

ALLOY FOR SEED LAYERS OF MAGNETIC RECORDING MEDIA,
SPUTTERING TARGET MATERIAL AND MAGNETIC RECORDING
MEDIUM

5 BACKGROUND OF THE INVENTION

Field of the Invention

[0001]

10 The present invention relates to a Ni-based alloy
sputtering target material characterized by refinement of a seed
layer thin film.

Background Art

[0002]

15 There has been remarkable progress in perpendicular
magnetic recording in recent years. In order to achieve higher
drive capacity, there have been attempts to achieve a higher
recording density of a magnetic recording medium. There is a
perpendicular magnetic recording system in practical use, which
can achieve a higher recording density by making use of
conventionally used in-plane magnetic recording media. Here,
20 the perpendicular magnetic recording system means a system
suitable for high recording density, which is established such
that a magnetization easy axis is oriented in the perpendicular
direction with respect to a media plane in a magnetic film of a
perpendicular magnetic recording medium.

25 [0003]

30 For the perpendicular magnetic recording system, a
recording medium having a magnetic recording film layer with
an improved recording density and a soft magnetic film layer
has been developed. A recording medium having such a
medium structure, in which a seed layer or a base film layer is
formed between a soft magnetic layer and a magnetic recording
layer, has been developed. In addition, there is a demand for
further refinement of magnetic recording layer to improve the
recording density of a storage medium in recent years. For a
35 seed layer of such a perpendicular magnetic recording system, a
NiW-based alloy disclosed in, for example, Unexamined Patent

Publication (Kokai) No. 2009-155722 (Patent Literature 1) is usually used. In addition, the invention disclosed in Unexamined Patent Publication (Kokai) No. 2012-128933 (Patent Literature 2), wherein a target material for a seed layer, which is a Ni-Fe-Co-M alloy and contains, as an M element, W, Mo, Ta, Cr, V, or Nb enables the improvement of orientation with respect to the (111) plane required for a seed layer and refinement of crystal grains when it includes W as a bcc-based metal having a high melting point, and the like are suggested.

10 Citation List

Patent Literature

[0004]

Patent Literature 1: Japanese Unexamined Patent Publication (Kokai) No. 2009-155722

15 Patent Literature 2: Japanese Unexamined Patent Publication (Kokai) No. 2012-128933

SUMMARY OF THE INVENTION

Technical Problem

20 [0005]

However, although NiW-based alloy is used for a seed layer for a perpendicular magnetic recording system as disclosed in Patent Literature 1 or a target material enables the improvement of orientation with respect to the (111) plane required for a seed layer and refinement of crystal grains when it includes W as a bcc-based metal having a high melting point as disclosed in Patent Literature 2, there is a limitation to refinement with the use of a high melting point metal comprising an alloy target material for a Ni-based seed layer such as one disclosed in Patent Literature 2.

30 Solution to Problem

[0006]

The present inventors made intensive studies to solve the above problems. As a result, the inventors succeeded in providing an alloy for a seed layer of a Ni-based magnetic recording medium, which has a crystal grain size smaller than

that in Patent Literature 2 and a sputtering target material thereof. In other words, the inventors found that it is possible to achieve improvement of the orientation of a seed layer with respect to the (111) plane and refinement of the crystal grain size by allowing the seed layer to contain a noble metal (Au, Ag, Pd, Rh, Ir, Ru, Re, or Pt) instead of a bcc-based metal having a high melting point. This has led to the completion of the invention.

[0007]

10 The invention is summarized as follows.

(1) An alloy for a seed layer of a magnetic recording medium, comprising a Ni-Fe-Co-M alloy used for a Ni-based sputtering target material,

 wherein the Ni-Fe-Co-M alloy comprises 2 to 20 at.% in total of one or more M1 elements selected from Au, Ag, Pd, Rh, Ir, Ru, Re, and Pt, and the balance comprising Ni, Fe, Co, and unavoidable impurities, and

 wherein the ratio of the contents of Ni, Fe, and Co is Ni:Fe:Co=100 to 20:0 to 50:0 to 60 in terms of at.%.

20 [0008]

(2) The alloy for a seed layer of a magnetic recording medium according to the abovementioned (1), wherein the Ni-Fe-Co-M alloy further comprises more than 0 at.% to 10 at.% in total of one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, Mn, and Sn.

[0009]

(3) A sputtering target material comprising the alloy for a seed layer of a magnetic recording medium according to the abovementioned (1) or (2).

30 (4) A magnetic recording medium comprising the alloy for a seed layer according to the abovementioned (1) or (2).

[0010]

 According to the present invention, a Ni-Fe-Co-M alloy target material that enables the refinement of the crystal grain size of a seed layer in a perpendicular magnetic recording medium can be provided, thereby realizing technology very

useful for the improvement of the recording density of a magnetic storage medium.

DETAILED DESCRIPTION OF THE INVENTION

5 [0011]

Hereinafter, the reasons for limiting the present invention will be described. As stated above, the most important feature of the present invention is that the orientation of the (111) plane of a seed layer is improved and the crystal grain size is refined by allowing the seed layer to contain a noble metal (Au, Ag, Pd, Rh, Ir, Ru, Re, or Pt) instead of a bcc-based metal having a high melting point. The reason for setting the content of one or more M1 elements selected from Au, Ag, Pd, Rh, Ir, Ru, Re, and Pt to from 2 to 20 at.% in total will be described below.

15 [0012]

Given that Au, Ag, Pd, Rh, Ir, Ru, Re, or Pt in a Ni-Fe-Co-M alloy is hereinafter referred to as an "M1 element," the M1 element enables the improvement of the orientation with respect to the (111) plane required for a seed layer and refinement of crystal grains when added within a range of the component composition stipulated in accordance with the present invention to a Ni-Fe-Co-based fcc structure, although details of the mechanism are not necessarily clear. The content of one or more types of Au, Ag, Pd, Rh, Ir, Ru, Re, and Pt is set to from 2 to 20% in terms of at.%. However, when the content is less than 2%, the effects thereof are not insufficient. An alloy for a seed layer needs to have fcc monolayer. However, when it is more than 20%, the fcc structure cannot be maintained or amorphization tends to occur. Therefore, the content is set in a range of preferably 2% to 20% and more preferably 5% to 15%.

[0013]

The reason for setting the ratio of Ni, Fe, and Co contents to Ni:Fe:Co = 100 to 20:0 to 50:0 to 60 in terms of at.% will be described below.

Given that the ratio of Ni, Fe, and Co in the Ni-Fe-Co-M

alloy according to the present invention is expressed as $\text{Ni:Fe:Co} = \alpha:\beta:\gamma$, α is set to 20 to 100. The reason for setting the lower limit to 20 or more is that when it is less than 20, coercivity increases as described above. Therefore, the range of α has been set to 20 to 100 and preferably 60 to 100.

[0014]

β in the at. ratio: 0 to 50

Fe is an element that reduces coercivity and also improves the orientation of a film. However, when β exceeds 50, coercivity increases. Therefore, β is set in a range of 0 to 50, preferably 2 to 50%, and more preferably 10 to 40.

[0015]

γ in the at. ratio: 0 to 60

Co is an element that reduces coercivity in the (111) direction. However, when the content of Co exceeds 60, coercivity increases. Therefore, the upper limit thereof is set to 60 and preferably 40 or less. In addition, given that Au, Ag, Pd, Rh, Ir, Ru, Re, or Pt in a Ni-Fe-Co-M alloy is hereinafter referred to as an "M1 element," the M1 element enables the improvement of the orientation with respect to the (111) plane required for a seed layer and refinement of crystal grains when added within a range of the component composition stipulated in accordance with the present invention to a Ni-Fe-Co-based fcc structure, although the mechanism is not necessarily clear,

[0016]

Further, given that Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, or Mn is hereinafter referred to as an "M2 element," the M2 element allows the (111) plane to be oriented and also allows crystal grains to be refined. The content of one or more types of Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, and Mn is set to more than 0% to 10% in terms of at.%. However, when the content exceeds 10%, a compound is formed or amorphization occurs. Therefore, the upper limit thereof is set to 10% and preferably 5%. In addition, M1+M2 is preferably not more than 25 at% and further preferably not more than 20 at%.

EXAMPLES

[0017]

The present invention is more specifically described with reference to the Examples below.

5 A seed layer in a perpendicular magnetic recording medium can usually be obtained by sputtering of a target material containing components the same as the components of the seed layer and film formation on a glass substrate or the like. The thin film formed by sputtering is rapidly quenched. A
10 rapidly quenched ribbon produced using a single-roller rapid quenching apparatus is used as a test material in the present invention. Here, the influence of components of a thin film that was actually formed by rapid quenching via sputtering was evaluated using a rapidly liquid-quenched ribbon in a simplified
15 manner.

[0018]

 Conditions for producing a rapidly quenched ribbon included depressurization of 30 g of starting materials weighed to results in each composition of components listed in the table
20 below in a water-cooling type copper template about 10 in diameter and 40 mm in length and arc melting in Ar. Accordingly, a molten base metal in the form of a rapidly quenched ribbon was obtained. Conditions for producing a rapidly quenched ribbon further included setting the molten
25 base metal in a quartz tube 15 mm in diameter of a single roller system and performing tapping with a tapping nozzle diameter of 1 mm at an atmospheric pressure of 61kPa, an atomizing differential pressure of 69kPa, a rotation rate of a copper roller (300 mm in diameter) of 3000 rpm, and a gap between a
30 copper roller and a tapping nozzle of 0.3 mm. The tapping temperature was set to the temperature measured immediately after burn-through of each molten base metal. The thus produced rapidly quenched ribbons were used as test materials to evaluate the following items.

35 [0019]

For evaluation of the crystal grain size of each rapidly

quenched ribbon, measurement was conducted using a cross-sectional microstructure image of the rapidly quenched ribbon in the rolling direction in accordance with JIS G0551 "Steels-micrographic determination of the apparent grain."

5 P/Lt values of not less than 1.4, not less than 1.2 and less than 1.4, and less than 1.2 were rated as I, II, and III, respectively. For evaluation of coercivity of each rapidly quenched ribbon, the rapidly quenched ribbon was attached via double-faced tape to a sample table, and measurement was conducted using a
10 vibrating sample coercivity meter in an initial applied magnetic field at 144kA/m. Coercivity levels of not more than 300A/m, from more than 300A/m to not more than 500A/m, and more than 500A/m were rated as I, II, and III, respectively.

[0020]

15 For evaluation of saturation magnetic flux density of each rapidly quenched ribbon, measurement was conducted using a vibrating sample magnetometer (VSM) in an initial applied magnetic field at 1200 kA/m. The weight of each test material was about 15 mg, and not less than 0.2T and less than 0.2T
20 were rated as I and III, respectively. For evaluation of the (111) plane orientation of each rapidly quenched ribbon, a seed layer formed by sputtering was determined to have an fcc structure. After rapid quenching, the (200) plane in a seed layer is oriented. Usually, the X-ray diffraction intensity of the
25 (200) plane (I (200)) becomes greater than that of the (111) plane (I (111)) as a result of random orientation. In view of this, the orientation of (111) plane was evaluated by the method described below.

[0021]

30 Each test material was attached via double-faced tape to a glass plate, and a diffraction pattern was obtained by an X-ray diffraction apparatus. Here, the test material was attached such that a face of the rapidly quenched ribbon, which was brought into contact with a copper roller, was determined to be a
35 measurement face. An X-ray source was measured using a Cu- α ray at a scanning speed of 4°/min. Regarding the intensity

- ratio of intensity $I(111)$ of X-ray diffraction in the (111) plane and intensity $I(200)$ of X-ray diffraction in the (200) plane of this diffraction pattern, which is expressed as $I(111) / I(200)$, a value of less than 0.7 and a value of not less than 0.7 were
- 5 rated as III and I, respectively. In addition, when a compound was formed or amorphization occurred, the results were rated as III.

[0022]

[Table 1]

Table 1

No	Component composition (at.%)			Crystal grain size	Coercivity	Saturation magnetic flux density	Orientation	Remarks
	Ni-Fe-Co	M1 element	M2 element					
1	Ni2Fe	2Ru		II	II	I	I	Inventive Examples
2	Ni2Fe	2Ru-3Au		II	I	I	I	
3	Ni	3Re	1Al	I	I	I	I	
4	Ni	5Re	1Al	I	I	I	I	
5	Ni	5Ir	1Al	I	I	I	I	
6	Ni	5Ru	1Al	I	I	I	I	
7	Ni	5Pt	1Al	I	I	I	I	
8	Ni	5Au	1Al	I	I	I	I	
9	Ni10Fe10Co	5Re	1Al	I	I	I	I	
10	Ni10Fe20Co	5Re	1Al	I	I	I	I	
11	Ni20Fe10Co	5Re	1Al	I	I	I	I	
12	Ni20Fe20Co	5Re	1Al	I	I	I	I	
13	Ni10Fe30Co	5Re	1Al	I	I	I	I	
14	Ni20Fe30Co	5Re	1Al	I	I	I	I	
15	Ni30Fe30Co	5Re	1Al	II	I	I	I	
16	Ni40Fe30Co	5Re	1Al	II	I	I	I	
17	Ni50Fe30Co	5Re	1Al	II	II	I	I	
18	Ni10Fe40Co	5Re	1Al	II	I	I	I	
19	Ni20Fe40Co	5Re	1Al	II	I	I	I	
20	Ni30Fe40Co	5Re	1Al	II	I	I	I	
21	Ni40Fe40Co	5Re	1Al	II	II	I	I	
22	Ni10Fe50Co	5Re	1Al	II	II	I	I	
23	Ni20Fe50Co	5Re	1Al	II	II	I	I	
24	Ni30Fe50Co	5Re	1Al	II	II	I	I	
25	Ni10Fe60Co	5Re	1Al	II	II	I	I	
26	Ni20Fe60Co	5Re	1Al	II	II	I	I	
27	Ni5Fe	5Ag	1Al	II	I	I	I	
28	Ni10Fe	5Ag	1Al	II	I	I	I	
29	Ni15Fe	5Ag	1Al	II	I	I	I	
30	Ni15Fe	5Pt	1Cu	I	I	I	I	
31	Ni15Fe	5Ag	1Al	I	I	I	I	
32	Ni15Fe	5Rh	1Al	I	I	I	I	
33	Ni20Fe	5Ir	1Al	I	I	I	I	
34	Ni20Fe	5Pd	1Al	I	I	I	I	
35	Ni40Fe	2Pd-5Au	1Al	I	I	I	I	
36	Ni30Fe	2Rh-5Re	1Al	I	I	I	I	
37	Ni40Fe	5Au	1Al	I	I	I	I	
38	Ni40Fe	5Au	1Al	I	I	I	I	
39	Ni40Fe	2Ir-5Pd	1Al	I	I	I	I	
40	Ni50Fe	2Ag-1Rh-3Pd		I	II	I	I	
41	Ni30Fe	5Re		I	I	I	I	
42	Ni30Fe	10Re		I	I	I	I	

[0023]

[Table 2]

Table 2

No	Component composition (at.%)			Crystal grain size	Coercivity	Saturation magnetic flux density	Orientation	Remarks
	Ni-Fe-Co	M1 element	M2 element					
43	Ni30Fe	5Pt		I	I	I	I	Inventive Examples
44	Ni30Fe	10Pt		I	I	I	I	
45	Ni30Fe	5Ag		I	I	I	I	
46	Ni30Fe	10Ag		I	I	I	I	
47	Ni30Fe	5Ru		I	I	I	I	
48	Ni30Fe	10Ru		I	I	I	I	
49	Ni30Fe	5Au		I	I	I	I	
50	Ni30Fe	10Au		I	I	I	I	
51	Ni30Fe	5Ir		I	I	I	I	
52	Ni30Fe	10Ir		I	I	I	I	
53	Ni50Fe	2Ag-1Rh-3Pd	1Al	I	II	I	I	
54	Ni50Fe	2Ir-3Pd-1Re		I	II	I	I	
55	Ni50Fe	2Ir-1Pd-1Re-1Au	1Al	I	II	I	I	
56	Ni40Fe	2Ir-1Pd-1Re-1Au-1Ru-1Ag		I	II	I	I	
57	Ni50Fe	2Rh-1Pd-1Re-1Au	1Al	I	II	I	I	
58	Ni50Fe	20Ag		II	I	I	I	
59	Ni50Fe	20Ir		II	I	I	I	
60	Ni50Fe	2Re	10Al	I	II	I	I	
61	Ni50Fe	2Re	5Ga	I	II	I	I	
62	Ni50Fe	2Pt	5In	I	II	I	I	
63	Ni50Fe	2Pt	5Si	I	II	I	I	
64	Ni50Fe	2Pt	5Ge	I	II	I	I	
65	Ni50Fe	2Pt	5Sn	I	II	I	I	
66	Ni50Fe	2Pt	10Zr	I	I	I	I	
67	Ni50Fe	2Pt	5Ti	I	II	I	I	
68	Ni50Fe	2Pt	5Hf	I	I	I	I	
69	Ni50Fe	2Pt	10B	I	I	I	I	
70	Ni50Fe	2Pt	5Cu	I	I	I	I	
71	Ni50Fe	2Pt	5P	II	II	I	I	
72	Ni50Fe	2Pt	1C	II	II	I	I	
73	Ni50Fe	2Pt	3Mn	I	II	I	I	
74	Ni50Fe	2Pt	1Al-1Ga	I	II	I	I	
75	Ni50Fe	2Pt	1Al-1In	II	II	I	I	
76	Ni50Fe	2Pt	1Al-1In-1Si	II	II	I	I	
77	Ni50Fe	2Pt	1Al-1In-1Si-1G	II	II	I	I	
78	Ni50Fe	2Pt	1Al-1In-1Si-1Ge-1Sn	I	II	I	I	

[0024]

[Table 3]

Table 3

No	Component composition (at.%)			Crystal grain size	Coercivity	Saturation magnetic flux density	Orientation	Remarks
	Ni-Fe-Co	M1 element	M2 element					
79	Ni50Fe	2Pt	1Al-1In-1Si-1Ge-1Sn-1Zr	II	II	I	I	Inventive Examples
80	Ni50Fe	2Pt	1Si-1Ge-1Sn-1Zr-1Ti	I	II	I	I	
81	Ni50Fe	2Pt	1Si-1Ge-1Sn-1Zr-1Ti-1Hf	I	II	I	I	
82	Ni50Fe	2Pt	1Al-1In-1Si-1Ge-1Sn-1Zr-1Ti-1Hf-1B	I	I	I	I	
83	Ni50Fe	2Pt	1Al-1In-1Si-1Ge-1Sn-1Zr-1Ti-1Hf-1B-1Cu	I	I	I	I	
84	Ni50Fe	2Pt	1Al-1In-1Si-1Ge-1Sn-1Zr-1Ti-1Hf-1B-1Cu-1Mn	I	II	I	I	
85	Ni50Fe	2Pt	1Al-1In-1Si-1Ge-1Sn-1Zr-1Ti-1Hf-1B-1Cu-1Mn-1P	I	I	I	I	
86	Ni50Fe	2Pt	1Sn-1Zr-1Ti-1Hf-1B-1C-1Mn-1P	I	I	I	I	
87	Ni2Fe5Co	2Ag	1Al	I	II	I	I	
88	Ni20Fe10Co	5Ag	1Si	II	I	I	I	
89	Ni30Fe10Co	5Ag	1Si	II	I	I	I	
90	Ni20Fe20Co	5Ag	1Si	II	I	I	I	
91	Ni20Fe20Co	10Re-5Rh	1Al	I	I	I	I	
92	Ni20Fe60Co	5Ag	1Si	I	II	I	I	
93	Ni50Fe20Co	5Ag	1Si	I	II	I	I	
94	Ni10Fe10Co	5Ag	1Mn	I	I	I	I	
95	Ni50Fe10Co	5Ag	5Mn	II	I	I	I	
96	Ni	5Ag-5Pt		I	I	I	I	
97	Ni	5Ag-5Pd		I	I	I	I	
98	Ni	5Ag	1Si	II	I	I	I	
99	Ni50Fe30Co	5Ag-1Rh		II	II	I	I	
100	Ni10Fe40Co	5Ag-5Au		II	I	I	I	
101	Ni10Fe50Co	5Ag-5Re		II	II	I	I	
102	Ni30Fe50Co	5Ag-5Ru		II	II	I	I	
103	Ni20Fe60Co	5Ag-5Ir		II	II	I	I	
104	Ni5Fe	5Ag	1Al	II	I	I	I	
105	Ni10Fe	5Ag	1Al	I	I	I	I	
106	Ni15Fe	5Ag	1Al	II	I	I	I	
107	Ni50Fe	5Ag	1Al	I	I	II	I	

[0025]

[Table 4]

Table 4

No	Component composition (at.%)			Crystal grain size	Coercivity	Saturation magnetic flux density	Orientation	Remarks
	Ni-Fe-Co	M1 element	M2 element					
108	Ni10Fe	<u>5W</u>	1Al	III	I	I	I	Comparative Example
109	Ni25Fe	<u>5W</u>	1Al	III	I	I	I	
110	Ni10Fe10Co	<u>5W</u>	1Al	III	I	I	I	
111	Ni20Fe10Co	<u>5W</u>	1Al	III	I	I	I	
112	Ni30Fe10Co	<u>5W</u>	1Al	III	I	I	I	
113	Ni40Fe10Co	<u>5W</u>	1Al	III	I	I	I	
114	Ni50Fe10Co	<u>5W</u>	1Al	III	I	I	I	
115	Ni10Fe20Co	<u>5W</u>	1Al	III	I	I	I	
116	Ni20Fe20Co	<u>5W</u>	1Al	III	I	I	I	
117	Ni30Fe20Co	<u>5W</u>	1Al	III	I	I	I	
118	Ni40Fe20Co	<u>5W</u>	1Al	III	I	I	I	
119	Ni50Fe20Co	<u>5W</u>	1Al	III	I	I	I	
120	Ni10Fe30Co	<u>5W</u>	1Al	III	I	I	I	
121	Ni20Fe30Co	<u>5W</u>	1Al	III	I	I	I	
122	Ni30Fe	<u>5W</u>		III	I	I	I	
123	Ni30Fe	<u>10W</u>		III	I	I	I	
124	Ni30Fe	<u>5Mo</u>		III	I	I	I	
125	Ni30Fe	<u>10Mo</u>		III	I	I	I	
126	Ni30Fe	<u>5Nb</u>		III	I	I	I	
127	Ni30Fe	<u>10Nb</u>		III	I	I	I	
128	Ni30Fe30Co	<u>5W</u>	1Al	III	I	I	I	
129	Ni40Fe30Co	<u>5W</u>	1Al	III	I	I	I	
130	Ni50Fe	<u>2W</u>	5Hf	III	I	I	I	
131	Ni50Fe	<u>2W</u>	10B	III	I	I	I	
132	Ni50Fe	<u>2W</u>	5Cu	III	I	I	I	
133	Ni40Fe	<u>2W</u>	<u>5Mo-1Al</u>	III	I	I	I	
134	Ni30Fe	<u>2W</u>	<u>5Ta-1Al</u>	III	I	I	I	
135	Ni40Fe	<u>5Cr</u>	<u>2V-1Al</u>	III	I	I	I	
136	Ni40Fe	<u>2Nb</u>	<u>4V-1Al</u>	III	I	I	I	
137	Ni40Fe	<u>5Nb</u>	<u>2Mo-1Al</u>	III	I	I	I	
138	Ni			III	III	I	III	
139	Ni2Fe			III	I	I	III	
140	Ni60Fe	<u>5Ag</u>	1Al	I	III	I	I	
141	Ni50Fe	<u>1Ag</u>	<u>15Al</u>	I	II	I	III	
142	Ni50Fe	<u>30Pt</u>		I	-	III	III	
143	Ni50Fe	<u>1Ag</u>	<u>16Zr</u>	I	I	I	III	
144	Ni50Fe	<u>1Ag</u>	<u>15B</u>	I	I	I	III	
145	<u>Ni10Fe70Co</u>	<u>5Ag</u>	1Al	I	III	I	I	

Note) Underlined component compositions are outside the conditions defined in the present invention.

[0026]

[Table 5]

Table 5

No	Component composition (at.%)			Crystal grain size	Coercivity	Saturation magnetic flux density	Orientation	Remarks
	Ni-Fe-Co	M1 element	M2 element					
146	Ni60Fe20Co	5Ag	1Al	I	III	I	I	Comparative Examples
147	Ni20Fe20Co	<u>1Re</u>		III	III	I	III	
148	Ni20Fe20Co	<u>25Re</u>		III	III	III	III	
149	Ni20Fe20Co	1Pt		III	III	I	III	
150	Ni20Fe20Co	25Pt		III	III	III	III	
151	Ni20Fe20Co	1Rh		III	III	I	III	
152	Ni30Fe30Co	<u>25Rh</u>		III	III	III	III	
153	Ni20Fe20Co	<u>1Ir</u>		III	III	I	III	
154	Ni20Fe30Co	25Ir		III	III	III	III	
155	Ni20Fe20Co	<u>1Au</u>		III	III	I	III	
156	Ni20Fe30Co	<u>25Au</u>		III	III	III	III	
157	Ni30Fe20Co	5Re	<u>15Ga</u>	III	I	I	III	
158	Ni30Fe30Co	5Re	<u>15In</u>	III	I	I	III	
159	Ni30Fe30Co	5Re	<u>15Si</u>	III	I	I	III	
160	Ni30Fe20Co	5Re	<u>15Ge</u>	III	I	I	III	
161	Ni30Fe30Co	5Re	<u>15Sn</u>	III	I	I	III	
162	Ni30Fe30Co	5Re	<u>15Zr</u>	III	I	I	III	
163	Ni30Fe20Co	5Re	<u>15Ti</u>	III	I	I	III	
164	Ni30Fe20Co	5Re	<u>15Hf</u>	III	I	I	III	
165	Ni30Fe30Co	5Re	<u>15B</u>	III	I	I	III	
166	Ni30Fe30Co	5Re	<u>15Cu</u>	III	I	I	III	

Note) Underlined component compositions are outside the conditions defined in the present invention.

[0027]

[Table 6]

Table 6

No	Component composition (at.%)			Crystal grain size	Coercivity	Saturation magnetic flux density	Orientation	Remarks
	Ni-Fe-Co	M1 element	M2 element					
167	Ni5Co	2Ag	1Al	II	II	I	I	Inventive Examples
168	Ni5Co	2Rh	1Al	I	II	II	I	
169	Ni5Co	5.1Rh	1Al	I	II	II	I	
170	Ni40Co	5.7Rh	1Al-1Si	I	II	I	I	
171	Ni1Co1Fe	2Ag	1Al	II	II	I	I	
172	Ni1Co1.5Fe	2Ag	1Al	II	II	II	I	
173	Ni1Co2Fe	2Re	1Al	II	II	I	I	
174	Ni0.8Co1.0Fe	2Re	1Al	II	II	I	I	
175	Ni0.6Co1.0Fe	2Re	1Al	II	II	II	I	
176	Ni0.5Co0.7Fe	2Au		II	II	II	I	
177	Ni0.8Co0.7Fe	1Rh	1Ag	II	II	II	I	
178	Ni0.7Co0.8Fe	1Rh	1Ag	II	II	II	I	
179	Ni1.0Co0.5Fe	2Rh		II	II	II	I	
180	Ni0.5Co0.5Fe	2Rh		II	II	II	I	
181	Ni0.6Co0.9Fe	1Rh	1Ag	II	II	II	I	
182	Ni0.3Co1.2Fe	1Rh	1Ag	II	II	II	I	
183	Ni0.1Co1.4Fe	1Rh	1Ag	II	II	II	I	
184	Ni0.9Co0.6Fe	2Pt		II	II	II	I	
185	Ni1.2Co0.3Fe	2Pt		II	II	II	I	
186	Ni1.4Co0.1Fe	2Pt		II	II	II	I	
187	Ni1.5Co	2Ir		II	II	II	I	
188	Ni1.5Fe	2Ir		II	II	II	I	
189	Ni1.0Co0.5Fe	2Ir		II	II	II	I	
190	Ni1.0Co0.9Fe	2Ru		II	II	II	I	
191	Ni0.9Co1.0Fe	2Ru		II	II	II	I	
192	Ni1.2Co0.7Fe	2Ag		II	II	II	I	
193	Ni1.3Co0.6Fe	2Ag		II	II	II	I	
194	Ni1.5Co0.4Fe	2Ag		II	II	II	I	
195	Ni1.7Co0.2Fe	2Ag		II	II	II	I	
196	Ni0.9Co1.0Fe	2Pd		II	II	II	I	
197	Ni1.2Co0.7Fe	2Pd		II	II	II	I	
198	Ni1.3Co0.6Fe	2Au		II	II	II	I	
199	Ni1.5Co0.4Fe	2Au		II	II	II	I	
200	Ni1.7Co0.2Fe	2Au		II	II	II	I	
201	Ni2Fe	5.1Pd	1Al	I	II	II	I	
202	Ni2Fe	5.7Pd	1Al	I	II	II	I	
203	Ni10Co	5.7Pd	1Re	I	II	I	I	

[0028]

[Table 7]

Table 7

No	Component composition (at.%)			Crystal grain size	Coercivity	Saturation magnetic flux density	Orientation	Remarks
	Ni-Fe-Co	M1 element	M2 element					
204	Ni20Co	5Pd	1Ti-1Cu	I	II	I	I	Inventive Examples
205	Ni30Co	5Pd-2Au	1Ge-1Sn	I	II	I	I	
206	Ni40Fe40Co	20Re		I	I	I	I	
207	Ni20Fe40Co	20Ir		I	I	I	I	
208	Ni30Fe30Co	20Au		I	I	I	I	
209	Ni40Fe40Co	20Ru		I	I	I	I	
210	Ni20Fe20Co	5Ag	10Ga	I	I	I	I	
211	Ni20Fe30Co	5Re	10In	I	I	I	I	
212	Ni30Fe40Co	5Rh	10Si	I	II	I	I	
213	Ni20Fe40Co	5Ir	10Ge	I	II	I	I	
214	Ni40Fe20Co	5Ru	10Sn	I	II	I	I	
215	Ni30Fe30Co	5Au	10Zr	I	II	I	I	
216	Ni20Fe20Co	5Pd	10Ti	I	II	I	I	
217	Ni20Fe40Co	5Pt	10Hf	I	II	I	I	
218	Ni40Fe20Co	5Ag	10B	I	II	I	I	
219	Ni20Fe30Co	5Re	10Cu	I	I	I	I	
220	Ni2Fe2Co	4.9Ag	1Al	II	II	II	I	
221	Ni2Fe2Co	4.5Ag	1Al	II	II	II	I	
222	Ni20Fe20Co	5.1Ag	1Al	I	I	I	I	
223	Ni30Fe30Co	5.1Ag	1Al	I	I	I	I	
224	Ni30Fe30Co	5.5Ag	1Al	I	I	I	I	
225	Ni20Fe30Co	5.5Ag	1Al	I	I	I	I	
226	Ni2Fe2Co	5.5Ag	1Al	II	II	II	I	
227	Ni20Fe20Co	5.5Ag	1Al	I	I	I	I	
228	Ni2Fe2Co	5.5Ag	1Al	II	I	II	I	
229	Ni2Fe2Co	5.1Ag	1Al	II	I	II	I	
230	Ni50Fe	5Au-1Ir -1Pd	1In-1Sn -1Zr-1Ti-1B	I	II	I	I	
231	Ni1Co	2Ag	1Al	II	III	I	I	Comparative Examples
232	Ni1Fe	2Ag	1Al	II	III	I	I	
233	Ni0.4Fe1Co	2Au	1Al	II	III	I	I	
234	Ni0.8Fe	2Au	1Al	II	III	I	I	
235	Ni0.5Co0.5Fe	2Rh	1Al	II	III	I	I	
236	Ni2Fe2Co	4.9Pt		II	III	II	II	

Note) Underlined component compositions are outside the conditions defined in the present invention.

[0029]

As shown in Tables 1 to 7, Nos. 1 to 107 and 167 to 230 represent Inventive Examples, and Nos. 108 to 166 and 231 to 236 represent Comparative Examples.

[0030]

Regarding the component compositions listed in Tables 1 to 7, for example, in the case of No. 1, since Ru is 2 at%, (Ni₂Fe) is 100%-2%, which means 98 at%. Assuming that 98% corresponds to 1, Ni has a proportion of (100-2) and Fe has a proportion of 2. Note that since Co is not contained, the proportion thereof corresponds to 0. Similarly, in the case of No. 62, the sum of Pt and In results in 7 at%, and thus, (Ni₅₀Fe) is 100%-7%, which means 93 at%. Given that 93 at% corresponds to 1, the proportion of Ni is 100-50 and the proportion of Fe is 50, which means that the value of at% of Ni and that of Fe are identical. This indicates that each proportion is half of 93 at%, which is equal to 46.5 at%.

[0031]

In Comparative Example Nos. 108 to 123 and 128 to 134, when W was added instead of an M element, the crystal grain size declined. In Comparative Example No. 135, when Cr and V were added instead of M, the crystal grain size declined. In Comparative Example No. 136, when Nb and V were added instead of M, the crystal grain size declines. In Comparative Example No. 137, when Nb and Mo were added instead of M, the crystal grain size declined. In Comparative Example No. 138, as Ni was used singly, coercivity was high while each of the orientation and the crystal grain size declined. In Comparative Example No. 139, as an M element was not contained, each of the orientation and the crystal grain size declined. In Comparative Example No. 140, as the Fe content was high, coercivity increased. In Comparative Example No. 141, as the Ag content was low while the Al content was high, the coercivity relatively increased while the orientation declined. In Comparative Example No. 142, as the Pt content was high,

measurement of coercivity was difficult and the saturation magnetic flux density and the orientation declined.

[0032]

In Comparative Example Nos. 143 and 144, as the Ag
5 content was low while the Zr and B contents were high, the orientation declined. In Comparative Example No. 145, as the Ni content was low while the Co content was high, the coercivity increased. In Comparative Example No. 146, as the Ni content
10 was low while the Fe content was high, the coercivity increased. In Comparative Example No. 147, as the Re content was low, the coercivity was high and each of the orientation and the crystal grain size declined. In Comparative Example No. 148, as the Re content was high, all properties declined. In Comparative Example No. 149, as the Pt content was low, the
15 coercivity was high and each of the orientation and the crystal grain size declined.

[0033]

In Comparative Example No. 150, as the Pt content was high, all properties declined. In Comparative Example No. 151,
20 as the Rh content was low, the coercivity was high and each of the orientation and the crystal grain size declined. In Comparative Example No. 152, as the Rh content was high, all properties declined. In Comparative Example No. 153, as the Ir content was low, the coercivity was high and each of the
25 orientation and the crystal grain size declined. In Comparative Example No. 154, as the Ir content was high, all properties declined. In Comparative Example No. 155, as the Au content was low, the coercivity was high and each of the orientation and the crystal grain size declined. In Comparative Example No. 156,
30 as the Au content was high, all properties declined.

[0034]

In Comparative Example No. 157, as the Ga content was high, the orientation and the crystal grain size declined. In Comparative Example No. 158, as the In content was high, the
35 orientation and the crystal grain size declined. In Comparative Example No. 159, as the Si content was high, the orientation

and the crystal grain size declined. In Comparative Example No. 160, as the Ge content was high, the orientation and the crystal grain size declined. In Comparative Example No. 161, as the Sn content was high, the orientation and the crystal grain size declined. In Comparative Example No. 162, as the Zr content was high, the orientation and the crystal grain size declined. In Comparative Example No. 163, as the Ti content was high, the orientation and the crystal grain size declined. In Comparative Example No. 164, as the Hf content was high, the orientation and the crystal grain size declined. In Comparative Example No. 165, as the B content was high, the orientation and the crystal grain size declined. In Comparative Example No. 166, as the Cu content was high, the orientation and the crystal grain size declined.

[0035]

In Comparative Example No. 231, as the Fe+Co content was low, the coercivity declined. In Comparative Example No. 232, as the Fe+Co content was low, the coercivity declined. In Comparative Example No. 233, as the Fe+Co content was low, the coercivity declined. In Comparative Example No. 234, as the Fe+Co content was low, the coercivity declined. In Comparative Example No. 235, as the Fe+Co content was low, the coercivity declined. Regarding No. 236, although the results were within the scope of the conditions of the present invention, as the Pt was 4.9, which means below 5, properties relatively declined. Therefore, No. 236 was regarded as a Comparative Example.

[0036]

As stated above, it was found that it is possible to allow a Ni-Fe-Co-M alloy to have magnetic properties and increase magnetic permeability thereof in the (111) direction by limiting the contents of components in the alloy at certain levels within the above range. Therefore, it is possible to reduce a distance between a magnetic head and a soft magnetic base film by allowing a Ni-based seed layer to have magnetic properties, which is an advantageous effect.

[0037]

Next, a method of producing a sputtering target material is described below. A starting material prepared by weighing and melting components of the composition of each of Inventive Example Nos. 2, 10, 14, 18, 25, 35, 38, 55, 63, 82, 91, 97, 101, and 107, Comparative Example Nos. 114, 135, 136, 140, 146, 153, and 162, Inventive Example Nos. 177, 188, 194, 206, 208, 211, 217, 223, and 229, and Comparative Example Nos. 231 and 234 in Table 1 was treated by induction heating melting in a refractory crucible in an Ar gas atmosphere under reduced pressure. Then, each molten material was atomized using Ar gas via tapping from a nozzle 8 mm in diameter provided at the bottom of the crucible. A capsule 250 mm in diameter and 100 mm in length was filled with each obtained gas-atomized powder serving as a starting material powder and sealed by vacuum deaeration.

[0038]

The billet filled with the powder obtained above was molded by hot isostatic pressing (HIP) at a molding temperature of 1100°C and a molding pressure of 147MPa for a molding time of 5 hours. This HIP product was processed into a disc 180 mm in diameter and 7 mm in thickness by wire cutting, turning processing, and planar polishing and used as a sputtering target material.

[0039]

A sputtered film was formed with each of the thus prepared 32 kinds of component compositions on a glass substrate using a sputtering target material. The microstructure of the film was found to have a fine crystal grain size in any of Inventive Example Nos. 2, 10, 14, 18, 25, 35, 38, 55, 63, 82, 91, 97, 101, 107, 177, 188, 194, 206, 208, 211, 217, 223, and 229. Meanwhile, such fine crystal grain size was not observed in Comparative Example Nos. 114, 135, 136, 153, and 162.

[0040]

The X-ray diffraction pattern in any of Inventive Example

Nos. 2, 10, 14, 18, 25, 35, 38, 55, 63, 82, 91, 97, 101, 107, 177, 188, 194, 206, 208, 211, 217, 223, and 229 was found to have favorable orientation. Meanwhile, the X-ray diffraction pattern in any of Comparative Example Nos. 153 and 162 was not found to have favorable orientation.

[0041]

In addition, as a result of determination of magnetic properties as in the case of rapidly quenched ribbons, favorable magnetic properties were observed in any of Inventive Example Nos. 2, 10, 14, 18, 25, 35, 38, 55, 63, 82, 91, 97, 101, 107, 177, 188, 194, 206, 208, 211, 217, 223, and 229. Meanwhile, favorable magnetic properties were not observed in any of Comparative Example Nos. 140, 146, 153, 231, and 234.

[0042]

In addition, measurement was conducted as in the case of rapidly quenched ribbons also regarding the X-ray diffraction pattern. As a result, the evaluation results based on I, II, and III were similar to those obtained for rapidly quenched ribbons. In summary, it was confirmed that the tendency of evaluation results for rapidly quenched ribbons is equivalent to the tendency of evaluation results for sputtered films formed using sputtering target materials.

CLAIMS

1. An alloy for a seed layer of a magnetic recording medium, comprising a Ni-Fe-Co-M alloy used for a Ni-based sputtering target material,

wherein the Ni-Fe-Co-M alloy comprises 2 to 20 at.% in total of one or more M1 elements selected from Au, Ag, Pd, Rh, Ir, Ru, Re, and Pt, and the balance comprising Ni, Fe, Co, and unavoidable impurities, and

wherein the ratio of the contents of Ni, Fe, and Co is Ni:Fe:Co=100 to 20:0 to 50:0 to 60 in terms of at.%.

2. The alloy for a seed layer of a magnetic recording medium according to claim 1, wherein the Ni-Fe-Co-M alloy further comprises more than 0 at.% to 10 at.% in total of one or more M2 elements selected from Al, Ga, In, Si, Ge, Sn, Zr, Ti, Hf, B, Cu, P, C, Mn, and Sn.

3. A sputtering target material comprising the alloy for a seed layer of a magnetic recording medium according to claim 1 or 2.

4. A magnetic recording medium comprising the alloy for a seed layer according to claim 1 or 2.