

SOFT MAGNETIC ALLOY FOR MAGNETIC RECORDING,
SPUTTERING TARGET MATERIAL, AND MAGNETIC RECORDING
MEDIUM

5 [Cross-Reference to Related Application]

[0001]

This application claims priority to Japanese Patent Application
No. 2010-240184 filed on October 26, 2010 and Japanese
Patent Application No. 2011-92631 filed on April 19, 2011, the
10 entire content of which is incorporated herein by reference.

[Technical Field]

[0002]

The present invention relates to a Co-based soft magnetic alloy
15 for magnetic recording used for a soft magnetic undercoat layer
(SUL layer) in a thermally assisted magnetic recording medium
for a hard disk drive; and to a sputtering target material and a
magnetic recording medium, in which this alloy is used.

20 [Background Art]

[0003]

In recent years, there have been remarkable progresses in
magnetic recording technology, heightening of recording
densities in magnetic recording media has been proceeding due
25 to increasing drive capacities, and a thermally assisted magnetic
recording system, which can achieve further high recording
density when compared to perpendicular magnetic recording
media conventionally used, has been examined.

[0004]

30 The thermally assisted magnetic recording system is a system
which records data while heating a magnetic recording medium
by a laser. When higher densification of a magnetic recording
medium proceeds, the problem of heat fluctuation in that
magnetically recorded data disappears under the influence of
35 neighboring heat occurs significantly. Avoidance of this
problem of the heat fluctuation requires the increased coercive

force of a magnetic material used in a recording medium. However, a too high coercive force interferes recording. A system that solves this problem is the thermally assisted magnetic recording system.

5 [0005]

On the other hand, heating of a recording medium results in a decreased coercive force and therefore enables recording while cooling of the medium after the recording results in a reincreased coercive force, thereby improving resistance to heat
10 fluctuation. As the magnetic recording medium for the thermally assisted system, for example, a magnetic recording medium shown in Japanese Patent Laid-Open Publication No. 2010-182386 (Patent Literature 1) has been examined. Although a soft-magnetic layer demands an amorphous state as
15 disclosed in this Patent Literature 1, a recording medium is heated in the thermally assisted system as described above. Therefore, an alloy for a soft-magnetic layer shown in Patent Literature 1 demands a sufficiently high crystallization temperature at which crystallization does not occur even during
20 heating. However, there is a problem of crystallization since the crystallization temperature of the soft-magnetic layer shown in Patent Literature 1 is about 400°C (670 K) according to Japanese Patent Laid-Open Publication No. 2001-110044 (Patent Literature 2).

25 [0006]

Further, although the composition disclosed in Tsuyoshi Masumoto "Amorufasu Kinzoku No Kiso" (Materials Science of Amorphous Metals), Ohmsha, Ltd., 1982, P 94 (Non Patent Literature 1) has a crystallization temperature of around 800 K,
30 it has had the problem of corrosion resistance when used in a soft-magnetic layer since a metalloid such as Si, Ge, P, B, or C is used. Further, as for a nonmagnetic alloy, an alloy that has a crystallization temperature of more than 800 K is also notified as shown in Non Patent Literature 2, but is not applicable to
35 uses for soft magnetic films as the uses require magnetism.

[Citation List]

[Patent Literature]

[0007]

[PTL 1] Japanese Patent Laid-Open Publication No. 2010-182386

5 [PTL 2] Japanese Patent Laid-Open Publication No. 2001-110044

[Non Patent Literature]

[0008]

10 [NPTL 1] Tsuyoshi Masumoto "Amorufasu Kinzoku No Kiso"
(Materials Science of Amorphous Metals), Ohmsha, Ltd., 1982, P
94

[NPTL 2] OH JE, WOOLLAM J A, AYLESWORTHKD, SELLMYER D J,
POUCH J J, J Appl Phys., Vol. 60, No. 12 PP. 4271-4286, 1986

15 [Summary of the Invention]

[0009]

As described above, although the amorphous state is demanded
in the soft-magnetic layer of the alloy in Patent Literature 1,
there is the problem that the crystallization occurs in the
20 soft-magnetic layer shown in Patent Literature 1 since the
recording medium is heated in the thermally assisted system.
Further, although the crystallization temperature of around 800
K is exhibited in the composition disclosed in Non Patent
Literature 1, it has the problem of corrosion resistance for use
25 in a soft-magnetic layer since a metalloid such as Si, Ge, P, B,
or C is used.

[0010]

The inventors have now found that it is possible to provide a
soft magnetic alloy for magnetic recording, achieving excellent
30 characteristics in that, in a Co alloy, (1) amorphousness can be
secured by adding an amorphization-promoting element such as
Zr, Hf, and/or Ti; (2) addition of V, Nb, Ta, Cr, Mo, and/or W
enables high crystallization temperature and also enables
contribution to improvement in amorphousness; (3) a saturation
35 magnetic flux density can be adjusted by adding Ni and/or Mn;
(4) improvement in corrosion resistance can be effected by

adding Al and/or Cu; and (5) improvement in amorphousness can be effected by adding Si, Ge, P, B, and/or C.

[0011]

It is therefore an object of the present invention to provide a
5 soft magnetic alloy for a thermally assisted magnetic recording medium, excellent in saturation magnetic flux density, amorphous property, crystallization temperature and corrosion resistance; and a sputtering target material and a magnetic recording medium, in which the soft magnetic alloy is used.

10 [0012]

According to one embodiment of the present invention, there is provided a soft magnetic alloy for magnetic recording, comprising in at%:

Fe: 0 to 70%;

15 (A) 5 to 20% of one or two or more elements selected from the group consisting of Ti, Zr, and Hf;

(B) 0 to 30% of one or two or more elements selected from the group consisting of Cr, Mo and W;

20 (C) 0 to 30% of one or two or more elements selected from the group consisting of V, Nb, and Ta;

(D) 0 to 30% of one or two elements selected from the group consisting of Ni and Mn;

(E) 0 to 5% of one or two elements selected from the group consisting of Al and Cu; and

25 (F) 0 to 10% of one or two or more elements selected from the group consisting of Si, Ge, P, B, and C; and

the balance Co and unavoidable impurities.

[0013]

30 According to another embodiment of the present invention, there is provided a sputtering target material made of such a soft magnetic alloy for magnetic recording as mentioned above.

[0014]

35 According to another embodiment of the present invention, there is provided a magnetic recording medium comprising a soft magnetic film made of such a soft magnetic alloy for magnetic recording as mentioned above.

[Description of Embodiments]

[0015]

The present invention is specifically explained below. Unless
5 otherwise specified, "%" as used herein means at%.

[0016]

The soft magnetic alloy for magnetic recording according to the
present invention comprises in at%: Fe: 0 to 70%; (A) 5 to
20% of one or two or more elements selected from the group
10 consisting of Ti, Zr, and Hf; (B) 0 to 30% of one or two or more
elements selected from the group consisting of Cr, Mo and W;
(C) 0 to 30% of one or two or more elements selected from the
group consisting of V, Nb, and Ta; (D) 0 to 30% of one or two
elements selected from the group consisting of Ni and Mn; (E) 0
15 to 5% of one or two elements selected from the group
consisting of Al and Cu; and (F) 0 to 10% of one or two or more
elements selected from the group consisting of Si, Ge, P, B, and
C; and the balance Co and unavoidable impurities, preferably
consists essentially of these elements, and more preferably
20 consists of these elements.

[0017]

The alloy according to the present invention comprises 0 to 70%,
preferably 20 to 70%, more preferably 30 to 50%, of Fe.
Although Fe is an element for obtaining a soft magnetic material,
25 more than 70% of Fe results in deterioration of corrosion
resistance.

[0018]

The alloy according to the present invention comprises 5 to 20%,
preferably 6 to 15%, further preferably 9 to 14%, of the one or
30 two or more (A) group elements selected from the group
consisting of Ti, Zr, and Hf. Ti, Zr, and Hf are elements for
securing amorphization (amorphization property) in a Co-based
alloy, and amorphization can be sufficiently achieved when the
total content of these elements is 5 to 20%.

35 [0019]

According to a preferred embodiment of the present invention,

the alloy may also comprise 5 to 30%, preferably 10 to 25%, of the one or two or more (B) group elements selected from the group consisting of Cr, Mo, and W. Cr, Mo, and W are elements for achieving high crystallization temperature in a Co alloy, and the effect can be sufficiently achieved while contributing to amorphization when the total content of one or two or more of the elements is 5 to 30%.

[0020]

According to a preferred embodiment of the present invention, the sum of the (A) group element(s) and the (B) group element(s) may also be 10 to 35%. The sum within this range contributes to amorphization and enables magnetism to be effectively prevented from decreasing.

[0021]

According to a preferred embodiment of the present invention, the alloy may also comprise 30% or less, preferably 20% or less, further preferably 10% or less, of the one or two or more (C) group elements selected from the group consisting of V, Nb, and Ta. V, Nb, and Ta are elements for significantly improving corrosion resistance and promoting amorphization in a Co alloy and, when being added particularly in combination with the (B) group, high corrosion resistance and high crystallization temperature can be achieved. The total content of these elements of 30% or less contributes to amorphization.

[0022]

According to a preferred embodiment of the present invention, the alloy may also comprise 30% or less, preferably 20%, further preferably 10%, of the one or two (D) group elements selected from the group consisting of Ni and Mn. Ni and Mn are elements for adjusting a saturation magnetic flux density in a Co alloy, and excellent magnetism is obtained when the total content of these elements is 30% or less.

[0023]

According to a preferred embodiment of the present invention, the alloy may also comprise 5% or less of the one or two (E) group elements selected from the group consisting of Al and Cu.

Al and Cu are elements for improving corrosion resistance in a Co alloy, and the total content of these elements of 5% or less contributes to amorphization.

[0024]

5 According to a preferred embodiment of the present invention, the alloy may also comprise 10% or less of the one or two (F) group elements selected from the group consisting of Si, Ge, P, B, and C. Si, Ge, P, B, and C are elements for improving amorphousness in a Co alloy, and the total content of these
10 elements of 10% or less contributes to amorphization.

[Examples]

[0025]

The alloy according to the present invention is specifically explained below with reference to Examples.

15 [0026]

Normally, a thin film in a perpendicular magnetic recording medium is formed by sputtering a sputtering target material having the same composition as that of the thin film to form the film on a glass substrate or the like. In this case, the thin film
20 formed by sputtering has been quenched. In relation to this, quenched ribbons produced in a single-roll-type liquid quenching device have been used as sample materials in the present examples. This is to evaluate the influence of the thin films, which are actually quenched and formed by sputtering, on
25 various properties by the components, in a simple manner using liquid quenched ribbons.

[0027]

Production Conditions of Quenched Ribbon

A raw material of 30 g weighed to have the composition shown
30 in Table 1 and Table 2 was arc-melted in Ar with a reduced pressure in a water-cooled copper die having a diameter of about 10×40 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
35 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 atmospheric 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 thus produced were used as sample materials to evaluate the properties described below.

[0028]

10 Evaluation of Saturation Magnetic Flux Density of Quenched Ribbon

The saturation flux density of the quenched ribbon was measured at an applied magnetic field of 1200 kA/m in a VSM device (vibration-sample-type magnetometer). The weight of the sample material was around 15 mg, and the material with a saturation magnetic flux density of 0.3 T or more and less than 0.8 T was evaluated as "good" and the material with a saturation magnetic flux density of 0.8 T or more as "excellent." The material with a saturation magnetic flux density of less than 0.3% was evaluated as "poor."

[0029]

Structure of Quenched Ribbon

In general, when an X-ray diffraction pattern of the amorphous material is measured, no diffraction peak is observed to show a halo pattern specific to amorphous materials. 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 following method.

[0030]

Evaluation of Amorphous Properties

In the evaluation of the amorphous properties, the sample material was adhered on a glass plate with a double-faced tape to obtain a diffraction pattern 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- α ray, and the measurement was conducted at a scan speed of 4°/min. The diffraction patterns in which a halo pattern was able to be confirmed and in which no halo pattern was observed were considered to be "good" and "poor," respectively, for evaluating amorphous properties.

[0031]

Crystallization Temperature of Quenched Ribbon

In general, heating causes crystallization in an amorphous material, and the temperature at which the crystallization occurs is referred to as a crystallization temperature. Further, an exothermic reaction occurs during the crystallization. The crystallization temperature is evaluated by measuring the temperature of heat generated by the crystallization. Thus, the crystallization temperature was evaluated by the following method. It was examined by differential scanning calorimetry (DSC) under the condition of a heating rate of 0.67 Ks⁻¹. A crystallization temperature of 773 K or more and less than 873 K was evaluated as "good," a crystallization temperature of 873 K or more as "excellent," and a crystallization temperature of less than 773 K as "poor."

[0032]

Evaluation of Corrosion Resistance of Quenched Ribbon (NaCl)

In the evaluation based on a salt spray test (in 5% NaCl aqueous solution, at 35°C, 16 hours) conducted with a sample in which a quenched ribbon was adhered to glass pellets with a double-faced tape, a sample that showed no observable rust was evaluated as "good" and a sample that showed observable rust as "poor."

[0033]

Corrosion Resistance of Quenched Ribbon (HNO₃)

There was weighed 50 mg of a sample material, 10 ml of 3 at% HNO₃ aqueous solution was added dropwise, and the resultant was then left standing at room temperature for 1 hr, followed by analyzing the amount of Co eluted into the 3% HNO₃ aqueous

solution. The amount of eluted Co of less than 500 ppm was evaluated as "excellent," the amount of 500 or more and less than 1000 ppm as "good," and 1000 ppm or more as "poor."

[0034]

- 5 Meanwhile, since sample No.9 shown in the composition of Table 1, for example, contains Zr, W and Mo in an amount of 10%, 5% and 5%, respectively, the content of (Co-30Fe) is $100\% - 20\% = 80\%$, and, when assuming that this 80% is equivalent to 100, the proportions of Co and Fe are (100-30)
- 10 and 30, respectively. That is, it is meant that the content of Co is 56% and the content of Fe is 24%.

[0035]

[Table 1]

No.	Composition (at.%)	Saturation Magnetic Flux Density	Amorphous Property	Crystallization Temperature	Corrosion Resistance (NaCl)	Corrosion Resistance (HNO ₃)
1	Co-5Zr-3W-2Mo	Excellent	Good	Good	Good	Good
2	Co-5Zr-3W-2Mo-6Ni	Good	Good	Good	Good	Good
3	Co-5Zr-3V-5Cr-2Ni-2Mn	Good	Good	Excellent	Good	Good
4	(Co-20Fe)-3Zr-2Ti-5Mo-3V	Good	Good	Excellent	Good	Good
5	(Co-20Fe)-3Ti-2Hf-1Ta-5Cr	Good	Good	Excellent	Good	Good
6	(Co-20Fe)-2Ti-2Hf-1Zr-5Mo-3Nb	Good	Good	Excellent	Good	Excellent
7	(Co-20Fe)-5Zr-5Cr-2Ta	Excellent	Good	Excellent	Good	Excellent
8	(Co-20Fe)-5Zr-5Cr-2Nb-5Ni	Good	Good	Excellent	Good	Excellent
9	(Co-30Fe)-10Zr-5W-5Mo	Excellent	Good	Excellent	Good	Good
10	(Co-30Fe)-10Zr-10W-20Cr	Good	Good	Good	Good	Good
11	(Co-30Fe)-7Zr-10W-20Mo	Good	Good	Good	Good	Good
12	(Co-30Fe)-9Zr-20W-10Mo	Good	Good	Good	Good	Good
13	(Co-30Fe)-10Zr-7Cr-10Mo	Good	Good	Excellent	Good	Good
14	(Co-30Fe)-10Zr-10W-7Mo	Good	Good	Excellent	Good	Good
15	(Co-30Fe)-6Zr-10W-15Mo	Good	Good	Excellent	Good	Good
16	(Co-50Fe)-6Zr-5Cr-3W-20Ni	Good	Good	Good	Good	Good
17	(Co-50Fe)-6Zr-5Mo-3Nb-10Mn	Excellent	Good	Excellent	Good	Excellent
18	(Co-50Fe)-5Zr-5W-3Nb-1Ni	Good	Good	Excellent	Good	Excellent
19	(Co-50Fe)-5Zr-3Cr-3Nb-1Ni	Good	Good	Excellent	Good	Excellent
20	(Co-70Fe)-5Zr-2W-3Cr	Excellent	Good	Good	Good	Good
21	(Co-70Fe)-5Zr-5W-3Ta-30Ni	Good	Good	Excellent	Good	Excellent
22	(Co-70Fe)-5Zr-5W-3Nb-10Mn	Good	Good	Excellent	Good	Excellent
23	(Co-70Fe)-15Hf-10W-10V	Good	Good	Excellent	Good	Excellent
24	(Co-70Fe)-15Zr-20W-10Mo	Good	Good	Good	Good	Good
25	(Co-70Fe)-14Zr-10W-20Mo	Good	Good	Good	Good	Good
26	(Co-70Fe)-14Zr-10Cr-20Mo	Good	Good	Excellent	Good	Good
27	(Co-70Fe)-20Zr-5Mo-10Cr	Good	Good	Excellent	Good	Good
28	(Co-70Fe)-20Zr-5W-10Mo	Good	Good	Excellent	Good	Good
29	(Co-70Fe)-5Ti-30Mo-15Ta	Good	Good	Excellent	Good	Good
30	(Co-70Fe)-5Ti-5W-2Nb-10Ni-10Mn	Good	Good	Excellent	Good	Excellent
31	(Co-70Fe)-5Ti-5Mo-2V-20Ni-10Mn	Good	Good	Excellent	Good	Excellent
32	(Co-70Fe)-2Zr-2Ti-1Hf-2V-2Nb-2Ta-2Cr-2Mo-2W-1Ni-1Mn	Good	Good	Excellent	Good	Excellent
33	Co-5Zr-3W	Excellent	Poor	Poor	Good	Good
34	Co-10Zr-35Mo	Poor	Poor	Poor	Good	Good
35	(Co-30Fe)-5Zr-1W-3Mo	Excellent	Good	Poor	Good	Good
36	(Co-70Fe)-5Zr-16Cr-16Mo	Excellent	Poor	Poor	Good	Good
37	Co-5W-5Mo	Excellent	Poor	Poor	Good	Good
38	Co-3Zr-5W-5Mo	Good	Poor	Poor	Good	Good
39	(Co-75Fe)-25Zr-2W-3Cr	Good	Poor	Poor	Poor	Poor
40	(Co-75Fe)-5Zr-2W-3Cr	Excellent	Good	Good	Poor	Poor
41	Co-3Zr-2W-3Mo	Excellent	Poor	Poor	Good	Good
42	(Co-70Fe)-15Zr-15W-10Mo	Poor	Poor	Poor	Good	Good
43	(Co-70Fe)-10Zr-2W-3Cr-31Mn	Poor	Good	Good	Good	Good
44	Fe-10B-10Si	Excellent	Good	Good	Poor	Poor
45	(Co-40Fe)-5Zr-4Nb	Excellent	Poor	Poor	Good	Excellent
46	Ta-30Cu	Poor	Good	Excellent	Good	Good

[0036]

Sample No. 33 shown in Table 1 has a low crystallization temperature because of having the low content of a (B) group element. Sample No. 34 has a low saturation magnetic flux density and a low crystallization temperature because of having the high content of a (B) group element. Sample No. 35 has a low crystallization temperature because of having the low total amount of (B) group elements. Sample No. 36 does not become amorphous and has a low crystallization temperature because of having the high total amount of (B) group elements. Sample No. 37 has a poor amorphous property because of having no (A) group element.

[0037]

Sample No. 38 has a poor amorphous property because of having the low content of an (A) group element. Sample No. 39 has a poor amorphous property due to the high content of an (A) group element and has poor corrosion resistance because of having a high Fe content. Sample No. 40 has poor corrosion resistance because of having a high Fe content. Sample No. 41 has a poor amorphous property because of having the low content of an (A) group element and the low total amount of the (A) group element and (B) group elements. Sample No. 42 has low magnetism and a poor amorphous property because of having the high total amount of an (A) group element and (B) group elements.

[0038]

Sample No. 43 has poor magnetism due to the high content of a (D) group element. Sample No. 44 has poor corrosion resistance because of containing B and Si elements, which are metalloids. Sample No. 45 has a poor amorphous property because of having the low content of a (B) group element and the low total amount of an (A) group element and the (B) group element. Sample No. 46 has nonmagnetism because of containing neither Co nor Fe and containing no (D) group element. In contrast, it is found that all samples Nos. 1 to 32 are excellent in saturation magnetic flux density and amorphous

property, has a high crystallization temperature, and is excellent in corrosion resistance because of satisfying the conditions of the present invention.

[0039]

- 5 In addition to the above-mentioned examples, other samples are shown in Table 2.

[Table 2]

No.	Composition (at.%)	Saturation Magnetic Flux Density	Amorphous Property	Crystallization Temperature	Corrosion Resistance (NaCl)	Corrosion resistance (HNO ₃)
1	(Co-20Fe)-5Zr-5W-3Al	Good	Good	Good	Good	Good
2	(Co-30Fe)-5Zr-5W-5Cr-3Cu	Good	Good	Good	Good	Good
3	(Co-50Fe)-5Zr-5W-5Cr-4Al-3Cu	Good	Good	Good	Good	Good
4	(Co-70Fe)-10Zr-10Mo-10Cr-5Al	Good	Good	Good	Good	Good
5	(Co-70Fe)-10Ti-10W-10Cr-5Cu	Good	Good	Good	Good	Good
6	(Co-70Fe)-10Zr-10W-10Cr-3Al-2Cu	Good	Good	Good	Good	Good
7	(Co-30Fe)-5Zr-5W-5Cr-3B	Good	Good	Good	Good	Good
8	(Co-50Fe)-5Zr-5W-5Cr-7B	Good	Good	Excellent	Good	Excellent
9	(Co-70Fe)-5Zr-5Cr-30Ta-5B	Excellent	Good	Good	Good	Good
10	(Co-70Fe)-10Zr-10W-10Cr-10B	Good	Good	Excellent	Good	Good
11	(Co-30Fe)-5Zr-5W-5Cr-3Si	Good	Good	Good	Good	Good
12	(Co-50Fe)-5Zr-5W-5Cr-7Si	Good	Good	Good	Good	Good
13	(Co-70Fe)-5Zr-5Cr-30V-5Si	Good	Good	Good	Good	Good
14	(Co-70Fe)-10Zr-10W-10Cr-10Si	Good	Good	Excellent	Good	Good
15	(Co-30Fe)-5Zr-5W-5Cr-3P	Good	Good	Good	Good	Good
16	(Co-50Fe)-5Zr-5W-5Cr-7P	Good	Good	Good	Good	Good
17	(Co-70Fe)-20Hf-10W-10Cr-5P	Good	Good	Good	Good	Good
18	(Co-70Fe)-5Hf-10W-10Cr-10P	Good	Good	Excellent	Good	Good
19	(Co-30Fe)-5Zr-5W-5Cr-3C	Good	Good	Good	Good	Good
20	(Co-50Fe)-5Zr-5W-5Cr-5P	Good	Good	Good	Good	Good
21	(Co-70Fe)-20Ti-10W-10Cr-5C	Good	Good	Good	Good	Good
22	(Co-70Fe)-10Zr-10W-10Cr-10C	Good	Good	Good	Good	Good
23	(Co-70Fe)-10Zr-10W-10Cr-2B-2Si-2C-1P	Good	Good	Good	Good	Good
24	(Co-70Fe)-5Zr-5Cr-30Nb-1Ni-5Ge	Good	Good	Good	Good	Excellent
25	(Co-70Fe)-5Zr-5W-30Mn-10Ge	Good	Good	Good	Good	Good
26	(Co-50Fe)-5Zr-5W-5Cr- <u>10Al</u>	Good	Poor	Poor	Good	Good
27	(Co-50Fe)-5Zr-5W-5Cr- <u>10Cu</u>	Good	Poor	Poor	Good	Good
28	(Co-50Fe)-5Zr-5W-5Cr- <u>15C</u>	Good	Poor	Poor	Good	Good
29	(Co-50Fe)-5Zr-5W-5Cr- <u>15B-15Si-15P</u>	Good	Poor	Poor	Good	Good
30	(Co-70Fe)-5Zr-5W- <u>31Ta-20Al</u>	Good	Poor	Poor	Good	Excellent
31	(Co-70Fe)-5Hf-5W- <u>31V-20Cu</u>	Good	Poor	Poor	Good	Excellent
32	(Co-70Fe)-5Ti-5Cr- <u>31Nb-20C</u>	Good	Poor	Poor	Good	Excellent
33	(Co-50Fe)-5Ti-5Mo-5Cr- <u>15P</u>	Good	Poor	Poor	Good	Good
34	(Co-50Fe)-5Hf-5W-5Cr- <u>15Ge</u>	Good	Poor	Poor	Good	Good

[0040]

Sample No. 26 does not become amorphous because of having a high Al content. Sample No. 27 does not become amorphous because of having a high Cu content. Sample No. 28 does not become amorphous because of having a high C content. Sample No. 29 does not become amorphous because of having the high total content of B, Si, and P. Sample No. 30 does not become amorphous because of having a high Ta content and a high Al content. Sample No. 31 does not become amorphous because of having a high V content and a high Cu content. Sample No. 32 does not become amorphous because of having a high Nb content and a high C content. Sample No. 33 does not become amorphous because of having a high P content. Sample No. 34 does not become amorphous because of having a high Ge content.

[0041]

Next, there is shown the method for producing a sputtering target material. As for the 12 compositions shown in the samples No. 1, No. 3, No. 4, No. 5, No. 8, No. 13, No. 18, No. 23, No. 27 and No. 32 in Table 1, and the samples No. 33 and No. 36 in Table 1, molten raw materials were weighed, melted by induction heating in a refractory crucible with an Ar gas atmosphere under a reduced pressure, then tapped from a nozzle having a diameter of 8 mm in the lower portion of the crucible, and atomized with an Ar gas. The gas-atomized powders as raw materials were degassed and charged into a can having an outside diameter of 220 mm, an inside diameter of 210 mm, and a length of 200 mm and made of SC. The vacuum achievement degree during the degassing was set to about 1.3×10^{-2} Pa. The above-described powder-filled billets were heated to 1150°C, then charged into a restraint container with a diameter of 230 mm, and molded by pressurization at 500 MPa. The solidified molded products produced by the above-described method were processed into a disk shape with a diameter of 180 mm and a thickness of 7 mm by wire cut, turning processing, and surface grinding to make sputtering

target materials.

[0042]

As for these 12 compositions, sputtered films were formed on glass substrates using the sputtering target materials. In the
5 X-ray diffraction patterns, halo patterns were observed in all the samples No. 1, No. 3, No. 4, No. 5, No. 8, No. 13, No. 18, No. 23, No. 27, and No. 32 while crystalline peaks were observed in the samples No. 33 and No. 36. Further, when crystallization
10 temperature was measured in the same manner as in the case of the quenched ribbons, all the samples No. 1, No. 3, No. 4, No. 5, No. 8, No. 13, No. 18, No. 23, No. 27, and No. 32 had high crystallization temperatures of 773 K or more while the samples No. 33 and No. 36 showed low crystallization temperatures of less than 773 K.

15 [0043]

The corrosion resistances are not shown in the tables but were "excellent," "good," and "poor," similarly to the results evaluated in the quenched ribbons. As for a magnetic property, the magnetic properties were measured, in the same manner as
20 in the case of the quench ribbons, to be "excellent," "good," and "poor," similarly to the results evaluated in the quench ribbons. The above was summarized as follows: it was confirmed that the results evaluated in the quench ribbons tended to be similar to the evaluations of the sputtered films formed using the
25 sputtering target materials.

[0044]

Further, as for the 13 compositions shown in the samples No. 1, No. 3, No. 5, No. 7, No. 11, No. 15, No. 18, No. 24, and No. 25 in Table 2, and the samples No. 26, No. 28, No. 29, and No. 33
30 in Table 2, molten raw materials were weighed, melted by induction heating in a refractory crucible with an Ar gas atmosphere under a reduced pressure, then tapped from a nozzle having a diameter of 8 mm in the lower portion of the crucible, and atomized with an Ar gas. The gas-atomized
35 powders as raw materials were degassed and charged into a can having an outside diameter of 220 mm, an inside diameter of

210 mm, and a length of 200 mm and made of SC. The vacuum achievement degree during the degassing was set to about 1.3×10^{-2} Pa. The above-described powder-filled billets were heated to 1000°C, then charged into a restraint container with a diameter of 230 mm, and molded by pressurization at 500 MPa. The solidified molded products produced by the above-described method were processed into a disk shape with a diameter of 165 mm and a thickness of 6 mm by wire cut, turning processing, and surface grinding to make sputtering target materials.

[0045]

As for these 13 compositions, sputtered films were formed on glass substrates using the sputtering target materials. In the X-ray diffraction patterns, halo patterns were observed in all the samples No. 1, No. 3, No. 5, No. 7, No. 11, No. 15, No. 18, No. 24, and No. 25 while crystalline peaks were observed in the samples No. 26, No. 28, No. 29, and No. 33. Further, when crystallization temperature was measured in the same manner as in the case of the quenched ribbons, all the samples No. 1, No. 3, No. 5, No. 7, No. 11, No. 15, No. 18, No. 24, and No. 25 had high crystallization temperatures of 773 K or more while the samples No. 33 and No. 36 showed low crystallization temperatures of less than 773 K.

[0046]

The corrosion resistances are not shown in the tables but were "excellent," "good," and "poor," similarly to the results evaluated in the quenched ribbons. As for a magnetic property, the magnetic properties were measured, in the same manner as in the case of the quench ribbons, to be "excellent," "good," and "poor," similarly to the results evaluated in the quench ribbons. The above was summarized as follows: it was confirmed that the results evaluated in the quench ribbons tended to be equivalent to the evaluations of the sputtered films formed using the sputtering target materials.

[0047]

As described above, according to the present invention, there

can be provided a soft magnetic alloy for a thermally assisted magnetic recording medium, which has a saturation magnetic flux density and an amorphous property (amorphousness) that are particularly secured, has high crystallization temperature, and is excellent in corrosion resistance; and a sputtering target material and a magnetic recording medium, made of the alloy.

CLAIMS

1. A soft magnetic alloy for magnetic recording, comprising in at%:

Fe: 0 to 70%;

(A) 5 to 20% of one or two or more elements selected from the group consisting of Ti, Zr, and Hf;

(B) 0 to 30% of one or two or more elements selected from the group consisting of Cr, Mo and W;

(C) 0 to 30% of one or two or more elements selected from the group consisting of V, Nb, and Ta;

(D) 0 to 30% of one or two elements selected from the group consisting of Ni and Mn;

(E) 0 to 5% of one or two elements selected from the group consisting of Al and Cu; and

(F) 0 to 10% of one or two or more elements selected from the group consisting of Si, Ge, P, B, and C; and

the balance Co and unavoidable impurities.

2. The soft magnetic alloy for magnetic recording according to claim 1, consisting of in at%:

Fe: 0 to 70%;

(A) 5 to 20% of one or two or more elements selected from the group consisting of Ti, Zr, and Hf;

(B) 0 to 30% of one or two or more elements selected from the group consisting of Cr, Mo and W;

(C) 0 to 30% of one or two or more elements selected from the group consisting of V, Nb, and Ta;

(D) 0 to 30% of one or two elements selected from the group consisting of Ni and Mn;

(E) 0 to 5% of one or two elements selected from the group consisting of Al and Cu;

(F) 0 to 10% of one or two or more elements selected from the group consisting of Si, Ge, P, B, and C; and

the balance Co and unavoidable impurities.

3. The soft magnetic alloy for magnetic recording according to claim 1 or 2, comprising 5 to 30 at% of the (B) group element, wherein the sum of the (A) group element and the (B) group element is 10 to 35 at%.
4. The soft magnetic alloy for magnetic recording according to any one of claims 1 to 3, comprising more than 0% and 30 at% or less of the (C) group element.
5. The soft magnetic alloy for magnetic recording according to any one of claims 1 to 4, comprising more than 0% and 30 at% or less of the (D) group element.
6. The soft magnetic alloy for magnetic recording according to any one of claims 1 to 5, comprising more than 0% and 5 at% or less of the (E) group element.
7. The soft magnetic alloy for magnetic recording according to any one of claims 1 to 6, comprising more than 0% and 10 at% or less of the (F) group element.
8. A sputtering target material made of the soft magnetic alloy for magnetic recording according to any one of claims 1 to 7.
9. A magnetic recording medium comprising a soft magnetic film made of the soft magnetic alloy for magnetic recording according to any one of claims 1 to 7.