

CoFe-BASED ALLOY FOR SOFT MAGNETIC FILM LAYER IN
PERPENDICULAR MAGNETIC RECORDING MEDIUM AND
SPUTTERING TARGET MATERIAL

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

This application claims priority to Japanese Patent Application No. 2013-28726 filed on February 18, 2013, the entire content of which is incorporated herein by reference.

10 [Technical Field]
[0002]

The present invention relates to a CoFe-based alloy and a sputtering target material for a soft magnetic thin film layer in a perpendicular magnetic recording medium.

15 [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 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.

[0004]
25 Perpendicular magnetic recording system is a system in which a magnetization-easy axis is oriented in the direction vertical to the medium surface of a magnetic film of a perpendicular magnetic recording medium and is suitable for 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. In the magnetic recording film layer, a CoCrPt-SiO₂-based alloy is commonly used. Thermally-assisted and microwave-assisted
35 perpendicular magnetic recording media capable of achieving further high recording density have also been researched.

[0005]

As for a conventional soft magnetic film layer, a high saturation magnetic flux density (hereinafter referred to as Bs) and a high amorphous property have been necessary and, in addition, various properties such as 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 proposed in Japanese Patent Laid-Open Publication No. 2008-299905 (Patent Literature 1), addition of Fe results in high Bs, and addition of B results in high hardness. As proposed in Japanese Patent Laid-Open Publication No. 2011-68985 (Patent Literature 2), addition of Y and Ti results in improvement in corrosion resistance (weather resistance).

[0006]

In recent years, writing in a lower magnetic flux than ever before has been enabled by improving a head for reading and writing in a drive or by adjusting the magnetic flux density of a soft magnetic alloy to optimize an exchange-coupled magnetic field between a soft magnetic film and a Ru film. Accordingly, an amorphous alloy with comparatively low Bs rather than a conventional alloy with high Bs has been used as a soft magnetic layer placed under a recording layer.

[0007]

When a low-Bs alloy is used as a soft magnetic layer for a perpendicular magnetic recording medium as described above, recording magnetization in the soft magnetic film is prevented from excessively exerting a magnetic influence on its surroundings, and recording in small space is consequently enabled. This phenomenon is considered to be apparent improvement in recording density due to reduction in "blurred writing". However, it is still necessary to secure minimum Bs. On the basis of the above, a material having a saturation magnetic flux density of around 0.95 to 1.35 T is considered to be favorable.

[0008]

Furthermore, in recent years, the distance between a recording layer in a disc and a head has been extremely reduced, resulting in such improvement that magnetization in a lower
5 magnetic field from the head is enabled. It is desirable to allow a carbon protective film placed on the recording layer to be as thin as possible in order to reduce the distance between the recording layer and the head. However, the allowing of the carbon protective film to be thin can cause a problem that
10 layers below it are oxidized due to permeation of oxygen in the atmosphere.

[0009]

Because a soft magnetic film often has the lowest corrosion resistance in a multilayer structure in a disc, the necessary
15 thickness of a carbon protective film is determined based on the protection of this layer, which is a limiting factor. Accordingly, allowing of the corrosion resistance of the soft magnetic film to be higher than ever before enables the carbon protective film to be thin, consequently enables reduction in the distance between
20 a recording layer and a head, and can lead to improvement in recording capacity.

[0010]

As described above, in recent years, it has become important to impart a soft magnetic layer with markedly excellent corrosion
25 resistance preventing rust even in a severer environment, unlike the conventional idea of imparting the soft magnetic layer with the minimum corrosion resistance for preventing rust in a normal environment. Accordingly, use of conventional corrosion-resistance-improving elements for obtaining such
30 markedly high corrosion resistance results in the excessively large amount of the added element and consequently precludes minimum Bs from being secured. On the basis of such a background, the present inventors have examined a novel addition element causing a low decrease in Bs and a great
35 corrosion-resistance-improving effect.

[Citation List]

[0011]

[Patent Literature]

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

5 [PTL 2] Japanese Patent Laid-Open Publication No. 2011-68985

[Summary of the Invention]

[0012]

Patent Literature 1 mentioned above is excellent in that addition of Fe to an alloy results in high Bs and addition of B results in
10 high hardness. However, such methods are insufficient to obtain a soft magnetic alloy for a perpendicular magnetic recording medium that prevents rust even in a severer environment and has excellent corrosion resistance. In Patent Literature 2, the corrosion resistance (weather resistance) of an
15 alloy is improved by adding Y and Ti. However, these addition elements result in high decrease in Bs and are insufficient to obtain a great corrosion resistance improvement effect.

[0013]

To solve such problems as mentioned above, the present
20 inventors diligently examined the influences of various addition elements on corrosion resistance and other properties in an amorphous alloy for soft magnetism. As a result, addition of one or more selected from Ge, Ru, Rh, Pd, Re, Os, Ir, and Pt in small amounts was found to enable great improvement in
25 corrosion resistance without markedly decreasing Bs, and the present invention was thus accomplished.

[0014]

Furthermore, the present inventors newly found that in a soft magnetic amorphous thin film used in a perpendicular magnetic
30 recording medium, addition of one or more selected from Ge, Ru, Rh, Pd, Re, Os, Ir, and Pt in small amounts causes a marked corrosion resistance improvement effect with respect to a decrease in Bs, compared to elements which have been conventionally used, although Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W,
35 and the like have been conventionally considered to be corrosion resistance improvement elements, and the present

invention was thus accomplished. It is therefore an object of the present invention to provide a soft magnetic alloy for a perpendicular magnetic recording medium excellent in corrosion resistance and a sputtering target material for producing a thin film of the alloy.

[0015]

According to one embodiment of the present invention,

there is provided an alloy for a soft magnetic film layer in a perpendicular magnetic recording medium, wherein

the alloy comprises:

one or more selected from Ge, Ru, Rh, Pd, Re, Os, Ir, and Pt;

one or more selected from Sc, Y, lanthanoids (atomic numbers 57 to 71), Ti, Zr, Hf, V, Nb, Ta, Mo, W, and B; and

the balance of Co and Fe with unavoidable impurities; and

satisfies, in atomic%, all of the following formulae (a) to (d):

(a) $0.1\% \leq \text{TCR} \leq 10\%$;

(b) $5\% \leq \text{TAM} \leq 25\%$;

(c) $13\% \leq \text{TCR}/2 + \text{TAM} + \text{TNM} \leq 25\%$; and

(d) $0 \leq \text{Fe}\% / (\text{Fe}\% + \text{Co}\%) \leq 0.80$

[in the formulae (a) to (d)

$\text{TCR} = \text{Ge}\% + \text{Ru}\% + \text{Rh}\% + \text{Pd}\% + \text{Re}\% + \text{Os}\% + \text{Ir}\% + \text{Pt}\%$;

$\text{TAM} = \text{Sc}\% + \text{Y}\% + \text{total}\% \text{ of lanthanoids} + \text{Ti}\% + \text{Zr}\% + \text{Hf}\% + \text{V}\% + \text{Nb}\% + \text{Ta}\% + \text{Mo}\% + \text{W}\% + \text{B}\%/2$; and

$\text{TNM} = \text{C}\% + \text{Al}\% + \text{Si}\% + \text{P}\% + \text{Cr}\% + \text{Mn}\% + \text{Ni}\%/3 + \text{Cu}\%/3 + \text{Zn}\% + \text{Ga}\% + \text{Sn}\%$].

[0016]

According to another embodiment of the present invention,

there is provided an alloy for a soft magnetic film layer in a perpendicular magnetic recording medium, wherein

the alloy comprises in atomic%:

one or more of Ge, Ru, Rh, Pd, Re, Os, Ir, and Pt;

one or more of Sc, Y, lanthanoids (atomic numbers 57 to

71), Ti, Zr, Hf, V, Nb, Ta, Mo, W, and B; and
the balance of Co and Fe with unavoidable impurities;
and

satisfies all of the following formulae (1) to (4):

- 5 (1) $0.1\% \leq \text{TCR} \leq 10\%$;
(2) $5\% \leq \text{TAM} \leq 25\%$;
(3) $13\% \leq \text{TCR}/2 + \text{TAM} + \text{TNM} \leq 25\%$; and
(4) $0 \leq \text{Fe}\% / (\text{Fe}\% + \text{Co}\%) \leq 0.80$
(in the formulae (a) to (d))

10 $\text{TCR} = \text{Ge}\% + \text{Ru}\% + \text{Rh}\% + \text{Pd}\% + \text{Re}\% + \text{Os}\% + \text{Ir}\%$
 $+ \text{Pt}\%$;

$\text{TAM} = \text{Sc}\% + \text{Y}\% + \text{total}\% \text{ of lanthanoids} + \text{Ti}\% + \text{Zr}\%$
 $+ \text{Hf}\% + \text{V}\% + \text{Nb}\% + \text{Ta}\% + \text{Mo}\% + \text{W}\% + \text{B}\% / 2$

in which as for B, a value of 1/2 thereof is used because
15 B has an amorphous promotion effect that is about two times
those of the other elements; and

$\text{TNM} = \text{C}\% + \text{Al}\% + \text{Si}\% + \text{P}\% + \text{Cr}\% + \text{Mn}\% + \text{Ni}\% / 3 +$
 $\text{Cu}\% / 3 + \text{Zn}\% + \text{Ga}\% + \text{Sn}\%$

in which as for Ni and Cu, values of 1/3 thereof are used
20 because Ni and Cu cause reductions in saturation magnetic flux
density that are about one-third those of the other elements).

[0017]

According to a preferred embodiment of the present invention,

there is provided the above-described alloy, wherein the
25 alloy further comprises one or more selected from C, Al, Si, P, Cr,
Mn, Ni, Cu, Zn, Ga, and Sn.

[0018]

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

[0019]

As described above, the present invention is to exert the
excellent effect of providing a soft magnetic alloy for a
perpendicular magnetic recording medium particularly excellent
35 in corrosion resistance and a sputtering target material for
producing a thin film of the alloy.

[Brief Description of Drawings]

[0020]

[FIG. 1] FIG. 1 is a view showing the influences of the kinds of addition elements on Bs and elution amounts.

5 [FIG. 2] FIG. 2 is a view showing the influences of the kinds of the amounts of addition elements on elution amounts.

[FIG. 3] FIG. 3 is a view showing the relationships of addition amounts, elution amounts, and Bs.

[Description of Embodiments]

10 [0021]

The present invention is specifically explained below. Unless otherwise specified, "%" means atomic%.

[0022]

15 The alloy for a soft magnetic film layer in a perpendicular magnetic recording medium according to the present invention comprises: one or more selected from Ge, Ru, Rh, Pd, Re, Os, Ir, and Pt; one or more selected from Sc, Y, lanthanoids (atomic numbers 57 to 71), Ti, Zr, Hf, V, Nb, Ta, Mo, W, and B; and the balance of Co and Fe with unavoidable impurities, preferably
20 consists essentially of the above elements and unavoidable impurities, and more preferably consists of the above elements and unavoidable impurities.

[0023]

(a) $0.1\% \leq \text{TCR} \leq 10\%$

25 In the above formula, $\text{TCR} = \text{Ge}\% + \text{Ru}\% + \text{Rh}\% + \text{Pd}\% + \text{Re}\% + \text{Os}\% + \text{Ir}\% + \text{Pt}\%$ is satisfied. One or more selected from Ge, Ru, Rh, Pd, Re, Os, Ir, and Pt in the present invention are essential elements that greatly increase corrosion resistance without markedly decreasing Bs, a total of their addition
30 amounts of less than 0.1% fails to lead to the effect of improving corrosion resistance, and a total of more than 10% results in decrease of Bs to a lower level than necessary and also leads to a cost increase. The amount of the added elements is preferably 0.5 to 7%, more preferably 1 to 5%.
35 With regard to a kind of the elements, the elements other than Ge are preferred, and Ru, Rh, and Pt are more preferred.

[0024]

(b) $5\% \leq \text{TAM} \leq 25\%$

In the above formula, $\text{TAM} = \text{Sc}\% + \text{Y}\% + \text{total}\% \text{ of lanthanoids} + \text{Ti}\% + \text{Zr}\% + \text{Hf}\% + \text{V}\% + \text{Nb}\% + \text{Ta}\% + \text{Mo}\% + \text{W}\% + \text{B}\%/2$ is satisfied. As for B, a value of $1/2$ thereof is used because B has an amorphous promotion effect that is about two times those of the other elements. One or more selected from Sc, Y, lanthanoids (atomic numbers 57 to 71), Ti, Zr, Hf, V, Nb, Ta, Mo, W, and B in the present invention are essential elements for enhancing amorphous properties, a total of their addition amounts of less than 5% results in insufficient amorphous properties, and a total of more than 25% results in decrease of Bs to a lower level than necessary. The amount of the added elements is preferably 10 to 23%, more preferably 15 to 20%.

[0025]

(c) $13\% \leq \text{TCR}/2 + \text{TAM} + \text{TNM} \leq 25\%$

In the above formula, $\text{TNM} = \text{C}\% + \text{Al}\% + \text{Si}\% + \text{P}\% + \text{Cr}\% + \text{Mn}\% + \text{Ni}\%/3 + \text{Cu}\%/3 + \text{Zn}\% + \text{Ga}\% + \text{Sn}\%$ is satisfied. As for Ni and Cu, values of $1/3$ thereof are used because Ni and Cu cause reductions in saturation magnetic flux density that are about one-third those of the other elements. All of the elements belonging to TCR, TAM, and TNM are elements that decrease Bs. Accordingly, it is necessary to define the total amount thereof. A value of $\text{TCR}/2 + \text{TAM} + \text{TNM}$ of less than 13% results in too high Bs, which is greater than Bs of a soft magnetic film required for a disc in recent years, while its value of more than 25% results in insufficient Bs. The amount of the added elements is preferably 15 to 23%, more preferably 17 to 20%.

[0026]

(d) $0 \leq \text{Fe}\% / (\text{Fe}\% + \text{Co}\%) \leq 0.80$

Co and Fe in the present invention are essential elements for imparting ferromagnetism. However, a rate of $\text{Fe}\% / (\text{Fe}\% + \text{Co}\%)$ of more than 0.80 results in marked decrease in Curie point and in insufficient Bs at room temperature. The rate is preferably 0.30 to 0.70, more preferably 0.40 to 0.65.

[Examples]

[0027]

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

- 5 Normally, a soft magnetic film layer in a perpendicular magnetic recording medium is formed by sputtering a sputtering target material having the same composition as that of the film layer to form the film layer on a glass substrate or the like. At this time, the sputtered film has been quenched. In this regard, in
10 Experiments A and B described below, quenched ribbons produced in a single-roll-type liquid quenching device were used as sample materials. This is to evaluate, in a simple manner using liquid quenched ribbons, how various properties are affected by the components of the films which are actually
15 quenched and formed by sputtering.

[0028]

Then, in Experiment C, a sputtering target material was actually produced to evaluate a thin film produced by sputtering the sputtering target material.

20 [0029]

[Conditions for Production of Quenched Ribbon]

- 30 g of a raw material which was weighed to have the predetermined composition was arc-melted in Ar with a reduced pressure in a water-cooled copper mold having a diameter of
25 about 10 mm and a length of about 40 mm, to provide a molten raw material for producing a 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
30 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
35 which each raw material melted down was taken as the tapping temperature. The quenched ribbon produced in such a manner

was used as a sample material to evaluate the saturation magnetic flux density (hereinafter referred to as B_s) and amorphous properties thereof. The volume of the sample of which B_s was calculated was calculated from an average specific gravity calculated from its weight measured with an electronic balance and its composition ratio. The average specific gravity was obtained by averaging the specific gravities of elements forming the sample as pure substances with the composition ratio.

10 [0030]

[B_s of Quenched Ribbon]

B_s at room temperature was measured at an applied magnetic field of 1200 kA/m by a VSM device (vibration-sample-type magnetometer).

15 [0031]

[Evaluation of Amorphous properties 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 shown. Therefore, the amorphous properties were evaluated by the following method.

25 [0032]

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- $\text{K}\alpha$ ray, and the measurement was conducted at a scan speed of 4°/min. A material in which a halo pattern was able to be confirmed in such a diffraction pattern was evaluated as good while a material in which no halo pattern was observed was evaluated as poor, for evaluating amorphous properties.

[0033]

[Evaluation of Corrosion Resistance of Quenched Ribbon]

50 mg of the quenched ribbon was weighed and dipped in 10 ml of 3 mass% of nitric acid solution for 60 min. Then, the elution
5 amounts of Fe and Co ions were measured by the ICP method. In the evaluation of the elution amount, a value in terms of ppm obtained by dividing the total amount of the elution ions of Fe and Co by the weight of the tested quenched ribbon was used.

[0034]

10 [Production of Sputtering Target Material]

5 kg of a base material which was weighed to have predetermined components was induction-melted in a refractory crucible under Ar with a reduced pressure and then solidified. The crucible had a size of 120 mm in diameter and 150 mm in
15 height. A sputtering target material having a diameter of 95 mm and a thickness of 2 mm was produced from the lower portion of this ingot by turning processing, wire cut processing, and surface grinding processing.

[0035]

20 [Production of Sputtered Film and Evaluation of Bs and Amorphous Properties]

The inside of a chamber was evacuated to 1×10^{-4} Pa or less, an Ar gas with a purity of 99.99% and at 0.6 Pa was charged, and then sputtering was performed. The thin film having a
25 thickness of 500 nm was generated on a glass substrate having a thickness of 1 mm. The Bs value and amorphous properties of this thin film sample were evaluated in a manner similar to that in the quenched ribbon. The volume of the sample of which Bs was calculated was calculated from the area of the thin
30 film sample and the thickness of the thin film observed with a TEM equipment.

[0036]

[Evaluation of Corrosion Resistance of Sputtered Film]

The sputtered film was cut into 10 × 25 mm for each glass plate and dipped in 10 ml of 10 mass% of nitric acid solution for 60
35 min. Then, the elution amounts of Fe and Co ions were

measured by the ICP method. In the evaluation of the elution amount, a value in terms of mg/l obtained by dividing the total amount of the elution ions of Fe and Co by the volume of the aqueous solution used for the test was used.

5 [0037]

First, to examine the influence of the kind of an addition element on Bs and corrosion resistance, quenched ribbons with $(\text{Co}_{50}\text{Fe}_{50})_{78}\text{-Zr}_8\text{-B}_6\text{-M}_8$ (M = addition element) as a basic composition to which various addition elements were added
10 were evaluated (Experiment A). Then, Ge, Ru, and Pt as typical elements belonging to TCR and Ti, Hf, and W as comparative elements were selected, and the influences of the amounts of the added elements on Bs and corrosion resistance were evaluated with the quenched ribbons with varying addition
15 amounts (Experiment B). Finally, to evaluate the influences of the various elements, Bs, corrosion resistance, and amorphous properties were evaluated with the sputtered films (Experiment C).

[0038]

[Table 1]

Table 1

No.	Addition Element	TCR (%)	TAM (%)	TNM (%)	TCR/2+TAM+TNM (%)	Bs/T	Elution Amount (ppm)	Amorphous property	
1	Not added	<u>0.0</u>	11.0	0.0	<u>11.0</u>	1.43	937	Good	Comp.
2	Ge	8.0	11.0	0.0	15.0	1.02	60	Good	Present Invention Examples
3	Ru	8.0	11.0	0.0	15.0	1.17	1	Good	
4	Rh	8.0	11.0	0.0	15.0	1.25	3	Good	
5	Pd	8.0	11.0	0.0	15.0	1.31	5	Good	
6	Re	8.0	11.0	0.0	15.0	1.15	8	Good	
7	Os	8.0	11.0	0.0	15.0	1.19	4	Good	
8	Ir	8.0	11.0	0.0	15.0	1.24	0	Good	
9	Pt	8.0	11.0	0.0	15.0	1.31	0	Good	
10	Sc	<u>0.0</u>	19.0	0.0	19.0	1.03	1011	Good	Comparative Examples
11	Y	<u>0.0</u>	19.0	0.0	19.0	0.97	1149	Good	
12	La	<u>0.0</u>	19.0	0.0	19.0	0.88	1112	Good	
13	Ce	<u>0.0</u>	19.0	0.0	19.0	0.81	991	Good	
14	Pr	<u>0.0</u>	19.0	0.0	19.0	0.79	1002	Good	
15	Nd	<u>0.0</u>	19.0	0.0	19.0	0.85	923	Good	
16	Sm	<u>0.0</u>	19.0	0.0	19.0	0.85	1104	Good	
17	Gd	<u>0.0</u>	19.0	0.0	19.0	0.66	1008	Good	
18	Tb	<u>0.0</u>	19.0	0.0	19.0	0.72	1052	Good	
19	Dy	<u>0.0</u>	19.0	0.0	19.0	0.67	1093	Good	
20	Er	<u>0.0</u>	19.0	0.0	19.0	0.78	950	Good	
21	Yb	<u>0.0</u>	19.0	0.0	19.0	0.80	983	Good	
22	Ti	<u>0.0</u>	19.0	0.0	19.0	1.04	3	Good	
23	Hf	<u>0.0</u>	19.0	0.0	19.0	1.00	110	Good	
24	V	<u>0.0</u>	19.0	0.0	19.0	0.92	23	Good	
25	Nb	<u>0.0</u>	19.0	0.0	19.0	0.86	0	Good	
26	Ta	<u>0.0</u>	19.0	0.0	19.0	0.88	1	Good	
27	Mo	<u>0.0</u>	19.0	0.0	19.0	0.90	7	Good	
28	W	<u>0.0</u>	19.0	0.0	19.0	0.84	1	Good	
29	C	<u>0.0</u>	11.0	8.0	19.0	1.07	605	Good	
30	Al	<u>0.0</u>	11.0	8.0	19.0	1.07	521	Good	
31	Si	<u>0.0</u>	11.0	8.0	19.0	0.99	574	Good	
32	P	<u>0.0</u>	11.0	8.0	19.0	1.02	624	Good	
33	Cr	<u>0.0</u>	11.0	8.0	19.0	0.93	1	Good	
34	Mn	<u>0.0</u>	11.0	8.0	19.0	1.10	830	Good	
35	Ni	<u>0.0</u>	11.0	2.7	13.7	1.30	868	Good	
36	Cu	<u>0.0</u>	11.0	2.7	13.7	1.25	485	Good	
37	Zn	<u>0.0</u>	11.0	8.0	19.0	1.09	755	Good	
38	Ga	<u>0.0</u>	11.0	8.0	19.0	1.08	808	Good	
39	Sn	<u>0.0</u>	11.0	8.0	19.0	1.02	694	Good	

NOTE 1: Each Fe%/(Fe% + Co%) of the components of Table 1 is 0.50.

NOTE 2: The composition of "Not Added" is (Co₅₀Fe₅₀)₈₆-Zr₈-B₆

NOTE 3: "Comp." means comparative examples.

NOTE 4: The underlined figures fall outside the scope of the present invention.

[0039]

[Table 2]

Table 2

No.	Addition Element	Addition Amount (%)	TCR (%)	TAM (%)	TNM (%)	TCR/2+TAM+TNM (%)	Bs/T	Elution Amount (ppm)	Amorphous Property	
1	Not Added	0.0	<u>0.0</u>	12.0	8.0	20.0	1.07	866	Good	Comp. Ex.
2	Ge	0.1	0.1	12.0	8.0	20.1	1.06	350	Good	Present Invention
3	Ge	2.0	2.0	12.0	8.0	21.0	0.97	152	Good	
4	Ge	12.0	<u>12.0</u>	12.0	8.0	<u>26.0</u>	0.46	5	Good	Comp. Ex.
5	Ru	0.1	0.1	12.0	8.0	20.1	1.07	321	Good	Present Invention
6	Ru	2.0	2.0	12.0	8.0	21.0	1.01	131	Good	
7	Ru	12.0	<u>12.0</u>	12.0	8.0	<u>26.0</u>	0.68	0	Good	Comp. Ex.
8	Pt	0.1	0.1	12.0	8.0	20.1	1.07	296	Good	Present Invention Ex.
9	Pt	2.0	2.0	12.0	8.0	21.0	1.05	124	Good	
10	Pt	12.1	<u>12.0</u>	12.0	8.0	<u>26.0</u>	0.92	0	Good	Comp. Ex.
11	Ti	0.1	<u>0.0</u>	12.1	8.0	20.1	1.07	834	Good	
12	Ti	2.0	<u>0.0</u>	14.0	8.0	22.0	0.97	545	Good	
13	Ti	12.0	<u>0.0</u>	24.0	8.0	<u>32.0</u>	0.29	20	Good	
14	Hf	0.1	<u>0.0</u>	12.1	8.0	20.1	1.06	852	Good	
15	Hf	2.0	<u>0.0</u>	14.0	8.0	22.0	0.96	629	Good	
16	Hf	12.0	<u>0.0</u>	24.0	8.0	<u>32.0</u>	0.23	98	Good	
17	W	0.1	<u>0.0</u>	12.1	8.0	20.1	1.06	420	Good	
18	W	2.0	<u>0.0</u>	14.0	8.0	22.0	0.92	400	Good	
19	W	12.0	<u>0.0</u>	24.0	8.0	<u>32.0</u>	0.19	0	Good	

NOTE 1: Each Fe%/(Fe% + Co%) of the components of Table 2 is 0.65.

NOTE 2: The composition of "Not Added" is $(\text{Co}_{35}\text{Fe}_{65})_{76}\text{Ta}_8\text{-B}_8\text{-Mn}_8$.

NOTE 3: The underlined figures fall outside the scope of the present invention.

[0040]

[Table 3]

Table 3

No.	Composition (at%)			TCR (%)	TAM (%)	TNM (%)	TCR/2+ TAM+ TNM (%)	Bs/T	Elution Amount (mg/l)	Amorphous Property	
	Co	Fe	Other compositions								
1	21.5	64.5	1Rh-5Zr-7Cr-1C	1	5	8	13.5	0.95	1.5	Good	Present Invention Examples
2	65.6	16.4	5Pd-3W-5Ta-2Sc-3Cr	5	10	3	15.5	1.10	0.5	Good	
3	36.5	36.5	1Re-18V-5Nb-3Ni	1	23	1	24.5	0.96	0.4	Good	
4	53.9	23.1	70S-10Ti-5La-0.5Sn-0.5Al	7	15	1	19.5	1.09	0.9	Good	
5	26.4	49.1	0.5Ir-8Ta-15V-1Ga	0.5	23	1	24.3	0.97	0.8	Good	
6	47.4	31.6	4Re-3Ge-2V-8Hf-2P-2Si	7	10	4	17.5	1.25	0.3	Good	
7	78.0	0.0	1Ir-4Ru-10Zr-5Mo-2Zn	5	15	2	19.5	0.95	0.2	Good	
8	36.8	36.8	0.5Pt-10Zr-3Mo-10Y-3Cu	0.5	23	1	24.3	0.97	1.1	Good	Comparative Examples
9	43.5	43.5	1Rh-4Zr-7Cr-1C	1	<u>4</u>	8	<u>12.5</u>	1.70	41.2	Poor	
10	35.3	35.3	0.5Pt-10Zr-6Mo-10Y-3Cu	0.5	<u>26</u>	1	<u>27.25</u>	0.40	1.0	Good	
11	43.5	43.5	1Rh-5Zr-6Cr-1C	1	5	7	<u>12.5</u>	1.62	1.7	Good	
12	8.6	77.4	1Rh-5Zr-7Cr-1C	1	5	8	13.5	0.11	1.8	Good	
13	0.0	<u>86.0</u>	1Rh-5Zr-7Cr-1C	1	5	8	13.5	0.03	1.9	Good	
14	26.6	49.4	8Ta-15V-1Ga	<u>0</u>	23	1	24	0.98	5.4	Good	

NOTE 1: The underlined figures fall outside the scope of the present invention.

In Experiment A, the influences of the kinds of the addition elements (evaluation with a fixed addition amount) with (Co₅₀Fe₅₀)₇₈-Zr₈-B₆-M₈ (M = addition element) as a basic composition are shown in Table 1. In other words, Table 1 shows the various properties of the quenched ribbons to which the various elements were added. The composition of "Not Added" is (Co₅₀Fe₅₀)₈₆-Zr₈-B₆, and each Fe%/(Fe% + Co%) of the component of Table 1 is 0.50.

[0041]

A graph indicating the plots of the Bs values and elution amounts in Table 1 is shown in FIG. 1. FIG. 1 is the view showing the influences of the kinds of the addition elements on the Bs values and the elution amounts (Experiment A). FIG. 1 shows that among addition elements with small elution amounts and high corrosion resistance, Ru, Rh, Pd, Re, Os, Ir, and Pt can exhibit comparatively high Bs. Ge also exhibits an effect

similar to those of Ti and Hf. In contrast, V, Nb, Ta, Cr, Mo, and W exhibit great decreases in Bs although exhibiting small elution amounts. Furthermore, the other addition elements exhibit the small effects of improving corrosion resistance. The

5 addition of Ti and the addition of Hf exhibit effects equivalent to that of the addition of Ge in this Experiment A with the fixed amounts of the addition elements, whereas Ti and Hf are excluded from elements belonging to TCR because of exhibiting less effects than that of the addition of Ge in Experiment B with
10 varying addition amounts described later.

[0042]

Then, the influences of the amounts of addition elements with $(\text{Co}_{35}\text{Fe}_{65})_{(76-x)}\text{-Ta}_8\text{-B}_8\text{-Mn}_8\text{-M}_x$ ($M = \text{addition element}$) as a basic composition in Experiment B are shown in Table 2. Table 2
15 shows the various properties of quenched ribbons with the varying addition amounts of the addition elements. The composition of the material with "Not Added" is $(\text{Co}_{35}\text{Fe}_{65})_{76}\text{-Ta}_8\text{-B}_8\text{-Mn}_8$.

[0043]

20 The relationships between the addition amounts and elution amounts of the various elements in Table 2 are shown in FIG. 2. Ge, Ru, and Pt belonging to TCR exhibit the high effects of improving corrosion resistance even in the slight addition amounts thereof. In contrast, it is revealed that although Ti, Hf,
25 and W that do not belong to TCR exhibit corrosion resistance improved with increasing the addition amounts thereof, comparatively large addition amounts are required. Furthermore, plots of the Bs values and elution amounts of the results in Table 2 are shown in FIG. 3. As shown in FIG. 3, the
30 compositions with added Ge, Ru, and Pt exhibit high Bs and small elution amounts compared to the other addition elements.

[0044]

Experiments A and B described above revealed that high corrosion resistance is obtained while reducing a decrease in Bs
35 in the case of adding the elements belonging to TCR compared to the case of adding the other elements. Then, sputtering

target materials with the compositions with the added elements belonging to TCR and the compositions without the added elements in the various compositions were produced to evaluate sputtered thin films using the sputtering target materials
5 (Experiment C).

[0045]

In Experiment C, Bs, corrosion resistance, and amorphous properties were evaluated with the sputtered films to evaluate the influences of the various elements. As shown in Table 3,
10 the various properties of the sputtered films with the various compositions are shown. Nos.1 to 8 are present invention examples, while Nos. 9 to 14 are comparative examples. Comparative Example No. 9 results in too high Bs, a poor amorphous property, and poor corrosion resistance due to low
15 values of TAM and TCR/2 + TAM + TNM. Comparative Example No. 10 results in low Bs due to high values of TAM and TCR/2 + TAM + TNM.

[0046]

Comparative Example No. 11 results in too high Bs due to a low
20 value of TCR/2 + TAM + TNM. Comparative Example Nos. 12 and 13 result in low Bs due to a high Fe content. Comparative Example No. 14 is found to be poor in corrosion resistance because of containing no TCR. In contrast, all of Present Invention Example Nos. 1 to 8 are found to satisfy the
25 conditions and to be excellent in Bs and corrosion resistance.

[0047]

As described above, the present invention is to provide an excellent alloy for a soft magnetic film layer in a perpendicular magnetic recording medium that inexpensively makes it possible
30 to greatly improve particularly corrosion resistance while lowering a decrease in Bs and to provide a sputtering target material for producing a thin film of the alloy.

CLAIMS

1. An alloy for a soft magnetic film layer in a perpendicular magnetic recording medium, wherein
the alloy comprises:
one or more selected from Ge, Ru, Rh, Pd, Re, Os, Ir, and Pt;
one or more selected from Sc, Y, lanthanoids (atomic numbers 57 to 71), Ti, Zr, Hf, V, Nb, Ta, Mo, W, and B; and
the balance of Co and Fe with unavoidable impurities;
and
satisfies, in atomic%, all of the following formulae (a) to (d):
(a) $0.1\% \leq \text{TCR} \leq 10\%$;
(b) $5\% \leq \text{TAM} \leq 25\%$;
(c) $13\% \leq \text{TCR}/2 + \text{TAM} + \text{TNM} \leq 25\%$; and
(d) $0 \leq \text{Fe}\% / (\text{Fe}\% + \text{Co}\%) \leq 0.80$
[in the formulae (a) to (d)
 $\text{TCR} = \text{Ge}\% + \text{Ru}\% + \text{Rh}\% + \text{Pd}\% + \text{Re}\% + \text{Os}\% + \text{Ir}\% + \text{Pt}\%$;
 $\text{TAM} = \text{Sc}\% + \text{Y}\% + \text{total}\% \text{ of lanthanoids} + \text{Ti}\% + \text{Zr}\% + \text{Hf}\% + \text{V}\% + \text{Nb}\% + \text{Ta}\% + \text{Mo}\% + \text{W}\% + \text{B}\%/2$; and
 $\text{TNM} = \text{C}\% + \text{Al}\% + \text{Si}\% + \text{P}\% + \text{Cr}\% + \text{Mn}\% + \text{Ni}\%/3 + \text{Cu}\%/3 + \text{Zn}\% + \text{Ga}\% + \text{Sn}\%]$.
2. The alloy according to claim 1, further comprising one or more selected from C, Al, Si, P, Cr, Mn, Ni, Cu, Zn, Ga, and Sn.
3. The alloy according to claim 1, wherein
the alloy consists of:
one or more selected from Ge, Ru, Rh, Pd, Re, Os, Ir, and Pt;
one or more selected from Sc, Y, lanthanoids (atomic numbers 57 to 71), Ti, Zr, Hf, V, Nb, Ta, Mo, W, and B; and
the balance of Co and Fe with unavoidable impurities;
and

satisfies, in atomic%, all of the following formulae (a) to (d):

$$(a) 0.1\% \leq \text{TCR} \leq 10\%;$$

$$(b) 5\% \leq \text{TAM} \leq 25\%;$$

$$(c) 13\% \leq \text{TCR}/2 + \text{TAM} + \text{TNM} \leq 25\%; \text{ and}$$

$$(d) 0 \leq \text{Fe}\% / (\text{Fe}\% + \text{Co}\%) \leq 0.80$$

[in the formulae (a) to (d)

$$\text{TCR} = \text{Ge}\% + \text{Ru}\% + \text{Rh}\% + \text{Pd}\% + \text{Re}\% + \text{Os}\% + \text{Ir}\% + \text{Pt}\%;$$

$$\text{TAM} = \text{Sc}\% + \text{Y}\% + \text{total}\% \text{ of lanthanoids} + \text{Ti}\% + \text{Zr}\% + \text{Hf}\% + \text{V}\% + \text{Nb}\% + \text{Ta}\% + \text{Mo}\% + \text{W}\% + \text{B}\%/2; \text{ and}$$

$$\text{TNM} = \text{C}\% + \text{Al}\% + \text{Si}\% + \text{P}\% + \text{Cr}\% + \text{Mn}\% + \text{Ni}\%/3 + \text{Cu}\%/3 + \text{Zn}\% + \text{Ga}\% + \text{Sn}\%].$$

4. The alloy according to claim 1, wherein the alloy consists of:

one or more selected from Ge, Ru, Rh, Pd, Re, Os, Ir, and Pt;

one or more selected from Sc, Y, lanthanoids (atomic numbers 57 to 71), Ti, Zr, Hf, V, Nb, Ta, Mo, W, and B;

one or more selected from C, Al, Si, P, Cr, Mn, Ni, Cu, Zn, Ga, and Sn; and

the balance of Co and Fe with unavoidable impurities; and

satisfies, in atomic%, all of the following formulae (a) to (d):

$$(a) 0.1\% \leq \text{TCR} \leq 10\%;$$

$$(b) 5\% \leq \text{TAM} \leq 25\%;$$

$$(c) 13\% \leq \text{TCR}/2 + \text{TAM} + \text{TNM} \leq 25\%; \text{ and}$$

$$(d) 0 \leq \text{Fe}\% / (\text{Fe}\% + \text{Co}\%) \leq 0.80$$

[in the formulae (a) to (d)

$$\text{TCR} = \text{Ge}\% + \text{Ru}\% + \text{Rh}\% + \text{Pd}\% + \text{Re}\% + \text{Os}\% + \text{Ir}\% + \text{Pt}\%;$$

$$\text{TAM} = \text{Sc}\% + \text{Y}\% + \text{total}\% \text{ of lanthanoids} + \text{Ti}\% + \text{Zr}\% + \text{Hf}\% + \text{V}\% + \text{Nb}\% + \text{Ta}\% + \text{Mo}\% + \text{W}\% + \text{B}\%/2; \text{ and}$$

$$\text{TNM} = \text{C}\% + \text{Al}\% + \text{Si}\% + \text{P}\% + \text{Cr}\% + \text{Mn}\% + \text{Ni}\%/3 +$$

$\text{Cu}\% / 3 + \text{Zn}\% + \text{Ga}\% + \text{Sn}\%]$.

5. A sputtering target material comprising the alloy for a soft magnetic film layer according to any one of claims 1 to 4.