

ALLOY FOR SOFT-MAGNETIC THIN-FILM LAYER ON
PERPENDICULAR MAGNETIC RECORDING MEDIUM, AND
SPUTTERING-TARGET MATERIAL

5 [Cross-Reference to Related Application]
[0001]

This application claims priority to Japanese Patent Application No. 2011-178187 filed on August 17, 2011, the entire content of which is incorporated herein by reference.

10 [Technical Field]
[0002]

The present invention relates to an alloy for a soft magnetic thin film layer in a perpendicular magnetic recording medium having a low coercive force, and a sputtering target material for
15 producing a thin film of the alloy.

[Background Art]
[0003]

In recent years, there have been remarkable progresses in magnetic recording technology, heightening of recording
20 densities in magnetic recording media has been proceeding due to increasing drive capacities, and perpendicular magnetic recording system, which achieves further high recording density when compared to longitudinal magnetic recording system conventionally used, has been put into practical use.

25 [0004]

Perpendicular magnetic recording system is a system in which a magnetization-easy axis is formed to be oriented perpendicularly to the medium surface in the magnetic film of the perpendicular magnetic recording medium, and this system
30 achieves a high recording density. For perpendicular magnetic recording system, a double-layer recording medium having a magnetic recording film layer with an increased recording sensitivity and a soft magnetic film layer has been developed. For the magnetic recording film layer, a CoCrPt-SiO₂-based alloy
35 is commonly used.

[0005]

As for a conventional soft magnetic film layer, ferromagnetism and amorphous properties have been necessary and, in addition, various properties such as a high saturation magnetic flux density, high corrosion resistance, and a high hardness have been additionally required depending on applications of perpendicular magnetic recording media and environments in which they are used. For example, as in Japanese Patent Laid-Open Publication No. 2008-260970 (Patent Literature 1), there are used substances which are based on Co, which is a ferromagnetic element with high corrosion resistance, and to which amorphization promotion elements including Zr are added to enhance amorphous properties. In addition, in Japanese Patent Laid-Open Publication No. 2008-299905 (Patent Literature 2), the addition of Fe results in a high saturation magnetic flux density, and the addition of B results in a high hardness.

[0006]

Furthermore, there have been required alloys for soft magnetic films having a low coercive force as well as the conventionally required properties described above. The improvement of heads for reading and writing and the adjustment of the magnetic flux densities of soft magnetic alloys to optimize exchange coupling magnetic fields between soft magnetic films and Ru films have enabled writing to recent hard disk drives in a low magnetic flux when compared to conventional hard disk drives. Depending on this, it has been effective that a soft magnetic film disposed under a recording film has a low coercive force so that magnetization can be reversed even in a low writing magnetic flux, when compared to a high saturation magnetic flux density saturated in a high writing magnetic flux.

[Citation List]

[0007]

[Patent Literature]

- [PTL 1] Japanese Patent Laid-Open Publication No. 2008-260970
[PTL 2] Japanese Patent Laid-Open Publication No. 2008-299905

[Summary of the Invention]

[0008]

As a result of examining in detail the influence of alloy elements on the coercive force of the alloy for a soft magnetic film of a perpendicular magnetic recording medium, the inventors have now found that a soft magnetic alloy exhibiting a low coercive force can be obtained by adding appropriate amounts of W and/or Sn. It has also been found that V and/or Mn are effective as auxiliary addition elements that reduce a coercive force. Furthermore, it was also revealed that the excessive addition of Zr and/or Hf, which are conventionally used amorphization promotion elements, increases a coercive force.

[0009]

Furthermore, as will be revealed in examples described below, the most important characteristic in the present invention is a finding that W and/or Sn have the highest effects, when closely evaluating the coercive force reduction effects of various addition elements with respect to the reductions in saturation magnetic flux density by the elements. Furthermore, it was also revealed that next to W and/or Sn, the coercive force reduction effects of V and/or Mn are high.

[0010]

It is therefore an object of the present invention to provide an alloy for a soft magnetic thin film layer in a perpendicular magnetic recording medium having a low coercive force; and a sputtering target material for producing a thin film of the alloy.

[0011]

According to one embodiment of the present invention, there is provided an alloy for a soft magnetic thin film layer in a perpendicular magnetic recording medium, comprising:

- one or more selected from the group consisting of Ti, Zr, Hf, Nb, Ta, and B;
- one or two of W and Sn (wherein a part or all of one or two of W and Sn may be substituted by one or two of V and Mn);
- optionally, one or more selected from the group

consisting of Al, Cr, Mo, Si, P, C, and Ge;

- optionally, one or two of Ni and Cu; and
- the balance Co and Fe,

and satisfying, in at.%, expressions described below:

- 5 (1) $6 \leq \text{Ti}\% + \text{Zr}\% + \text{Hf}\% + \text{Nb}\% + \text{Ta}\% + \text{B}\% / 2 \leq 24$;
- (2) $\text{Zr}\% + \text{Hf}\% \leq 14$;
- (3) $3 \leq \text{W}\% + \text{Sn}\% \leq 19$;
- (4) $0.20 \leq \text{Fe}\% / (\text{Fe}\% + \text{Co}\%) \leq 0.90$;
- (5) $3 \leq \text{W}\% + \text{Sn}\% + \text{V}\% + \text{Mn}\% \leq 19$ (wherein $\text{V}\% + \text{Mn}\%$ may
- 10 be 0);
- (6) $0 \leq \text{Al}\% + \text{Cr}\% + \text{Mo}\% + \text{Si}\% + \text{P}\% + \text{C}\% + \text{Ge}\% \leq 9$; and
- (7) $0 \leq \text{Ni}\% + \text{Cu}\% \leq 5$.

[0012]

According to another embodiment of the present invention,
15 there is provided a sputtering target material comprising the above alloy.

[Description of Embodiments]

[0013]

The present invention is specifically explained below. Unless
20 otherwise specified, "%" or a numeral without any unit as used herein means at%.

[0014]

The present invention is an alloy for a soft magnetic thin film layer in a perpendicular magnetic recording medium, the alloy
25 comprising: one or more selected from the group consisting of Ti, Zr, Hf, Nb, Ta, and B; one or two of W and Sn (wherein a part or all of one or two of W and Sn may be substituted by one or two of V and Mn); optionally, one or more selected from the group consisting of Al, Cr, Mo, Si, P, C, and Ge; optionally, one
30 or two of Ni and Cu; and the balance Co and Fe, preferably consisting essentially of these elements, and more preferably consisting of these elements. Moreover, the alloy of the present invention satisfies, in at.%, expressions described below:

- 35 (1) $6 \leq \text{Ti}\% + \text{Zr}\% + \text{Hf}\% + \text{Nb}\% + \text{Ta}\% + \text{B}\% / 2 \leq 24$;
- (2) $\text{Zr}\% + \text{Hf}\% \leq 14$;

(3) $3 \leq W\% + Sn\% \leq 19$;

(4) $0.20 \leq Fe\% / (Fe\% + Co\%) \leq 0.90$;

(5) $3 \leq W\% + Sn\% + V\% + Mn\% \leq 19$ (wherein $V\% + Mn\%$ may be 0);

5 (6) $0 \leq Al\% + Cr\% + Mo\% + Si\% + P\% + C\% + Ge\% \leq 9$; and

(7) $0 \leq Ni\% + Cu\% \leq 5$.

The reasons of the limitation of the component compositions according to the present invention are mentioned below.

[0015]

10 One or more selected from the group consisting of Ti, Zr, Hf, Nb, Ta, and B are essential elements for promoting amorphization and are contained in an amount satisfying $6 \leq Ti\% + Zr\% + Hf\% + Nb\% + Ta\% + B\% / 2 \leq 24$ in the alloy. Since the amorphization promotion effect and the saturation magnetic
15 flux density reduction effect of B are about 1/2 of those of the other elements, B is treated in B/2 in the expression. In addition, $Ti\% + Zr\% + Hf\% + Nb\% + Ta\% + B\% / 2$ of less than 6 results in an insufficient amorphization promotion effect, while $Ti\% + Zr\% + Hf\% + Nb\% + Ta\% + B\% / 2$ of more than 24 results in a
20 saturated amorphization promotion effect and an excessively decreased saturation flux density, and therefore, the range thereof is 6 to 24, preferably 8 to 18, more preferably 9 to 14.

[0016]

Zr and/or Hf are elements having a high amorphization
25 promotion effect, but also increase a coercive force. $Zr\% + Hf\%$ of more than 14 results in an increased coercive force, and therefore, the upper limit thereof is set to 14 (i.e., $Zr\% + Hf\% \leq 14$), preferably 12, more preferably 8.

[0017]

30 W and/or Sn are essential elements for enhancing the effect of reducing a coercive force with respect to the reduction rate of a saturation flux density, and are the most important addition elements in the present invention. However, an addition amount of $W\% + Sn\%$ of less than 3% results in the insufficient
35 effect of reducing a coercive force, while an addition amount of $W\% + Sn\%$ of more than 19% results in a saturated effect to

excessively decrease a saturation flux density, and therefore, the range thereof is set to 3 to 19 (i.e., $3 \leq W\% + Sn\% \leq 19$), preferably 4 to 17, more preferably 6 to 14. Although being unclear, the detailed principles of the high effect of reducing a coercive force are presumed to be influenced by reduction in saturation magnetostriction constant.

[0018]

Co and Fe are essential elements for keeping a high saturation magnetic flux density. However, $Fe\% / (Fe\% + Co\%)$ of less than 0.20 or more than 0.90 makes it impossible to obtain a high saturation magnetic flux density. Accordingly, the range of $Fe\% / (Fe\% + Co\%)$ is set to 0.20 to 0.90, preferably 0.25 to 0.70, more preferably 0.30 to 0.65.

[0019]

V and/or Mn are elements that effectively reduce a coercive force, next to W and/or Sn, and may be substituted by a part or all of W and/or Sn. However, $W\% + Sn\% + V\% + Mn\%$ of less than 3 results in an insufficient coercive force reduction effect, while $W\% + Sn\% + V\% + Mn\%$ of more than 19 results in saturating the coercive force reduction effect and excessively decreasing a saturation flux density. Accordingly, the range of $W\% + Sn\% + V\% + Mn\%$ is set to 3 to 19, preferably 4 to 17, more preferably 6 to 14.

[0020]

One or more selected from the group consisting of Al, Cr, Mo, Si, P, C, and Ge are optional elements that do not greatly influence reduction in coercive force but can be added for adjusting a saturation magnetic flux density. However, since a total amount thereof of more than 9% results in an excessively decreased saturation magnetic flux density, the upper limit of $Al\% + Cr\% + Mo\% + Si\% + P\% + C\% + Ge\%$ is set to 9, preferably 4, more preferably 0.

[0021]

Ni and/or Cu are optional elements that can be added for adjusting a saturation magnetic flux density. However, since they increase a coercive force, the upper limit thereof is set to

5% (i.e., $\text{Ni}\% + \text{Cu}\% \leq 5$), preferably 3, more preferably 0.

[Examples]

[0022]

5 The present invention is specifically explained below with reference to Examples.

[0023]

10 Normally, a soft magnetic thin film layer in a perpendicular magnetic recording medium is formed on a glass substrate or the like by sputtering a sputtering target material having the same composition as that of the soft magnetic thin film layer. At this time, the thin film formed by sputtering has been quenched. From this aspect, quenched ribbons produced in a single-roll-type liquid quenching device are used as sample materials in Examples and Comparative Examples in accordance with the present invention. This is to evaluate the influence of the components of the thin films which are actually quenched and formed by sputtering on various properties in a simplified manner using liquid quenched ribbons.

[0024]

20 The quenched ribbon was produced under the condition in which a raw material of 30 g weighed to have the predetermined composition was arc-melted in argon with a reduced pressure in a water-cooled copper mold having a diameter of about 10 mm and a length of about 40 mm to provide a molten raw material for the quenched ribbon. The production of the quenched ribbon was conducted by a single roll method under the condition in which the molten raw material was set in a silica tube having a diameter of 15 mm and was tapped from a tapping nozzle having a diameter of 1 mm, at an atmosphere pressure of 61 kPa, at an atomizing pressure difference of 69 kPa, and at a rotational number of 3000 rpm of a copper roll (diameter of 300 mm), with a gap between the copper roll and the tapping nozzle being set to 0.3 mm. The temperature at which each raw material melted down was taken as the tapping temperature. Quenched ribbons produced in the manner as described above were used as sample materials to evaluate the

35

properties described below.

[0025]

In the evaluation of the effect of reducing a coercive force with respect to a reduction in saturation magnetic flux density, the quenched ribbon was adhered on a sample stage with a double-faced tape in a vibration-sample-type coercive force meter to measure the coercive force of the quenched ribbon at an initial applied magnetic field of 144 kA/m. Then, the saturation flux density was measured at an applied magnetic field of 1200 kA/m in a VSM device (vibration-sample-type magnetometer) with the weight of the sample material being around 15 mg. From the measurement results, the evaluation was conducted with a ratio between a reduction in coercive force and a reduction in saturation magnetic flux density before and after addition of various elements [(reduction in coercive force)/(reduction in saturation magnetic flux density)]. Accordingly, the higher value thereof means that a larger coercive force reduction effect is obtained with a smaller reduction in saturation magnetic flux density.

[0026]

Meanwhile, when an X-ray diffraction pattern of an amorphous material is measured to evaluate the amorphous properties of a quenched ribbon, no diffraction peak is generally observed and a halo pattern, which is specific to amorphous materials, is observed. Although a diffraction peak is observed in a material not completely amorphous, the height of the peak is lower than that of a crystal material and a halo pattern is also observed. Therefore, the amorphous properties were evaluated by the method below.

[0027]

The sample material was adhered on a glass plate with a double-faced tape to obtain a diffraction pattern of the sample material by an X-ray diffraction device. At this time, the sample material was adhered on the glass plate so that a surface to be measured could be a copper-roll-contact surface of the quenched ribbon. The X-ray source was Cu-ka ray, and the

measurement was conducted under the condition in which a scan speed is 4° per minute. The diffraction patterns in which a halo pattern was able to be confirmed were ranked as "good," and the diffraction patterns in which no halo pattern was observed were ranked as "poor" when evaluating amorphous properties. First, two fundamental compositions were chosen, fixed amounts of addition elements were added to each thereof, and the effect of reducing a coercive force depending on the kind of each addition element was examined. The results are shown in Tables 1 and 2.

[0028]

[Table 1]

Table 1

No.	Composition of Quenched Ribbon (at.%)											[Reduction in coercive force (A/m)]/[Reduction in saturation magnetic flux density(T)]*	Amorphous Properties
	Co+Fe	Co:Fe	Ti	Zr	Hf	Nb	Ta	B	W	Sn	Others		
1	86	50:50	-	8	-	-	-	6	-	-	-	Fundamental Composition	Good
2	78	50:50	-	8	-	-	-	6	-	-	V:8	10	Good
3	78	50:50	-	8	-	-	-	6	-	-	Cr:8	3	Good
4	78	50:50	-	8	-	-	-	6	-	-	Mo:8	-1	Good
5	78	50:50	-	8	-	-	-	6	8	-	-	22	Good
6	78	50:50	-	8	-	-	-	6	-	-	Mn:8	12	Good
7	78	50:50	-	8	-	-	-	6	-	-	Ni:8	-16	Good
8	78	50:50	-	8	-	-	-	6	-	-	Cu:8	-22	Good
9	78	50:50	-	8	-	-	-	6	-	8	-	20	Good
10	78	50:50	-	8	-	-	-	6	-	-	Al:8	-1	Good
11	78	50:50	-	8	-	-	-	6	-	-	C:8	-4	Good
12	78	50:50	-	8	-	-	-	6	-	-	Si:8	-5	Good
13	78	50:50	-	8	-	-	-	6	-	-	P:8	-3	Good
14	78	50:50	-	8	-	-	-	6	-	-	Ge:8	-1	Good

NOTE) *: A minus value shows that a coercive force is increased by addition elements.

Table 1 shows the Influences of the kinds of the addition elements (evaluation in the fixed additive amounts) with 86(50Co50Fe)-8Zr-6B as the fundamental composition. The notation shows 43Co-43Fe-8Zr-6B.

- 5 [0029]
[Table 2]

Table 2

No.	Composition of Quenched Ribbon (at.%)											[Reduction in coercive force (A/m)]/[Reduction in saturation magnetic flux density (T)]*	Amorphous Properties
	Co+Fe	Co:Fe	Ti	Zr	Hf	Nb	Ta	B	W	Sn	Others		
1	87	35:65	3	5	-	3	2	-	-	-	-	Fundamental Composition	Good
2	81	35:65	3	5	-	3	2	-	-	-	V:6	11	Good
3	81	35:65	3	5	-	3	2	-	-	-	Cr:6	3	Good
4	81	35:65	3	5	-	3	2	-	-	-	Mo:6	-3	Good
5	81	35:65	3	5	-	3	2	-	6	-	-	21	Good
6	81	35:65	3	5	-	3	2	-	-	-	Mn:6	14	Good
7	81	35:65	3	5	-	3	2	-	-	-	Ni:6	-19	Good
8	81	35:65	3	5	-	3	2	-	-	-	Cu:6	-22	Good
9	81	35:65	3	5	-	3	2	-	-	6	-	18	Good
10	81	35:65	3	5	-	3	2	-	-	-	Al:6	0	Good
11	81	35:65	3	5	-	3	2	-	-	-	C:6	1	Good
12	81	35:65	3	5	-	3	2	-	-	-	Si:6	3	Good
13	81	35:65	3	5	-	3	2	-	-	-	P:6	-3	Good
14	81	35:65	3	5	-	3	2	-	-	-	Ge:6	0	Good

NOTE) *: A minus value shows that a coercive force is increased by addition elements.

Table 2 shows the influences of the kinds of the addition elements (evaluation in the fixed additive amounts) with 87(35Co65Fe)-3Ti-5Zr-3Nb-2Ta as the fundamental composition. The notation shows

5 30.45Co-56.55Fe-3Ti-5Zr-3Nb-2Ta.
[0030]

As shown in Table 1, the addition of W and/or Sn most effectively reduces a coercive force, and the addition of V and/or Mn is secondarily effective. Also, the addition of Cr, Mo,
10 Al, C, Si, P, and/or Ge is unable to greatly change a coercive force. It is further found that the addition of Ni and/or Cu greatly increases a coercive force. In Table 2, in which the same effects are also shown as those in Table 1, the addition of W and/or Sn most effectively reduces a coercive force, and
15 the addition of V and/or Mn is secondarily effective. The addition of Cr, Mo, Al, C, Si, P, and/or Ge is unable to greatly change a coercive force. It is further found that the addition of Ni and/or Cu greatly increases a coercive force.

[0031]

20 From the test results shown in Tables 1 and 2, it is found that (W, Sn)>(V, Mn)>(Cr, Mo, Al, C, Si, P, Ge)>(Ni, Cu) holds for the effect of reducing a coercive force, and W, Sn, V, and/or Mn reduce a coercive force, Cr, Mo, Al, C, Si, P, and/or Ge results in small change in coercive force, and Ni and/or Cr
25 greatly increase a coercive force. From the results, it was found that the order of the upper limits of addition amounts in the present invention is defined as (W, Sn)=(V, Mn)>(Cr, Mo, Al, C, Si, P, Ge)>(Ni, Cu), and in particular, it was necessary to strictly control the upper limits of the addition amounts of Ni
30 and/or Cu having the large adverse influence of increasing a coercive force.

[0032]

[Table 3]

Table 3

No.	Composition of Quenched Ribbon(at.%)									Addition Element and Amount		[Reduction in coercive force(A/m)]/[Reduction in saturation magnetic flux density(T)]	Amorphous Properties	Saturation Magnetic Flux Density
	Co+Fe	Co:Fe	Zr	Ta	Ti	Hf	B	Nb	W	Sn	Others			
1	91	80:20	8	1	-	-	-	-	3	-		Excellent	Good	Good
2	91	75:25	8	1	-	-	-	-	3	5		Excellent	Good	Good
3	91	70:30	8	1	-	-	-	-	10	5		Excellent	Good	Good
4	91	50:50	8	1	-	-	-	-	19	-		Excellent	Good	Good
5	91	35:65	8	1	-	-	-	-	-	14		Excellent	Good	Good
6	91	30:70	8	1	-	-	-	-	1	9		Excellent	Good	Good
7	91	10:90	8	1	-	-	-	-	-	3		Excellent	Good	Good
8	90	70:30	-	-	5	5	-	-	8	-		Excellent	Good	Good
9	94	70:30	-	-	-	6	-	-	-	10		Excellent	Good	Good
10	81	35:65	2	15	2	-	-	-	2	2		Excellent	Good	Good
11	82	35:65	-	10	-	-	8	-	2	2		Excellent	Good	Good
12	72	50:50	10	10	-	-	8	-	-	3		Excellent	Good	Good
13	86	50:50	7	-	-	7	-	-	3	-		Excellent	Good	Good
14	91	50:50	8	1	-	-	-	-	5	-	V:7,Mn:7	Excellent	Good	Good
15	91	50:50	8	1	-	-	-	-	3	-	V:2,Mn:2	Excellent	Good	Good
16	91	70:30	8	1	-	-	-	-	-	-	V:10	Good	Good	Good
17	85	70:30	-	-	-	5	-	10	-	-	Mn:6	Good	Good	Good
18	81	70:30	2	15	2	-	-	-	3	-	Mo:2	Excellent	Good	Good
19	91	70:30	8	-	-	-	1	-	-	3	P:2	Excellent	Good	Good
20	91	35:65	8	-	-	-	1	-	5	-	V:1,Mn:1,C:1	Excellent	Good	Good
21	91	35:65	8	-	-	-	1	-	-	-	V:5,Mo:1,Ge:1	Good	Good	Good
22	92	35:65	8	-	-	-	-	-	8	-	Mo:1	Excellent	Good	Good
23	92	35:65	8	-	-	-	-	-	-	-	V:4,Mn:4,P:1	Good	Good	Good
24	92	35:65	8	-	-	-	-	-	3	-	Al:3,Cr:3,Si:3	Excellent	Good	Good
25	91	70:30	-	1	8	-	-	-	6	-	V:2,Ni:5	Excellent	Good	Good
26	91	70:30	-	1	8	-	-	-	6	-	V:2,Ni:1,Cu:1	Excellent	Good	Good
27	91	70:30	-	1	8	-	-	-	-	3	Mn:4, Cu:3	Excellent	Good	Good
28	91	<u>90:10</u>	8	1	-	-	-	-	15	-		Excellent	Good	Poor
29	91	<u>0:100</u>	8	1	-	-	-	-	-	15		Excellent	Good	Poor
30	91	80:20	8	1	-	-	-	-	2	-		Fair	Good	Good
31	89	10:90	7	4	-	-	-	-	-	2		Fair	Good	Good
32	91	50:50	8	1	-	-	-	-	<u>20</u>	-		Good	Good	Poor
33	95	70:30	-	-	-	<u>5</u>	-	-	-	10		Imponderable	Poor	Good
34	70	50:50	<u>10</u>	<u>10</u>	-	-	<u>10</u>	-	-	8		Excellent	Good	Poor
35	85	50:50	<u>7</u>	-	-	<u>8</u>	-	-	3	-		Fair	Good	Good
36	90	50:50	8	1	-	-	1	-	<u>5</u>	-	V:8,Mn:7	Good	Good	Poor
37	90	50:50	8	1	-	-	1	-	-	-	V:10,Mn:10	Good	Good	Poor
38	84	35:65	8	-	-	-	-	8	3	-	Al:4,Cr:3,Si:3	Good	Good	Poor
39	91	70:30	-	-	8	-	-	1	-	3	Mn:4, Cu:6	Poor	Good	Good
40	91	70:30	-	-	8	-	-	1	-	3	Mn:4, Cu:6	Poor	Good	Good

NOTE: The underlined figures fall outside the scope of the present invention.

Present Invention Examples

Comparative Examples

[0033]

Then, in order to quantitatively examine the upper limit of the addition amount of each element, sample materials with various fundamental components and sample materials in which various amounts of various elements were added thereto were produced, and tests for coercive force, saturation magnetic flux density, amorphous properties, and saturation magnetic flux density were conducted. The results are shown in Table 3.

[0034]

10 In Table 3, the addition elements are replaced with a part of (Co+Fe) in the fundamental components. In other words, the fundamental components of No. 1 in Table 3 are represented by 72.8Co-18.2Fe-8Zr-1Ta, while the components in which the addition element of No. 1 is added are represented by
15 70.4Co-17.6Fe-8Zr-1Ta-3W. It should be noted that, the evaluations were conducted with the composition in which the ratio between Co and Fe and the amounts of the other fundamental components were fixed, since the ratio between Co and Fe is presumed to influence a coercive force, and the
20 purpose of this test is to purely ascertain the influence of the addition elements on a coercive force. Therefore, such notations are shown.

[0035]

In Table 3, a reduction in coercive force and a reduction in
25 saturation magnetic flux density show reductions in the coercive force and saturation magnetic flux density of a sample material in which each addition element is added from the coercive force and saturation magnetic flux density of a sample material with each fundamental component, respectively. The evaluations of
30 amorphous properties and saturation magnetic flux density show the properties of a sample material in which each addition element is added. Furthermore, values of [reduction in coercive force (A/m)]/[reduction in saturation magnetic flux density (T)] of 15 or more were ranked as "excellent," those of
35 8 or more and less than 15 were ranked as "good," those of -7 or more and less than 8 were ranked as "fair," and those of less

than -8 were evaluated as "poor." Further, saturation magnetic flux densities of 0.3 T or more were ranked as "good," while those of less than 0.3 T were evaluated as "poor."

[0036]

- 5 As shown in Table 3, Nos.1 to 27 are present invention examples, while Nos. 28 to 40 are comparative examples. Comparative Example No. 28 results in a poor saturation magnetic flux density due to the low content of Fe. Comparative Example No. 29 results in a poor saturation
10 magnetic flux density due to no content of Co. Comparative example No. 30 results in an insufficient coercive force reduction effect due to the low content of W, which is an element that promotes a low coercive force. Comparative Example No. 31 results in an insufficient coercive force
15 reduction effect due to the low content of Sn, which is an element that promotes reduction in coercive force.

[0037]

- Comparative Example No. 32 results in a poor saturation magnetic flux density due to the high content of W, which is an
20 element that promotes a low coercive force. Comparative Example No. 33 results in poor amorphous properties and a coercive force above the evaluable range of the device used for the measurement, due to the low content of a single element of Hf, which is an element that promotes an amorphous state. In
25 general, generation of a large amount of crystal phase in an amorphous phase is known to result in a significantly increased coercive force. Comparative Example No. 34 results in a poor saturation magnetic flux density due to the high sum of the contents of Zr, Ta, and B/2, which are elements that promote an
30 amorphous state. Comparative Example No. 35 results in an insufficient coercive force reduction effect due to the high sum of the contents of Zr and Hf, which are elements that promote an amorphous state and increase a coercive force.

[0038]

- 35 Comparative Example No. 36 results in a poor saturation magnetic flux density due to the high sum of the contents of W,

V, and Mn, which are elements that promote a low coercive force. Comparative Example No. 37 results in a poor saturation magnetic flux density due to the high sum of the contents of V and Mn, which are elements that promote a low coercive force.

- 5 Comparative Example No. 38 results in a poor saturation magnetic flux density due to the high sum of the contents of Al, Cr, and Si which are elements for adjusting a saturation magnetic flux density. Comparative Example No. 39 results in a poor coercive force reduction effect due to the high content of
10 a Cu element. Comparative Example No. 40 results in a poor coercive force reduction effect due to the high content of a Ni element.

[0039]

- As described above, in accordance with the present invention,
15 there are provided an alloy for a soft magnetic thin film layer in a perpendicular magnetic recording medium with the excellent balance of a saturation magnetic flux density, amorphous properties, and a low coercive force which enables a low coercive force without deteriorating a saturation magnetic flux
20 density and amorphous properties by particularly adding W, Sn, V, and Mn, which are elements that promote a low coercive force; and a sputtering target material for producing a thin film of the alloy.

Claims

1. An alloy for a soft magnetic thin film layer in a perpendicular magnetic recording medium, comprising:

- one or more selected from Ti, Zr, Hf, Nb, Ta, and B;
- one or two of W and Sn; and
- the balance Co and Fe, and

satisfying, in at.%, expressions described below:

$$(1) 6 \leq \text{Ti}\% + \text{Zr}\% + \text{Hf}\% + \text{Nb}\% + \text{Ta}\% + \text{B}\% / 2 \leq 24;$$

$$(2) \text{Zr}\% + \text{Hf}\% \leq 14;$$

$$(3) 3 \leq \text{W}\% + \text{Sn}\% \leq 19; \text{ and}$$

$$(4) 0.20 \leq \text{Fe}\% / (\text{Fe}\% + \text{Co}\%) \leq 0.90, \text{ and}$$

having amorphous properties,

wherein a ratio of a reduction in coercive force to a reduction in saturation magnetic flux density:

$[(\text{reduction in coercive force (A/m)}) / (\text{reduction in saturation magnetic flux density (T)})]$

is 8 or more,

wherein the reduction in coercive force is a difference between a coercive force of the alloy satisfying the above expressions (1) to (4) and a coercive force of an alloy satisfying the above expressions (1), (2) and (4), and

the reduction in saturation magnetic flux density is a difference between a saturation magnetic flux density of the alloy satisfying the above expressions (1) to (4) and a saturation magnetic flux density of an alloy satisfying the above expressions (1), (2) and (4), and

wherein a saturation magnetic flux density is 0.3 T or more.

2. The alloy for a soft magnetic thin film layer in a perpendicular magnetic recording medium according to claim 1,

wherein a part or all of one or more of W and Sn are substituted by one or two of V and Mn, and

the alloy satisfies the expression (5):

$$(5) 3 \leq \text{W}\% + \text{Sn}\% + \text{V}\% + \text{Mn}\% \leq 19.$$

3. The alloy for a soft magnetic thin film layer in a perpendicular magnetic recording medium according to claim 1 or 2,

wherein the alloy comprises one or more than two of Al, Cr, Mo, Si, P, C, and Ge, and

the alloy satisfies expression (6):

$$(6) \text{ Al}\% + \text{Cr}\% + \text{Mo}\% + \text{Si}\% + \text{P}\% + \text{C}\% + \text{Ge}\% \leq 9.$$

4. The alloy for a soft magnetic thin film layer in a perpendicular magnetic recording medium according to any one of claims 1 to 3,

wherein the alloy comprises one or two of Ni and Cu in an amount of 5 % or less.

5. A sputtering target material for producing the thin film layer according to any one of claims 1 to 4.