

NI-BASED TARGET MATERIAL EXCELLENT IN SPUTTERING PROPERTY

BACKGROUND OF THE INVENTION

5 Field of the Invention

[0001]

The present invention relates to a Ni-based alloy
sputtering target material that is capable of obtaining a strong
pass-through-flux and has a low magnetic permeability and a
10 high use efficiency.

Background Art

[0002]

In recent years, there have been remarkable progresses
15 in perpendicular magnetic recording, heightening of recording
densities in magnetic recording media has been proceeding due
to increasing drive capacities, and perpendicular magnetic
recording system capable of achieving a further high recording
density due to a longitudinal magnetic recording medium
20 conventionally used has been put into practical use.
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
25 density.

[0003]

For perpendicular magnetic recording system, a recording
medium having a magnetic recording film phase with an
increased recording density and a soft magnetic film phase has
30 been developed. For such a medium structure, a recording
medium including a seed layer and an undercoat film layer
formed between a soft magnetic layer and a magnetic recording
layer has been developed. A NiW-based alloy has been
commonly used in a seed layer for the perpendicular magnetic
35 recording system.

[0004]

On the other hand, a method for imparting magnetism to a seed layer has been proposed as a technique for improving the magnetic recording properties of a hard disk drive. For example, a seed layer imparted with magnetism by adding Fe and Co which are VIII group elements having magnetism has been proposed as disclosed in Japanese Patent Laid-Open Publication No. 2012-128933 (Patent Literature 1).

Citation List

[0005]

Patent Literature

[PTL 1] Japanese Patent Laid-Open Publication No. 2012-128933

[PTL 2] Japanese Patent Laid-Open Publication No. 2010-59540

SUMMARY OF THE INVENTION

Technical Problem

[0006]

A magnetron sputtering method has been commonly used for forming the seed layer described above. The magnetron sputtering method is a sputtering method that enables high-speed film formation by placing a magnet behind the target material, leaking a magnetic flux on a surface of the target material, and converging plasma in its pass-through-flux region. Since the magnetron sputtering method is characterized in that the magnetic flux is leaked on the sputtering surface of the target material, it is difficult to form a pass-through-flux necessary and sufficient for the magnetron sputtering method on the sputtering surface of the target material when the magnetic permeability of the target material itself is high. Thus, it is necessary to minimize the magnetic permeability of the target material itself. However, there is a problem in that the target material described above has a low pass-through-flux and poor sputtering properties because of having a high magnetic permeability.

[0007]

On the other hand, a method for decreasing a magnetic

permeability using a pure Co powder as a raw material in a pure Co sputtering target material, as described in Japanese Patent Laid-Open Publication No. 2010-59540 (Patent Literature 2), is taken as an example of a technique for reducing a magnetic permeability. However, the method of Patent Literature 2 can be adapted only to a Co-Fe-based alloy target material for a soft magnetic phase but is unable to be applied to a Ni-based alloy target material for a seed layer and the like. Further, an alloy is used in an Fe source, and a powder sintering method using a pure Fe powder is not examined.

[0008]

Thus, as a result of examining a method for producing a Ni-Co-Fe-based alloy target material for a seed layer using a Ni-M-based alloy powder, a pure Fe powder, and a pure Co powder as raw powders, the present inventor found a Ni-Co-Fe-based alloy target material capable of obtaining a strong pass-through-flux.

Solution to Problem

[0009]

The present invention encompasses the following inventions:

(1) A Ni-based sputtering target material, comprising a $(\text{Ni}_X\text{-Fe}_Y\text{-Co}_Z)\text{-M}$ alloy, wherein:

X represents the ratio of the content of Ni to the total content of Ni, Fe, and Co, Y represents the ratio of the content of Fe to the total content of Ni, Fe, and Co, and Z represents the ratio of the content of Co to the total content of Ni, Fe, and Co;

the alloy comprises

as M elements, 2 to 20 at.% in total of one or more M1 elements selected from W, Mo, Ta, Cr, V, and Nb, and 0 to 10 at.% in total of one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru, and

the balance of Ni, Fe, Co and unavoidable impurities;

assuming that $X + Y + Z = 100$ is satisfied, $20 \leq X \leq 98$, $0 \leq Y \leq 50$, and $0 \leq Z \leq 60$ are satisfied; and

the alloy comprises a microstructure that contains a Ni-M phase as a matrix phase, wherein an Fe phase and/or a Co phase are dispersed in the matrix phase.

[0010]

5 (2) The Ni-based sputtering target material according to the above (1), wherein the alloy comprises 1.5 at.% or more in total of Fe and Co.

(3) The Ni-based sputtering target material according to the above (1) or (2), wherein the alloy comprises, as M elements,
10 more than 0 to 10 at.% in total of one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru.

[0011]

(4) The Ni-based sputtering target material according to any
15 one of the above (1) to (3), wherein the Ni-based sputtering target material comprises Co with an fcc or hcp phase.

(5) The Ni-based sputtering target material according to any one of the above (1) to (3), wherein the Ni-based sputtering target material comprises Fe with an fcc or bcc phase.

20 (6) The Ni-based sputtering target material according to any one of the above (1) to (3), wherein the Ni-based sputtering target material has a pass-through-flux of 10% or more.

Advantageous Effects of Invention

25 [0012]

In accordance with the present invention, a Ni-Fe-Co-M-based alloy sputtering target material capable of efficiently performing magnetron sputtering can be provided and becomes a technology that is very effective at producing an
30 industrial product requiring a Ni-Fe-Co-based alloy seed layer, such as a perpendicular magnetic recording medium.

DETAILED DESCRIPTION OF THE INVENTION

[0013]

35 The present invention will be described in detail below.

The present invention relates to a Ni-based sputtering

target material, comprising a $(\text{Ni}_X\text{-Fe}_Y\text{-Co}_Z)\text{-M}$ alloy, wherein:

X represents the ratio of the content of Ni to the total content of Ni, Fe, and Co, Y represents the ratio of the content of Fe to the total content of Ni, Fe, and Co, and Z represents the ratio of the content of Co to the total content of Ni, Fe, and Co;

the $(\text{Ni}_X\text{-Fe}_Y\text{-Co}_Z)\text{-M}$ alloy (hereinafter may be referred to as "Ni-Fe-Co-M alloy") comprises

as M elements, 2 to 20 at.% in total of one or more M1 elements selected from W, Mo, Ta, Cr, V, and Nb, and 0 to 10 at.% in total of one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru; and

the balance of Ni, Fe, Co and unavoidable impurities, assuming that $X + Y + Z = 100$ is satisfied, $20 \leq X \leq 98$, $0 \leq Y \leq 50$, and $0 \leq Z \leq 60$ are satisfied; and

the $(\text{Ni}_X\text{-Fe}_Y\text{-Co}_Z)\text{-M}$ alloy comprises a microstructure which contains a Ni-M phase as a matrix phase, wherein an Fe phase and/or a Co phase are dispersed in the matrix phase.

The Ni-based sputtering target material of the present invention is preferably a sputtering target material for a seed layer.

[0014]

The most important feature of the present invention is in that Fe and/or Co with magnetism are allowed to separately coexist in a Ni-based alloy with weak magnetism or without magnetism by using a Ni-M-based alloy powder, a pure Fe powder, and a pure Co powder as raw powders, and mixing and molding the powders in a sputtering target material (preferably, a sputtering target material for a seed layer).

[0015]

In the Ni-based sputtering target material of the present invention, the Ni-Fe-Co-M alloy comprises, as M elements, 2 to 20 at.% in total of one or more M1 elements selected from W, Mo, Ta, Cr, V, and Nb. The M1 elements are bcc-based metals having high melting points, and are elements that improve orientation to a (111) plane demanded in a seed layer, although the mechanism of the improvement is unclear, and that cause

crystal grains to be finer, by adding the elements to a Ni-Fe-Co system which is fcc in a constituent range defined in the present invention. The total content of the one or more M1 elements selected from W, Mo, Ta, Cr, V, and Nb is set at, in at.% amount, 2 to 20%. A total content of less than 2 at.% of the M1 elements causes the effect to be insufficient, while a total content of more than 20 at.% of the M1 elements causes a compound to be precipitated or to be amorphous. Since it is demanded that the alloy for a seed layer has an fcc single phase, the range of the total content of the M1 elements is set to 2 to 20 at.%, and preferably to 5 to 15 at.%.

[0016]

In the Ni-based sputtering target material of the present invention, the Ni-Fe-Co-M alloy comprises Ni, Fe, and Co. X is 98 to 20 (i.e., $20 \leq X \leq 98$), Y is 0 to 50 (i.e., $0 \leq Y \leq 50$), and Z is 0 to 60 (i.e., $0 \leq Z \leq 60$) on the assumption that the ratios (at. ratio) of the content (at.%) of Ni, the content (at.%) of Fe, and the content (at.%) of Co to the total content (at.%) of Ni, Fe and Co are X, Y, and Z, respectively (i.e., Ni: Fe: Co = X: Y: Z), and $X + Y + Z = 100$ is satisfied.

[0017]

The ratio X of the content of Ni to the total content of Ni, Fe, and Co is 98 to 20 on the assumption that $X + Y + Z = 100$ is satisfied. The reason that X is set at 98 or less is because coercive force becomes higher when $Y + Z$ is less than 2.0. The reason that X is set at 20 or more is because coercive force becomes higher when X is less than 20. Accordingly, the range thereof is set to 98 to 20, and preferably to 98 to 60.

[0018]

The ratio Y of the content of Fe to the total content of Ni, Fe, and Co is 0 to 50 on the assumption that $X + Y + Z = 100$ is satisfied. Fe is an element that reduces coercive force and that improves the orientation of a film. Since a Y value of more than 50 results in high coercive force, the range thereof is set to 0 to 50, preferably to 2 to 50, and more preferably to 10 to 40.

[0019]

Assuming that $X + Y + Z = 100$ is satisfied, the ratio Z of the content of Co to the total content of Ni, Fe, and Co is 0 to 60. Co is an element that reduces coercive force in a (111) direction. Since a Z value of more than 60 results in high coercive force, the upper limit thereof is set at 60, and preferably at 40 or less.

[0020]

In the Ni-based sputtering target material of the present invention, the Ni-Fe-Co-M alloy comprises a microstructure which contains a Ni-M phase as a matrix phase and in which an Fe phase and/or a Co phase are dispersed in the matrix phase. The microstructure can be identified using X-ray diffraction, an optical microscope, or the like. The magnetism of a base material can be reduced to decrease a magnetic permeability by dispersing the Fe phase and/or the Co phase with magnetism in the Ni-M phase with weak magnetism or without magnetism. The decrease in the magnetic permeability enables a strong pass-through-flux to be obtained and sputtering properties to be improved. Sufficient magnetism can be imparted to a Ni-based intermediate layer when the total amount of Fe and Co is 1.5 at.% or more in the Ni-Fe-Co-M alloy. Accordingly, it is preferable to set the total content of Fe and Co at 1.5 at.% or more.

[0021]

In the Ni-based sputtering target material of the present invention, the Ni-Fe-Co-M alloy comprises, as M elements, 0 to 10 at.% in total of one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru. Although the M2 elements are optional components, the M2 elements are elements that orient a (111) plane and cause crystal grains to be finer, and therefore, it is preferable that the Ni-Fe-Co-M alloy comprises one or more of the M2 elements. Since a total content of more than 10 at.% of the M2 elements causes a compound to be produced or to be amorphous, the upper limit thereof is set at 10 at.%, and preferably at 5 at.%. In addition,

the total content of M1 + M2 is preferably set at 25 at.% or less, and still more preferably at 20 at.% or less.

[0022]

Co singly exists in an fcc or hcp phase rather than alloys with a Ni-M-based alloy which is a matrix phase in the Ni-Fe-Co-M alloy, and the Ni-Fe-Co-M alloy thus becomes a target material having a low magnetic permeability and excellent sputtering properties. Fe singly exists in an fcc or bcc phase rather than alloys with the Ni-M-based alloy which is the matrix phase in the Ni-Fe-Co-M alloy, and the Ni-Fe-Co-M alloy thus becomes a target material having a low magnetic permeability and excellent sputtering properties. A pass-through-flux of 10% or more can be obtained by allowing Fe and/or Co with magnetism to separately coexist in the Ni-M-based alloy with weak magnetism or without magnetism in the Ni-Fe-Co-M alloy, whereby the Ni-Fe-Co-M alloy becomes a target material having excellent sputtering properties.

[0023]

The present inventor found that a Ni-based target having a low magnetic permeability and excellent sputtering properties can be produced by mixing a powder obtained by rapid solidification treatment of a Ni-M alloy molten metal with a pure Fe powder and/or a pure Co powder at a predetermined composition ratio in a sputtering target material comprising a Ni-Fe-Co-M alloy, and molding and machining the mixture. The Ni-based sputtering target material of the present invention is based on such findings of the present inventor.

[0024]

Pure Fe and/or pure Co powders can be used when the Ni-based sputtering target material of the present invention is produced. It is preferable that pure Co forms an fcc or hcp structure, and it is preferable that pure Fe forms an fcc or bcc structure. Accordingly, the existence of pure Co with an fcc or hcp phase and/or pure Fe with an fcc or bcc phase in the target material produced by using the Ni-M-based alloy powder, the pure Fe powder, and the pure Co powder and mixing the

powders according to the present invention can be clearly observed by X-ray diffraction. In contrast, it is found that these peaks are not observed in alloyed Fe and/or Co.

[0025]

5 The produced alloy powder is preferably a powder classified into 500 μm or less. A gas atomization method, a water atomization method, a rotation disk type atomization method, and the like can be applied to the production of the powder. A method of arranging a permanent magnet on the
10 back surface of the target material and measuring a magnetic flux leaking to the surface of the target material can be used in the measurement of the pass-through-flux (hereinafter referred to as "PTF") of the produced target material. The method enables a pass-through-flux in a state near to that of a
15 magnetron sputtering device to be quantitatively measured. The actual measurement is performed based on ASTM F2806-01 (Standard Test Method for Pass Through Flux of Circular Magnetic Sputtering Targets Method 2) to determine PTF according to the following equation:

20 $(\text{PTF}) = 100 \times (\text{magnetic flux in state in which target material is placed}) / (\text{magnetic flux in state in which target material is not placed}) (\%)$.

EXAMPLES

25 [0026]

Further, the present invention will be specifically described with reference to Examples.

A pure Fe powder, a pure Co powder, and a Ni-M-based alloy powder were produced as raw powders by a gas
30 atomization method. The gas atomization method was performed on the conditions of argon gas as the kind of gas, a nozzle diameter of 6 mm, and a gas pressure of 5 MPa.

[0027]

Each of powders for mixture which was the pure Fe
35 powder and the pure Co powder as well as the Ni-M-based alloy powder was filled into a sealing can comprising an SC material,

and encapsulated under degassing vacuum at an ultimate vacuum of 10^{-1} Pa or more, a molded body was then produced by a pressure sintering method on the conditions of a temperature of 1100 K, 147 MPa, and a retention time of 5 hours or on the conditions of a temperature of 950 K, 147 MPa, and a retention time of 5 hours, and a target material having a final shape having an outer diameter of 180 mm and a thickness of 7 mm was then obtained by machining. The mixed powder obtained by stirring the pure Fe powder, the pure Co powder, and the Ni-M-based alloy powder by a V type mixer for 1 hour was used. Hot press, hot isostatic pressing, electric-current pressure sintering, hot extrusion, or the like can be applied as a method for pressure sintering of the mixed powder.

[0028]

The measurement and evaluation of the properties of the obtained target material will be described.

[Magnetic Permeability]

In the measurement of the magnetic permeability of the produced target material, a ring specimen having an outer diameter of 15 mm, an inner diameter of 10 mm, and a height of 5 mm was produced, and a BH tracer was used to measure the maximum permeability of the ring specimen in an applied magnetic field of 8 kA/m. A ring specimen having a maximum permeability of 1000 or less was evaluated as "good", and a ring specimen having a maximum permeability of more than 1000 was evaluated as "poor".

[0029]

[PTF]

In the measurement of the PTF of the produced target material, a permanent magnet was arranged on the back surface of the target material, and a magnetic flux leaking to the surface of the target material was measured. The PTFs of the target materials of Comparative Examples were 10% or less, while each of the target materials of Examples of the present invention shows a PTF of 10% or more.

[0030]

[Fe phase and Co phase]

In the observation of the Co phase and/or Fe phase of the produced target material, a specimen having a width of 10 mm, a length of 20 mm, and a thickness of 5 mm was produced, and the diffraction pattern of the specimen was obtained by an X-ray diffractometer. The X source was Cu- α ray, and the measurement was conducted at a scan speed of 4°/min. Peaks caused by a Co phase with fcc or hcp and/or an Fe phase with fcc or bcc as well as main peaks were observed in the XRD patterns of the target materials of Examples. A specimen in which a Co phase with fcc or hcp and/or an Fe phase with fcc or bcc were observed by XRD was evaluated as "good", and a specimen in which the observation thereof was not performed was evaluated as "poor".

[0031]

[Component Segregation]

In the measurement of the component distribution of the produced target material, a specimen having a width of 10 mm, a length of 20 mm, and a thickness of 5 mm was produced, and the distribution of each main component was observed by an EPMA (electron probe microanalyzer). It was observed that Fe and Co homogeneously existed in the target materials of Comparative Examples while an imbalance in the distribution of Fe and Co components occurred in the target materials of Examples, and the single phases of Fe and Co coexisted in the state of being separated in a Ni-M system. A specimen in which an imbalance in the distribution of Fe and Co components was shown by the EPMA was evaluated as "good", and a specimen in which Fe and Co homogeneously existed was evaluated as "poor."

[0032]

[Table 1]

Table 1

No.	Target Material Composition (at.%)						Composition of Raw Powder	Property Evaluation				Remarks	
	Ni:Fe:Co Ratio		M1+M2	M1	M2	Maximum Permeability		PTF (%)	Fe Phase (XRD)	Co Phase (XRD)	Component Segregation (EPMA)		
	X	Y	Z	W	Element: Addition Amount								
1	60	30	10	6	W:5	Al:1	Pure Fe, Pure Co, Ni-M1-M2 alloy	Good	19	Good	Good	Good	Present Invention Examples
2	50	30	20	6	W:5	Al:1	Pure Fe, Pure Co, Ni-M1-M2 alloy	Good	17	Good	Good	Good	
3	50	30	20	8	W:7	Al:1	Pure Fe, Pure Co, Ni-M1-M2 alloy	Good	27	Good	Good	Good	
4	50	40	10	6	W:5	Al:1	Pure Fe, Pure Co, Ni-M1-M2 alloy	Good	14	Good	Good	Good	
5	40	40	20	6	W:5	Al:1	Pure Fe, Pure Co, Ni-M1-M2 alloy	Good	13	Good	Good	Good	
6	40	40	20	8	W:7	Al:1	Pure Fe, Pure Co, Ni-M1-M2 alloy	Good	20	Good	Good	Good	
7	30	50	20	6	W:5	Al:1	Pure Fe, Pure Co, Ni-M1-M2 alloy	Good	16	Good	Good	Good	
8	85	15	-	6	W:5	Al:1	Pure Fe, Ni-M1-M2 alloy	Good	23	Good	Poor	Good	
9	80	20	-	6	W:5	Al:1	Pure Fe, Ni-M1-M2 alloy	Good	34	Good	Poor	Good	
10	75	25	-	6	W:5	Al:1	Pure Fe, Ni-M1-M2 alloy	Good	28	Good	Poor	Good	
11	70	30	-	6	W:5	Al:1	Pure Fe, Ni-M1-M2 alloy	Good	24	Good	Poor	Good	
12	65	35	-	6	W:5	Al:1	Pure Fe, Ni-M1-M2 alloy	Good	23	Good	Poor	Good	
13	50	-	50	6	W:5	Al:1	Pure Co, Ni-M1-M2 alloy	Good	18	Poor	Good	Good	
14	50	-	50	8	W:7	Al:1	Pure Co, Ni-M1-M2 alloy	Good	33	Poor	Good	Good	
15	50	-	50	5	W:5	-	Pure Co, Ni-M1-M2 alloy	Good	17	Poor	Good	Good	
16	60	40	-	8	W:3, Mo:5	-	Pure Fe, Ni-M1-M2 alloy	Good	13	Good	Poor	Good	
17	60	40	-	8	W:3, Ta:5	-	Pure Fe, Ni-M1-M2 alloy	Good	16	Good	Poor	Good	
18	60	40	-	10	Cr:5, V:2, Mo:3	-	Pure Fe, Ni-M1-M2 alloy	Good	18	Good	Poor	Good	
19	60	-	40	10	V:5, Nb:2, Mo:3	-	Pure Co, Ni-M1-M2 alloy	Good	19	Poor	Good	Good	
20	60	-	40	14	Mo:2, Nb:5, W:2, Ta:5	-	Pure Co, Ni-M1-M2 alloy	Good	16	Poor	Good	Good	
21	60	40	-	12	W:2, Mo:5	Cu:5	Pure Fe, Ni-M1-M2 alloy	Good	13	Good	Poor	Good	
22	60	40	-	8	W:2, Mo:5	Ga:1	Pure Fe, Ni-M1-M2 alloy	Good	13	Good	Poor	Good	
23	60	40	-	11	W:2, Ta:5	Zr:1, Ti:1, Hf:1, B:1	Pure Fe, Ni-M1-M2 alloy	Good	16	Good	Poor	Good	
24	60	40	-	10	Cr:5, V:2	Si:1, Ge:1, Sn:1	Pure Fe, Ni-M1-M2 alloy	Good	18	Good	Poor	Good	
25	60	40	-	10	V:5, Nb:2	Zr:1, B:1, Cu:1	Pure Fe, Ni-M1-M2 alloy	Good	19	Good	Poor	Good	
26	60	40	-	10	Mo:2, Nb:5	Si:1, Ge:1, Sn:1	Pure Fe, Ni-M1-M2 alloy	Good	16	Good	Poor	Good	
27	60	40	-	12	W:5	Zr:1, Ti:1, Hf:1, B:1, Cu:1, P:1, C:1	Pure Fe, Ni-M1-M2 alloy	Good	13	Good	Poor	Good	
28	60	40	-	11	W:5	Al:1, Ga:1, In:1, Si:1, Ge:1, Sn:1	Pure Fe, Ni-M1-M2 alloy	Good	16	Good	Poor	Good	
29	60	40	-	13	W:2, Ta:5	Zr:1, Ti:1, Hf:1, B:1, Cu:1, P:1	Pure Fe, Ni-M1-M2 alloy	Good	18	Good	Poor	Good	
30	60	-	40	11	Ta:5, Nb:1	In:1, Sn:1, Zr:1, Ti:1, B:1	Pure Co, Ni-M1-M2 alloy	Good	19	Poor	Good	Good	

NOTE 1: A raw powder was prepared to have target material composition.

[0033]
[Table 2]

Table 2

No	Target Material Composition (at. %)							Composition of Raw Powder	Property Evaluation					Remarks
	Ni:Fe:Co Ratio			M1+M2	M1	M2	Maximum Permeability		PTF (%)	Fe Phase (XRD)	Co Phase (XRD)	Component Segregation (EPMA)		
	X	Y	Z	W	Element: Addition Amount	Element: Addition Amount								
31	65	25	10	6	W:5	Al:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	7	Poor	Poor	Poor	Comparative Examples
32	60	30	10	6	W:5	Al:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	6	Poor	Poor	Poor	
33	55	25	20	6	W:5	Al:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	6	Poor	Poor	Poor	
34	50	30	20	6	W:5	Al:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	4	Poor	Poor	Poor	
35	70	30	-	6	W:5	Al:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	4	Poor	Poor	Poor	
36	65	35	-	6	W:5	Al:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	4	Poor	Poor	Poor	
37	50	-	50	6	W:5	Al:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	4	Poor	Poor	Poor	
38	50	-	50	8	W:7	Al:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	7	Poor	Poor	Poor	
39	60	40	-	8	W:2, Mo:5	Al:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	5	Poor	Poor	Poor	
40	60	40	-	8	W:2	Zr:1, Ti:1, Hf:1, B:1, Cu:1, P:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	4	Poor	Poor	Poor	
41	60	-	40	11	Ta:5, Nb:1	In:1, Sn:1, Zr:1, Ti:1, B:1		<u>Ni-Fe-Co-M1-M2 alloy</u>	Poor	5	Poor	Poor	Poor	

NOTE 1: A raw powder was prepared to have target material composition.

NOTE 2: The underlined figures fall outside the scope of the present invention.

[0034]

As shown in Table 1 and Table 2, Nos. 1 to 30 are present invention Examples, while Nos. 31 to 41 are Comparative Examples. In Table 1 and Table 2, X represents the ratio of the content (at.%) of Ni to the total content (at.%) of Ni, Fe, and Co, Y represents the ratio of the content (at.%) of Fe to the total content (at.%) of Ni, Fe, and Co, and Z represents the ratio of the content (at.%) of Co to the total content (at.%) of Ni, Fe, and Co. $X + Y + Z = 100$ is satisfied. The total content (at.%) of Ni, Fe, and Co is determined by subtracting the total content W (at.%) of M1 + M2 from 100 (at.%). For example, in No. 1, the total content (at.%) of Ni, Fe, and Co is $100 \text{ (at.\%)} - 6 \text{ (at.\%)} = 94 \text{ (at.\%)}$.

[0035]

As shown in Table 2, in Comparative Examples 31 to 41, only an alloy is used as the raw material of an alloy target material for a Ni-based seed layer with magnetism in an Fe source and/or a Co source, and therefore, Fe and/or Co with magnetism exist homogeneously. Accordingly, a magnetic permeability of more than 1000 was observed, and PTF was less than 10%. Fe and/or Co exist in the state of alloys, and peaks unique to Fe and Co, respectively, were not observed by XRD.

[0036]

In contrast, as shown in Table 1, in each of present invention example Nos. 1 to 30, Fe and/or Co with magnetism were allowed to separately coexist in a Ni-based alloy with weak magnetism or without magnetism by using a Ni-M-based alloy powder, a pure Fe powder, and a pure Co powder as raw powders, and mixing and molding the powders, and therefore, a magnetic permeability of 1000 or less and a PTF of 10% or more were shown. Fe and/or Co existed as simple substances, and Co with an fcc or hcp phase and/or Fe with an fcc or bcc phase were observed by X-ray diffraction. As a result, it is found that a sputtering target material in which a pure Fe powder and a pure Co powder are used for molding and the single phases of Fe and/or Co coexist in a Ni-M system in the

state of being separated, like the present invention example Nos. 1 to 30, exhibits a decreased magnetic permeability.

[0037]

As described above, in accordance with the present invention, a Ni-based sputtering target material comprising a Ni-Fe-Co-M alloy, wherein the ratio of Ni, Fe, and Co is Ni: Fe: Co = 98 to 20: 0 to 50: 0 to 60 on an at% basis, and the Ni-based sputtering target material comprises, as M elements, 2 to 20 at% of one or more M1 elements selected from W, Mo, Ta, Cr, V, and Nb, and 0 to 10 at.% in total of one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru, and is allowed to have a strong pass-through-flux and excellent sputtering properties by allowing the single phases of Fe and/or Co to coexist in a Ni-M system which is a matrix phase in the state of being separated, is provided, and the Ni-based sputtering target material of the present invention exhibits excellent results. In the Ni-based sputtering target material of the present invention, $Fe + Co \geq 1.5 \text{ at.}\%$ is preferably satisfied.

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CLAIMS

1. A Ni-based sputtering target material, comprising a $(\text{Ni}_X\text{-Fe}_Y\text{-Co}_Z)\text{-M}$ alloy, wherein:

X represents the ratio of the content of Ni to the total content of Ni, Fe, and Co, Y represents the ratio of the content of Fe to the total content of Ni, Fe, and Co, and Z represents the ratio of the content of Co to the total content of Ni, Fe, and Co;

the alloy comprises

as M elements, 2 to 20 at.% in total of one or more M1 elements selected from W, Mo, Ta, Cr, V, and Nb, and 0 to 10 at.% in total of one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru, and

the balance of Ni, Fe, Co and unavoidable impurities;

assuming that $X + Y + Z = 100$ is satisfied, $20 \leq X \leq 98$, $0 \leq Y \leq 50$, and $0 \leq Z \leq 60$ are satisfied; and

the alloy comprises a microstructure that contains a Ni-M phase as a matrix phase, wherein an Fe phase and/or a Co phase are dispersed in the matrix phase.

2. The Ni-based sputtering target material according to claim 1, wherein the alloy comprises 1.5 at.% or more in total of Fe and Co.

3. The Ni-based sputtering target material according to claim 1 or 2, wherein the alloy comprises, as M elements, more than 0 to 10 at.% in total of one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru.

4. The Ni-based sputtering target material according to any one of claims 1 to 3, wherein the Ni-based sputtering target material comprises Co with an fcc or hcp phase.

5. The Ni-based sputtering target material according to any one of claims 1 to 3, wherein the Ni-based sputtering target material comprises Fe with an fcc or bcc phase.

6. The Ni-based sputtering target material according to any one of claims 1 to 3, wherein the Ni-based sputtering target material has a pass-through-flux of 10% or more.