

Ni-BASED SPUTTERING TARGET MATERIAL AND MAGNETIC RECORDING MEDIUM

BACKGROUND OF THE INVENTION

5 Field of the Invention

[0001]

The present invention relates to a Ni-based sputtering target material and a magnetic recording medium and particularly to a sputtering target material that is used for a seed layer in a magnetic recording medium and that, for a perpendicular magnetic recording medium, has a low magnetic permeability, is capable of affording a strong pass-through-flux, and has a high use efficiency in a magnetron sputtering method; and to a magnetic recording medium.

15

Background Art

[0002]

In recent years, there have been remarkable progresses 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 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 density.

30 [0003]

For perpendicular magnetic recording system, a recording medium having a magnetic recording film layer with an increased recording density and a soft magnetic film layer has 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

35

layer has been developed. A NiW-based alloy has been commonly used in a seed layer for the perpendicular magnetic recording system.

[0004]

5 One of properties demanded in a seed layer is in that the seed layer itself has a single fcc structure and a plane parallel to a medium plane is oriented in a (111) plane in order to control the orientation of a layer formed on the seed layer and to orient the magnetization-easy axis of a magnetic film on which
10 magnetic information is recorded, perpendicularly to the medium plane, as shown by the name of the seed layer. In recent years, a method for imparting magnetism to a seed layer has been examined as a technique for improving the magnetic recording properties of a hard disk drive. Therefore,
15 development of an alloy for a seed layer having properties demanded for the alloy for a seed layer as described above and magnetism has been demanded. As the alloy for a seed layer having magnetism, a Ni-Fe-Co-M-based alloy has been proposed as disclosed in, for example, Japanese Patent Laid-Open
20 Publication No. 2012-128933 (Patent Literature 1). A major difference between a soft magnetic layer and a seed layer is shown as follows: it is demanded that the soft magnetic layer is amorphous for reducing noise, whereas it is demanded that the seed layer has the action of controlling the orientation of a layer
25 formed on the seed layer and has high crystallinity in contrast to an amorphous material which is amorphous.

[0005]

 A magnetron sputtering method has been commonly used for forming the seed layer described above. The magnetron
30 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
35 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.

[0006]

As an example of a technique for reducing a magnetic permeability, a method for decreasing a magnetic permeability by using as a raw powder an Fe/25-35 at.% Ni alloy powder which contains 25 to 35 at.% Ni relative to Fe has been proposed, as disclosed in Japanese Patent Laid-Open Publication No. 2010-248603 (Patent Literature 2). This method utilizes the characteristic of the Fe/Ni alloy that will lose magnetism at a ratio by weight of Fe:Ni = 70:30, and thus controls the structure of a target material, thereby enabling the saturation magnetic flux density of the target material itself to be reduced.

Citation List

Patent Literature

[0007]

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

[PTL 2] Japanese Patent Laid-Open Publication No. 2010-248603

SUMMARY OF THE INVENTION

Technical Problem

[0008]

However, the method of Patent Literature 2 can be adapted only to a Co/Fe-based target material for a soft magnetic layer but is unable to be applied to a target material for a seed layer. In addition, the Fe/25-35 at.% Ni alloy powder used in Patent Literature 2 is based on two elements of Fe and Ni, and no example in which a third added element powder is used is shown.

Solution to Problem

[0009]

As a result of intensively advancing development in order

to sufficiently achieve such demands as described above, the present inventors have found a sputtering target material that is used for a seed layer and that has a low magnetic permeability, is capable of affording a large pass-through-flux, and has a high use efficiency in a magnetron sputtering method, and the present invention has been thus accomplished.

[0010]

The present invention encompasses the following inventions:

- (1) A Ni-based sputtering target material, including an $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, wherein x represents a ratio of the Fe content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the alloy, y represents a ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the alloy, and z represents a ratio of the Co content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the alloy,

in which the alloy contains, as M elements, one or more M1 elements selected from W, Mo, Ta, Cr, V, and Nb at the total of 2 to 20 at.% and one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru at the total of 0 to 10 at.%, and the balance consists of Ni, one or two of Fe and Co, and unavoidable impurities,

in which, assuming that $x + y + z = 100$ is satisfied, x is from 0 to 50, y is from 20 to 98, and z is from 0 to 60,

in which the alloy includes a microstructure containing an $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, wherein α represents a ratio of the Fe content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, β represents a ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, and γ represents a ratio of the Co content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase,

in which, assuming that $\alpha + \beta + \gamma = 100$ is satisfied, β is from 20 to 35 and γ is 30 or less, and

in which the microstructure includes an M element(s) incorporated into the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in a solid solution and/or an M element(s) formed into a compound with at least one element of Fe, Ni, and Co.

5 (2) The Ni-based sputtering target material according to the above (1), in which the alloy includes, as the M elements, one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru at the total of 1 to 10 at.% in addition to the M1 element(s).

10 (3) The Ni-based sputtering target material according to the above (1) or (2), in which the Ni-based sputtering target material is used for a seed layer in a magnetic recording medium.

(4) A magnetic recording medium, including a Ni-based sputtering target material according to the above (1) or (2).

Advantageous Effects of Invention

[0011]

The present invention can provide an Fe-Ni-Co-M-based sputtering target material with which magnetron sputtering can be performed efficiently, and affords a technology that is very effective at producing industrial products such as a perpendicular magnetic recording medium that require an Fe-Ni-Co-based alloy seed layer.

25 DETAILED DESCRIPTION OF THE INVENTION

[0012]

The present invention will be described below.

The present invention relates to a Ni-based sputtering target material including an $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy (preferably a Ni-based sputtering target material for a seed layer in a magnetic recording medium). In this Description, the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy may be referred to as the "Fe-Ni-Co-M-based alloy".

[0013]

35 In the composition formula $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$, x represents a ratio of the Fe content (on an at.% basis) to the total content

(on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, y represents a ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, and z represents a ratio of the Co content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy).
 [0014]

Assuming that $x + y + z = 100$ is satisfied for the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, x (a ratio of Fe) is from 0 to 50, y (a ratio of Ni) is from 20 to 98, and z (a ratio of Co) is from 0 to 60. For the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, setting Fe:Ni:Co to 0-50:98-20:0-60 can afford an fcc structure demanded in a seed layer.
 [0015]

The $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy contains, as M elements, one or more M1 elements selected from W, Mo, Ta, Cr, V, and Nb at the total of 2 to 20 at.% and one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru at the total of 0 to 10 at.%, and the balance consists of Ni, one or two of Fe and Co, and unavoidable impurities. The M1 elements (elements selected from W, Mo, Ta, Cr, V, and Nb) are bcc-based metals having high melting points, and can improve orientation to a (111) plane demanded in a seed layer, although the mechanism of the improvement is unclear, and make crystal grains finer, by adding the elements to an Fe-Ni-Co system which is fcc in a constituent range defined in the present invention. The total content of the one or more M1 elements (atoms) selected from W, Mo, Ta, Cr, V, and Nb is set at 2 to 20 at.%. A total content of the M1 elements of less than 2 at.% causes the effect to be insufficient, while a total content of the M1 elements of more than 20 at.% 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]

Among W, Mo, Ta, Cr, V, and Nb, elements effective for the orientation of the (111) plane are W and Mo. Thus, the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy preferably contains one or two of W and Mo as an essential component. In this case, the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy may contain one or more of Cr, Ta, V, and Nb, in addition to one or two of W and Mo. Among high melting point bcc metals (W, Mo, Ta, Cr, V, and Nb) to be combined with Ni, Mo and W have a higher melting point than Cr and are advantageous. In comparison with the addition of Ta, V, and Nb, the addition of W and Mo does not act on enhancement of amorphous properties, and hence is advantageous for formation of an fcc phase demanded in a seed layer. It is desirable to add more than 5 at.% Cr, and the addition of more than 5 at.% Cr is advantageous in view of orientation.

[0017]

The $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy can contain, as M elements, one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru in addition to the M1 element(s). Although the M2 elements (elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru) are optional components, the M2 elements are elements that orient a (111) plane and make crystal grains finer, and therefore, it is preferable that the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy contain one or more of the M2 elements. It is preferable to set the total content of the one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru at 1 to 10 at.%. Since a total content of the M2 element(s) of more than 10 at.% may unfavorably result in producing a compound or become amorphous, the upper limit thereof is set preferably at 10 at.%, and more preferably at 5 at.%. In addition, the sum of the total content of the M1 element(s) and the total content of the M2 element(s) is preferably 25 at.% or less, and more preferably 20 at.% or less.

[0018]

The $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy has a microstructure including an $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase. The microstructure can be

identified using X-ray diffraction, an optical microscope, or the like.

[0019]

In the composition formula $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$, α represents a ratio of the Fe content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, β represents a ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, and γ represents a ratio of the Co content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase.

[0020]

Assuming that $\alpha + \beta + \gamma = 100$ is satisfied for the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, β (a ratio of Ni) is 20 to 35 and γ (a ratio of Co) is 30 or less. This is because the saturation magnetic flux density (Bs) is increased either when β (a ratio of Ni) is less than 20 or more than 35 or when γ (a ratio of Co) is more than 30. γ (a ratio of Co) is preferably 15 or less, more preferably 5 or less. When β (a ratio of Ni) is 20 to 35 and γ (a ratio of Co) is 30 or less, α (a ratio of Fe) is 35 to 80; when β (a ratio of Ni) is 20 to 35 and γ (a ratio of Co) is 15 or less, α (a ratio of Fe) is 50 to 80; and when β (a ratio of Ni) is 20 to 35 and γ (a ratio of Co) is 5 or less, α (a ratio of Fe) is 60 to 80.

[0021]

The microstructure includes an M element(s) incorporated into the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in a solid solution and/or an M element(s) formed into a compound with at least one element of Fe, Ni, and Co. Because the M1 element(s) is/are essential components of the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, the microstructure includes an M1 element(s) incorporated into the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in a solid solution and/or an M1 element(s) formed into a compound with at least one element of Fe, Ni, and Co. By having the total content of the M1 element(s) at 2 to 20 at.% in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, the M1 element(s) can be incorporated into the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in a solid solution, and/or a compound of the M1 element(s) and at least one

element of Fe, Ni, and Co can be produced. This can reduce the magnetism of the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy. In the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, the total content of the M1 element(s) of less than 2 at.% does not sufficiently achieve the effect of a solid solution nor the effect of the element for forming a compound, and the total content of the M1 element(s) of more than 20 at.% increases the amount of the compound and thus causes embrittlement, so that the total content of the M1 element(s) should be 2 to 20 at.%, preferably 2 to 15 at.%, further preferably 3 to 12 at.%.
 5
 10

[0022]

When the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy contains, as M elements, one or more M2 elements in addition to the M1 element(s), the microstructure includes an M2 element(s) incorporated into the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in a solid solution and/or an M2 element(s) formed into a compound with at least one element of Fe, Ni, and Co. By having the total content of the M2 element(s) at 1 to 10 at.% in the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, the M2 element(s) can be incorporated into the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in a solid solution, and/or a compound of the M2 element(s) and at least one element of Fe, Ni, and Co can be produced. This can reduce the magnetism of the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy. In the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, the total content of the M2 element(s) of less than 1 at.% does not sufficiently achieve the effect of a solid solution or the effect of the element for forming a compound, and the total content of the M2 element(s) of more than 10 at.% increases the amount of the compound and thus causes embrittlement, so that the total content of the M2 element(s) is preferably 1 to 10 at.%.
 15
 20
 25

[0023]

The $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy can be produced by mixing an $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy powder and other raw powders at a certain ratio and pressure-sintering the mixed powder. For example, hot press, hot isostatic pressing, electric-current pressure sintering, hot extrusion, or the like can be applied for pressure sintering of the mixed powder.
 30
 35

[0024]

When the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy is produced by mixing an $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy powder and other raw powders at a certain ratio and pressure-sintering the mixed powder, the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy has an $\text{Fe}_{\alpha}\text{-Ni}_{\beta}\text{-Co}_{\gamma}$ phase derived from the $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy powder.

[0025]

In the composition formula $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$, $\alpha 1$ represents a ratio of the Fe content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy powder, $\beta 1$ represents a ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy powder, and $\gamma 1$ represents a ratio of the Co content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy powder.

[0026]

Assuming that $\alpha 1 + \beta 1 + \gamma 1 = 100$ is satisfied for the $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy powder, it is preferable that $\beta 1$ (a ratio of Ni) be 20 to 35 and $\gamma 1$ (a ratio of Co) be 30 or less. This is because the saturation magnetic flux density (B_s) is increased either when $\beta 1$ (a ratio of Ni) is less than 20 or more than 35 or when $\gamma 1$ (a ratio of Co) is more than 30. $\gamma 1$ (a ratio of Co) is preferably 15 or less, more preferably 5 or less. When $\beta 1$ (a ratio of Ni) is 20 to 35 and $\gamma 1$ (a ratio of Co) is 30 or less, $\alpha 1$ (a ratio of Fe) is 35 to 80; when $\beta 1$ (a ratio of Ni) is 20 to 35 and $\gamma 1$ (a ratio of Co) is 15 or less, $\alpha 1$ (a ratio of Fe) is 50 to 80; and when $\beta 1$ (a ratio of Ni) is 20 to 35 and $\gamma 1$ (a ratio of Co) is 5 or less, $\alpha 1$ (a ratio of Fe) is 60 to 80.

[0027]

The $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy powder can contain, as an M element(s), one or more M1 elements selected from W, Mo, Ta, Cr, V, and Nb. The total content (on an at.% basis) of the M1 element(s) in the $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy powder is preferably 2 to 20 at.%. By having the total content of the M1 element(s) at 2 to 20 at.% in the $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy

powder, the M1 element(s) can be incorporated into the Fe_α - Ni_β - Co_γ phase in a solid solution, and/or a compound of the M1 element(s) and at least one element of Fe, Ni, and Co can be produced. This can reduce the magnetism of the Fe_x - Ni_y - Co_z -M-based alloy. In the $\text{Fe}_{\alpha 1}$ - $\text{Ni}_{\beta 1}$ - $\text{Co}_{\gamma 1}$ -M-based alloy powder, the total content of the M1 element(s) of less than 2 at.% does not sufficiently achieve the effect of a solid solution or the effect of the element for forming a compound, and the total content of the M1 element(s) of more than 20 at.% increases the amount of the compound and thus causes embrittlement, so that the total content of the M1 element(s) should be 2 to 20 at.%, preferably 2 to 15 at.%, further preferably 3 to 12 at.%.
[0028]

The $\text{Fe}_{\alpha 1}$ - $\text{Ni}_{\beta 1}$ - $\text{Co}_{\gamma 1}$ -M-based alloy powder can contain, as an M element(s), one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru. The total content (on an at.% basis) of the M2 element in the $\text{Fe}_{\alpha 1}$ - $\text{Ni}_{\beta 1}$ - $\text{Co}_{\gamma 1}$ -M-based alloy powder is preferably 1 to 10 at.%. By having the total content of the M2 element(s) at 1 to 10 at.% in the $\text{Fe}_{\alpha 1}$ - $\text{Ni}_{\beta 1}$ - $\text{Co}_{\gamma 1}$ -M-based alloy powder, the M2 element(s) can be incorporated into the Fe_α - Ni_β - Co_γ phase in a solid solution, and/or a compound of the M2 element(s) and at least one element of Fe, Ni, and Co can be produced. This can reduce the magnetism of the Fe_x - Ni_y - Co_z -M-based alloy. In the $\text{Fe}_{\alpha 1}$ - $\text{Ni}_{\beta 1}$ - $\text{Co}_{\gamma 1}$ -M-based alloy powder, the total content of the M2 element(s) of less than 1 at.% does not sufficiently achieve the effect of a solid solution nor the effect of the element for forming a compound, and the total content of the M2 element(s) of more than 10 at.% increases the amount of the compound and thus causes embrittlement, so that the total content of the M2 element(s) is preferably 1 to 10 at.%.
[0029]

The $\text{Fe}_{\alpha 1}$ - $\text{Ni}_{\beta 1}$ - $\text{Co}_{\gamma 1}$ -M-based alloy powder can contain one or both of the M1 element(s) and the M2 element(s). When the both are contained, the sum of the total content of the M1

element(s) and the total content of the M2 element(s) is preferably 25 at.% or less, and more preferably 20 at.% or less.
[0030]

As other raw powders, pure metal powders or alloy
5 powders for providing elements which a composition of interest lacks can be used.
[0031]

When the ratios of the Fe content (on an at.% basis), the
Ni content (on an at.% basis), and the Co content (on an at.%
10 basis) to the total content (on an at.% basis) of Fe, Ni, and Co
in the balance other than the $\text{Fe}_{\alpha 1}\text{-Ni}_{\beta 1}\text{-Co}_{\gamma 1}\text{-M}$ -based alloy
powder (hereinafter referred to as "balance raw material") in
raw powders used in producing the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy
are assumed to be $\alpha 2$, $\beta 2$, and $\gamma 2$ respectively, and when $\alpha 2 +$
15 $\beta 2 + \gamma 2 = 100$ is assumed, it is preferable that $\beta 2$ (a ratio of Ni)
be 80 to 100 and $\alpha 2 + \gamma 2$ (a ratio of Fe + a ratio of Co) be 0 to
20. Setting $\beta 2$ (a ratio of Ni) to 80 to 100 allows $B_s \leq 10$ kG.
 $\beta 2$ (a ratio of Ni) is preferably to 85 to 100.
[0032]

20 The balance raw material can contain, as M elements,
one or more M1 elements selected from W, Mo, Ta, Cr, V, and Nb.
The total content (on an at.% basis) of the M1 element(s) in the
balance raw material is preferably 2 to 20 at.%. By having the
total content of the M1 element(s) at 2 to 20 at.% in the
25 balance raw material, the M1 element(s) can be incorporated
into the $\text{Fe}_{\alpha}\text{-Ni}_{\beta}\text{-Co}_{\gamma}$ phase in a solid solution, and/or a
compound of the M1 element(s) and at least one element of Fe,
Ni, and Co can be produced. This can reduce the magnetism of
the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy. In the balance raw material, the
30 total content of an M1 element(s) of less than 2 at.% does not
sufficiently achieve the effect of a solid solution nor the effect of
the element for forming a compound, and the total content of
an M1 element(s) of more than 20 at.% increases the amount of
the compound and thus causes embrittlement, so that the total
35 content of the M1 element(s) should be 2 to 20 at.%, preferably
2 to 15 at.%, further preferably 3 to 12 at.%.

[0033]

The balance raw material can contain, as an M element(s), one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru. The total content (on an at.% basis) of the M2 element(s) in the balance raw material is preferably 1 to 10 at.%. By having the total content of the M2 element(s) at 1 to 10 at.% in the balance raw material, the M2 element(s) can be incorporated into the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in a solid solution, and/or a compound of the M2 element(s) and at least one element of Fe, Ni, and Co can be produced. This can reduce the magnetism of the $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy. In the balance raw material, the total content of an M2 element(s) of less than 1 at.% does not achieve the effect of a solid solution nor the effect of the element for forming a compound, and the total content of an M2 element(s) of more than 10 at.% increases the amount of the compound and thus causes embrittlement, so that the total content of the M2 element(s) is preferably 1 to 10 at.%.
 5
 10
 15

[0034]

The balance raw material can contain one or both of the M1 element(s) and the M2 element(s). When the both are contained, the sum of the total content of the M1 element(s) and the total content of the M2 element(s) is preferably 25 at.% or less, and more preferably 20 at.% or less.
 20
 25

EXAMPLES

[0035]

The present invention will be specifically described below with reference to Examples.

An Fe-Ni-M-based alloy powder, an Fe-Ni-Co-M-based alloy powder, and other raw powders were produced as raw powders by a gas atomization method. The gas atomization method was performed using argon gas, a nozzle diameter of 6 mm, and a gas pressure of 5 MPa as the conditions. Among the alloy powders produced, powders classified into 500 μm or less were used. In this regard, pure substance powders as
 30
 35

other raw powders may be produced by a method other than an atomization method. Alternatively, not only a gas atomization method but also a water atomization method, a rotation disk type atomization method, or the like can be applied to the production of the powder.

[0036]

An Fe-Ni-M-based alloy powder or an Fe-Ni-Co-M-based alloy powder and other raw powders were produced by the aforementioned method, mixed so as to satisfy the Fe-Ni-Co-M-based alloy composition shown in Tables 1 to 3, filled into a sealing can composed of an SC material, and encapsulated under degassing vacuum at an ultimate vacuum of 10^{-1} Pa or more, whereafter a molded body was produced by a pressure sintering method on the conditions of a temperature of 800 to 1200°C, a pressure of 100 MPa or more, and a retention time of 5 hours, and a target material having a final shape having an outer diameter of 165 to 180 mm and a thickness of 3 to 10 mm was then obtained by machining. The raw powders were mixed using a V type mixer, and the mixing time was 1 hour. 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.

[0037]

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 (emu) of the ring specimen in an applied magnetic field of 8 kA/m. In Tables 1 to 3, a target material having a magnetic permeability of 500 emu or less was rated as "G1 (Grade 1)", more than 500 emu to 1000 emu as "G2 (Grade 2)", and more than 1000 emu as "G3 (Grade 3)". In terms of the maximum magnetic permeability, G1 is particularly preferred for a Ni-based sputtering target material according to the present invention, G2 is preferred for a Ni-based sputtering target material according to the present

invention, and G3 is not suitable for a Ni-based sputtering target material according to the present invention.

[0038]

5 In the measurement of the pass-through-flux (hereinafter referred to as "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 method enables a pass-through-flux to be quantitatively measured in the state
10 near to that of a magnetron sputtering device. The actual measurement was 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:
15
$$(PTF) = 100 \times (\text{magnetic flux in the state in which a target material is placed}) / (\text{magnetic flux in the state in which a target material is not placed}) (\%).$$

In Tables 1 to 3, target materials having a PTF of 10% or more were rated as "G1 (Grade 1)" and less than 10% as "G2 (Grade 2)". In terms of PTF, G1 is preferred for a Ni-based sputtering target material according to the present invention, and G2 is not suitable for a Ni-based sputtering target material according to the present invention.

[0039]

[Table 1]

No	Component Composition				Raw Powder A				Raw Powder A		maximum magnetic permeability	PTF	Remarks
	Fe	Ni	Co	M1	Fe	Ni	Co	M1	Balance				
1	2	98	-	W:2	80	20	-	W:2	Ni: , W:		G2	G1	Examples of the present invention
2	5	95	-	W:2	75	25	-	W:2	Ni: , W:		G2	G1	
3	5	95	-	W:2	70	30	-	W:2	Ni: , W:		G2	G1	
4	10	90	-	W:13	70	30	-	W:13	Ni: , W:		G1	G1	
5	10	90	-	W:5	75	25	-	W:5	Ni: , W:		G2	G1	
6	20	80	-	W:5	80	20	-	W:5	Ni: , W:		G2	G1	
7	5	90	5	Mo:5	70	30	-	Mo:5	Ni: , Co: , Mo:		G1	G1	
8	5	90	5	Mo:5	65	30	5	Mo:5	Ni: , Co: , Mo:		G1	G1	
9	5	85	10	Mo:3	65	30	5	Mo:3	Ni: , Co: , Mo:		G1	G1	
10	7	80	13	Mo:7	65	30	5	Mo:7	Ni: , Co: , Mo:		G1	G1	
11	8	85	7	Mo:7	65	30	5	Mo:7	Ni: , Co: , Mo:		G1	G1	
12	10	80	10	W:5	70	30	-	W:5	Ni: , W: , Co:		G2	G1	
13	10	80	10	W:14	70	30	-	W:14	Ni: , W: , Co:		G1	G1	
14	10	80	10	W:7,Mo:7	70	30	-	W:7, Mo:7	Ni: , W: , Mo: , Co:		G1	G1	
15	15	85	-	W:7,Mo:7	70	30	-	W:7, Mo:7	Ni: , W: , Mo:		G1	G1	
16	10	80	10	W:10,Mo:4	70	30	-	W:10, Mo:4	Ni: , W: , Mo: , Co:		G1	G1	
17	10	65	25	W:7	68	32	-	W:7	Ni: , W: , Co:		G1	G1	
18	10	65	25	W:7	65	35	-	W:7	Ni: , W: , Co:		G1	G1	
19	30	65	5	W:5	75	25	-	W:5	Ni: , W: , Co:		G2	G1	
20	30	45	25	W:7,Mo:7	71	29	-	W:7, Mo:7	Ni: , W: , Mo: , Co:		G1	G1	
21	33	35	32	W:7,Mo:7	71	29	-	W:7, Mo:7	Ni: , W: , Mo: , Co:		G1	G1	

22	25	20	55	W:10,Mo:4	71	29	-	W:10, Mo:4	Ni: , W: , Mo: , Co:	G1	G1
23	50	20	30	W:20	70	30	-	W:20	Fe: , W: , Co:	G1	G1
24	5	95	-	W:2	<u>85</u>	<u>15</u>	-	W:2	Ni: , W:	G3	G2
25	5	95	-	W:2	<u>100</u>	-	-	-	Ni: , W:	G3	G2
26	2	98	-	W:2	-	-	-	-	-	G3	G2
27	5	85	10	Mo:3	-	-	-	-	-	G3	G2
28	7	80	13	Mo:7	<u>25</u>	30	<u>45</u>	Mo:13	Ni, Mo	G3	G2
29	15	85	-	W:7,Mo:7	-	-	-	-	-	G3	G2
30	25	20	55	W:10,Mo:4	-	-	-	-	-	G3	G2

Comparative
Examples

Note: The underlined items are not the requirements of the present invention.

[0040]

In Table 1, Nos. 1 to 23 are Examples according to the present invention, while Nos. 24 to 30 are Comparative Examples.

5 [0041]

In Table 1, the "Fe", "Ni", and "Co" under the "Component Composition" indicate the ratios of the Fe content (on an at.% basis), the Ni content (on an at.% basis), and the Co content (on an at.% basis) respectively to the total content (on an at.% basis) of Fe, Ni, and Co in the Fe-Ni-Co-M-based alloy, and the sum of these ratios ("Fe" + "Ni" + "Co") is 100. The total content (on an at.% basis) of Fe, Ni, and Co in the Fe-Ni-Co-M-based alloy is determined by subtracting the total content (on an at.% basis) of M1 from 100 at.%. For example, 10 in No. 1, the total content (on an at.% basis) of Fe, Ni, and Co is 100 at.% - 2 at.% = 98 at.%. The same procedure applies to the other Tables.

[0042]

In Table 1, the "Fe", "Ni", and "Co" under the "Raw Powder A" indicate the ratios of the Fe content (on an at.% basis), the Ni content (on an at.% basis), and the Co content (on an at.% basis) respectively to the total content (on an at.% basis) of Fe, Ni, and Co in the raw powder A, and the sum of these ratios ("Fe" + "Ni" + "Co") is 100. The total content (on an at.% basis) of Fe, Ni, and Co in the raw powder A is determined by subtracting the total content (on an at.% basis) of M1 in the raw powder A from 100 at.%. For example, in No. 1, the total content (on an at.% basis) of Fe, Ni, and Co in the raw powder A is 100 at.% - 2 at.% = 98 at.%. The same procedure applies to the other Tables.

[0043]

All of Nos. 1 to 23 which are Examples of the present invention satisfy the requirements of the present invention and thus have the maximum magnetic permeability of 1000 emu or less and a PTF of 10% or more. In contrast, the average compositions of Comparative Examples Nos. 24 and 25 are the

same as that of Example No. 3 of the present invention, but Nos. 24 and 25 do not satisfy the requirement that the ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the raw powder A should be 20 to 35 (in other words, the ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in the microstructure of the alloy should be 20 to 35), and hence the maximum magnetic permeability is more than 1000 emu, and the PTF is less than 10%. The average compositions of Comparative Examples Nos. 26, 27, 29, and 30 are the same as those of Examples Nos. 1, 9, 15, and 22 of the present invention, but Nos. 26, 27, 29, and 30 were produced using a single alloy powder, and thus did not have an $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase that satisfied a requirement of the present invention, and each of the Comparative Examples had the maximum magnetic permeability of more than 1000 emu and a PTF of less than 10%. The average composition of Comparative Example No. 28 is the same as that of Example No. 10 of the present invention, but No. 28 does not satisfy the requirement that the ratio of the Co content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the raw powder A should be 30 or less (in other words, the ratio of the Co content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in the microstructure of the alloy should be 30 or less), and hence the maximum magnetic permeability is more than 1000 emu, and the PTF is less than 10%.

[0044]

[Table 2]

No	Component Composition				Raw Powder A				Raw Powder C		maximum magnetic permeability	PTF	Remarks
	Fe	Ni	Co	M1	Fe	Ni	Co	M1	Balance				
31	2	98	-	W:2, Mo:2, Ta:2	80	20	-	W:2	Ni: , W: , Mo: , Ta:		G2	G1	Examples of the present invention
32	5	95	-	W:2, Ta:3	75	25	-	W:2	Ni: , W: , Ta:		G2	G1	
33	5	95	-	Ta:5	70	30	-	Ta:2	Ni: , Ta:		G2	G1	
34	10	90	-	Ta:7	70	30	-	Ta:7	Ni: , Ta:		G1	G1	
35	2	98	-	W:20, Cr:5	80	20	-	W:20, Cr:5	Ni: , W: , Cr:		G2	G1	
36	10	90	-	Cr:5	75	25	-	Cr:5	Ni: , Cr:		G1	G1	
37	20	80	-	Ta:5, Cr:5	75	25	-	Ta:5	Ni: , Ta: , Cr:		G1	G1	
38	5	90	5	Nb:5	70	30	-	Nb:5	Ni: , Co: , Nb:		G2	G1	
39	5	90	5	Nb:5	65	30	5	Nb:5	Ni: , Co: , Nb:		G2	G1	
40	5	85	10	Cr:5	65	30	5	Cr:3	Ni: , Co: , Cr:		G1	G1	
41	7	80	13	Mo:3, V:2, Nb:2	65	30	5	Mo:7	Ni,Co: , Mo: , V: , Nb:		G1	G1	
42	8	85	7	V:7	65	30	5	V:7	Ni: , Co: , V:		G1	G1	
43	10	80	10	W:5, Nb:2	70	30	-	W:5	Ni: , Co: , W: , Nb:		G1	G1	
44	10	80	10	Cr:7	70	30	-	Cr:7	Ni: , Co: , Cr:		G1	G1	
45	10	80	10	Mo:7, Cr:7	70	30	-	Mo:7, Cr:7	Ni: , Co: , Mo: , Cr:		G1	G1	
46	15	85	-	W:7, Cr:7	70	30	-	W:7, Cr:7	Ni: , W: , Mo: , Cr:		G1	G1	
47	10	80	10	Cr:9	70	30	-	Cr:9	Ni: , Co: , Cr:		G1	G1	
48	25	65	10	W:2, Ta:1, Cr:2, V:1	68	32	-	W:2	Ni: , Co: , W: , Ta: , Cr: , V:		G1	G1	
49	25	65	10	Mo:2, Ta:1, Cr:2, V:1	68	32	-	Mo:2	Ni: , Co: , Mo: , Ta: , Cr: , V:		G1	G1	

50	30	65	5	W:3, V:2	75	25	-	W:3	Ni: , Co: , W: , V:	G2	G1
51	30	45	25	W:5, Mo:5, Cr:3	71	29	-	W:5, Mo:5	Ni: , Co: , W: , Mo: , Cr:	G1	G1
52	33	35	32	W:5, Mo:5, Cr:3	71	29	-	W:5, Mo:5	Ni: , Co: , W: , Mo: , Cr:	G1	G1
53	25	20	55	W:5, Mo:5, Cr:3	71	29	-	W:5, Mo:5	Ni: , Co: , W: , Mo: , Cr:	G1	G1
54	5	95	-	W:2, Ta:3	<u>85</u>	<u>15</u>	-	W:2	Ni: , W: , Ta:	G3	G2
55	5	95	-	W:2, Ta:3	-	-	-	-	-	G3	G2
56	2	98	-	W:20, Cr:5	-	-	-	-	-	G3	G2
57	5	85	10	Cr:5	-	-	-	-	-	G3	G2
58	7	80	13	Mo:3, V:2, Nb:2	-	-	-	-	-	G3	G2
59	25	65	10	Mo:2, Ta:1, Cr:2, V:1	-	-	-	-	-	G3	G2
60	25	20	55	W:5, Mo:5, Cr:3	-	-	-	-	-	G3	G2
Comparative Examples											

Note: The underlined items are not the requirements of the present invention.

[0045]

In Table 2, Nos. 31 to 53 are Examples according to the present invention, while Nos. 54 to 60 are Comparative Examples.

5 [0046]

All of Nos. 31 to 53 which are Examples of the present invention satisfy the requirements of the present invention and thus have the maximum magnetic permeability of 1000 emu or less and a PTF of 10% or more. In contrast, the average
10 composition of Comparative Example No. 54 is the same as that of Example No. 32 of the present invention, but No. 54 does not satisfy the requirement that the ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the raw powder A should be 20 to 35 (in other words,
15 the ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in the microstructure of the alloy should be 20 to 35), and hence the maximum magnetic permeability is more than 1000 emu, and the PTF is less than 10%. The average
20 compositions of Comparative Examples Nos. 55 to 60 are each the same as those of Examples Nos. 32, 35, 40, 41, 49, and 53 of the present invention, but Nos. 55 to 60 were produced using a single alloy powder, and thus did not have an $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase that satisfied a requirement of the present invention, and
25 each of the Comparative Examples had the maximum magnetic permeability of more than 1000 emu and a PTF of less than 10%.

[0047]

[Table 3]

No.	Component Composition					Raw Powder A					Raw Powder B				Raw Powder C		Maximum Magnetic Permeability	PTF	Remarks
	Fe	Ni	Co	M1	M2	Fe	Ni	Co	M1	M2	Fe	Ni	Co	M1	M2	Balance			
61	2	98	-	W:2	Al:1	75	25	-	W:2	Al:1	-	-	-	-	-	Ni: , W:Al:	G2	G1	Examples of the present invention
62	5	95	-	W:2	Al:1, Ga:1	75	25	-	W:2	-	-	-	-	-	-	Ni: , W: , Al: , Ga:	G2	G1	
63	5	95	-	Mo:2	Al:1, Ga:1	70	30	-	Mo:2	-	-	-	-	-	-	Ni: , Mo: , Al: , Ga:	G2	G1	
64	10	90	-	W:5, Ta:3	In:2, Si:1	70	30	-	W:5, Ta:7	-	-	-	-	-	-	Ni: , W: , Ta: , In: , Si:	G1	G1	
65	2	98	-	W:2	Al:1, Ti:1	70	30	-	W:2	Al:1	-	-	-	-	-	Ni: , W: , Al: , Ti:	G2	G1	
66	10	90	-	W:2, Cr:5	Si:2	75	25	-	W:2, Cr:5	-	-	-	-	-	-	Ni: , W: , Cr: , Si:	G1	G1	
67	10	90	-	W:2, Cr:5	Si:2, Zr:1	75	25	-	W:2, Cr:5	-	-	-	-	-	-	Ni: , W: , Cr: , Si: , Zr:	G1	G1	
68	5	90	5	Mo:5, Nb:2	Ge:1, Hf:1	70	30	-	Mo:5, Nb:2	-	-	-	-	-	-	Ni: , Co: , Mo: , Nb: , Ge: , Hf:	G1	G1	
69	5	90	5	Mo:5, Nb:2	B:4	65	30	5	Mo:5, Nb:2	-	-	-	-	-	-	Ni: , Co: , Mo: , Nb: , B:	G1	G1	
70	5	85	10	Mo:5, Nb:2	B:2, Cu:1, Ru:1	65	30	5	Mo:5, Nb:2	-	-	-	-	-	-	Ni: , Co: , Mo: , Nb: , B: , Cu: , Ru:	G1	G1	
71	5	85	10	Mo:5, Nb:2	Sn:1, Cu:1, Ru:1, C:1	65	30	5	Mo:5, Nb:2	-	-	-	-	-	-	Ni: , Co: , Mo: , Nb: , Sn: , Cu: , Ru: , C:	G1	G1	
72	8	82	10	Mo:5, Nb:2	Sn:1, Cu:1, Ru:1, C:1	65	30	5	Mo:5, Nb:2	-	-	-	-	-	-	Ni: , Co: , Mo: , Nb: , Sn: , Cu: , Ru: , C:	G1	G1	
73	8	82	10	Mo:5, Nb:2	P:1, Cu:2, Ru:1, C:1	65	30	5	Mo:5, Nb:2	-	-	-	-	-	-	Ni: , Co: , Mo: , Nb: , P: , Cu: , Ru: , C:	G1	G1	
74	10	80	10	Cr:7	Al:5	70	30	-	Cr:7	-	-	-	-	-	-	Ni: , Co: , Cr: , Al:	G1	G1	
75	10	80	10	W:5, Cr:3	Al:1	80	20	-	W:7, Mo:7	-	-	-	-	-	-	Ni: , Co: , Mo: , Cr: , Al:	G1	G1	
76	15	85	-	W:5, Cr:3	Al:1	70	30	-	W:7, Mo:7	-	-	-	-	-	-	Ni: , W: , Mo: , Cr: , Al:	G1	G1	
77	10	80	10	W:8	Hf:2	70	30	-	W:8	-	-	-	-	-	-	Ni: , Co: , Hf:	G1	G1	
78	25	65	10	W:2, Ta:1	Al:1, Ga:1	68	32	-	W:2	-	-	-	-	-	-	Ni: , Co: , W: , Ta: ,	G1	G1	

[0048]

In Table 3, Nos. 61 to 83 are Examples according to the present invention, while Nos. 84 to 90 are Comparative Examples.

5 [0049]

All of Nos. 61 to 83 which are Examples of the present invention satisfy the requirements of the present invention and thus have the maximum magnetic permeability of 1000 emu or less and a PTF of 10% or more. The average compositions of
10 Comparative Examples Nos. 84 to 87 and 89 are each the same as those of Examples Nos. 61, 74, 79, 82, and 83 of the present invention, but Nos. 84 to 87 and 89 were produced using a single alloy powder, and thus did not have an $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase that satisfied a requirement of the present invention, and each
15 of the Comparative Examples had the maximum magnetic permeability of more than 1000 emu and a PTF of less than 10%. The average compositions of Comparative Examples Nos. 88 and 90 are the same as those of Examples Nos. 82 and 83 of the present invention, but Nos. 88 and 90 do not satisfy the
20 requirement that the ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the raw powder A should be 20 to 35 (in other words, the ratio of the Ni content (on an at.% basis) to the total content (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in the
25 microstructure of the alloy should be 20 to 35), and hence the maximum magnetic permeability is more than 1000 emu, and the PTF is less than 10%.

[0050]

As described above, using an Fe-Ni-Co-M-based alloy
30 powder as a raw powder can achieve an extremely excellent effect that makes it possible to obtain a sputtering target material for a seed layer, in which the sputtering target material has a low magnetic permeability, a large pass-through-flux, and a high use efficiency in a magnetron sputtering method.

35

CLAIMS

1. A Ni-based sputtering target material, comprising an
 5 $\text{Fe}_x\text{-Ni}_y\text{-Co}_z\text{-M}$ -based alloy, wherein x represents a ratio of the Fe
 content (on an at.% basis) to the total content (on an at.%
 basis) of Fe, Ni, and Co in the alloy, y represents a ratio of the
 Ni content (on an at.% basis) to the total content (on an at.%
 10 basis) of Fe, Ni, and Co in the alloy, and z represents a ratio of
 the Co content (on an at.% basis) to the total content (on an
 at.% basis) of Fe, Ni, and Co in the alloy,

wherein the alloy comprises, as M elements, one or more
 M1 elements selected from W, Mo, Ta, Cr, V, and Nb at the total
 of 2 to 20 at.% and one or more M2 elements selected from Al,
 15 Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru at the total of 0
 to 10 at.%, and the balance consists of Ni, one or two of Fe and
 Co, and unavoidable impurities,

wherein, assuming that $x + y + z = 100$ is satisfied, x is
 from 0 to 50, y is from 20 to 98, and z is from 0 to 60,

20 wherein the alloy comprises a microstructure comprising
 an $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, wherein α represents a ratio of the Fe
 content (on an at.% basis) to the total content (on an at.%
 basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase, β represents
 a ratio of the Ni content (on an at.% basis) to the total content
 25 (on an at.% basis) of Fe, Ni, and Co in the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase,
 and γ represents a ratio of the Co content (on an at.% basis) to
 the total content (on an at.% basis) of Fe, Ni, and Co in the
 $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase,

wherein, assuming that $\alpha + \beta + \gamma = 100$ is satisfied, β is
 30 from 20 to 35 and γ is 30 or less, and

wherein the microstructure comprises an M element(s)
 incorporated into the $\text{Fe}_\alpha\text{-Ni}_\beta\text{-Co}_\gamma$ phase in a solid solution
 and/or an M element(s) formed into a compound with at least
 one element of Fe, Ni, and Co.

35

2. The Ni-based sputtering target material according to

claim 1, wherein the alloy comprises, as the M elements, one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru at the total of 1 to 10 at.% in addition to the M1 element(s).

5

3. The Ni-based sputtering target material according to claim 1 or 2, wherein the Ni-based sputtering target material is used for a seed layer in a magnetic recording medium.

10 4. A magnetic recording medium, comprising the Ni-based sputtering target material according to claim 1 or 2.