

SOFT MAGNETIC ALLOY FOR MAGNETIC RECORDING,
SPUTTERING TARGET MATERIAL, AND MAGNETIC RECORDING
MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION

[0001]

This application claims priority to Japanese Patent Application No. 2014-94550 filed on May 1, 2014 and Japanese Patent Application No. 2015-27251 filed on February 16, 2015, the entire disclosures of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002]

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

Background Art

[0003]

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, which achieves further high recording density when compared to 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.

[0004]

Thus, a soft magnetic thin film having an alloy composition with a relatively low saturation magnetic flux density (Bs) of around 10 kG has been recently used. For example, a Fe-Co-based alloy soft magnetic film in which Nb and/or Ta, and B are selected as optimal elements for enhancing amorphous properties and crystallization temperature in a Fe-Co-based alloy, and which is used in a magnetic recording medium having high amorphous properties and high crystallization temperature is proposed as a soft magnetic film, as disclosed in Japanese Patent Laid-Open Publication No. 2011-181140 (PTL 1).

[0005]

Further, an alloy for a soft magnetic film layer in a perpendicular magnetic recording medium excellent in saturation magnetic flux density, amorphous property, and weather resistance is proposed as disclosed in Japanese Patent Laid-Open Publication No. 2008-299905 (PTL 2).

Citation List

Patent Literature

[0006]

[PTL 1] Japanese Patent Laid-Open Publication No. 2011-181140

[PTL 2] Japanese Patent Laid-Open Publication No. 2008-29905

SUMMARY OF THE INVENTION

[0007]

On the other hand, such a sputtering target to which more than 10% of Ta and Nb are abundantly added in order to achieve a saturation magnetic flux density (Bs) of around 10 kG has had a problem in that the mechanical strength of the sputtering target is decreased.

[0008]

As a result of intensively pursuing development in order to solve the problems described above, it has been found that a decrease in the mechanical strength of a soft magnetic sputtering target for magnetic recording is improved by

decreasing the content of hydrogen in the soft magnetic sputtering target for magnetic recording. Further, it has been found that a soft magnetic alloy having a low hydrogen content is improved in corrosion resistance. Thus, the present invention has been accomplished.

[0009]

According to one aspect of the present invention, there is provided a soft magnetic alloy for magnetic recording, comprising:

in at.%,

0.5 to 29.5% of one or more of A group elements selected from Ta, Nb, and V;

0.0 to 29.5% of one or more of B group elements selected from Cr, Mo, and W; and

the balance being Co, Fe, and unavoidable impurities, wherein:

a ratio of Fe:Co is 10:90 to 70:30;

a total content of the A group elements and the B group elements is 10 to 30%; and

a hydrogen content is less than 20 ppm.

[0010]

According to another aspect of the present invention, there is provided a soft magnetic alloy for magnetic recording, comprising:

in at.%,

0.5 to 29.5% of one or more of the following A group elements;

0.0 to 29.5% of one or more of the following B group elements; and

the balance being Co, Fe, and unavoidable impurities, wherein:

a ratio of Fe:Co is 10:90 to 70:30;

a sum of the A group elements and the B group elements is 10 to 30%; and

a hydrogen content is less than 20 ppm.

The A group elements: Ta, Nb, and V

The B group elements: Cr, Mo, and W

[0011]

According to another aspect of the present invention, there is provided a soft magnetic alloy for magnetic recording, comprising:

in at.%,

0.5 to 29.5% of one or more of A group elements selected from Ta, Nb, and V;

0.5 to 29.5% of one or more of B group elements selected from Cr, Mo, and W; and

the balance being Co, Fe, and unavoidable impurities, wherein:

a ratio of Fe:Co is 10:90 to 70:30;

a total content of the A group elements and the B group elements is 10 to 30%; and

a hydrogen content is less than 20 ppm.

[0012]

According to another aspect of the present invention, there is provided a soft magnetic alloy for magnetic recording, comprising:

in at.%,

0.5 to 29.5% of one or more of the following A group elements;

0.5 to 29.5% of one or more of the following B group elements; and

the balance being Co, Fe, and unavoidable impurities, wherein:

a ratio of Fe:Co is 10:90 to 70:30;

a sum of the A group elements and the B group elements is 10 to 30%; and

a hydrogen content is less than 20 ppm.

The A group elements: Ta, Nb, and V

The B group elements: Cr, Mo, and W

[0013]

According to a preferred aspect of the present invention,

there is provided any one of the above-described soft magnetic alloys for magnetic recording, further comprising one or more elements of elements described in the following C group elements, D group elements, E group elements, and F group elements in a range of at.% described in each group:

the C group elements: one or more elements selected from Ti, Zr, and Hf, a total content thereof being less than 5%, and a total content of the A group elements, the B group elements, and the C group elements being 10 to 30%;

the D group elements: one or two elements selected from Ni and Mn, a total content thereof being 30% or less;

the E group elements: one or two elements selected from Al and Cu, a total content thereof being 5% or less; and

the F group elements: one or more elements selected from Si, Ge, P, B, and C, a total content thereof being 10% or less.

[0014]

According to another aspect of the present invention, there is provided any one of the above-described soft magnetic alloys for magnetic recording, further comprising one or more elements of elements described in the following C group elements to F group elements in a range of at.% described in each group:

the C group elements: less than 5% of one or more of Ti, Zr, and Hf, provided that a sum of the A group elements, the B group elements, and the C group elements is 10 to 30%;

the D group elements: 30% or less of one or two of Ni and Mn;

the E group elements: 5% or less of one or two of Al and Cu; and

the F group elements: 10% or less of one or more of Si, Ge, P, B, and C.

[0015]

According to another aspect of the present invention, there is provided a sputtering target material for forming a soft magnetic alloy for magnetic recording, the sputtering target

material comprising any one of the above-described soft magnetic alloys for magnetic recording.

[0016]

According to still another aspect of the present invention, there is provided a magnetic recording medium, comprising any one of the above-described soft magnetic alloys for magnetic recording.

[0017]

According to the present invention, the soft magnetic sputtering target for magnetic recording excellent in mechanical strength, and the soft magnetic alloy excellent in corrosion resistance can be provided as described above.

DETAILED DESCRIPTION OF THE INVENTION

[0018]

The reasons for specific composition according to the present invention will be described below.

[0019]

The present invention relates to a soft magnetic alloy for magnetic recording, and therefore, a sufficient saturation magnetic flux density, preferably B_s of 10 kG or less, more preferably B_s of 9 kG or less, amorphous properties, hardness, and corrosion resistance are needed.

[0020]

Fe:Co Ratio: 10:90 to 70:30

Fe and Co are elements composing a soft magnetic alloy. The ratio between Fe and Co is a parameter that ensures soft magnetism, and greatly influences a saturation magnetic flux density, amorphous properties, hardness, and corrosion resistance. In particular, a ratio of Fe:Co of 10 or more results in a sufficient saturation magnetic flux density, and the ratio reduced to 70 or less results in suppression of deterioration of corrosion resistance. Accordingly, the ratio is set within 10:90 to 70:30.

[0021]

One or More Elements Selected from A Group Elements: 0.5 to

29.5%

All of Ta, Nb, and V are elements that improve amorphous properties and hardness. The improvement effect is sufficiently exhibited by 0.5% or more of the elements. Accordingly, the lower limit thereof is set at 0.5%. The total content of the A group elements is preferably set within 2 to 20%, and more preferably set within 4 to 15%. However, a total content of more than 29.5% results in saturation of the effect, and therefore, the upper limit thereof is set at 29.5%.

[0022]

One or More Elements Selected from B Group Elements: 0.0 to 29.5%

All of Cr, Mo, and W are elements that improve amorphous properties and corrosion resistance. Inclusion of these elements as well as the A group elements results in an increase in the improvement effect. The total content of the B group elements is preferably set within 0.5 to 20%, and more preferably set within 1 to 10%. However, a total content of more than 29.5% results in saturation of the effect, and therefore, the upper limit thereof is set at 29.5%.

[0023]

Total Content of A Group Elements and B Group Elements: 10 to 30%

The reason that the total content of the A group elements and the B group elements is set within 10 to 30% is because both the elements are elements that improve amorphous properties and hardness, and inclusion of both of the A group elements and the B group elements results in a further increase in the improvement effect. The improvement effect is sufficiently exhibited by setting the total content of the A group elements and the B group elements at 10% or more. Accordingly, the lower limit thereof is set at 10%. The total content of the A group elements and the B group elements is preferably set within 14 to 22%, and still more preferably set within 16 to 20%. However, a total content of more than 30% results in saturation of the effect, and therefore, the upper limit

thereof is set at 30%.

[0024]

One or More Elements Selected from C Group Elements: 5% or less

All of Ti, Zr, and Hf are elements that improve amorphous properties. A content of the elements of 5% or less results in a sufficient saturation magnetic flux density. Accordingly, the range thereof is set at 5% or less. The total content of the C group elements is preferably set within 2 to 4%.

[0025]

Total Content of A Group Elements, B Group Elements, and C Group Elements: 10 to 30%

The reason that the total content of the A group elements, the B group elements, and the C group elements is set within 10 to 30% is because all the elements are elements that improve amorphous properties and corrosion resistance. A total content of the A group elements, the B group elements, and the C group elements of 10% or more results in sufficient exhibition of the effect, and a total content of 30% or less results in a sufficient saturation magnetic flux density. Accordingly, the range thereof is set within 10 to 30%.

[0026]

One or Two Elements Selected from D Group Elements: 30% or less

Both of Ni and Mn are elements that adjust a saturation magnetic flux density. A content of the elements of 30% or less results in a sufficient saturation magnetic flux density. Accordingly, the range thereof is set at 30% or less. The total content of the D group elements is preferably set at 10% or less, and more preferably set at 5% or less.

[0027]

One or More Elements Selected from E Group Elements: 5% or less

Both of Al and Cu are elements that improve corrosion resistance. A content of the elements of 5% or less results in suppression of deterioration of amorphous properties.

Accordingly, the upper limit thereof is set at 5%. The total content of the E group elements is preferably set within 1 to 4%.

[0028]

One or More of Elements Selected from F Group Elements: 10% or less

All of Si, Ge, P, B, and C are elements that improve amorphous properties. A content of the elements of 10% or less results in suppression of deterioration of a saturation magnetic flux density without saturation of the improvement effect. Accordingly, the range thereof is set at 10% or less. The total content of the F group elements is preferably set within 1 to 8%.

[0029]

Content of Hydrogen: 20 ppm or less

Hydrogen is an element that decreases the mechanical strength of a sputtering target material and deteriorates the corrosion resistance of a soft magnetic alloy. Thus, the content of hydrogen is set at 20 ppm or less. The content of hydrogen is preferably 10 ppm or less, and more preferably set at 5 ppm or less.

EXAMPLES

[0030]

A target material according to the present invention will be specifically described below with reference to examples.

[0031]

A raw material to be melted was weighed for each composition of present invention examples No. 1 to No. 34 shown in Table 1 and Table 2, induction-heating melted in a refractory crucible having an Ar gas atmosphere with a reduced pressure or a vacuum atmosphere, then tapped from a nozzle having a diameter of 8 mm in the lower portion of the crucible, and atomized with an Ar gas. A coarse powder having a particle diameter of 500 μm or more, which was not suitable for molding, was removed from this gas atomized powder, and a

fine powder was removed so that the amount of a powder having a particle diameter of 5 μm or less in a powder used for molding was 10% or less in order to reduce the content of hydrogen. Then, a powder obtained by drying the gas atomized powder put in a furnace at 110°C to remove water from the gas atomized powder was degassing-charged as a raw material into an SC can having an outer diameter of 220 mm, an inner diameter of 210 mm, and a length of 200 mm. The content of hydrogen in the powder with a reduced hydrogen content was less than 20 ppm. The powder-filled billet described above was sintered by hot isostatic pressing under conditions of a temperature of 1100°C, a pressure of 120 MPa, and a retention time of 4 hours to produce a sintered body. The solidified molded body produced by the method described above was processed into a disk shape having a diameter of 180 mm and a thickness of 7 mm by wire cutting, turning processing, and plane polishing, whereby a sputtering target material was made.

[0032]

For the component of the present invention example No. 35 shown in Table 2, a gas atomized powder having a composition obtained by removing Cr was prepared, mixed with a Cr powder having a hydrogen content of less than 20 ppm, and molded as described above. For the present invention example No. 36 shown in Table 2, gas atomized powders of Co-10Ta-3Cr-2Hf-1Al-4C (at%) and Fe-10Ta-3Cr-2Hf-1Al-4C (at%) were prepared, mixed at a ratio of 30:70, and molded as described above.

[0033]

A raw material to be melted was weighed for each component of present invention examples Nos. 37 to 55 shown in Table 2 and Table 3, induction-heating melted in a refractory crucible having an Ar gas atmosphere with a reduced pressure or a vacuum atmosphere, then poured into a mold, cooled, then heat-treated for 5 hours or more at 1000°C in a vacuum, annealed, and then processed into a disk shape having a

diameter of 180 mm and a thickness of 7 mm by turning processing and plane polishing, whereby a sputtering target material was made.

[0034]
[Table 1]

No.		Composition (at.%)																				Melting atmosphere	Content of hydrogen (ppm)	Three-point bending strength (MPa)	Bs (kG)	Remarks				
		Co:Fe		A group element		B group element		A+B	C group element			A+B+C		D group element		E group element		F group element									Co			
		Ta	Nb	V	Cr	Mo	W	Ti	Zr	Hf	Ni	Mn	Al	Cu	Si	Ge	P	B	C											
1	35:65	18						18							18								Bal.	3	800	6.8	Present Invention Examples			
2	50:50		19					19						19								Bal.	3	800	6.8					
3	65:35			20				20						20								Bal.	4	900	5.9					
4	35:65	17						17						17								Bal.	5	930	8.6					
5	35:65	19						19						19								Bal.	3	780	6.7					
6	70:30	10	11					21						21								Bal.	7	830	6.4					
7	30:70	13		8				21						21								Bal.	5	790	4.3					
8	40:60		9	12				21						21								Bal.	4	810	5.9					
9	90:10			20		5		25						25								Bal.	2	1100	4.1					
10	90:10	10					20	30						30								Bal.	7	800	2.0					
11	90:10	8				2		10		4				14			1				6		Bal.	8	820	5.4				
12	90:10	8				2		10		4				14			1	2	2				Bal.	10	750	6.5				
13	90:10		10				2	12		4				16		2	2		2				Bal.	5	1000	4.5				
14	90:10	3		5	1		1	10	3					13			1	2		2		2		Bal.	3	1050		4.8		
15	80:20	8				2		10	1					11			1				8		Bal.	10	740	6.5				
16	80:20		8			2		10						10			1	2					Bal.	2	1110	10.4				
17	80:20	5		3		2		10	2					12		2							Bal.	2	1080	10.2				
18	80:20				7	5		12						12									Bal.	12	720	10.3				
19	70:30	0.6			10			10.6		2				12.6			1	1					Bal.	6	1040	10.2				

[0035]

[Table 2]

Table 2

No.	Co:Fe	Composition (at.%)																				Melting atmosphere	Content of hydrogen (ppm)	Three-point bending strength (MPa)	Bs (kG)	Remarks			
		A group element		B group element		A+B		C group element		A+B+C		D group element		E group element		F group element				Co									
		Ta	Nb	V	Cr	Mo	W			Ti	Zr	Hf			Ni	Mn	Al	Cu	Si		Ge						P	B	C
20	70:30	10			1			11		3			14		6	1								Bal.	Vacuum	1	1100	6.0	Present Invention Examples
21	70:30	11			3			14		3			17			12	1						Bal.	Ar with reduced pressure	16	730	4.5		
22	70:30	8			3			11		3			14			1						Bal.	Ar with reduced pressure	19	740	8.7			
23	70:30	8				2		10	2		2		14	1	1							5	Bal.	Vacuum	5	1020	9.3		
24	70:30	6	2			2		10					10	2	2							Bal.	Vacuum	4	1030	10.4			
25	70:30	13					2	15	3	3			18			5						Bal.	Vacuum	5	1020	4.3			
26	50:50	10			1			11					11		1							Bal.	Ar with reduced pressure	10	780	6.5			
27	50:50		8			2	3	13	3				16		1							Bal.	Ar with reduced pressure	9	820	8.5			
28	50:50			8	5			13	3	3			16		1	1						Bal.	Vacuum	7	770	8.8			
29	50:50	6		4	2			12	3	3			15		1							Bal.	Vacuum	1	1150	9.7			
30	50:50	6	4			2		12	3	3			15	1	1	1						Bal.	Ar with reduced pressure	6	850	8.8			
31	40:60	8				2		10	2	2			12	1								Bal.	Ar with reduced pressure	7	790	9.3			
32	40:60		8		3			11			3		14		1	1						Bal.	Vacuum	5	1020	9.5			
33	40:60			8		10		18	2	2			20		1							Bal.	Vacuum	4	1050	3.5			
34	40:60	6		4	3			13	3	3			16		1							Bal.	Ar with reduced pressure	9	770	5.5			
35	40:60	6	4		3			13	3	3			16	1	1	1						Bal.	Ar with reduced pressure	9	760	6.9			
36	30:70	10			3			13	2	2			15		1							Bal.	Vacuum	4	1050	8.6			
37	30:70		8		5			13	4	4			17	1								Bal.	Ar with reduced pressure	10	750	6.0			
38	30:70				8	5		13	4	4			17		1	2						Bal.	Ar with reduced pressure	9	780	5.7			

[0036]

[Table 3]

Table 3

No.	Co:Fe	Composition (at.%)																				Melting atmosphere	Content of hydrogen (ppm)	Three-point bending strength (MPa)	Bs (kG)	Remarks			
		A group element		B group element			A+B	C group element			A+B+C		D group element			E group element			F group element								Co		
		Ta	Nb	V	Cr	Mo		W	Ti	Zr	Hf	Ni	Mn	Al	Cu	Si	Ge	P	B	C									
39	30:70	6		4	5			15	4			19					1					8		Bal.	Ar with reduced pressure	8	760	4.1	Present Invention Examples
40	30:70	6	4		5			15	2	2		19	1				1					8		Bal.	Vacuum	2	1050	3.8	
41	70:30	3	3	3	1			10				10												Bal.	Vacuum	7	1400	10.4	
42	70:30	3	3	3		3		12	1	1	1	15												Bal.	Vacuum	3	1050	9.2	
43	70:30	3	3	3			1	10				10								1	1	1		Bal.	Vacuum	6	1300	10.1	
44	70:30	3			3	3	3	12				12								1	1	1	1	Bal.	Ar with reduced pressure	2	1200	9.2	
45	70:30	2	2	2	2	2	2	12	1	1	1	15								1	1	1		Bal.	Ar with reduced pressure	3	1000	8.1	
46	35:65		9			9		18				18												Bal.	Vacuum	3	1050	8.8	
47	35:65	10				10		20				20												Bal.	Ar with reduced pressure	4	900	8.1	
48	35:65		9				9	18				18												Bal.	Vacuum	1	1030	8.6	
49	35:65	10				5	5	20				20												Bal.	Ar with reduced pressure	2	930	8.0	
50	35:65	9				9		18				18												Bal.	Vacuum	3	1100	8.7	
51	80:20		9			9		18	1			19												Bal.	Ar with reduced pressure	3	1080	6.8	
52	80:20		5	4		5	4	18				18	1											Bal.	Vacuum	5	900	6.6	
53	80:20		10				9	19				19					1							Bal.	Vacuum	7	1000	6.5	
54	80:20				10	6		16				16										1		Bal.	Ar with reduced pressure	10	1030	7.6	
55	80:20	10						21				21								1				Bal.	Ar with reduced pressure	5	800	5.8	

[0037]
[Table 4]

No.		Composition (at.%)																				Melting atmosphere	Content of hydrogen (ppm)	Three-point bending strength (MPa)	Bs (kG)	Remarks	
		Co:Fe		A group element		B group element		A+B	C group element		A+B+C	D group element		E group element		F group element											Co
Ta	Nb	V	Cr	Mo	W			Ti	Zr	Hf		Ni	Mn	Al	Cu	Si	Ge	P	B	C							
56	90:10		20		5		25					25										Bal.	Atmospheric air	25	300	3.1	Comparative Examples
57	90:10	10				20	30					30										Bal.	Atmospheric air	30	280	1.2	
58	90:10	8			2		10		4			14		1						6		Bal.	Atmospheric air	40	240	6.5	
59	90:10	8				2	10		4			14		1	2	2						Bal.	Atmospheric air	25	300	5.6	
60	90:10		10				2	12		4		16	2	2			2					Bal.	Atmospheric air	28	280	6.0	
61	90:10	3		5	1		1	10	3			13		1	2			2		2		Bal.	Atmospheric air	30	250	8.4	
62	80:20	8				2		10	1			11		1						8		Bal.	Atmospheric air	32	240	5.9	
63	80:20		8			2		10				10		1	2							Bal.	Atmospheric air	40	230	10.2	
64	80:20	5		3		2		10	2			12		2								Bal.	Atmospheric air	21	220	9.8	
65	80:20			7		5		12				12										Bal.	Atmospheric air	25	230	10.3	
66	70:30	0.6			10			10.6		2		12.6			1	1						Bal.	Atmospheric air	26	280	8.9	
67	70:30	10			1			11		3		14	6		1							Bal.	Atmospheric air	30	290	7.5	
68	70:30	11			3			14		3		17		12	1							Bal.	Atmospheric air	50	270	2.5	
69	70:30	8			3			11		3		14		1								Bal.	Atmospheric air	80	250	9.9	
70	70:30	8				2		10	2		2	14	1	1								Bal.	Atmospheric air	47	280	10.0	
71	70:30	6	2			2		10				10	2		2							Bal.	Atmospheric air	60	250	10.3	

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

[0038]
[Table 5]

Table 5

No.	Co:Fe	Composition (at.%)																				Melting atmosphere	Content of hydrogen (ppm)	Three-point bending strength (MPa)	Bs (kG)	Remarks					
		A group element		B group element		A+B		C group element		A+B+C		D group element		E group element		F group element															
		Ta Nb		V Cr		Mo W		Ti Zr		Hf		Ni Mn		Al Cu		Si Ge		P B		C											
72	70:30	13				2			3		18			5									2		Bal.	Atmospheric air	30	240	5.0	Comparative Examples	
73	50:50	10		1			11				11			1									8		Bal.	Atmospheric air	25	230	6.8		
74	50:50		8			2	3	3			16			1											Bal.	Atmospheric air	60	280	9.7		
75	50:50			8	5			3			16			1		1									Bal.	Atmospheric air	50	270	8.9		
76	50:50	6		4	2			3			15			1											Bal.	Atmospheric air	40	260	9.9		
77	50:50	6	4			2		3			15	1		1										1	Bal.	Atmospheric air	70	250	9.7		
78	40:60	8				2		2			12	1											4		Bal.	Atmospheric air	73	240	10.0		
79	40:60		8		3					3	14			1		1									Bal.	Atmospheric air	76	220	10.3		
80	40:60			8		10		2			20			1									4		Bal.	Atmospheric air	23	230	6.4		
81	40:60	6		4	3			3			16			1									4		Bal.	Atmospheric air	25	280	8.0		
82	40:60	6	4		3			3			16	1		1									4		Bal.	Atmospheric air	28	250	7.9		
83	30:70	10			3			2			15			1									4		Bal.	Atmospheric air	24	280	7.4		
84	30:70		8		5			3			17	1													8	Bal.	Atmospheric air	30	260		8.5
85	30:70			8	5			3			17			1		2									8	Bal.	Atmospheric air	33	250		4.0
86	30:70	6		4	5				4		15			1									8		Bal.	Atmospheric air	32	240	3.5		
87	30:70	6	4		5			2	2		19	1		1									8		Bal.	Atmospheric air	45	230	3.4		

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

[0039]

[Table 6]

Table 6

No.	Co:Fe	Composition (at.%)																				Melting atmosphere	Content of hydrogen (ppm)	Three-point bending strength (MPa)	Bs (kG)	Remarks				
		A group element		B group element			A+B		C group element			A+B+C			D group element			E group element			F group element						Co			
		Ta Nb		V	Cr	Mo	W	Ti		Zr	Hf	Ni			Mn	Al	Cu	Si	Ge	P	B							C		
		Ta	Nb	V	Cr	Mo	W	Ti	Zr	Hf	Ni	Mn	Al	Cu	Si	Ge	P	B	C											
88	40:60	0.1			15										15.1										Bal.	45	220	10.2	Comparative Examples	
89	30:70				35										35										Bal.	55	230	0.5		
90	50:50		9								10				28										Bal.	32	300	0.6		
91	40:60	9													18										Bal.	38	230	0.5		
92	30:70		9												18										Bal.	50	210	0.7		
93	50:50	9			9										18										Bal.	70	220	0.5		
94	50:50		20				20								40										Bal.	51	270	0.0		

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

Nos. 56 to 94 shown in Table 4 to Table 6 are comparative examples.

[0040]

5 A raw material to be melted was weighed for each composition of the comparative examples Nos. 56 to 83 of Table 4 and Table 5, induction-heating melted in a refractory crucible having an atmospheric air atmosphere, then tapped from a nozzle having a diameter of 8 mm in the lower portion of the crucible, and atomized with an Ar gas. A powder obtained by
10 removing a coarse powder having a particle diameter of 500 μm or more, which was not suitable for molding, from this gas atomized powder was degassing-charged as a raw material into an SC can having an outer diameter of 220 mm, an inner diameter of 210 mm, and a length of 200 mm. The
15 powder-filled billet described above was sintered by hot isostatic pressing under conditions of a temperature of 1100°C, a pressure of 120 MPa, and a retention time of 4 hours to produce a sintered body. The solidified molded body produced by the method described above was processed into a disk shape having
20 a diameter of 180 mm and a thickness of 7 mm by wire cutting, turning processing, and plane polishing, whereby a sputtering target material was made.

[0041]

25 A raw material to be melted was weighed for each component of the comparative examples Nos. 84 to 94 in Tables 5 and 6, induction-heating melted in a refractory crucible having an atmospheric air atmosphere, then poured into a mold, cooled, and then processed into a disk shape having a diameter of 180 mm and a thickness of 7 mm by turning processing and plane
30 polishing, whereby a sputtering target material was made.

[0042]

The content of hydrogen was measured by an inert gas fusion-nondispersive infrared absorption method as an evaluation method. The mechanical strength of TP having a
35 width of 4 mm, a height of 3 mm, and a length of 25 mm, obtained by division by a wire, was evaluated by a three-point

bending test. In the three-point bending test conducted under the condition of a supporting-point distance of 20 mm, a stress (N) in the case of applying a pressure in a height direction was measured as a three-point bending strength based on the following expression: three-point bending strength (MPa) = $[3 \times \text{stress (N)} \times \text{supporting-point distance (mm)}] / [2 \times \text{test piece width (mm)} \times (\text{test piece thickness (mm)})^2]$. For evaluation of a saturation magnetic flux density (Bs), the saturation magnetic flux density (Bs) was measured with a VSM device (vibration-sample-type magnetometer) at an applied magnetic field of 1200 kA.

[0043]

As evaluation results, the sputtering targets with hydrogen of less than 20 ppm in Table 1 to Table 3 for the present invention examples exhibit a three-point bending strength of 730 MPa or more. In contrast, hydrogen is more than 20 ppm, and three-point bending strength is as low as 300 MPa or less in all of Table 4 to Table 6 for the comparative examples. Even if all raw materials are not gas atomized powders as in the case of No. 35 in Table 2, the effect of the present invention is obtained when the content of hydrogen in a sputtering target is 20 ppm or less. Even if gas atomized powders as raw powders are two kinds or more as in the case of No. 36 in Table 2, the effect of the present invention is obtained when the content of hydrogen is 20 ppm or less.

[0044]

The alloy according to the present invention will be specifically described with reference to the examples.

[0045]

Normally, a thin film in a perpendicular magnetic recording medium is formed by sputtering a sputtering target material having the same composition as the film layer to form the film layer on a glass substrate or the like. The thin film formed by sputtering is quenched. In contrast, quenched ribbons produced in a single-roll-type liquid quenching device are used as the sample materials of the examples and the

comparative examples in the present invention. In this case, the effects of the components of the thin films which are actually quenched and formed by sputtering on various properties are evaluated in a simple manner using liquid
5 quenched ribbons.

[0046]

Each raw material of 30 g weighed to have composition shown in present invention examples Nos. 101 to 147 shown in
10 Tables 7 to 9 was inserted into a water-cooled copper mold having an inner diameter of 10 mm and a depth of around 40 mm, arc-melted and solidified in Ar atmosphere with a reduced pressure, to provide a molten base material for a quenched ribbon. The production of the quenched ribbon was conducted by a single roll method under the condition in which the molten
15 base material was set in a silica tube having an inner diameter of 15 mm and the molten base material was melted and then tapped from a tapping nozzle having an inner diameter of 1 mm, at an atmosphere pressure of 61 kPa, at an atomizing pressure difference of 69 kPa, and at a rotational number of 3000 rpm of
20 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. The quenched ribbon produced in such a manner was used as a sample material, and the content
25 of hydrogen and corrosion resistance were evaluated.

[0047]

Each raw material of 30 g weighed to have composition shown in comparative examples Nos. 154 to 192 shown in Table
30 10 to Table 12 was inserted into a water-cooled copper mold having an inner diameter of 10 mm and a depth of around 40 mm, arc-melted and solidified in atmospheric air atmosphere, to provide a molten base material for a quenched ribbon. The production of the quenched ribbon was conducted by a single roll method under the condition in which the molten base
35 material was set in a silica tube having an inner diameter of 15 mm and the molten base material was melted and then tapped

from a tapping nozzle having an inner diameter of 1 mm, at an atmosphere 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. The quenched ribbon produced in such a manner was used as a sample material, and the content of hydrogen and corrosion resistance were evaluated. The content of hydrogen was measured by an inert gas fusion-nondispersive infrared absorption method as an evaluation method.

[0048]

[Corrosion Resistance of Quenched Ribbon (HNO_3)]

A sample material that was 50 mg was weighed, 10 ml of 3% HNO_3 aqueous solution was dropwise added to the sample material, the resultant was then left standing for 1 hr at room temperature, and the amount of Co eluted in the 3% HNO_3 aqueous solution was analyzed. A Co elution amount of less than 500 ppm was evaluated as A, a Co elution amount of 500 or more and less than 1000 ppm as B, and a Co elution amount of 1000 ppm or more as C.

[0049]
[Table 7]

Table 7																								
No.	Co:Fe	Composition (at.%)															Content of hydrogen (ppm)	Elution amount (ppm)	Corrosion resistance	Remarks				
		A group element		B group element			A+B	C group element			A+B+C	D group element		E group element	F group element						Co			
		Ta	Nb	V	Cr	Mo	W	Ti	Zr	Hf	Ni	Mn	Al	Cu	Si	Ge					P	B	C	
95	35:65	18									18									Bal.	5	200	A	Present Invention Examples
96	50:50		19								19									Bal.	7	180	A	
97	65:35			20							20									Bal.	4	250	A	
98	70:30	10	11								21									Bal.	6	180	A	
99	30:70	13		8						4	25									Bal.	8	230	A	
100	40:60		9	12					4	25										Bal.	9	250	A	
101	90:10			20		5			4	25										Bal.	8	200	A	
102	90:10	10					20			30										Bal.	13	250	A	
103	90:10	8			2				4	14			1					6		Bal.	8	520	B	
104	90:10	8				2			4	14			1	2	2					Bal.	7	230	A	
105	90:10		10				2	12		4	16	2	2			2				Bal.	12	400	A	
106	90:10	3		5	1		1	10	3		13			1	2		2		2	Bal.	8	520	B	
107	80:20	8				2		10	1		11			1				8		Bal.	5	280	A	
108	80:20		8			2		10			10			1	2					Bal.	3	270	A	
109	80:20	5		3		2		10	2		12			2						Bal.	8	250	A	
110	80:20			7		5		12			12									Bal.	12	480	A	
111	70:30	0.6			10			10.6		2	12.6			1	1					Bal.	3	300	A	
112	70:30	10			1			11		3	14	6	1							Bal.	5	530	B	

[0050]
[Table 8]

Table 8																													
No	Co:Fe	Composition (at.%)																			Content of hydrogen (ppm)	Elution amount (ppm)	Corrosion resistance	Remarks					
		A group element		B group element			A+B		C group element			A+B+C		D group element		E group element	F group element								Co				
		Ta	Nb	V	Cr	Mo	W			Ti	Zr	Hf			Ni	Mn	Al	Cu	Si	Ge					P	B	C		
113	70:30	11			3			14		3			17		12		1								Bal.	8	580	B	Present Invention Examples
114	70:30	8			3			11		3			14				1								Bal.	8	590	B	
115	70:30	8				2		10		2	2		14	1	1								5	Bal.	3	300	A		
116	70:30	6	2			2		10					10	2		2								Bal.	4	490	A		
117	70:30	13					2	15		3			18			5						2		Bal.	10	480	A		
118	50:50	10			1			11					11			1						8		Bal.	19	530	B		
119	50:50		8			2	3	13		3			16			1								Bal.	10	200	A		
120	50:50			8	5			13		3			16			1	1							Bal.	10	230	A		
121	50:50	6		4	2			12		3			15			1								Bal.	15	580	B		
122	50:50	6	4			2		12		3			15	1	1							1		Bal.	3	250	A		
123	40:60	8				2		10		2			12	1							4			Bal.	2	100	A		
124	40:60		8		3			11				3	14			1	1							Bal.	3	600	B		
125	40:60			8		10		18		2			20			1					4			Bal.	5	300	A		
126	40:60	6		4	3			13		3			16			1					4			Bal.	13	450	A		
127	40:60	6	4		3			13		3			16	1	1						4			Bal.	10	430	A		
128	30:70	10			3			13		2			15			1					4			Bal.	7	420	A		
129	30:70		8		5			13		4			17		1									Bal.	13	410	A		
130	30:70			8	5			13		4			17				1	2						Bal.	4	300	A		

[0051]
[Table 9]

Table 9

No	Composition (at.%)																							Content of hydrogen (ppm)	Elution amount (ppm)	Corrosion resistance	Remarks		
	Co:Fe	A group element		B group element			A+B		C group element				A+B+C		D group element		E group element		F group element									Co	
		Ta	Nb	V	Cr	Mo	W		Ti	Zr	Hf				Ni	Mn	Al	Cu	Si	Ge	P	B	C						
131	30:70	6		4	5			15		4			19				1						8		Bal.	11	200	A	Present Invention Examples
132	30:70	6	4		5			15	2	2			19		1		1						8		Bal.	8	250	A	
133	70:30	3	3	3	1			10					10												Bal.	11	530	B	
134	70:30	3	3	3		3		12	1	1	1		15												Bal.	8	400	A	
135	70:30	3	3	3			1	10					10						1	1	1				Bal.	6	380	A	
136	70:30	3			3	3	3	12					12						1	1	1	1	1		Bal.	7	350	A	
137	70:30	2	2	2	2	2	2	12	1	1	1		15						1	1	1				Bal.	6	300	A	
138	35:65		9			9		18					18												Bal.	10	400	A	
139	35:65	10				10		20					20												Bal.	10	400	A	
140	35:65		9				9	18					18												Bal.	7	350	A	
141	35:65	10				5	5	20					20												Bal.	6	380	A	
142	35:65	9				9		18					18												Bal.	8	350	A	
143	80:20		9		9		9	18	1				19												Bal.	10	390	A	
144	80:20		5	4		5	4	18					18		1										Bal.	5	250	A	
145	80:20		10				9	19					19					1							Bal.	7	300	A	
146	80:20			10	6			16					16												Bal.	8	380	A	
147	80:20	10				11		21					21						1						Bal.	7	280	A	

[0052]
[Table 10]

Table 10																														
No	Co:Fe	Composition (at.%)																			Content of hydrogen (ppm)	Elution amount (ppm)	Corrosion resistance	Remarks						
		A group element		B group element			A+B		C group element			A+B+C		D group element		E group element									F group element			Co		
		Ta	Nb	V	Cr	Mo	W		Ti	Zr	Hf		Ni	Mn	Al	Cu	Si	Ge	P	B					C					
148	35:65	18						18				18											Bal.	40	1300	C	Comparative Examples			
149	50:50		19					19				19											Bal.	30	1200	C				
150	65:35			20				20				20											Bal.	28	1500	C				
151	70:30	10	11					21				21											Bal.	30	1400	C				
152	30:70	13		8				21				21											Bal.	35	1200	C				
153	40:60		9	12				21				21											Bal.	38	1300	C				
154	90:10			20		5		25				25											Bal.	25	1500	C				
155	90:10	10					20	30				30											Bal.	30	1200	C				
156	90:10	8			2			10		4		14				1					6		Bal.	40	1300	C				
157	90:10	8				2		10		4		14				1	2	2					Bal.	25	1210	C				
158	90:10		10				2	12		4		16		2	2			2					Bal.	28	1220	C				
159	90:10	3		5	1		1	10	3			13				1	2		2		2		Bal.	30	1300	C				
160	80:20	8				2		10	1			11				1				8			Bal.	32	1000	C				
161	80:20		8			2		10				10				1	2						Bal.	40	1200	C				
162	80:20	5		3		2		10	2			12			2								Bal.	21	1000	C				
163	80:20			7		5		12				12											Bal.	25	1000	C				
164	70:30	0.6			10			10.6		2		12.6				1	1						Bal.	26	1030	C				
165	70:30	10			1			11		3		14		6		1							Bal.	30	1050	C				

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

[0053]
[Table 11]

Table 11																											
No		Composition(at.%)																				Corrosion resistance	Remarks				
		Co:Fe	A group element		B group element		A+B	C group element			A+B+C	D group element		E group element	F group element					Co							
			Ta	Nb	V	Cr		Mo	W	Ti		Zr	Hf		Ni	Mn	Al	Cu	Si		Ge			P	B	C	
166	70:30	11				3			14		3		17		12	1								50	1400	C	Comparative Examples
167	70:30	8				3			11		3		14			1							80	1330	C		
168	70:30	8					2		10		2	2	14	1		1					5		47	1220	C		
169	70:30	6	2				2		10				10	2									60	1030	C		
170	70:30	13						2	15		3		18			5				2			30	1500	C		
171	50:50	10				1			11				11			1				8			25	1330	C		
172	50:50		8				2	3	13		3		16			1						60	1320	C			
173	50:50			8	5				13		3		16			1	1					50	1280	C			
174	50:50	6		4	2				12		3		15			1						40	1150	C			
175	50:50	6	4			2			12		3		15	1	1						1	70	1300	C			
176	40:60	8					2		10		2		12	1						4		73	1200	C			
177	40:60		8		3				11			3	14			1	1					76	1220	C			
178	40:60			8		10			18		2		20			1				4		23	1400	C			
179	40:60	6		4	3				13		3		16			1				4		25	1300	C			
180	40:60	6	4		3				13			3	16	1		1				4		28	1220	C			
181	30:70	10			3				13		2		15			1				4		24	1400	C			
182	30:70		8		5				13		4		17	1							8	30	1000	C			
183	30:70			8	5				13		4		17			1	2					33	1020	C			
NOTE: The underlined figures fall outside the scope of the present invention.																											

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

[0054]
[Table 12]

Table 12

No	Composition (at.%)																				Corrosion resistance	Remarks					
	Co:Fe	A group element		B group element			A+B	C group element			A+B+C	D group element		E group element	F group element					Co			Content of hydrogen (ppm)	Elution amount (ppm)			
		Ta	Nb	V	Cr	Mo		W	Ti	Zr		Hf	Ni		Mn	Al	Cu	Si	Ge						P	B	C
184	30:70	6		4	5			15		4		19			1				8		Bal.	32			1000	C	Comparative Examples
185	30:70	6	4		5			15		2	2	19	1		1				8		Bal.	45	1300	C			
186	40:60	0.1			15			15.1				15.1									Bal.	65	1800	C			
187	30:70				35			35				35									Bal.	35	1600	C			
188	50:50		9			9		18		10		28									Bal.	49	1380	C			
189	40:60	9				9		18				18	35								Bal.	47	1580	C			
190	30:70		9				9	18				18		8							Bal.	35	1320	C			
191	50:50	9			9			18				18				15					Bal.	68	1400	C			
192	50:50		20		20			40				40									Bal.	70	1200	C			

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

The present invention examples are shown in Table 7 to Table 9, while the comparative examples are shown in Table 10 to Table 12.

[0055]

As described above, the present invention makes it possible to improve the mechanical strength of a soft magnetic sputtering target for magnetic recording by decreasing the content of hydrogen in the soft magnetic sputtering target for magnetic recording, and to provide a soft magnetic alloy excellent in corrosion resistance, and a magnetic recording medium.

CLAIMS

1. A soft magnetic alloy for magnetic recording, comprising:
in at.%,
0.5 to 29.5% of one or more of A group elements selected from Ta, Nb, and V;
0.0 to 29.5% of one or more of B group elements selected from Cr, Mo, and W; and
the balance being Co, Fe, and unavoidable impurities, wherein:
a ratio of Fe:Co is 10:90 to 70:30;
a total content of the A group elements and the B group elements is 10 to 30%; and
a hydrogen content is less than 20 ppm.
2. A soft magnetic alloy for magnetic recording, comprising:
in at.%,
0.5 to 29.5% of one or more of A group elements selected from Ta, Nb, and V;
0.5 to 29.5% of one or more of B group elements selected from Cr, Mo, and W; and
the balance being Co, Fe, and unavoidable impurities, wherein:
a ratio of Fe:Co is 10:90 to 70:30;
a total content of the A group elements and the B group elements is 10 to 30%; and
a hydrogen content is less than 20 ppm.
3. The soft magnetic alloy for magnetic recording according to claim 1 or 2, further comprising one or more elements of elements described in the following C group elements, D group elements, E group elements, and F group elements in a range of at.% described in each group:
the C group elements: one or more elements selected from Ti, Zr, and Hf, a total content thereof being less than 5%,
a total content of the A group elements, the B group elements,

and the C group elements being 10 to 30%;

the D group elements: one or two elements selected from Ni and Mn, a total content thereof being 30% or less;

the E group elements: one or two elements selected from Al and Cu, a total content thereof being 5% or less; and

the F group elements: one or more elements selected from Si, Ge, P, B, and C, a total content thereof being 10% or less.

4. A sputtering target material for forming a soft magnetic alloy for magnetic recording, the sputtering target material comprising the soft magnetic alloy for magnetic recording according to claim 1 or 2.

5. A sputtering target material for forming a soft magnetic alloy for magnetic recording, the sputtering target material comprising the soft magnetic alloy for magnetic recording according to claim 3.

6. A magnetic recording medium, comprising the soft magnetic alloy for magnetic recording according to claim 1 or 2.

7. A magnetic recording medium, comprising the soft magnetic alloy for magnetic recording according to claim 3.