

NI-BASED SPUTTERING TARGET AND MAGNETIC RECORDING MEDIUM

BACKGROUND OF THE INVENTION

5

Field of the Invention

[0001]

The present invention relates to a Ni-based sputtering
target for forming a seed layer of a magnetic recording medium,
10 and a magnetic recording medium.

Background Art

[0002]

Conventionally, perpendicular magnetic recording
15 systems have been employed as a technique for achieving an
increase in magnetic recording density of hard disk drives. A
perpendicular magnetic recording medium that stores
information by the perpendicular magnetic recording system
generally has a multi-layer structure in which a soft magnetic
20 backing layer, a control underlayer, a magnetic recording layer
that stores magnetic information and a carbon protective layer
are laminated, in the order mentioned, on a substrate made of
glass or the like. The control underlayer includes a seed layer
that controls the orientation of the magnetic recording layer.
25 The seed layer has a face-centered cubic lattice structure (fcc
structure) having the plane (111) parallel to the surface of the
medium, and allows the easy axis of magnetization of a
magnetic film of the magnetic recording layer to be oriented
perpendicular to the surface of the medium.

30 [0003]

In recent years, the magnetization of the seed layer has
been investigated, in order to improve the magnetic recording
properties of a hard disc drive. Patent Document 1 proposes an
Fe-Ni-Co-M-based alloy, as an alloy for forming a seed layer
35 having magnetic properties.

[0004]

In general, the magnetron sputtering method is used for forming a seed layer. The magnetron sputtering method is a sputtering method in which a magnet is placed behind a sputtering target so that the plasma is concentrated to the pass-through-flux region on the surface of the sputtering target, to enhance the probability for argon atoms to collide with the sputtering target (namely, sputtering rate), thereby increasing the adhesion speed to a substrate. A sputtering target for forming a seed layer having magnetic properties is required to have magnetic properties (saturation magnetic flux density and magnetic permeability) that are low enough to form the pass-through-flux region on the surface of the sputtering target. On the other hand, the sputtering target is required to have magnetic properties that are high enough to improve the magnetic recording properties described above.

[0005]

To meet such demands, Patent Document 1 proposes a material which has, as a sputtering target, magnetic properties that are sufficiently low to the degree that the pass-through-flux can be obtained and which has, as a sputtered film, magnetic properties that are sufficiently high as a seed layer. In the Fe-Ni-Co-M-based alloy disclosed in Patent Document 1, the properties of an Fe-Ni-based alloy that the saturation magnetic flux density B_s thereof is minimized when the alloy has a composition of around Fe-30 at.% Ni (a composition containing from 25 to 35 at.% of Ni with respect to Fe) is utilized to control the microstructure of the sputtering target, thereby achieving a decrease in the saturation magnetic flux density of the sputtering target itself.

Citation List

Patent Literature

[0006]

Patent Document 1: JP 6254295 B

SUMMARY OF THE INVENTION

Technical Problem

[0007]

5 The saturation magnetic flux density B_s of an Fe-30 at.% Ni alloy varies sensitively depending on the Ni content. Therefore, in a sputtering target having an Fe-30 at.% Ni alloy region, a microscopic bias in magnetic distribution is more likely to occur, due to a minute variation in Ni content within the Fe-30 at.% Ni alloy region or depending on the state of diffusion
10 of Ni at a boundary between the Fe-30 at.% Ni alloy region and another region. The occurrence of a magnetic bias in a sputtering target causes the occurrence of bias in electrical discharge properties between the portions of the target during sputtering, possibly resulting in a failure to obtain a high
15 sputtering rate.

[0008]

The present invention has been made in view of the above mentioned circumstances, and an object of the present invention is to provide: a Ni-based sputtering target for forming
20 a seed layer of a magnetic recording medium, which allows for obtaining a sufficiently strong pass-through-flux as a sputtering target, which has magnetic properties suitable for a seed layer of a magnetic recording medium, and in which the bias in the magnetic distribution within the sputtering target is small and thus enables to obtain a high sputtering rate; and a magnetic
25 recording medium including a seed layer formed using the Ni-based sputtering target.

Solution to Problem

30 [0009]

The Ni-based sputtering target according to one embodiment of the present invention is characterized by consisting of an Fe-Ni-Co-M-based alloy, the Fe-Ni-Co-M-based alloy consisting of: an additive element M; at least one element
35 selected from Fe and Co; and the balance consisting of Ni and unavoidable impurities,

wherein the additive element M includes one or more elements M1 selected from a first group consisting of W, Mo, Ta, Cr, V and Nb,

5 wherein the Fe-Ni-Co-M-based alloy has a microstructure composed of regions varying in Ni content,

wherein the additive element M is present in each of the regions, and

10 wherein the additive element M is present only in the form of a solid solution, only in the form of a compound of at least one element selected from Fe, Ni and Co and the additive element M, or in the forms of both the solid solution and the compound.

[0010]

15 The magnetic recording medium according to one embodiment of the present invention is characterized by including a seed layer consisting of an Fe-Ni-Co-M-based alloy, the Fe-Ni-Co-M-based alloy consisting of: an additive element M; at least one element selected from Fe and Co; and the balance consisting of Ni and unavoidable impurities,

20 wherein the additive element M includes one or more elements M1 selected from a first group consisting of W, Mo, Ta, Cr, V and Nb,

wherein the Fe-Ni-Co-M-based alloy has a microstructure composed of regions varying in Ni content,

25 wherein the additive element M is present in each of the regions, and

30 wherein the additive element M is present only in the form of a solid solution, only in the form of a compound of at least one element selected from Fe, Ni and Co and the additive element M, or in the forms of both the solid solution and the compound.

[0011]

35 In the Ni-based sputtering target and the magnetic recording medium described above, the regions may include a first region, a second region and a third region, and, when the total of the contents [at.%] of Fe, Ni and Co in each of the

regions is taken as 100, the first region may have a Ni content of 0 or more and 20 or less, the second region may have a Ni content of 80 or more and 100 or less, and the third region may have a Ni content of more than 20 and less than 80.

5 [0012]

In the Ni-based sputtering target and the magnetic recording medium described above, when the total of the contents [at.-%] of Fe, Ni and Co in the Fe-Ni-Co-M-based alloy is taken as 100, the Fe-Ni-Co-M-based alloy may have an Fe
10 content of 0 or more 50 and or less, a Ni content of 20 or more and 98 or less and a Co content of 0 or more and 40 or less, and the total content of the one or more elements M1 in the Fe-Ni-Co-M-based alloy may be 2 at.-% or more and 20 at.-% or less.

15 [0013]

In the Ni-based sputtering target and the magnetic recording medium described above, the additive element M may further include one or more elements M2 selected from a second group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C,
20 Re and Ru.

[0014]

In the Ni-based sputtering target and the magnetic recording medium described above, the total content of the one or more elements M2 in the Fe-Ni-Co-M-based alloy may be
25 more than 0 at.-% and 10 at.-% or less.

Advantageous Effects of Invention

[0015]

The present invention enables to provide: a sputtering
30 target for forming a seed layer of a magnetic recording medium, which allows for obtaining a sufficiently strong pass-through-flux as a sputtering target, which has magnetic properties suitable for a seed layer of a magnetic recording medium, and in which the bias in the magnetic distribution
35 within the sputtering target is small and thus enables to perform a stable sputtering; and a magnetic recording medium

including a seed layer formed using the sputtering target.

DETAILED DESCRIPTION OF THE INVENTION

5 [0016]

Each of the Ni-based sputtering target and the seed layer of the magnetic recording medium according to the present invention consists of an $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy. The Ni-based sputtering target is suitable for use in magnetron sputtering. The $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy consists of: an additive element M; at least one element selected from Fe and Co; and the balance consisting of Ni and unavoidable impurities. Hereinafter, Fe, Ni and Co are referred to as base elements of the Fe-Ni-Co-M-based alloy, for convenience. In the composition formula $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$, x represents the proportion of the Fe content [at.%) with respect to the total content [at.%) of the base elements in the alloy, y represents the proportion of the Ni content [at.%) with respect to the total content [at.%) of the base elements in the alloy, and z represents the proportion of the Co content [at.%) with respect to the total content [at.%) of the base elements in the alloy. It is noted that the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy as used herein is sometimes referred to as "Fe-Ni-Co-M-based alloy".

[0017]

25 When the sum of $x + y + z$ in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy is taken as 100, it is preferred that x (the proportion of Fe) be 0 or more 50 and or less, y (the proportion of Ni) be 20 or more and 98 or less, and z (the proportion of Co) be 0 or more and 40 or less. When the ratio Fe: Ni: Co in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy is adjusted to 0 to 50:98 to 20:0 to 40, the crystal structure of a sputtered film formed using the sputtering target consisting of the alloy will be an fcc structure.

[0018]

35 x is more preferably 2 or more and 45 or less, and still more preferably 5 or more and 40 or less. y is more preferably 40 or more and 98 or less, and still more preferably 45 or more

and 75 or less. z is more preferably 0 or more and 30 or less.
[0019]

The additive element M includes one or more elements M1. The additive element M may further include one or more
5 elements M2.
[0020]

The one or more elements M1 consist of one or more elements selected from a first group consisting of W, Mo, Ta, Cr, V and Nb. The elements M1 are bcc-based metals having a
10 high melting point. Although the mechanism thereof is not clear, the addition of the one or more elements M1 within the component range defined in the present invention, to the Fe-Ni-Co-M-based alloy, enables to improve the orientation to the plane (111) of the cubic lattice, which is required for the
15 seed layer, and to achieve the refinement of crystal grains. When the total content of the one or more elements M1 is less than 2 at.%, the effect of the one or more elements M1 cannot be sufficiently obtained. As an alloy for forming a seed layer, the Fe-Ni-Co-M-based alloy is required to have a single fcc
20 phase, but the alloy becomes amorphous when the total content of the one or more elements M1 is more than 20 at.%. From such points of view, the total content of the one or more elements M1 in the Fe-Ni-Co-M-based alloy is preferably 2 at.% or more and 20 at.% or less, more preferably 2 at.% or more and 15 at.% or less, and still more preferably 3 at.% or more
25 and 12 at.% or less.

[0021]

Of the elements M1, the elements having a high effect for improving the orientation of the plane (111) are W and Mo.
30 Therefore, the Fe-Ni-Co-M-based alloy preferably contains at least one of W and Mo, as an essential component. In this case, the Fe-Ni-Co-M-based alloy may contain at least one of Cr, Ta, V and Nb, in addition to at least one of W and Mo. Of the high-melting point bcc metals to be combined with Ni (namely,
35 W, Mo, Ta, Cr, V and Nb), Mo and W are advantageous, because they have a melting point higher than that of Cr. Further, the

addition of W and Mo is advantageous in the formation of the fcc phase required for the seed layer, because it does not act to cause an increase in amorphousness, as compared to the addition of Ta, V and Nb. Cr is desirably added in an amount of more than 5 at.%, and it is advantageous from the viewpoint of the orientation, when added in an amount of more than 5 at.%.

[0022]

The one or more elements M2 consist of one or more elements selected from a second group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, Re and Ru. The one or more elements M2 are elements which contribute to the orientation of the plane (111) of the cubic lattice, and the refinement of crystal grains. Therefore, although the elements M2 are optional components, the Fe-Ni-Co-M-based alloy preferably contains at least one element M2. When the total content of the one or more elements M2 in the Fe-Ni-Co-M-based alloy is more than 10 at.%, there is a risk that the alloy becomes amorphous. From such points of view, the total content of the one or more elements M2 in the Fe-Ni-Co-M-based alloy is preferably more than 0 at.% and 10 at.% or less, and more preferably more than 0 at.% and 5 at.% or less.

[0023]

The Fe-Ni-Co-M-based alloy has a microstructure including an $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase. The microstructure is composed of a plurality of regions varying in Ni content. The plurality of regions include a first region, a second region and a third region. The additive element M is present in each of the regions.

[0024]

In the composition formula $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$, α represents the proportion of the Fe content [at.%] with respect to the total content [at.%] of the base elements in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, β represents the proportion of the Ni content [at.%] with respect to the total content [at.%] of the base elements in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, and γ represents the proportion of the Co

content [at.%) with respect to the total content [at.%) of the base elements in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase. The identification of the microstructure can be carried out using X-ray diffraction, a light microscope or the like.

5 [0025]

When the total of the contents [at.%) of Fe, Ni and Co in each of the first region, the second region and the third region is taken as 100 ($\alpha + \beta + \gamma = 100$), it is preferred that the first region have a Ni content of 0 or more and 20 or less (namely, β is 0 or more and 20 or less), the second region have a Ni content of 80 or more and 100 or less (namely, β is 80 or more and 100 or less), and the third region have a Ni content of more than 20 and less than 80 (namely, β is more than 20 and less than 80). The first region in which the proportion (β) of Ni is 0 or more and 20 or less has a high saturation magnetic flux density B_s , and the second region in which the proportion (β) of Ni is 80 or more and 100 or less has a low saturation magnetic flux density B_s . The third region is a diffusion layer of the first region and the second region.

20 [0026]

In the microstructure, the additive element M in each of the regions is present only in the form of a solid solution, only in the form of a compound of at least one element selected from Fe, Ni and Co and the additive element M, or in the forms of both the solid solution and the compound.

[0027]

Since the one or more elements M1 are essential components of the Fe-Ni-Co-M-based alloy, the microstructure of the alloy contains the element(s) M1 dissolved in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase and/or the element(s) M1 which formed a compound(s) with the base elements. This allows for a decrease in the magnetic properties of the Fe-Ni-Co-M-based alloy. The incorporation of the one or more elements M1 within the range defined in the present invention, into the Fe-Ni-Co-M-based alloy, allows the element(s) M1 to dissolve in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, and/or enables to form a compound(s) of

the base elements and the element(s) M1. When the total content of the one or more elements M1 in the Fe-Ni-Co-M-based alloy is less than 2 at.%, the effect of solid solution or the effect as a compound-forming element(s) cannot be sufficiently obtained. When the total content of the one or more elements M1 in the alloy is more than 20 at.%, on the other hand, it results in an increase in the amount of the compound(s), to cause an embrittlement. From such points of view, the total content of the one or more elements M1 is preferably 2 at.% or more and 20 at.% or less, more preferably 2 at.% or more and 15 at.% or less, and still more preferably 3 at.% or more and 12 at.% or less.

[0028]

In cases where the Fe-Ni-Co-M-based alloy contains one or more elements M2 as the additive element M, the microstructure of the alloy contains the element(s) M2 dissolved in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase and/or the element(s) M2 which formed a compound(s) with the base elements. This allows for a decrease in the magnetic properties of the Fe-Ni-Co-M-based alloy. The incorporation of the one or more elements M2 within the range defined in the present invention, into the Fe-Ni-Co-M-based alloy, allows the element(s) M2 to dissolve in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, and/or enables to form a compound(s) of the base elements and the element(s) M2. When the total content of the one or more elements M2 in the Fe-Ni-Co-M-based alloy is less than 1 at.%, the effect of solid solution or the effect as a compound-forming element(s) cannot be sufficiently obtained. When the total content of the one or more elements M2 in the alloy is more than 10 at.%, on the other hand, it results in an increase in the amount of the compound(s), to cause an embrittlement. From such points of view, the total content of the one or more elements M2 is preferably more than 0 at.% and 10 at.% or less, and more preferably more than 0 at.% and 5 at.% or less.

[0029]

The Fe-Ni-Co-M-based alloy can be produced by mixing

an $\text{Fe}_{\alpha 1}\text{-Co}_{\gamma 1}\text{-Ni}_{\beta 1}\text{-M}$ -based alloy powder (raw material powder A), a $\text{Ni}_{\beta 2}\text{-Co}_{\gamma 2}\text{-Fe}_{\alpha 2}\text{-M}$ -based alloy powder (raw material powder B) and a powder of any other raw material (hereinafter, referred to as the "other raw material powder") in a predetermined ratio, and pressure sintering the mixed powder. As the other raw material powder, it is possible to use a pure metal powder that supplements any element insufficient for achieving the target composition, and/or an alloy powder. Hot pressing, hot isostatic pressing (HIP), electric pressure sintering, hot extrusion or the like can be used, for example, for the pressure sintering of the mixed powder. The resulting Fe-Ni-Co-M-based alloy can be formed into a final shape by machine processing, to obtain a Ni-based sputtering target.

[0030]

In the composition formula $\text{Fe}_{\alpha 1}\text{-Co}_{\gamma 1}\text{-Ni}_{\beta 1}\text{-M}$, $\alpha 1$ represents the proportion of the Fe content [at.%) with respect to the total content [at.%) of the base elements in the alloy of the raw material powder A, $\beta 1$ represents the proportion of the Ni content [at.%) with respect to the total content [at.%) of the base elements in the alloy of the raw material powder A, and $\gamma 1$ represents the proportion of the Co content [at.%) with respect to the total content [at.%) of the base elements in the alloy of the raw material powder A. In order for the microstructure of the $\text{Fe}_{\alpha}\text{-Ni}_{\beta}\text{-Co}_{\gamma}$ phase to include the first region in which β is 0 or more and 20 or less, $\beta 1$ is adjusted to 0 or more and 20 or less. In other words, the first region of the $\text{Fe}_{\alpha}\text{-Ni}_{\beta}\text{-Co}_{\gamma}$ phase is derived from the $\text{Fe}_{\alpha 1}\text{-Co}_{\gamma 1}\text{-Ni}_{\beta 1}\text{-M}$ -based alloy powder in the raw material powder A.

[0031]

In the composition formula $\text{Ni}_{\beta 2}\text{-Co}_{\gamma 2}\text{-Fe}_{\alpha 2}\text{-M}$, $\alpha 2$ represents the proportion of the Fe content [at.%) with respect to the total content [at.%) of the base elements in the alloy of the raw material powder B, $\beta 2$ represents the proportion of the Ni content [at.%) with respect to the total content [at.%) of the base elements in the alloy of the raw material powder B, and $\gamma 2$ represents the proportion of the Co content [at.%) with respect

to the total content [at.-%] of the base elements in the alloy of the raw material powder B. In order for the microstructure of the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase to include the second region in which β is 80 or more and 100 or less, β_2 is adjusted to 80 or more and 100 or less. In other words, the second region of the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase is derived from the $\text{Ni}_{\beta_2}\text{-Co}_{\gamma_2}\text{-Fe}_{\alpha_2}\text{-M}$ -based alloy powder in the raw material powder B.

[0032]

The Ni-based sputtering target produced as described above is used for forming a seed layer of a perpendicular magnetic recording medium. The seed layer in the perpendicular magnetic recording medium can be formed by forming a film of the Fe-Ni-Co-M-based alloy described above, by the magnetron sputtering method using the Ni-based sputtering target. The thus formed seed layer of the perpendicular magnetic recording medium consists of the Fe-Ni-Co-M-based alloy described above.

EXAMPLES

[0033]

The effects of the present invention will now be clarified by way of Examples. It is noted, however, that the present invention should not be construed as being limited to the description of these Examples.

[0034]

[Method of Preparing Target Samples]

For each of Examples and Comparative Examples, an Fe-Co-Ni-M-based alloy powder (raw material powder A), a Ni-Co-Fe-M-based alloy powder (raw material powder B) and the other raw material powder, as raw material powders, were prepared by gas atomization. The gas atomization was carried out using an argon gas, under the conditions of a nozzle diameter of 6 mm and a gas pressure of 5 MPa. The powders classified as having a particle size of 500 μm or less, of each kind of the thus prepared alloy powders, were used. It is noted

that a pure substance powder, which is the other raw material powder, may be one prepared by a method other than atomization. Further, the preparation of the powders may be carried out not only by gas atomization, but also by water atomization, rotary disk atomization or the like.

[0035]

In each of the Examples and Comparative Examples, the Fe-Co-Ni-M-based alloy powder (raw material powder A), the Ni-Co-Fe-M-based alloy powder (raw material powder B) and the other raw material powder, which had been prepared by the method(s) described above, were mixed so as to satisfy the Fe-Ni-Co-M-based alloy composition shown in Tables 1 to 3. The resulting mixture was filled into a sealing can made of an SC material, and degassed and vacuumsealed at an ultimate vacuum pressure of 10^{-1} Pa or more. Thereafter, a molded product was prepared by pressure sintering, under the conditions of a temperature of from 800 to 1200°C, a pressure of 100 MPa or more and a retention time of 5 hours. The resulting molded product was then formed into a final shape by machine processing, to obtain a target sample having an outer diameter of from 165 to 180 mm and a thickness of from 3 to 10 mm. The mixing of the raw material powders was carried out using a type V mixer, for a period of time of 1 hour. Further, a method such as hot pressing, hot isostatic pressing, electric pressure sintering, hot extrusion or the like may be used for the pressure sintering of the mixed powder.

[0036]

In Tables 1 to 3, the "Component Composition" indicates the component composition of each Fe-Ni-Co-M-based alloy. The "Fe", "Ni" and "Co" under the "Component Composition" represent the proportion of the Fe content [at.%], the proportion of the Ni content [at.%] and the proportion of the Co content [at.%], respectively, with respect to the total content [at.%] of the base elements (namely, one or more elements selected from a third group consisting of Fe, Ni and Co) in the Fe-Ni-Co-M-based alloy. The sum of "Fe" + "Ni" + "Co" is 100.

The "Fe", "Ni" and "Co" in the "Raw Material Powder A" represent the proportion of the Fe content [at.%], the proportion of the Ni content [at.%] and the proportion of the Co content [at.%], respectively, with respect to the total content [at.%] of the base elements in the raw material powder A. The sum of "Fe" + "Ni" + "Co" in the "Raw Material Powder A" is 100. The "Fe", "Ni" and "Co" in the "Raw Material Powder B" represent the proportion of the Fe content [at.%], the proportion of the Ni content [at.%] and the proportion of the Co content [at.%], respectively, with respect to the total content [at.%] of the base elements in the raw material powder B. The sum of "Fe" + "Ni" + "Co" in the "Raw Material Powder B" is 100. The total content [at.%] of the base elements in the Fe-Ni-Co-M-based alloy can be determined by subtracting the total content [at.%] of the element(s) M1 in the Fe-Ni-Co-M-based alloy from 100 at.%. The same applies to the raw material powder A and the raw material powder B.

[0037]

[Table 1]

(Note) Blank cells in the Table indicate that no corresponding elements are added.

No.	Component Composition						Raw Material Powder A						Raw Material Powder B					
	Fe	Ni	Co	M1	M2		Fe	Ni	Co	M1	M2		Fe	Ni	Co	M1	M2	
1	2	98		Mo: 3			100			Mo: 3				100		Mo: 3		
2	50	50		Mo: 3			100			Mo: 3				100		Mo: 3		
3	25	75		W: 5	Al: 2		100			W: 5	Al: 2			100		W: 5	Al: 2	
4	33	67		W: 5	Al: 2		100			W: 5	Al: 2			100		W: 5	Al: 2	
5	28	72		W: 5	Ru: 3		100			W: 5	Ru: 3			100		W: 5	Ru: 3	
6	33	67		W: 4 V: 4	Al: 2		100			W: 4 V: 4	Al: 2			100		W: 4 V: 4	Al: 2	
7	30	40	30	Ta: 3	Si: 1		60		40	Ta: 3	Si: 1			80	20	Ta: 3	Si: 1	
8	20	40	40	Nb: 5			40		60	Nb: 5				80	20	Nb: 5		
9	33	67		Nb: 5	Re: 5		100			Nb: 5	Re: 5			100		Nb: 5	Re: 5	
10	40	45	15	V: 8			70	10	20	V: 8			10	80	10	V: 8		
11	5	55	40	Cr: 5	Ga: 2		20	20	60	Cr: 5	Ga: 2			80	20	Cr: 5	Ga: 2	
12	40	20	40	Ta: 4	Ga: 2 Sn: 1		50		50	Ta: 4	Ga: 2 Sn: 1			100		Ta: 4	Ga: 2 Sn: 1	
13	33	67		W: 3	In: 2		100			W: 3	In: 2			100		W: 3	In: 2	
14	25	75		W: 5	Zr: 2 Ge: 1		100			W: 5	Zr: 2 Ge: 1			100		W: 5	Zr: 2 Ge: 1	
15	25	75		V: 3	Ti: 2 Cu: 3		100			V: 3	Ti: 2 Cu: 3			100		V: 3	Ti: 2 Cu: 3	
16	20	40	40	Nb: 5	Hf: 3 B: 4		40		60	Nb: 5	Hf: 3 B: 4			80	20	Nb: 5	Hf: 3 B: 4	
17	33	67		Nb: 2	Re: 5 P: 4		100			Nb: 2	Re: 5 P: 4			100		Nb: 2	Re: 5 P: 4	
18	30	40	30	Ta: 3	C: 1		60		40	Ta: 3	C: 1			80	20	Ta: 3	C: 1	
19	25	75		V: 2			100			V: 2				100		V: 2		
20	40	45	15	W: 2			70	10	20	W: 2			10	80	10	W: 2		

Examples

[0038]

[Table 2]

(Note) Blank cells in the Table indicate that no corresponding elements are added.

No.	Component Composition					Raw Material Powder A					Raw Material Powder B				
	Fe	Ni	Co	M1	M2	Fe	Ni	Co	M1	M2	Fe	Ni	Co	M1	M2
21	5	55	40	Ta: 2		20	20	60	Ta: 2			80	20	Ta: 2	
22	33	67		Cr: 2		100			Cr: 2			100		Cr: 2	
23	33	67		Nb: 2		100			Nb: 2			100		Nb: 2	
24	25	75		V: 2		100			V: 2			100		V: 2	
25	40	45	15	W: 2		70	10	20	W: 2		10	80	10	W: 2	
26	5	55	40	Ta;2		20	20	60	Ta;2			80	20	Ta;2	
27	33	67		Cr: 2		100			Cr: 2			100		Cr: 2	
28	33	67		Nb: 2		100			Nb: 2			100		Nb: 2	
29	25	75		V: 20		100			V: 20			100		V: 20	
30	40	45	15	W: 20		70	10	20	W: 20		10	80	10	W: 20	
31	5	55	40	Ta;20		20	20	60	Ta;20			80	20	Ta;20	
32	33	67		Cr: 20		100			Cr: 20			100		Cr: 20	
33	33	67		Nb: 20		100			Nb: 20			100		Nb: 20	
34	33	67		Cr: 2	Al: 1	100			Cr: 2	Al: 1		100		Cr: 2	Al: 1
35	33	67		Cr: 2	Ga: 1	100			Cr: 2	Ga: 1		100		Cr: 2	Ga: 1
36	33	67		Cr: 2	In: 1	100			Cr: 2	In: 1		100		Cr: 2	In: 1
37	33	67		Cr: 2	Si: 1	100			Cr: 2	Si: 1		100		Cr: 2	Si: 1
38	33	67		Cr: 2	Ge: 1	100			Cr: 2	Ge: 1		100		Cr: 2	Ge: 1
39	33	67		Cr: 2	Sn: 1	100			Cr: 2	Sn: 1		100		Cr: 2	Sn: 1
40	33	67		Cr: 2	Zr: 1	100			Cr: 2	Zr: 1		100		Cr: 2	Zr: 1
41	33	67		Cr: 2	Ti: 1	100			Cr: 2	Ti: 1		100		Cr: 2	Ti: 1
42	33	67		Cr: 2	Hf: 1	100			Cr: 2	Hf: 1		100		Cr: 2	Hf: 1
43	33	67		Cr: 2	B: 1	100			Cr: 2	B: 1		100		Cr: 2	B: 1
44	33	67		Cr: 2	Cu: 1	100			Cr: 2	Cu: 1		100		Cr: 2	Cu: 1
45	33	67		Cr: 2	P: 1	100			Cr: 2	P: 1		100		Cr: 2	P: 1
46	33	67		Cr: 2	Cu: 1	100			Cr: 2	Cu: 1		100		Cr: 2	Cu: 1
47	33	67		Cr: 2	Re: 1	100			Cr: 2	Re: 1		100		Cr: 2	Re: 1

Examples

[0039]

[Table 3]

(Note) Blank cells in the Table indicate that no corresponding elements are added.

No.	Component Composition					Raw Material Powder A					Raw Material Powder B				
	Fe	Ni	Co	M1	M2	Fe	Ni	Co	M1	M2	Fe	Ni	Co	M1	M2
Examples	48	33	67		Cr: 2	Ru: 1	100		Cr: 2	Ru: 1		100		Cr: 2	Ru: 1
	49	40	45	15	W: 2	Al: 1	100		W: 2	Al: 1		100		W: 2	Al: 1
	50	40	45	15	W: 2	Ga: 10	100		W: 2	Ga: 10		100		W: 2	Ga: 10
	51	40	45	15	W: 2	In: 10	100		W: 2	In: 10		100		W: 2	In: 10
	52	40	45	15	W: 2	Si: 10	100		W: 2	Si: 10		100		W: 2	Si: 10
	53	40	45	15	W: 2	Ge: 10	100		W: 2	Ge: 10		100		W: 2	Ge: 10
	54	40	45	15	W: 2	Sn: 10	100		W: 2	Sn: 10		100		W: 2	Sn: 10
	55	40	45	15	W: 2	Zr: 10	100		W: 2	Zr: 10		100		W: 2	Zr: 10
	56	40	45	15	W: 2	Ti: 10	100		W: 2	Ti: 10		100		W: 2	Ti: 10
	57	40	45	15	W: 2	Hf: 10	100		W: 2	Hf: 10		100		W: 2	Hf: 10
	58	40	45	15	W: 2	B: 10	100		W: 2	B: 10		100		W: 2	B: 10
	59	40	45	15	W: 2	Cu: 10	100		W: 2	Cu: 10		100		W: 2	Cu: 10
	60	40	45	15	W: 2	P: 10	100		W: 2	P: 10		100		W: 2	P: 10
	61	40	45	15	W: 2	Cu: 10	100		W: 2	Cu: 10		100		W: 2	Cu: 10
	62	40	45	15	W: 2	Re: 10	100		W: 2	Re: 10		100		W: 2	Re: 10
	63	40	45	15	W: 2	Ru: 10	100		W: 2	Ru: 10		100		W: 2	Ru: 10
	64	33	67		W: 5	Al: 22	100		W: 5	Al: 22		100		W: 5	Al: 22
Comparative Examples	1	33	67		Cr: 2	Zr: 1	79		Cr: 2	Zr: 1		100		Cr: 2	Zr: 1
	2	52	48		W: 5	Al: 2	100		W: 5	Al: 2		100		W: 5	Al: 2
	3	82	18		W: 5	Al: 2	100		W: 5	Al: 2		100		W: 5	Al: 2
	4		100		W: 5	Al: 2			W: 5	Al: 2		100		W: 5	Al: 2
	5		58	42	W: 5	Al: 2		100	W: 5	Al: 2		100		W: 5	Al: 2
	6	33	67		W: 1	Al: 2	100		W: 1	Al: 2		100		W: 1	Al: 2
	7	33	67		Nb: 22	Al: 2	100		Nb: 22	Al: 2		100		W: 5	Al: 2
	8	33	67		Cr: 2	Zr: 1	80		Cr: 2	Zr: 1	22	78		Cr: 2	Zr: 1

[0040]

[Method of Measuring Magnetic Permeability of Target Samples and Evaluation Method Thereof]

To measure the magnetic permeability of the thus
5 prepared target samples, a ring test specimen having an outer diameter of 15 mm, an inner diameter of 10 mm and a height of 5 mm was prepared for each target sample, and the measurement of the maximum magnetic permeability (emu) was carried out using a BH tracer at an applied magnetic field of
10 8 kA/m. In Tables 4 to 6, target samples having a maximum magnetic permeability of 500 emu or less are shown as "G1 (Grade 1)", target samples having a maximum magnetic permeability of more than 500 emu up to 1000 emu are shown as "G2 (Grade 2)", and target samples having a maximum
15 magnetic permeability of more than 1000 emu are shown as "G3 (Grade 3)". Regarding the maximum magnetic permeability, those evaluated as G1 are particularly suitable as the Ni-based sputtering target according to the present invention, those evaluated as G2 are suitable as the Ni-based
20 sputtering target according to the present invention, and those evaluated as G3 are not suitable as the Ni-based sputtering target according to the present invention.

[0041]

[Method of Measuring Pass-Through-Flux of Target Samples and
25 Evaluation Method Thereof]

To measure the pass-through-flux (hereinafter, referred to as "PTF") of the above prepared target samples, a permanent magnet was placed on the back side of each target sample, and the magnetic flux passed through to the surface of the target
30 sample was measured. This method allows for a quantitative measurement of the pass-through-flux in a state close to the measurement in a magnetron sputtering apparatus. The actual measurement was carried out based on ASTM F2806-01, "Standard Test Method for Pass Through Flux of Circular
35 Magnetic Sputtering Targets, Method 2), and the PTF was determined in accordance with the following equation.

(PTF) = $100 \times (\text{intensity of magnetic flux in a state where target sample is placed}) \div (\text{intensity of magnetic flux in a state where target sample is not placed})$ (%)

In Tables 4 to 6, target samples having a PTF of 10% or more are shown as "G1 (Grade 1)", and target samples having a PTF of less than 10% are shown as "G2 (Grade 2)". Regarding the PTF, those evaluated as G1 are suitable as the Ni-based sputtering target according to the present invention, and those evaluated as G2 are not suitable as the Ni-based sputtering target according to the present invention.

[0042]

[Method of Measuring Variation in Magnetic Properties within Target Sample and Evaluation Method Thereof]

The PTF described above was measured at 12 locations on the circumference of the same circle on each target sample, at intervals of 30 degrees, the difference between the maximum value and the minimum value of the measured values was calculated, and the variation in magnetic properties within the target sample was evaluated based on the difference value. Target samples having a difference value of 3% or less are shown as "G1 (Grade 1)", target samples having a difference value of 10% or less are shown as "G2 (Grade 2)", and target samples having a difference value of 10% or more are shown as "G3 (Grade 3)". Those evaluated as G1 are particularly suitable as the Ni-based sputtering target according to the present invention, those evaluated as G2 are suitable as the Ni-based sputtering target according to the present invention, and those evaluated as G3 are not suitable as the Ni-based sputtering target according to the present invention.

[0043]

[Observation of Sputtered Films]

Each of the above prepared target samples was used as a sputtering target, to form a sputtered film on a substrate by the magnetron sputtering method. The resulting sputtered film is a simulation of a seed layer of a perpendicular magnetic recording medium. The sputtered films formed using the respective

target samples were each subjected to an X-ray diffraction analysis using an X-ray diffraction analyzer, to analyze the form of presence of the element M in the microstructure of each sputtered film and the crystal structure of the sputtered film.

- 5 Further, the sputtered films formed using the respective target samples were each subjected to microscopic observation, to confirm the presence or absence of cracks in each sputtered film. In addition, a microstructural image of each sputtered film was captured using a transmission electron microscope (TEM), and
- 10 the crystal grain size of the sputtered film was calculated based on the image analysis of the captured image. At this time, the longer diameter and the shorter diameter of an oval-shaped crystal included in the captured image were measured, and the mean diameter thereof was defined as the grain size. Further,
- 15 the mean value of the grain sizes of a plurality of crystals included in a predetermined region in the microstructural image was defined as the "crystal grain size". Sputtered films having a crystal grain size of 20 nm or less were evaluated as "G1 (Grade 1)", and sputtered films having a crystal grain size of
- 20 more than 20 nm were evaluated as "G2 (Grade 2)".
- [0044]

Tables 4 to 6 show various observation results and evaluation results of the target samples and sputtered films of Examples 1 to 64 and Comparative Examples 1 to 8.

[0045]

[Table 4]

No.	Target Sample					Sputtered Film		
	Form of Presence of Element M		Maximum Magnetic Permeability	PTF	Variation in PTF	Crystal Structure	Presence or Absence of Cracks	Crystal Grain Size
	First Region	Second Region						
1	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
2	Solid solution	Solid solution	G2	G1	G2	fcc	Absent	G1
3	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
4	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
5	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
6	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
7	Solid solution	Solid solution	G1	G1	G2	fcc	Absent	G1
8	Solid solution	Solid solution	G2	G1	G1	fcc	Absent	G1
9	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
10	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
11	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
12	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
13	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
14	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
15	Solid solution	Solid solution	G1	G1	G1	fcc	Absent	G1
16	Solid solution + compound	Solid solution + compound	G2	G1	G1	fcc	Absent	G1
17	Solid solution + compound	Solid solution + compound	G1	G1	G1	fcc	Absent	G1
18	Solid solution + compound	Solid solution + compound	G1	G1	G1	fcc	Absent	G1
19	Solid solution	Solid solution	G1	G1	G2	fcc	Absent	G1
20	Solid solution	Solid solution	G1	G1	G2	fcc	Absent	G1
21	Solid solution + compound	Solid solution + compound	G1	G1	G2	fcc	Absent	G1

Examples

[0046]
[Table 5]

No.	Target Sample				Sputtered Film			
	Form of Presence of Element M		Maximum Magnetic Permeability	PTF	Variation in PTF	Crystal Structure	Presence or Absence of Cracks	Crystal Grain Size
	First Region	Second Region						
Examples	31	compound	compound	G1	G1	fcc	Absent	G1
	32	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1
	33	compound	compound	G1	G1	fcc	Absent	G1
	34	Solid solution	Solid solution	G1	G2	fcc	Absent	G1
	35	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	36	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	37	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	38	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	39	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	40	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	41	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	42	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	43	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	44	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	45	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	46	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	47	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	48	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	49	Solid solution	Solid solution	G1	G1	fcc	Absent	G1
	50	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1
	51	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1

	52	Solid solution + compound	Solid solution + compound	G1	G1	G1	fcc	Absent	G1
	53	Solid solution + compound	Solid solution + compound	G1	G1	G1	fcc	Absent	G1
	54	Solid solution + compound	Solid solution + compound	G1	G1	G1	fcc	Absent	G1
	55	Solid solution + compound	Solid solution + compound	G1	G1	G1	fcc	Absent	G1

[0047]
[Table 6]

No.	Target Sample					Sputtered Film		
	Form of Presence of Element M		Maximum Magnetic Permeability	PTF	Variation in PTF	Crystal Structure	Presence or Absence of Cracks	Crystal Grain Size
	First Region	Second Region						
Examples	56	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1
	57	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1
	58	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1
	59	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1
	60	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1
	61	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1
	62	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1
	63	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G1
Comparative Examples	64	compound	compound	G1	G1	fcc	Present	G1
	1	Solid solution	Solid solution	G1	G3	fcc	Absent	G1
	2	Solid solution + compound	Solid solution + compound	G1	G1	bcc	Absent	G1
	3	Solid solution + compound	Solid solution + compound	G1	G1	bcc	Absent	G1
	4	Solid solution + compound	Solid solution + compound	G1	G1	bcc	Absent	G1
	5	Solid solution + compound	Solid solution + compound	G1	G1	hcp	Absent	G1
	6	Solid solution + compound	Solid solution + compound	G1	G1	fcc	Absent	G2
	7	Solid solution + compound	Solid solution + compound	G1	G1	Amorphous	Absent	G1
8	Solid solution	Solid solution	G2	G2	G1	fcc	Absent	G1

[0048]

In each of the target samples of Examples 1 to 64, the proportion of the Ni content [at.-%] with respect to the total content [at.-%] of the base elements in the raw material powder A is 0 or more and 20 or less, and the proportion of the Ni content [at.-%] with respect to the total content [at.-%] of the base elements in the raw material powder B is 80 or more and 100 or less. In other words, in each of the target samples of Examples 1 to 64, the microstructure of the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase includes the first region in which β (the proportion of Ni) is 0 or more and 20 or less, and the second region in which β is 80 or more and 100 or less. Further, the additive element M is present in each of the first region and the second region. In each of the regions, the additive element M is present only in the form of a solid solution dissolved in the $\text{M Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, or only in the form of a compound with the base elements, or in the forms of both the solid solution and the compound.

[0049]

Since all of the target samples of Examples 1 to 64 satisfy the requirements of the present invention, as described above, these target samples have a maximum magnetic permeability of 1,000 emu or less and a PTF of 10% or more, and the variation in magnetic properties within each target sample is reduced. In addition, since the sputtered films formed from the target samples of Examples 1 to 64 have an fcc crystal structure and have a crystal grain size of 20 nm or less, these sputtered films are suitable as a seed layer of a magnetic recording layer. It is noted here that, in each of the sputtered films formed from the target samples of Examples 1 to 63, the occurrence of cracks was not observed during the film formation, because the total content of the element(s) M2 in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy is within the range of from 0 at.-% to 10 at.-%; however, in the sputtered film formed from the target sample of Example 64, cracks occurred during the film formation, because the total content of the element M2 in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy is outside the range of from 0 at.-% to

10 at.%.
[0050]

The above results have revealed that the present invention enables to provide: a Ni-based sputtering target for forming a seed layer of a magnetic recording medium, which allows for obtaining a sufficiently strong pass-through-flux as a target for use in magnetron sputtering, which has magnetic properties suitable for a seed layer of a magnetic recording medium, and in which the bias in the magnetic distribution within the sputtering target is small and thus enables to perform a stable sputtering; and a magnetic recording medium including a seed layer formed using the Ni-based sputtering target.

[0051]

In the target sample of Comparative Example 1, the proportion of the Ni content [at.-%] with respect to the total content [at.-%] of the base elements in the raw material powder A is 21. In other words, in the target sample of Comparative Example 1, the microstructure of the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase does not include the first region in which β (the proportion of Ni) is 0 or more and 20 or less. The target sample of Comparative Example 1 has a large variation in magnetic properties, and thus is not suitable as a sputtering target for forming a seed layer.

[0052]

In the target sample of Comparative Example 2, the proportion of the Fe content [at.-%] with respect to the total content [at.-%] of the base elements in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy is outside the range of 0 or more 50 and or less. In each of the target samples of Comparative Examples 3 and 4, the proportion of the Ni content [at.-%] with respect to the total content [at.-%] of the base elements in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy is outside the range of 20 or more and 98 or less. The sputtered films formed using the target samples of Comparative Examples 2 to 4 had a bcc structure (body-centered cubic lattice structure). In the target sample of Comparative Example 5,

the proportion of Co content [at.-%] with respect to the total content [at.-%] of the base elements in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy is outside the range of 0 or more and 40 or less. The sputtered film formed using the target sample of Comparative Example 5 had an hcp structure (hexagonal close-packed structure). The sputtered films formed from the target samples of Comparative Examples 2 to 5 are not suitable as a seed layer of a magnetic recording layer.

[0053]

In each of the target samples of Comparative Examples 6 and 7, the total content of the element M1 in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy is outside the range of 2 at.-% or more and 20 at.-% or less. The sputtered film formed using the target sample of Comparative Example 6 had a crystal grain size of more than 20 nm. The sputtered film formed using the target sample of Comparative Example 7 had an amorphous structure. The sputtered films formed from the target samples of Comparative Examples 6 and 7 are not suitable as a seed layer of a magnetic recording layer.

[0054]

In the target sample of Comparative Example 8, the proportion of the Ni content [at.-%] with respect to the total content [at.-%] of the base elements in the raw material powder B is outside the range of 80 or more and 100 or less. In other words, in the target sample of Comparative Example 8, the microstructure of the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase does not include the second region in which β (the proportion of Ni) is 80 or more and 100 or less. The target sample of Comparative Example 8 is insufficient in both the magnetic permeability and the PTF, and thus is not suitable as a sputtering target for forming a seed layer.

CLAIMS

1. A Ni-based sputtering target consisting of an Fe-Ni-Co-M-based alloy, the Fe-Ni-Co-M-based alloy consisting of: an additive element M; at least one element selected from Fe and Co; and the balance consisting of Ni and unavoidable impurities, wherein the additive element M consists of: one or more elements M1 selected from a first group consisting of W, Mo, Ta, Cr, V and Nb; and one or more elements M2 selected from a second group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, Re and Ru,

wherein the total content of the one or more elements M2 in the Fe-Ni-Co-M-based alloy is more than 0 at.% and 5 at.% or less,

wherein the Fe-Ni-Co-M-based alloy has a microstructure composed of regions varying in Ni content,

wherein the additive element M is present in each of the regions,

wherein the additive element M is present only in the form of a solid solution, only in the form of a compound of at least one element selected from Fe, Ni and Co and the additive element M, or in the forms of both the solid solution and the compound,

wherein the regions comprise a first region, a second region and a third region, and wherein, when the total of the contents [at.%] of Fe, Ni and Co in each of the regions is taken as 100, the first region has a Ni content of 0 or more and less than 20, the second region has a Ni content of 80 or more and 100 or less, and the third region has a Ni content of 20 or more and less than 80.

2. The Ni-based sputtering target according to claim 1, wherein, when the total of the contents [at.%] of Fe, Ni and Co in the Fe-Ni-Co-M-based alloy is taken as 100, the Fe-Ni-Co-M-

based alloy has an Fe content of 0 or more and 50 or less, a Ni content of 20 or more and 98 or less and a Co content of 0 or more and 40 or less, and wherein the total content of the one or more elements M1 in the Fe-Ni-Co-M-based alloy is 2 at.% or more and 20 at.% or less.

3. The Ni-based sputtering target according to claim 1 or 2, wherein the first region has a Ni content of 0 or more and 10 or less, the second region has a Ni content of 80 or more and 100 or less, and the third region has a Ni content of more than 10 and less than 80.