

CO-BASED ALLOY FOR SOFT MAGNETIC LAYER OF MAGNETIC RECORDING MEDIUM

BACKGROUND OF THE INVENTION

5 Field of the Invention

[0001]

The present invention relates to a soft magnetic layer of
a magnetic recording medium. More particularly, the present
invention relates to a Co-based alloy suitable for a soft magnetic
10 layer of a magnetic recording medium.

Background Art

[0002]

Having a large capacity is important for magnetic
15 recording media. To achieve a larger capacity, a higher
recording density is required.

[0003]

Media employing a longitudinal magnetic recording
system have been popular. Instead of these media, media
20 employing a perpendicular magnetic recording system (namely,
perpendicular magnetic recording media) are gaining popularity,
in recent years. In a perpendicular magnetic recording
medium, the easy axis of magnetization is oriented in the
direction perpendicular to the medium surface, in a magnetic
25 film. Perpendicular magnetic recording media are suitable for
achieving a high recording density.

[0004]

A perpendicular magnetic recording medium includes a
magnetic recording layer and a soft magnetic layer. The
30 perpendicular magnetic recording medium further includes a
seed layer, an undercoat layer, and the like, between the
magnetic recording layer and the soft magnetic layer.

[0005]

The soft magnetic layer prevents the spread of the
35 magnetic flux generated from the head during recording, to
ensure a perpendicular magnetic field. Patent Literature 1 (JP

2006-294090 A) discloses a soft magnetic layer whose material is an Fe-Co-based alloy.

[0006]

Patent Literature 2 (JP 2008-299905 A) discloses a soft
5 magnetic layer whose material is a Co-based alloy containing
amorphization-promoting elements, such as Zr, Hf, Nb and Ta.
This Co-based alloy has a high saturation magnetic flux density.
A high saturation magnetic flux density can contribute to a high
recording density.

10 [0007]

Patent Literature 3 (JP 2011-68985 A) discloses a soft
magnetic layer whose material is a Co-based alloy which
contains Y, and also contains Ta or Nb. This Co-based alloy has
a high saturation magnetic flux density. A high saturation
15 magnetic flux density can contribute to a high recording density.

[0008]

Patent Literature 4 (JP 2011-99166 A) discloses a soft
magnetic layer whose material is a Co-based alloy containing Zr,
Hf, Y, Ta, Nb and the like. This Co-based alloy has a high
20 saturation magnetic flux density. A high saturation magnetic
flux density can contribute to a high recording density.

[0009]

A high saturation magnetic flux density causes the
occurrence of "writing blur". The "writing blur" refers to a
25 phenomenon in which the magnetic influence is exerted on a
wider surrounding area than necessary, in a state where an
alloy is magnetized by the writing head. In a magnetic
recording medium in which the "writing blur" occurs, a large
space is required for writing per unit recording information.
30 The "writing blur" interferes with achieving a high recording
density in the magnetic recording medium.

[0010]

A soft magnetic layer in which the saturation magnetic
flux density is controlled has been proposed, from the viewpoint
35 of reducing the occurrence of the "writing blur". Patent
Literature 5 (JP 2015-144032 A) discloses a soft magnetic layer

having a saturation magnetic flux density of from 0.5 T to 1.1 T. Patent Literature 6 (JP 2016-84538 A) discloses a soft magnetic layer having a saturation magnetic flux density of from 0.34 T to 1.18 T.

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Citation List

Patent Literature

[0011]

Patent Literature 1: JP 2006-294090 A

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Patent Literature 2: JP 2008-299905 A

Patent Literature 3: JP 2011-68985 A

Patent Literature 4: JP 2011-99166 A

Patent Literature 5: JP 2015-144032 A

Patent Literature 6: JP 2016-84538 A

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SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0012]

As described above, it has been aimed at obtaining a soft magnetic layer having a low saturation magnetic flux density, in recent years, from the viewpoint of reducing the occurrence of the "writing blur". In order to reduce the saturation magnetic flux density, it is effective to add an element(s) to an alloy. However, the element(s) added to the alloy can form intermetallic compounds with Fe and Co. A target containing such intermetallic compounds is brittle, and susceptible to cracking during sputtering.

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[0013]

An object of the present invention is to provide a Co-based alloy which enables to obtain a target having an excellent toughness, and to obtain a soft magnetic layer having a low saturation magnetic flux density.

30

Solution to Problem

35 [0014]

One aspect of the present invention provides a Co-based

alloy for a soft magnetic layer of a magnetic recording medium. The Co-based alloy for a soft magnetic layer of a magnetic recording medium, according to the present invention, contains: 11 at% or more and 25 at% or less of one or two or more elements XA selected from the group consisting of Nb, Mo, Ta and W; and 0.4 at% or more and 10 at% or less of one or two or more elements XB selected from the group consisting of V, Cr, Mn, Ni, Cu and Zn. In this alloy, the balance is Co, Fe and unavoidable impurities, and the total content of the one or two or more elements XA and the one or two or more elements XB is less than 30 at%.

[0015]

Another aspect of the present invention provides a sputtering target for a soft magnetic layer of a magnetic recording medium. The sputtering target for a soft magnetic layer of a magnetic recording medium, according to the present invention, is made of a material composed of the Co-based alloy according to the present invention. In other words, the material of the sputtering target for a soft magnetic layer of a magnetic recording medium according to the present invention is a Co-based alloy, and this Co-based alloy contains: 11 at% or more and 25 at% or less of one or two or more elements XA selected from the group consisting of Nb, Mo, Ta and W; and 0.4 at% or more and 10 at% or less of one or two or more elements XB selected from the group consisting of V, Cr, Mn, Ni, Cu and Zn. In this alloy, the balance is Co, Fe and unavoidable impurities, and the total content of the one or two or more elements XA and the one or two or more elements XB is less than 30 at%.

[0016]

Still another aspect of the present invention provides a magnetic recording medium. The magnetic recording medium according to the present invention includes a soft magnetic layer, and this soft magnetic layer contains the Co-based alloy according to the present invention. The soft magnetic layer included in the magnetic recording medium according to the

present invention is obtained by sputtering using a target whose material is a Co-based alloy, and this Co-based alloy contains: 11 at% or more and 25 at% or less of one or two or more elements XA selected from the group consisting of Nb, Mo, Ta and W; and 0.4 at% or more and 10 at% or less of one or two or more elements XB selected from the group consisting of V, Cr, Mn, Ni, Cu and Zn. In this alloy, the balance is Co, Fe and unavoidable impurities, and the total content of the one or two or more elements XA and the one or two or more elements XB is less than 30 at%.

Advantageous Effects of the Invention

[0017]

A target having an excellent crack resistance can be obtained from the Co-based alloy according to the present invention. Further, a magnetic recording medium which is less susceptible to the occurrence of "writing blur" can be obtained from the Co-based alloy according to the present invention.

20 DETAILED DESCRIPTION OF THE INVENTION

[0018]

The present invention will now be described in specific detail, based on preferred embodiments.

[0019]

25 [Alloy]

The Co-based alloy for a soft magnetic layer of a magnetic recording medium, according to the present invention, is suitable for a sputtering target. The Co-based alloy has the following composition:

30 Element(s) XA: 11 at% or more and 25 at% or less;
 Element(s) XB: 0.4 at% or more and 10 at% or less; and
 Balance: Co, Fe and unavoidable impurities.

[0020]

[Base Elements]

35 The base elements of the Co-based alloy are Fe and Co. A soft magnetic layer containing Fe and Co provides a sufficient

magnetism. Such a soft magnetic layer serves to stabilize the magnetization of the magnetic recording layer. The ratio of the content (at%) of Fe and the content (at%) of Co is preferably from 10:90 to 90:10. The saturation magnetic flux density can be reduced in a soft magnetic layer composed of an alloy in which the above ratio is 10:90 or more. From this point of view, the ratio is particularly preferably 20:80 or more. A soft magnetic layer composed of an alloy in which the above ratio is 90:10 or less can contribute to a high recording density in the resulting magnetic recording medium. From this point of view, the ratio is particularly preferably 80:20 or less.

[0021]

[Element(s) XA]

The element(s) XA is/are selected from the group A consisting of Nb, Mo, Ta and W. As the element XA, one kind of element may be selected from the group A, or as the elements XA, two or more kinds of elements may be selected from the group A. The element(s) XA can contribute to the amorphousness of the soft magnetic layer. The element(s) XA can further contribute to a reduction in the saturation magnetic flux density. From these points of view, the content of the element(s) XA in the Co-based alloy is preferably 11 at% or more, more preferably 13 at% or more, and particularly preferably 15 at% or more. The element(s) XA forms/form an intermetallic compound with Fe or Co. Such an intermetallic compound is brittle. A target obtained from an alloy containing such an intermetallic compound is susceptible to cracking during sputtering. From the viewpoint of improving the crack resistance of the target, the content of the element(s) XA is preferably 25 at% or less, more preferably 23 at% or less, and particularly preferably 21 at% or less. In cases where two or more kinds of elements are selected from the group A, the "content of the element(s) XA" refers to the total content of the two or more kinds of elements.

[0022]

[Element(s) XB]

The element(s) XB is/are selected from the group B consisting of V, Cr, Mn, Ni, Cu and Zn. As the elements XB, one kind of element may be selected from the group B, or as the elements XB, two or more kinds of elements may be selected from the group B. The element(s) XB can reduce the saturation magnetic flux density. The element(s) XB is/are an element(s) of Group IV of the periodic table. Fe and Co, as the base elements, are also elements of Group IV of the periodic table. Accordingly, the addition of the element(s) XB hardly causes the formation of an intermetallic compound of Fe and the element(s) XB, and hardly causes the formation of an intermetallic compound of Co and the element(s) XB, as well. The element(s) XB is/are less likely to cause the embrittlement of the target. The addition of the element(s) XB allows for both achieving a low saturation magnetic flux density, and obtaining a high-strength target.

[0023]

The content of the element(s) XB in the Co-based alloy is preferably 0.4 at% or more, more preferably 1 at% or more, and particularly preferably 3 at% or more, because such a content enables to reduce the saturation magnetic flux density. Further, the content of the element(s) XB is preferably 10 at% or less, because it does not cause an excessively low saturation magnetic flux density. In cases where two or more kinds of elements are selected from the group B, the "content of the element(s) XB" refers to the total content of the two or more kinds of elements.

[0024]

[Total Content of Element(s) XA and Element(s) XB]

The total content of the element(s) XA and the element(s) XB is preferably less than 30 at%, more preferably 28 at% or less, and particularly preferably 26 at% or less, because it does not cause an excessively low saturation magnetic flux density.

[0025]

[Production of Magnetic Recording Medium]

A powder composed of the alloy according to the present invention can be obtained by atomization. A preferred method of atomization is gas atomization. The above mentioned powder is subjected to classification (for example, extraction of particles having a particle size of 500 μm or less) as necessary. The classified powder is filled into a can made of carbon steel. The can is then vacuum degassed, and sealed to obtain a billet. The resulting billet is subjected to HIP formation (hot isostatic pressing). In the HIP formation, a preferred pressure is 50 MPa or more and 300 MPa or less, and a preferred sintering temperature is 800°C or higher and 1,350°C or lower. The HIP formation gives a formed product. The resulting formed product is processed to obtain a target. The target is then subjected to sputtering, to obtain a soft magnetic layer containing the same components as the components of the target. The thus obtained soft magnetic layer is incorporated into the magnetic recording medium.

EXAMPLES

[0026]

The effects of the present invention will now be clarified by way of Examples. However, the present invention should not be construed as limited to the descriptions in the Examples.

[0027]

As described above, the soft magnetic layer is formed by performing sputtering on a target containing the same components as the components of the soft magnetic layer. The soft magnetic layer is obtained by rapid cooling and solidification. Since the formation of the soft magnetic layer requires a lot of work, a test piece obtained by a single roll method is used in the following evaluation. The single roll method includes a rapid cooling and solidification step, as with sputtering. The use of the single roll method enables a simple evaluation of a soft magnetic layer which will be obtained by sputtering.

[0028]

[Amorphousness]

In each of Examples and Comparative Examples, 30 g of the raw material which had been weighed so as to achieve the composition shown in the following Table 1 or 2, was introduced
 5 into a water-cooling copper mold having a diameter of 10 mm and a length of 40 mm. The pressure in the mold was reduced, and the material was subjected to arc-melting in an argon gas atmosphere, to obtain a molten base material. The resulting
 10 base material was introduced into a quartz pipe having a diameter of 15 mm, tapped from a nozzle, and subjected to the single roll method to obtain a test piece. The conditions for the single roll method are as follows.

Diameter of tapping nozzle: 1 mm
 Air pressure of atmosphere: 61 kPa
 15 Spray differential pressure: 69 kPa
 Roll material: copper
 Roll diameter: 300 mm
 Rotational speed of roll: 3,000 rpm
 Gap between roll and tapping nozzle: 0.3 mm
 20 The balance of each alloy shown in each Table is unavoidable impurities.

[0029]

Each test piece was pasted on a glass plate with a double-sided adhesive tape, such that the surface to be
 25 measured was the surface in contact with the copper roll. An X-ray diffraction apparatus was used to obtain the diffraction pattern of the test piece. Diffraction conditions are as follows.

X-ray source: Cu-K α ray
 Scanning speed: 4°/min
 30 In the X-ray diffraction pattern of an amorphous material, no diffraction peak is observed, and a specific halo pattern is observed. In the X-ray diffraction pattern of an imperfect amorphous material, although diffraction peaks are observed, the heights of the peaks are lower as compared to the peaks in
 35 a crystal material, and a halo pattern is also observed. Therefore, grading was carried out in accordance with the

following criteria. The results of the grading are shown in the following Tables 1 and 2.

A: a halo pattern is observed

C: a halo pattern is not observed

5 [0030]

[Saturation Magnetic Flux Density]

In each of Examples and Comparative Examples, a test piece was obtained in the same manner as the method described in the evaluation of amorphousness mentioned above.

10 The saturation magnetic flux density of the test piece was measured by a vibrating sample magnetometer (VSM). Measurement conditions are as follows.

Applied magnetic field: 1,200 kA/m

Mass of test piece: about 15 mg

15 Grading was carried out in accordance with the following criteria. The results of the grading are shown in the following Tables 1 and 2.

A: 0.3 T or more and less than 1.0 T

B: 1.0 T or more and 1.3 T or less

20 C: less than 0.3 T or more than 1.3 T.

[0031]

[Crack Resistance]

In each of Examples and Comparative Examples, 30 g of the raw material which had been weighed so as to achieve the composition shown in the following Table 1 or 2, was introduced into a water-cooling copper mold having a diameter of 40 mm and a length of 50 mm. The pressure in the mold was reduced, and the material was subjected to arc-melting in an argon gas atmosphere, to obtain a molten base material. The resulting molten base material was tapped from a nozzle having a diameter of 8 mm. Immediately thereafter, a high-pressure Ar gas was sprayed to the molten base material, to obtain a powder. The resulting powder was classified to extract particles of 500 μm or less. The classified powder was filled into a can made of carbon steel. The can was then subjected to vacuum degassing, and sealed to obtain a billet. The resulting billet

was subjected to HIP formation (hot isostatic pressing). The conditions for the HIP formation are as follows.

Temperature: 1,000°C

Pressure: 120 MPa

5 Retention time: 2 hours

From the resulting formed product, a test piece having a length of 20 mm, a width of 1.8 mm and a height of 1.8 mm was obtained. The thus obtained test piece was subjected to a three-point bending test. The bending strength was calculated
10 from the load at which the test piece had ruptured or bent. Based on the bending strength, grading was carried out in accordance with the following criteria. The results of the grading are shown in the following Tables 1 and 2.

A: the bending strength is 600 MPa or more

15 B: the bending strength is 450 MPa or more and less than 600 MPa

C: the bending strength is less than 450 MPa

Table 1: Evaluation results

Component composition (at%)														
Fe:Co	Group A				Total of Group A	Group B					Total of Group B	A + B		
	Nb	Mo	Ta	W		V	Cr	Mn	Ni	Cu			Zn	
Example 1	70:30		9	9	18	0.4						0.4	18.4	
Example 2	70:30		9	9	18	1						1	19	
Example 3	70:30		9	9	18	3						3	21	
Example 4	70:30		9	9	18	5						5	23	
Example 5	70:30		9	9	18	10						10	28	
Example 6	70:30	18			18	5						5	23	
Example 7	70:30		18		18		5					5	23	
Example 8	70:30			18	18			5				5	23	
Example 9	70:30				18				5			5	23	
Example 10	70:30	18			18					5		5	23	
Example 11	70:30		18		18						5	5	23	
Example 12	70:30			18	18	1	1	1	1	1	1	6	24	
Example 13	70:30				18	1	1	1				2	20	
Example 14	70:30	18			18		1	2				3	21	
Example 15	70:30		18		18			2	2			4	22	
Example 16	70:30			18	18					3	2	5	23	
Example 17	70:30				18						5	1	24	
Example 18	70:30	18			18	5						2	25	
Example 19	70:30		18		18	4		4				8	26	
Example 20	70:30			18	18		4		5			9	27	
Example 21	70:30				18	18			5		5	10	28	

Table 1 (continued): Evaluation results

	Amorphous- ness	Saturation magnetic flux density	Bending strength
Example 1	A	B	A
Example 2	A	B	A
Example 3	A	A	A
Example 4	A	A	A
Example 5	A	A	A
Example 6	A	A	A
Example 7	A	A	A
Example 8	A	A	A
Example 9	A	A	A
Example 10	A	A	A
Example 11	A	A	A
Example 12	A	A	A
Example 13	A	B	A
Example 14	A	A	A
Example 15	A	A	A
Example 16	A	A	A
Example 17	A	A	A
Example 18	A	A	A
Example 19	A	A	A
Example 20	A	A	A
Example 21	A	A	A

[0033]

Table 2: Evaluation results

	Component composition (at%)																
	Fe:Co	Group A				Total of Group A				Group B					Total of Group B		A + B
		Nb	Mo	Ta	W					V	Cr	Mn	Ni	Cu	Zn		
Example 22	70:30			11					11		4					4	15
Example 23	70:30			15					15		4					4	19
Example 24	70:30			20					20		4					4	24
Example 25	70:30			25					25		4					4	29
Example 26	70:30	5	5	5	5				20		4					4	24
Example 27	70:30	6			6				12		4					4	16
Example 28	70:30		7	8					15		4					4	19
Example 29	70:30	9	9						18		4					4	22
Example 30	70:30			10	11				21		4					4	25
Example 31	70:30		8		15				23		4					4	27
Example 32	70:30	12			12				24		4					4	28
Example 33	95:5	9	9						18			5				5	23
Example 34	90:10	9	9						18			5				5	23
Example 35	80:20	9	9						18			5				5	23
Example 36	60:40	9	9						18			5				5	23
Example 37	50:50	9	9						18			5				5	23
Example 38	30:70	9	9						18			5				5	23
Example 39	20:80	9	9						18			5				5	23
Example 40	10:90	9	9						18			5				5	23
Example 41	5:95	9	9						18			5				5	23
Comparative Example 1	70:30	10			11				21	10						10	31
Comparative Example 2	70:30			25					25		8					8	33
Comparative Example 3	70:30			5					5		4					4	9
Comparative Example 4	70:30			28					28		1					1	29
Comparative Example 5	70:30		10		5				15					0.1		0.1	15.1
Comparative Example 6	70:30			21					21							0	21
Comparative Example 7	70:30		10		12				22							0	22

Table 2 (continued): Evaluation results

	Amorphous- ness	Saturation magnetic flux density	Bending strength
Example 22	A	B	A
Example 23	A	A	A
Example 24	A	A	A
Example 25	A	A	B
Example 26	A	A	A
Example 27	A	B	A
Example 28	A	A	A
Example 29	A	A	A
Example 30	A	A	A
Example 31	A	A	B
Example 32	A	A	B
Example 33	A	A	A
Example 34	A	A	A
Example 35	A	A	A
Example 36	A	A	A
Example 37	A	A	A
Example 38	A	A	A
Example 39	A	A	A
Example 40	A	A	A
Example 41	A	A	A
Comparative Example 1	A	C	C
Comparative Example 2	A	C	C
Comparative Example 3	C	C	A
Comparative Example 4	A	C	C
Comparative Example 5	A	C	A
Comparative Example 6	A	B	B
Comparative Example 7	A	B	B

[0034]

As shown in Tables 1 and 2, soft magnetic layers excellent in various performances can be obtained from the Co-based alloys according to the present invention. The
5 advantages of the present invention are obvious from these evaluation results.

Industrial Applicability

[0035]

10 The Co-based alloys described above are suitable for soft magnetic layers of various types of magnetic recording media.

CLAIMS

1. A Co-based alloy for a soft magnetic layer of a magnetic recording medium, the alloy consisting of:
 - 5 11 at% or more and 25 at% or less of one or two or more elements XA selected from the group consisting of Nb, Mo, Ta and W;
 - 0.4 at% or more and 10 at% or less of one or two or more elements XB selected from the group consisting of V, Cr,
 - 10 Mn, Ni, Cu and Zn; and
 - the balance being Co, Fe and unavoidable impurities,
 - wherein the total content of the one or two or more elements XA and the one or two or more elements XB is less than 30 at%.
- 15 2. A sputtering target for a soft magnetic layer of a magnetic recording medium, wherein the sputtering target is composed of the Co-based alloy according to claim 1.
- 20 3. A magnetic recording medium comprising a soft magnetic layer,
 - wherein the soft magnetic layer comprises the Co-based alloy according to claim 1.