

ALLOY FOR SEED LAYER IN MAGNETIC RECORDING MEDIUM,
AND SPUTTERING TARGET MATERIAL

[Cross-Reference to Related Application]

5 [0001]

This application claims priority to Japanese Patent Application No. 2010-259713 filed on November 22, 2010 and Japanese Patent Application No. 2011-94594 filed on April 21, 2011, the entire content of which is incorporated herein by reference.

10

[Technical Field]

[0002]

The present invention relates to a Ni-Fe-Co-based alloy for a seed layer in a magnetic recording medium, used for a seed
15 layer in a perpendicular magnetic recording medium, and to a sputtering target material.

[Background Art]

[0003]

20 In recent years, there have been remarkable progresses in magnetic recording technology, and heightening of recording densities in magnetic recording media has been proceeding due to increasing drive capacities. For example, perpendicular magnetic recording system, which achieves further high
25 recording density when compared to conventionally-used longitudinal magnetic recording system, 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
30 high recording density.

[0004]

For perpendicular magnetic recording system, a recording medium having a magnetic recording film layer with an
35 increased recording density and a soft magnetic film layer has been developed, and, for such a medium structure, a recording

medium with a seed layer or an undercoat film layer formed between a soft-magnetic layer and a magnetic recording layer has been developed. For the seed layer for the perpendicular magnetic recording system, a Ni-W-based alloy has been proposed, for example, as disclosed in Japanese Patent Laid-Open Publication No. 2009-155722 (Patent Literature 1).

[0005]

The Ni-W-based alloy described in this Patent Literature 1 does not comprise Group VIII having magnetism but comprises nonmagnetic elements of Group IVa (Ti, Zr, and Hf), Group Va (V, Nb, and Ta), Group VIa (Cr, Mo, and W), Group VIIa (Mn, Tc, and Re), Group IIIb (B, Al, Ga, In, and Tl), and Group IVb (C, Si, Ge, Sn, and Pb), and, consequently, has become nonmagnetic. One of the properties required for a seed layer is, as shown in the name thereof, that the seed layer in itself has a single fcc structure and a plane parallel to a media plane is oriented to a (111) plane, in order to control the orientation of a layer formed on the seed layer to orient the magnetization-easy axis of a magnetic film, which records magnetic information, perpendicularly with respect to the media plane. Further, improvement in recording density requires the minimization of the crystal grain size of the magnetic film, which is desirably less than that of the seed layer to that end.

[Summary of the Invention]

[0006]

On the other hand, in recent years, a method of providing a seed layer with magnetism has been examined as a technique for improving the magnetic recording properties of hard disk drives. However, as mentioned above, the alloy for a seed layer as described in Patent Literature 1 is nonmagnetic and is not appropriate as an alloy for a seed layer to be provided with magnetism. Therefore, there has been a demand for development of an alloy for a seed layer having properties required for the alloy for a seed layer as mentioned above and having magnetism. A marked difference between a

soft-magnetic layer and a seed layer is that a soft-magnetic layer is required to be amorphous in terms of noise reduction, while a seed layer is required to have high crystallinity, as opposed to amorphism, which is non-crystallinity, as a seed layer requires an action to control the orientation of a layer formed thereon.

[0007]

The inventors have now found that a magnetic permeability is increased by providing a seed layer with magnetism through adding Fe or Co, which is a Group VIII element having magnetism, and by reducing a coercive force in a (111) plane direction.

[0008]

It is therefore an object of the present invention to provide an alloy for a seed layer in a magnetic recording medium, capable of providing a Ni-based intermediate layer on a soft-magnetic undercoat film (SUL) with magnetism and also capable of increasing a magnetic permeability, and a sputtering target material in which the alloy is used.

[0009]

According to one embodiment of the present invention, there is provided an alloy for a seed layer in a magnetic recording medium, comprising:

2 to 20 at% of an M1 element which is one or two or more selected from the group consisting of W, Mo, Ta, Cr, V, and Nb, based on the alloy;

0 to 10 at% of an M2 element which is one or two or more selected from the group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru, based on the alloy; and

the balance being Ni, Fe, and Co in ratios of Ni:Fe:Co=98-20:0-50:0-60 and $Fe+Co \geq 1.5$ in at% based on a total amount of Ni+Fe+Co.

[0010]

According to another embodiment of the present invention, there is provided an alloy for a seed layer in a magnetic recording medium, comprising:

2 to 20 at% of an M1 element which is one or two or more selected from the group consisting of W, Mo, Ta, Cr, V, and Nb, based on the alloy;

0 to 10 at% of an M2 element which is one or two or more selected from the group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru, based on the alloy; and

the balance being Ni, Fe, and Co in a ratio of Ni:Fe:Co=98-20:2-50:0-60 in at% based on a total amount of Ni+Fe+Co.

[0011]

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

[0012]

According to another embodiment of the present invention, there is provided a magnetic recording medium comprising a seed layer constituted by the above-described alloy.

[Description of Embodiments]

[0013]

The present invention is specifically explained below. Unless otherwise specified, "%" as used herein means at%.

[0014]

The alloy for a seed layer in a magnetic recording medium according to the present invention comprises: 2 to 20 at% of M1 elements which are one or two or more selected from the group consisting of W, Mo, Ta, Cr, V, and Nb, based on the alloy; and 0 to 10 at% of M2 elements which are one or two or more selected from the group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru, based on the alloy; and the balance being at least two of Ni, Fe, and Co, preferably consists essentially of these elements and unavoidable impurities, and more preferably consists of these elements and unavoidable impurities. However, each amount of Ni, Fe, and Co is set to (i) ratios of Ni:Fe:Co=98-20:0-50:0-60 and $Fe+Co \geq 1.5$ or (ii) a ratio of Ni:Fe:Co=98-20:2-50:0-60 in at% based on the total

amount of Ni+Fe+Co.

[0015]

In the alloy according to the present invention, when the ratio of Ni, Fe and Co is represented by Ni:Fe:Co= α : β : γ , the atomic
5 ratio α of Ni is set to 98 (more precisely 98.5) to 20, preferably 98 (more precisely 98.5) to 60. When α is more than 98.5, β + γ is less than 1.5 and a coercive force becomes high, and when α is less than 20, the coercive force also becomes high similarly to the above-described case.

10 [0016]

Fe is an element that reduces a coercive force and also an element that improves the orientation of a film, and, in the case of Ni:Fe:Co= α : β : γ , the atomic ratio β of Fe is set to 0 to 50, preferably 2 to 50%, more preferably 10 to 40. When β is
15 more than 50, a coercive force becomes high.

[0017]

Co is an element that reduces a coercive force in a (111) direction, and, in the case of Ni:Fe:Co= α : β : γ , the atomic ratio γ of Co is set to 0 to 60, preferably 40 or less. When γ is more
20 than 60, a coercive force becomes high.

[0018]

The alloy according to the present invention comprises 2 to 20 at%, preferably 5 to 15%, of M1 elements which are one or two or more selected from the group consisting of W, Mo, Ta, Cr, V
25 and Nb, based on the total of the alloy. The M1 elements are bcc-based metals having high-melting points and elements that improve orientation to a (111) plane required for a seed layer and cause crystal grains to be finer by adding them to an alloy system which is fcc in the constituent range defined in the
30 present invention, although the mechanism thereof is not clear. However, an M1 element content of less than 2% causes the insufficient effect thereof, while that of more than 20% causes the precipitation of a compound or amorphization. Since the alloy for a seed layer is required to be an fcc single phase, the
35 range of the M1 element content is set as described above.

[0019]

Especially, W and Mo are highly effective for the orientation to the (111) plane, therefore, it is preferable to add one or two of W and Mo, and any one or two or more of Cr, Ta, V, and Nb may also be added thereto. The reason for this is due to the combination of Ni and a high-melting-point bcc metal. Mo and W have higher melting points than that of Cr and thus are advantageous. Addition of Ta, V, and Nb also acts on improvement in amorphousness in comparison with W and Mo and is disadvantageous for forming an fcc phase required for a seed layer. Addition of more than 5% of Cr is desirably advantageous in view of orientation.

[0020]

The alloy according to the present invention comprises, as optional elements, 0 to 10 at%, preferably 1 to 10%, more preferably 5%, of M2 elements which are one or two or more selected from the group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru, based on the alloy. The M2 elements are elements that orient a (111) plane and are elements that cause crystal grains to be finer. However, an M2 element content of more than 10% results in the generation of a compound or amorphization. Further, the total amount of M1+M2 is preferably set to 25 at% or less, further preferably 20 at% or less.

[Examples]

25 [0021]

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

[0022]

Normally, a seed layer in a perpendicular magnetic recording medium is formed by sputtering a sputtering target material having the same composition as that of the seed layer to form a film on a glass substrate or the like. In this case, the thin film formed by sputtering has been quenched. Quenched ribbons produced in a single-roll-type quenching device have been used as sample materials in accordance with the present invention. This is to evaluate the influence of the thin films, which are

actually quenched and formed by sputtering, on various properties by the components, in a simple manner using liquid quenched ribbons.

[0023]

5 Production of Quenched Ribbon

A raw material of 30 g weighed to have the compositions shown in Table 1 was arc-melted in Ar with a reduced pressure in a water-cooled copper mold of around 10 mm in diameter and 40 mm in length to provide a molten raw material for the quenched ribbon. The production of the quenched ribbon was conducted by a single roll method under the condition in which the molten raw material was set in a quartz tube having a diameter of 15 mm and was tapped from a tapping nozzle having a diameter of 1 mm, at an atmospheric pressure of 61 kPa, at an atomizing pressure difference of 69 kPa, and at a rotational number of 3000 rpm of a copper roll (diameter of 300 mm), with a gap between the copper roll and the tapping nozzle being set to 0.3 mm. The temperature at which each raw material melted down was taken as the tapping temperature. Quenched ribbons thus produced were used as sample materials to evaluate the properties described below.

[0024]

Evaluation of Coercive Force

In a vibration-sample-type coercive force meter, a quench ribbon was adhered on a sample support with a double-faced tape and the coercive force of the quench ribbon was measured at an initial applied magnetic field of 144 kA/m. A coercive force of 300 A/m or less was evaluated as "good," more than 300 A/m and 500 A/m or less as "fair," and more than 500 A/m as "poor."

[0025]

Evaluation of Saturation Magnetic Flux Density

The saturation flux density of the quenched ribbon was measured at an applied magnetic field of 1200 kA/m in a VSM device (vibration-sample-type magnetometer). The weight of the sample material was around 15 mg, and 0.2 T or more was

evaluated as "good" and less than 0.2 T as "poor."

[0026]

Evaluation of (111) Plane Orientation

A seed layer formed by sputtering has an fcc structure. By
5 quenching the seed layer, (200) is oriented. Typically, as for
the X-ray diffraction intensities of a (111) plane and a (200)
plane, random orientation causes $I(200)$ to be higher than $I(111)$.
Thus, the orientation of the (111) plane of the
quenched ribbon was evaluated by a method described below.

10 [0027]

The sample material was adhered on a glass plate with a
double-faced tape to obtain a diffraction pattern by an X-ray
diffraction device. At this time, the sample material was
adhered on the glass plate so that a surface to be measured
15 could be a copper-roll-contact surface of the quenched ribbon.
The X-ray source was Cu- α ray, and the measurement was
conducted at a scan speed of 4°/min. In the diffraction pattern,
 $I(111)/I(200)$, which was an intensity ratio of the intensity $I(111)$
of X-rays diffracted on the (111) plane to the intensity $I(200)$
20 on the (200) plane, of less than 0.7 was evaluated as
"poor" and 0.7 or more as "good." Further, the case of the
generation of a compound or amorphization was evaluated as
"poor."

[0028]

25 Evaluation of Crystal Grain Size

The crystal grain size of the quenched ribbon was measured in
the roll direction of the cross-sectional microstructure image of
the quenched ribbon according to JIS G0551
"Steels-Micrographic determination of the apparent grain size."
30 P/Lt of 1.0 or more was evaluated as "good," 0.5 or more and
less than 1.0 as "fair," and less than 0.5 as "poor."

[0029]

[Table 1]

Table 1

No.	Composition (at%)	Coercive Force	Saturation Magnetic Flux Density	Orientation	Crystal Grain Size	Present Invention Examples
1	(Ni ₂ Fe)-2W	Fair	Good	Good	Fair	
2	(Ni ₂ Fe)-2W-3Mo	Good	Good	Good	Good	
3	(Ni ₁₀ Fe ₁₀ Co)-5W-1Al	Good	Good	Good	Good	
4	(Ni ₂₀ Fe ₁₀ Co)-5W-1Al	Good	Good	Good	Good	
5	(Ni ₃₀ Fe ₁₀ Co)-5W-1Al	Good	Good	Good	Good	
6	(Ni ₄₀ Fe ₁₀ Co)-5W-1Al	Good	Good	Good	Good	
7	(Ni ₅₀ Fe ₁₀ Co)-5W-1Al	Good	Good	Good	Good	
8	(Ni ₁₀ Fe ₂₀ Co)-5W-1Al	Good	Good	Good	Good	
9	(Ni ₂₀ Fe ₂₀ Co)-5W-1Al	Good	Good	Good	Good	
10	(Ni ₃₀ Fe ₂₀ Co)-5W-1Al	Good	Good	Good	Good	
11	(Ni ₄₀ Fe ₂₀ Co)-5W-1Al	Good	Good	Good	Good	
12	(Ni ₅₀ Fe ₂₀ Co)-5W-1Al	Good	Good	Good	Good	
13	(Ni ₁₀ Fe ₃₀ Co)-5W-1Al	Good	Good	Good	Good	
14	(Ni ₂₀ Fe ₃₀ Co)-5W-1Al	Good	Good	Good	Good	
15	(Ni ₃₀ Fe ₃₀ Co)-5W-1Al	Good	Good	Good	Good	
16	(Ni ₄₀ Fe ₃₀ Co)-5W-1Si	Good	Good	Good	Good	
17	(Ni ₅₀ Fe ₃₀ Co)-5W-1Al	Fair	Good	Good	Good	
18	(Ni ₁₀ Fe ₄₀ Co)-5W-1Al	Good	Good	Good	Good	
19	(Ni ₂₀ Fe ₄₀ Co)-5W-1Al	Good	Good	Good	Good	
20	(Ni ₃₀ Fe ₄₀ Co)-5W-1Al	Good	Good	Good	Good	
21	(Ni ₄₀ Fe ₄₀ Co)-5W-1Si	Fair	Good	Good	Good	
22	(Ni ₁₀ Fe ₅₀ Co)-5W-1Al	Fair	Good	Good	Good	
23	(Ni ₂₀ Fe ₅₀ Co)-5W-1Al	Fair	Good	Good	Good	
24	(Ni ₃₀ Fe ₅₀ Co)-5W-1Al	Fair	Good	Good	Good	
25	(Ni ₁₀ Fe ₆₀ Co)-5W-1Al	Fair	Good	Good	Good	
26	(Ni ₂₀ Fe ₆₀ Co)-5W-1Si	Fair	Good	Good	Good	

[0030]

[Table 2]

Table 2

No.	Composition (at%)	Coercive Force	Saturation Magnetic Flux Density	Orientation	Crystal Grain Size	Present Invention Examples
27	(Ni5Fe)-5W-1Al	Good	Good	Good	Fair	
28	(Ni10Fe)-5W-1Al	Good	Good	Good	Fair	
29	(Ni15Fe)-5W-1Al	Good	Good	Good	Fair	
30	(Ni15Fe)-5Mo-1Cu	Good	Good	Good	Good	
31	(Ni15Fe)-5Ta-1Al	Good	Good	Good	Good	
32	(Ni15Fe)-5Cr-1Al	Good	Good	Good	Good	
33	(Ni20Fe)-5V-1Al	Good	Good	Good	Good	
34	(Ni30Fe)-5Nb-1Al	Good	Good	Good	Good	
35	(Ni40Fe)-2W-5Mo-1Al	Good	Good	Good	Good	
36	(Ni40Fe)-2W-5Ta-1Al	Good	Good	Good	Good	
37	(Ni40Fe)-2V-5Cr-1Al	Good	Good	Good	Good	
38	(Ni40Fe)-2Nb-5V-1Al	Good	Good	Good	Good	
39	(Ni40Fe)-2Mo-5Nb-1Al	Good	Good	Good	Good	
40	(Ni50Fe)-2W-1Mo-3Ta-1Al	Fair	Good	Good	Good	
41	(Ni50Fe)-2W-1Mo-1Ta-1Cr-1Al	Fair	Good	Good	Good	
42	(Ni50Fe)-2W-1Mo-1Cr-1V-1Al	Fair	Good	Good	Good	
43	(Ni50Fe)-2W-1Mo-1Cr-1V-1Nb	Fair	Good	Good	Good	
44	(Ni40Fe)-2W-1Mo-1Cr-1V-1Nb-1Al	Fair	Good	Good	Good	
45	(Ni40Fe)-2W-1Mo-1Cr-1V-1Nb	Fair	Good	Good	Good	
46	(Ni50Fe)-20W	Good	Good	Good	Fair	
47	(Ni50Fe)-20Mo	Good	Good	Good	Fair	

[0031]

[Table 3]

Table 3

No.	Composition (at%)	Coercive Force	Saturation Magnetic Flux Density	Orientation	Crystal Grain Size	Present Invention Examples
48	(Ni50Fe)-2W-10Al	Fair	Good	Good	Good	
49	(Ni50Fe)-2W-5Ga	Fair	Good	Good	Good	
50	(Ni50Fe)-2W-5In	Fair	Good	Good	Good	
51	(Ni50Fe)-2W-5Si	Fair	Good	Good	Good	
52	(Ni50Fe)-2W-5Ge	Fair	Good	Good	Good	
53	(Ni50Fe)-2W-5Sn	Fair	Good	Good	Good	
54	(Ni50Fe)-2W-10Zr	Good	Good	Good	Good	
55	(Ni50Fe)-2W-5Ti	Fair	Good	Good	Good	
56	(Ni50Fe)-2W-5Hf	Good	Good	Good	Good	
57	(Ni50Fe)-2W-10B	Good	Good	Good	Good	
58	(Ni50Fe)-2W-5Cu	Good	Good	Good	Good	
59	(Ni50Fe)-2W-5P	Fair	Good	Good	Good	
60	(Ni50Fe)-2W-1C	Fair	Good	Good	Fair	
61	(Ni40Fe)-2W-3Ru	Fair	Good	Good	Fair	
62	(Ni50Fe)-2W-1Al-Ga	Fair	Good	Good	Good	
63	(Ni50Fe)-2W-1Al-Ga-1In	Fair	Good	Good	Good	
64	(Ni50Fe)-2W-1Al-Ga-1In-1Si	Fair	Good	Good	Fair	
65	(Ni50Fe)-2W-1Al-1Ga-1In-1Si-1Ge	Fair	Good	Good	Fair	
66	(Ni50Fe)-2W-1Al-1Ga-1In-1Si-1Ge-1Sn	Fair	Good	Good	Fair	
67	(Ni50Fe)-2W-1Al-1Ga-1In-1Si-1Ge-1Sn-1Zr	Fair	Good	Good	Good	
68	(Ni50Fe)-2W-1Si-1Ge-1Sn-1Zr-1Ti	Fair	Good	Good	Fair	
69	(Ni50Fe)-2W-1Si-1Ga-1Sn-1Zr-1Ti-1Hf	Fair	Good	Good	Good	
70	(Ni50Fe)-2W-1Si-1Ge-1Sn-1Zr-1Ti-1Hf-1B	Good	Good	Good	Good	
71	(Ni50Fe)-2W-1Si-Ge-1Sn-1Zr-1Ti-Hf-1B-1Cu	Good	Good	Good	Good	
72	(Ni50Fe)-2W-1Zr-1Ti-1Hf-1B-1Cu-1P	Fair	Good	Good	Good	
73	(Ni50Fe)-1W-1Zr-1Ti-1Hf-1B-1Cu-1P-1C	Good	Good	Good	Good	
74	(Ni50Fe)-2W-1Zr-1Ti-1Hf-1B-1Cu-1P-1C-1Ru	Good	Good	Good	Good	

[0032]

[Table 4]

Table 4

No.	Composition (at%)	Coercive Force	Saturation Magnetic Flux Density	Orientation	Crystal Grain Size	
75	(Ni ₂ Fe ₅ Co)-2W-1Al	Fair	Good	Good	Good	Present Invention Examples
76	(Ni ₂₀ Fe ₁₀ Co)-5Mo-1Si	Good	Good	Good	Fair	
77	(Ni ₃₀ Fe ₁₀ Co)-5Mo-1Si	Good	Good	Good	Fair	
78	(Ni ₂₀ Fe ₂₀ Co)-5Mo-1Si	Good	Good	Good	Fair	
79	(Ni ₂₀ Fe ₂₀ Co)-10Cr-5Mo-1Si	Good	Good	Good	Good	
80	(Ni ₂₀ Fe ₆₀ Co)-5W-1Al	Fair	Good	Good	Good	
81	(Ni ₅₀ Fe ₂₀ Co)-5W-1Al	Fair	Good	Good	Good	
82	(Ni ₁₀ Fe ₁₀ Co)-5W-1Nb	Good	Good	Good	Good	
83	(Ni ₅₀ Fe ₁₀ Co)-5W-5Nb	Good	Good	Good	Fair	
84	(Ni ₁₀ Fe ₂₀ Co)-5W-3Cr	Good	Good	Good	Good	
85	(Ni ₅₀ Fe ₂₀ Co)-5W-3Mo	Good	Good	Good	Good	
86	(Ni ₁₀ Fe ₃₀ Co)-5W-1Ta	Good	Good	Good	Fair	
87	(Ni ₅₀ Fe ₃₀ Co)-5W-1Al	Fair	Good	Good	Fair	
88	(Ni ₁₀ Fe ₄₀ Co)-5W-5Mo	Good	Good	Good	Fair	
89	(Ni ₁₀ Fe ₅₀ Co)-5W-5V	Fair	Good	Good	Fair	
90	(Ni ₃₀ Fe ₅₀ Co)-5W-5Cr	Fair	Good	Good	Fair	
91	(Ni ₂₀ Fe ₆₀ Co)-5W-5Ta	Fair	Good	Good	Fair	
92	(Ni ₅ Fe)-5W-1Si	Good	Good	Good	Good	
93	(Ni ₁₀ Fe)-5W-1Si	Good	Good	Good	Good	
94	(Ni ₁₅ Fe)-5W-1Si	Good	Good	Good	Good	
95	(Ni ₅₀ Fe)-10W-10Mo-1Si	Good	Fair	Good	Good	

[0033]

[Table 5]

Table 5

No.	Composition (at%)	Coercive Force	Saturation Magnetic Flux Density	Orientation	Crystal Grain Size	
96	Ni	Poor	Good	Poor	Poor	Comparative Examples
97	Ni ₂ Fe	Good	Good	Poor	Poor	
98	(Ni ₆₀ Fe)-5W-1Al	Poor	Good	Good	Good	
99	(Ni ₅₀ Fe)-1W-15Al	Fair	Good	Poor	Good	
100	(Ni ₅₀ Fe)-30W	-	Poor	Poor	Good	
101	(Ni ₅₀ Fe)-1W-16Zr	Good	Good	Poor	Good	
102	(Ni ₅₀ Fe)-1W-15B	Good	Good	Poor	Good	
103	(Ni ₁₀ Fe ₇₀ Co)-5W-1Al	Poor	Good	Good	Good	
104	(Ni ₆₀ Fe ₂₀ Co)-5W-1Al	Poor	Good	Good	Good	
105	(Ni ₂₀ Fe ₂₀ Co)-1Cr	Poor	Good	Poor	Poor	
106	(Ni ₂₀ Fe ₂₀ Co)-25Cr	Poor	Poor	Poor	Poor	
107	(Ni ₂₀ Fe ₂₀ Co)-1Mo	Poor	Good	Poor	Poor	
108	(Ni ₂₀ Fe ₂₀ Co)-25Mo	Poor	Poor	Poor	Poor	
109	(Ni ₂₀ Fe ₂₀ Co)-1Ta	Poor	Good	Poor	Poor	
110	(Ni ₃₀ Fe ₃₀ Co)-25Ta	Poor	Poor	Poor	Poor	
111	(Ni ₂₀ Fe ₂₀ Co)-1V	Poor	Good	Poor	Poor	
112	(Ni ₂₀ Fe ₃₀ Co)-25V	Poor	Poor	Poor	Poor	
113	(Ni ₂₀ Fe ₂₀ Co)-1Nb	Poor	Good	Poor	Poor	
114	(Ni ₃₀ Fe ₂₀ Co)-25Nb	Poor	Poor	Poor	Poor	
115	(Ni ₃₀ Fe ₂₀ Co)-5W-15Ca	Good	Good	Poor	Poor	
116	(Ni ₃₀ Fe ₃₀ Co)-5W-15In	Good	Good	Poor	Poor	
117	(Ni ₃₀ Fe ₂₀ Co)-5W-15Si	Good	Good	Poor	Poor	
118	(Ni ₃₀ Fe ₂₀ Co)-5W-15Ge	Good	Good	Poor	Poor	
119	(Ni ₃₀ Fe ₃₀ Co)-5W-15Ti	Good	Good	Poor	Poor	
120	(Ni ₂₀ Fe ₂₀ Co)-5W-15Hf	Good	Good	Poor	Poor	
121	(Ni ₃₀ Fe ₂₀ Co)-5W-15Cu	Good	Good	Poor	Poor	
122	(Ni ₂₀ Fe ₂₀ Co)-5W-15P	Good	Good	Poor	Poor	
123	(Ni ₃₀ Fe ₃₀ Co)-5W-15C	Good	Good	Poor	Poor	
124	(Ni ₃₀ Fe ₂₀ Co)-5W-15Ru	Good	Good	Poor	Poor	

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

[0034]

[Table 6]

Table 6

No.	Composition (at%)	Coercive Force	Saturation Magnetic Flux Density	Orientation	Crystal Grain Size	
125	(Ni5Co)-2W-1Al	Fair	Good	Good	Good	Present Invention Examples
126	(Ni2Co)-2Cr-1Al	Fair	Fair	Good	Good	
127	(Ni2Co)-5.1Cr-1Al	Fair	Fair	Good	Good	
128	(Ni40Co)-5.7Cr-1Al-1Si	Fair	Good	Good	Good	
129	(Ni1Co1Fe)-2W-1Al	Fair	Good	Good	Good	
130	(Ni1Co1.5Fe)-2W-1Al	Fair	Fair	Good	Good	
131	(Ni1Co2Fe)-2Cr-1Al	Fair	Good	Good	Good	
132	(Ni0.8Co1.0Fe)-2Cr-1Al	Fair	Good	Good	Good	
133	(Ni0.6Co1.0Fe)-2Nb-1Al	Fair	Fair	Good	Good	
134	(Ni0.5Co1.0Fe)-2Mo	Fair	Fair	Good	Good	
135	(Ni0.8Co0.7Fe)-1Mo-1W	Fair	Fair	Good	Good	
136	(Ni0.7Co0.8Fe)-1Mo-1W	Fair	Fair	Good	Good	
137	(Ni1.0Co0.5Fe)-2Ta	Fair	Fair	Good	Good	
138	(Ni1.5Co0.5Fe)-2Ta	Fair	Fair	Good	Good	
139	(Ni0.6Co0.9Fe)-1Mo-1W	Fair	Fair	Good	Good	
140	(Ni0.3Co1.2Fe)-1Mo-1W	Fair	Fair	Good	Good	
141	(Ni0.1Co1.4Fe)-1Mo-1W	Fair	Fair	Good	Good	
142	(Ni0.9Co0.6Fe)-2V	Fair	Fair	Good	Good	
143	(Ni1.2Co0.3Fe)-2V	Fair	Fair	Good	Good	
144	(Ni1.4Co0.1Fe)-2V	Fair	Fair	Good	Good	
145	(Ni1.5Co)-2Ta	Fair	Fair	Good	Good	
146	(Ni1.5Fe)-2Ta	Fair	Fair	Good	Good	
147	(Ni1.0Co0.5Fe)-2Ta	Fair	Fair	Good	Good	
148	(Ni1.0Co0.9Fe)-2Mo	Fair	Fair	Good	Good	
149	(Ni0.9Co1.0Fe)-2Mo	Fair	Fair	Good	Good	
150	(Ni1.2Co0.7Fe)-2Cr	Fair	Fair	Good	Good	
151	(Ni1.3Co0.6Fe)-2Cr	Fair	Fair	Good	Good	
152	(Ni1.5Co0.4Fe)-2Cr	Fair	Fair	Good	Good	
153	(Ni1.7Co0.2Fe)-2Cr	Fair	Fair	Good	Good	
154	(Ni0.9Fe1.0Co)-2Nb	Fair	Fair	Good	Good	
155	(Ni1.2Fe0.7Co)-2Nb	Fair	Fair	Good	Good	

[0035]

[Table 7]

Table 7

No.	Composition (at%)	Coercive Force	Saturation Magnetic Flux Density	Orientation	Crystal Grain Size	
156	(Ni1.3Co0.6Fe)-2Nb	Fair	Fair	Good	Good	Present Invention Examples
157	(Ni1.5Fe0.4Co)-2Nb	Fair	Fair	Good	Good	
158	(Ni1.7Fe0.2Co)-2Nb	Fair	Fair	Good	Good	
159	(Ni2Fe)-5.1Cr-1Al	Fair	Fair	Good	Good	
160	(Ni2Fe)-5.7Cr-1Al	Fair	Fair	Good	Good	
161	(Ni10Co)-5W-1Nb	Fair	Good	Good	Good	
162	(Ni20Co)-5W-1Ti-1Cu	Fair	Good	Good	Good	
163	(Ni30Co)-5W-1V-1Ge-1Sn	Fair	Good	Good	Good	
164	(Ni40Fe40Co)-20Ta	Good	Good	Good	Fair	
165	(Ni20Fe40Co)-20Cr	Good	Good	Good	Fair	
166	(Ni30Fe30Co)-20V	Good	Good	Good	Fair	
167	(Ni40Fe40Co)-20Nb	Good	Good	Good	Fair	
168	(Ni20Fe20Co)-5Mo-10Ca	Good	Good	Good	Good	
169	(Ni20Fe30Co)-5V-10In	Fair	Good	Good	Good	
170	(Ni30Fe40Co)-5Nb-10Si	Fair	Good	Good	Good	
171	(Ni20Fe40Co)-5Cr-10Ge	Fair	Good	Good	Good	
172	(Ni40Fe20Co)-5Ta10Ti	Fair	Good	Good	Good	
173	(Ni30Fe30Co)-5V-10Hf	Fair	Good	Good	Good	
174	(Ni20Fe20Co)-5Nb-10Cu	Fair	Good	Good	Good	
175	(Ni20Fe40Co)-7Mo-10P	Fair	Good	Good	Good	
176	(Ni40Fe20Co)-8Mo-10C	Fair	Good	Good	Good	
177	(Ni20Fe30Co)-9Ta-10Ra	Good	Good	Good	Good	
178	(Ni2Fe2Co)-4.9Cr-1Al	Fair	Fair	Good	Fair	Comparative Examples
179	(Ni2Fe2Co)-4.5Cr-1Al	Fair	Fair	Good	Fair	
180	(Ni20Fe20Co)-5.1Cr-1Al	Good	Good	Good	Good	

[0036]

5 [Table 8]

Table 8

No.	Composition (at%)	Coercive Force	Saturation Magnetic Flux Density	Orientation	Crystal Grain Size	
181	(Ni30Fe30Co)-5.1Cr-1Al	Good	Good	Good	Good	Present Invention Examples
182	(Ni30Fe30Co)-5.5Cr-1Al	Good	Good	Good	Good	
183	(Ni20Fe30Co)-5.5Cr-1Al	Good	Good	Good	Good	
184	(Ni2Fe2Co)-5.5Cr-1Al	Fair	Fair	Good	Fair	
185	(Ni20Fe20Co)-5.5Cr-1Al	Good	Good	Good	Good	
186	(Ni2Fe2Co)-5.1Cr	Good	Fair	Good	Fair	
187	(Ni2Fe2Co)-5.5Cr	Good	Fair	Good	Fair	
188	(Ni50Co)-5Ta-1Nb-1In-1Sn-1Zr-1Ti-1B	Fair	Good	Good	Good	
189	(Ni1Co)-2W-1Al	Poor	Good	Good	Good	Comparative Examples
190	(Ni1Fe) 2W-1Al	Poor	Good	Good	Good	
191	(Ni1Co0.4Fe)-2Cr-1Al	Poor	Good	Good	Good	
192	(Ni0.8Fe)-2Cr-1Al	Poor	Good	Good	Good	
193	(Ni0.5Co0.5Fe)-2Nb-1Al	Poor	Good	Good	Good	
194	(Ni2Fe2Co)-4.9Cr	Fair	Fair	Fair	Fair	

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

As shown in Tables 1 to 8, Nos. 1 to 95 and 125 to 188 are present invention examples, while Nos. 96 to 124 and 189 to 193 are comparative examples and No. 194 is a reference example.

5 [0037]

In addition, since W is 2 at%, for example, in No. 1 indicated in the composition shown in Tables 1 to 8, (Ni₂Fe) is $100\%-2\%=98$ at%, and, assuming that this 98% is equivalent to 1, the proportions of Ni and Fe are (100-2) and 2,
10 respectively. Further, since Co is not contained, its proportion is equivalent to 0. Similarly, since the total of W and In is 7 at% in No. 50, (Ni₅₀Fe) is $100\%-7\%=93$ at%, and, assuming that this 93 at% is equivalent to 1, the proportions of Ni and Fe are 100-50 and 50, respectively, and that is, since Ni and Fe are
15 the same proportion by atomic ratio, this means that each of them is 46.5 at%, which is a half of 93 at%.

[0038]

Comparative Example No. 96 results in a high coercive force, poor orientation, and a poor crystal grain size as it contains Ni
20 alone. Comparative Example No. 97 results in poor orientation and a poor crystal grain size due to the absence of M element. Comparative Example No. 98 results in a high coercive force due to a high Fe content. Comparative Example No. 99 results in a slightly high coercive force and poor orientation due to the low
25 content of W and the high content of Al. Comparative Example No. 100 results in a difficult-to-measure coercive force and a poor saturation magnetic flux density and poor orientation due to the high content of W.

[0039]

30 Comparative Example Nos. 101 and 102 result in poor orientation due to the low content of W and the high contents of Zr and B. Comparative Example No. 103 results in a high coercive force due to the low content of Ni and the high content of Fe. Comparative Example No. 104 results in a high coercive
35 force due to the low content of Ni and the high content of Fe. Comparative Example No. 105 results in a high coercive force,

poor orientation, and a poor crystal grain size due to the low content of Cr. Comparative Example No. 106 is inferior in all the properties due to the high content of Cr. Comparative Example No. 107 results in a high coercive force, poor orientation, and a poor crystal grain size due to the low content of Mo.

[0040]

Comparative Example No. 108 is inferior in all the properties due to the high content of Mo. Comparative Example No. 109 results in a high coercive force, poor orientation, and a poor crystal grain size due to the low content of Ta. Comparative Example No. 110 is inferior in all the properties due to the high content of Ta. Comparative Example No. 111 results in a high coercive force, poor orientation, and a poor crystal grain size due to the low content of V. Comparative Example No. 112 is inferior in all the properties due to the high content of V. Comparative Example No. 113 results in a high coercive force, poor orientation, and a poor crystal grain size due to the low content of Nb.

[0041]

Comparative Example No. 114 is inferior in all the properties due to the high content of Nb. Comparative Example No. 115 results in poor orientation and a poor crystal grain size due to the high content of Ca. Comparative Example No. 116 results in poor orientation and a poor crystal grain size due to the high content of In. Comparative Example No. 117 results in poor orientation and a poor crystal grain size due to the high content of Si. Comparative Example No. 118 results in poor orientation and a poor crystal grain size due to the high content of Ge. Comparative Example No. 119 results in poor orientation and a poor crystal grain size due to the high content of Ti.

[0042]

Comparative Example No. 120 results in poor orientation and a poor crystal grain size due to the high content of Hf. Comparative Example No. 121 results in poor orientation and a poor crystal grain size due to the high content of Cu.

Comparative Example No. 122 results in poor orientation and a poor crystal grain size due to the high content of P. Comparative example No. 123 results in poor orientation and a poor crystal grain size due to the high content of C.
5 Comparative Example No. 124 results in poor orientation and a poor crystal grain size due to the high content of Ru.

[0043]

Comparative Example No. 189 in Table 8 results in a poor coercive force due to the low content of Fe+Co. Comparative
10 Example No. 190 results in a poor coercive force due to the low content of Fe+Co. No. 191 results in a poor coercive force due to the low content of Fe+Co. No. 192 results in a poor coercive force due to the low content of Fe+Co. No. 193 results in a poor coercive force due to the low content of Fe+Co. No. 194
15 results in slightly poor properties due to a content of added Cr of 4.9, not exceeding 5, although it is within the present invention conditions. Therefore, it was regarded as Reference Example.

[0044]

20 As described above, it is found that magnetism is provided and a magnetic permeability becomes high in a (111) direction by regulating Ni-Fe-Co-M alloy to have certain contents to result in regulation in the regions and there is shown an excellent effect that a distance between a magnetic head and a soft-magnetic
25 undercoat film can be shortened by imparting a Ni-based seed layer with magnetism.

[0045]

Production and Evaluation of Sputtering Target Material

Next, there is shown an example of the method for producing a
30 sputtering target material. Molten raw materials with the compositions shown in Present Invention Examples No. 2, No. 10, No. 14, No. 18, and No. 25 in Table 1, No. 35, No. 38, and No. 43 in Table 2, No. 51 and No. 70 in Table 3, No. 79, No. 85, No. 89, and No. 95 in Table 4, No. 102, No. 117, No. 118, and
35 No. 122 in Table 5, No. 128, No. 135, and No. 144 in Table 6, No. 159, No. 170, and No. 176 in Table 7, and No. 188 in Table 8;

and Comparative Example No. 190 and Comparative Example No. 193 were weighed, melted by induction heating in a refractory crucible with an Ar gas atmosphere under a reduced pressure, then tapped from a nozzle having a diameter of 8 mm in the lower portion of the crucible, and atomized with an Ar gas. The gas-atomized powders as raw materials were filled, exhausted and vacuum-sealed in capsules made of carbon steel of 250 mm in diameter and 100 mm in length.

[0046]

The above-described powder-filled bullets were HIP-molded under conditions of a molding temperature of 1000°C, a molding pressure of 147 MPa, and a molding time of 1 hour for No. 2, No. 10, No. 14, No. 18, and No. 25 in Table 1 and No. 51 and No. 70 in Table 3; a molding temperature of 1100°C, a molding pressure of 147 MPa, and a molding time of 3 hours for No. 35, No. 38, and No. 43 in Table 2 and No. 79, No. 85, No. 89, and No. 95 in Table 4; and a molding temperature of 950°C, a molding pressure of 147 MPa, and a molding time of 5 hours for No. 102, No. 117, No. 118, and No. 122 in Table 5, No. 128, No. 135, and No. 144 in Table 6, No. 159, No. 170, and No. 176 in Table 7, No. 188 in Table 8, Comparative Example No. 190, and Comparative Example No. 193. The HIP products were processed into a disk shape with a diameter of 180 mm and a thickness of 7 mm by wire cut, turning processing, and surface grinding to obtain sputtering target materials.

[0047]

As for these 27 compositions, sputtered films were formed on glass substrates using the sputtering target materials. In the X-ray diffraction patterns, good orientation was confirmed in each of Present Invention Examples No. 2, No. 10, No. 14, No. 18, No. 25, No. 35, No. 38, No. 43, No. 51, No. 70, No. 79, No. 85, No. 89, No. 95, No. 128, No. 135, No. 144, No. 159, No. 170, No. 176, and No. 186, while good orientation was not confirmed in Comparative Examples No. 102, No. 117, No. 118, and No. 122.

[0048]

Further, when magnetic properties were measured in the same manner as in the quenched ribbons, good magnetic properties were confirmed in all of Present Invention Examples No. 2, No. 10, No. 14, No. 18, No. 25, No. 35, No. 38, No. 43, No. 51, No. 5 70, No. 79, No. 85, No. 89, No. 95, No. 128, No. 135, No. 144, No. 159, No. 170, No. 176, and No. 186, while good magnetic properties were not confirmed in Comparative Example No. 189, Comparative Example No. 190, and Comparative Example No. 10 193. X-ray diffraction patterns were measured in the same manner as in the case of the quenched ribbons and were evaluated as "good," "fair," and "poor," similarly to the results evaluated in the quenched ribbons. The above was summarized as follows: it was confirmed that the results evaluated in the quenched ribbons tended to be similar to the 15 evaluations of the sputtered films formed using the sputtering target materials.

CLAIMS

1. An alloy for a seed layer in a magnetic recording medium, comprising:

2 to 20 at% of an M1 element which is one or two or more selected from the group consisting of W, Mo, Ta, Cr, V, and Nb, based on the alloy;

0 to 10 at% of an M2 element which is one or two or more selected from the group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru, based on the alloy; and

the balance being Ni, Fe, and Co in ratios of Ni:Fe:Co=98-20:0-50:0-60 and $\text{Fe}+\text{Co} \geq 1.5$ in at% based on a total amount of Ni+Fe+Co.

2. The alloy according to claim 1, consisting of 2 to 20 at% of an M1 element based on the alloy; 0 to 10 at% of an M2 element based on the alloy; and the balance being Ni, Fe, and Co and unavoidable impurities.

3. An alloy for a seed layer in a magnetic recording medium, comprising:

2 to 20 at% of an M1 element which is one or two or more selected from the group consisting of W, Mo, Ta, Cr, V, and Nb, based on the alloy;

0 to 10 at% of an M2 element which is one or two or more selected from the group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru, based on the alloy; and

the balance being Ni, Fe, and Co in a ratio of Ni:Fe:Co=98-20:2-50:0-60 in at% based on a total amount of Ni+Fe+Co.

4. The alloy according to claim 3, consisting of 2 to 20 at% of an M1 element based on the alloy; 0 to 10 at% of an M2 element based on the alloy; and the balance being Ni, Fe, and Co and unavoidable impurities.

5. The alloy according to claim 1 or 2, comprising one or two of W and Mo.
6. The alloy according to claim 3 or 4, comprising one or two of W and Mo.
7. The alloy according to claim 1 or 2, comprising more than 5% of Cr.
8. The alloy according to claim 3 or 4, comprising more than 5% of Cr.
9. The alloy according to claim 1 or 2, comprising more than 0% and 10 at% or less of one or two or more selected from the group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru.
10. The alloy according to claim 3 or 4, comprising more than 0% and 10 at% or less of one or two or more selected from the group consisting of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Ru.
11. A sputtering target material constituted by the alloy according to any one of claims 1 to 10.
12. A magnetic recording medium comprising a seed layer constituted by the alloy according to any one of claims 1 to 10.