magnetic alloy sputtering target of the present comparative example was shown in Fig. 31. Referring to Fig. 31, a light phase

and a dark phase were observed in the metallograph of the present comparative example. With reference to Tables 1 and 2, the light phase of the present comparative example was proved to be a magnetic phase consisted of the magnetic substance, and the dark phase of the present comparative example was prove to be a first oxide phase consisted of Mg_2TiO_4 .

In addition, referring to Fig. 31, the solid dissolution of Mg atoms and Ti atoms were not observed in the magnetic phase of the present comparative example, and the solid dissolution of Co atoms were not observed in the first oxide phase of the present comparative example. Besides, as shown in Table 2, the signals of Mg atoms and Ti atoms were not detected from the magnetic phase of the present comparative example by EDS, and the signals of Co atoms were not detected from the boron oxide phase of the present comparative example by EDS. Therefore, the first oxide of the magnetic alloy sputtering target of the present comparative example was not dissolved in the magnetic phase of the same.

Referring to Fig. 32, the characteristic peaks in the X-ray diffraction spectrum of the magnetic alloy sputtering target of the present comparative example matched the characteristic peaks of the crystallites of Mg_2TiO_4 and Co. Accordingly, the magnetic alloy sputtering target of the present comparative example was highly crystalline.

Since the first oxide phase of the magnetic alloy sputtering target of the present comparative example was crystalline Mg_2TiO_4 and the magnetic phase thereof was consisted of Co after sintering, a recording layer formed by sputtering the magnetic alloy sputtering target would comprise an crystalline

Mg-Ti oxide phase consisted of Mg_2TiO_4 and a magnetic phase consisted of Co. Since the crystalline phase had bad wettability, the Mg-Ti oxide phase of the recording layer formed by the magnetic alloy sputtering target of the present comparative example was hard to surround a grain of the magnetic phase, thereby failing to effectively impede the magnetic exchange coupling effect between two grains of the magnetic phase of the recording layer.

The metallograph of a recording layer formed by the sputtering of the magnetic alloy sputtering target of the present comparative example was taken by TEM. With reference to Figs. 33 and 34 the crystalline Mg-Ti oxide phase 10A consisted of Mg_2TiO_4 of the recording layer made by the target of the present comparative example was between two adjacent grains of the magnetic phase 20A; that is, the Mg-Ti oxide phase 10A was on the grain boundary between the adjacent grains of the magnetic phase 20A. However, after comparing the recording layer made from the target of the present comparative example with the recording layer made from the targets of experimental examples 2, 9, and 11 (referring to Figs. 23 to 28), the contour of each of the adjacent grains of the magnetic phase 20A of the recording layer made from the target of the present comparative example was less clear and less obvious than that of the magnetic phase 20 of the recording layer made from the target of the experimental example 2. Hence, the Mg-Ti oxide phase 10A of the recording layer made from the target of the present comparative example was hard to surround each grain of the magnetic phase 20A well; thereby, the Mg-Ti oxide phase 10A of the recording layer made from the target of the present comparative example could not effectively impede the magnetic exchange

coupling effect between two grains of the magnetic phase 20A as the amorphous phase 10 of the recording layer made from the target of the experimental example 2 did.

To sum up, by the amorphous phase consisted of MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, $\text{Al}_{18}\text{B}_4\text{O}_{33}$, or $\text{Al}_4\text{B}_2\text{O}_9$ and having fine and uniformly distributed grains after vacuum hot-pressed sintering process, the amorphous phase of the magnetic alloy sputtering target of each of the experimental examples 1 to 11 was proved to be stable at high temperature. In addition, since the grains of the amorphous phase were fine and uniformly distributed, the magnetic alloy sputtering target of each of the experimental examples 1 to 11 was capable of preventing arcing in sputtering processes and enhancing sputtering stability and product yield. Further, a recording layer, which comprises an amorphous phase and a magnetic phase, formed by sputtering the magnetic alloy sputtering target of each of the experimental examples 1 to 11 was capable of well impeding the magnetic exchange coupling effect between two grains of the magnetic phase of the recording layer by the amorphous phase of the recording layer, so as to improve the magnetocrystalline anisotropy, H_c , and SNR of magnetic recording media well and meet the demands of high-density magnetic recording media.

Claim(s):

1. A magnetic alloy sputtering target, comprising
a magnetic phase; and
an amorphous phase comprising a first oxide being selected from the group consisting of MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, $\text{Al}_{18}\text{B}_4\text{O}_{33}$, $\text{Al}_4\text{B}_2\text{O}_9$, and any combination thereof.
2. The magnetic alloy sputtering target as claimed in claim 1, wherein an amount of the first oxide of the magnetic alloy sputtering target ranges from 0.1 mol.% to 8.0 mol.% based on an amount of the magnetic alloy sputtering target.
3. The magnetic alloy sputtering target as claimed in claims 1 or 2, wherein the magnetic phase of the magnetic alloy sputtering target comprises Co or Fe.
4. The magnetic alloy sputtering target as claimed in claim 3, wherein the magnetic phase of the magnetic alloy sputtering target is selected from the group consisting of CoPt alloy, CoCrPt alloy, CoPtB alloy, CoPtMo alloy, CoPtTi alloy, CoPtSi alloy, CoPtTa alloy, CoPtMn alloy, FePt alloy, FeCrPt alloy, FePtB alloy, FePtMo alloy, FePtTi alloy, FePtSi alloy, FePtTa alloy, and FePtMn alloy.
5. The magnetic alloy sputtering target as claimed in claims 1 or 2, wherein the magnetic alloy sputtering target further comprises a second oxide differentiated from the first oxide, and the second oxide comprises at least one metal element selected from the group consisting of Al, Ti, Si, Cr, Ga, Mg, Mo, Mn, Y, Zr, Ta, and Fe.

6. The magnetic alloy sputtering target as claimed in claim 5, wherein an amount of the second oxide of the magnetic alloy sputtering target ranges from 0.1 mol.% to 9 mol.% based on the amount of the magnetic alloy sputtering target.

7. A recording layer for magnetic recording media comprising:
a magnetic phase; and
an amorphous phase comprising a first oxide selected from the group consisting of MgB_4O_7 , $\text{Mg}_2\text{B}_2\text{O}_5$, $\text{Mg}_3\text{B}_2\text{O}_6$, $\text{Al}_{18}\text{B}_4\text{O}_{33}$, $\text{Al}_4\text{B}_2\text{O}_9$, and any combination thereof.

8. The recording layer as claimed in claim 7, wherein the recording layer is made from sputtering the magnetic alloy sputtering target as claimed in claim 1.

9. The recording layer as claimed in claims 7 or 8, wherein an amount of the first oxide of the recording layer ranges from 0.1 mol.% to 8.0 mol.% based on an amount of the recording layer.

10. The recording layer as claimed in claims 7 or 8, wherein the magnetic phase of the recording layer comprises Co or Fe.

11. The recording layer as claimed in claim 10, wherein the magnetic phase of the recording layer is at least one selected from the group consisting of CoPt alloy, CoCrPt alloy, CoPtB alloy, CoPtMo alloy, CoPtTi alloy, CoPtSi alloy, CoPtTa alloy, CoPtMn alloy, CoPtRu alloy, FePt alloy, FeCrPt alloy, FePtB alloy, FePtMo alloy, FePtTi alloy, FePtSi alloy, FePtTa alloy, and FePtMn alloy.

12. The recording layer as claimed in claims 7 or 8, wherein the

recording layer further comprises a second oxide differentiated from the first oxide, and the second oxide comprises at least one metal element selected from the group consisting of Al, Ti, Si, Cr, Ga, Mg, Mo, Mn, Y, Zr, Ta, and Fe.

13. The recording layer as claimed in claim 12, wherein an amount of the second oxide of the recording layer ranges from 0.1 mol.% to 9 mol.% based on the amount of the recording layer.