

MANUFACTURING METHOD OF SPUTTERING TARGET MATERIAL

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

[0001] The present invention relates to a manufacturing method of an Fe-Co based alloy sputtering target material for forming a soft magnetic film.

2. Description of Related Art

[0002] In recent years, the magnetic recording technology has achieved significant
10 progress. In order to realize large capacity of a driver, a magnetic recording medium is continuously developing towards high recording density. However, if high recording density is desired for the current magnetic recording medium using longitudinal magnetic recording widely used in the world, a record bit needs to be miniaturized and have a high coercive force which cannot be recorded by a record head. As a result, the
15 industry is carrying out research on perpendicular magnetic recording as a method for solving these problems and improving the recording density.

[0003] The perpendicular magnetic recording is to form a magnetic film of a perpendicular magnetic recording medium in a manner that an axis of easy magnetization is oriented in a direction perpendicular to a medium surface, and the
20 perpendicular magnetic recording is applicable to a method with high recording density having a small demagnetizing field in the bit as well as a small reduction in recording and reproducing characteristics despite of the enhanced recording density. Moreover, in the perpendicular magnetic recording, a recording medium having a magnetic

recording film layer with improved recording sensitivity and a soft magnetic layer is developed.

[0004] Due to the requirement for excellent soft magnetic characteristics, an amorphous soft magnetic alloy is used as a soft magnetic film of the magnetic recording medium. As a representative amorphous alloy for the soft magnetic film, an alloy film containing an additive element in iron (Fe), cobalt (Co), or Fe-Co alloy has been practiced in use (for example, see Japanese Patent Publication No. 2004-030740).

[0005] Due to the requirement for high smoothness of the thin film, a sputter film is used as the soft magnetic film of the magnetic recording medium. In the sputter film, elements of boron (B), zirconium (Zr), hafnium (Hf), tantalum (Ta), niobium (Nb), yttrium (Y) or the like having high amorphous-forming capability greater than or equal to 5 atom% is added in Fe, Co, or Fe-Co alloy to form an amorphous or micro-crystallite film.

[0006] In order to fabricate the sputter film, a target material to form a base material is needed, but a cast ingot as a raw material has many casting defects when the target material is fabricated through a melting casting method, thereby forming directional macrostructures caused by the growth direction in solidification. Since such casting defects or macrostructures may easily cause the generation of particles in sputtering, non-uniform thickness sputter film, or non-uniform sputtering speed, plastic working such as hot rolling is performed on the cast ingot to reduce the casting defects or eliminate the directional macrostructures to obtain the sputtering target material. However, an Fe-Co alloy added with B, Zr, Hf, Ta, Nb, Y or the like element having high amorphous-forming capability greater than or equal to 5 atom% forms a hard and

brittle intermetallic compound phase, and thus has rather poor hot workability and cannot be used for manufacturing the target material stably through hot rolling.

SUMMARY OF THE INVENTION

5 [0007] Accordingly, the present invention is directed to a method for stably manufacturing a sputtering target material with an cast ingot being plastic worked when an Fe-Co based alloy sputtering target material for forming a soft magnetic film used in a perpendicular magnetic recording medium is manufactured from the cast ingot.

[0008] Regarding the sputtering target material formed of an Fe-Co based alloy for
10 forming the soft magnetic film of the perpendicular magnetic recording medium, the inventors have carried out various researches on the plastic working method of the cast ingot, and found that an appropriate relationship between a diameter/height ratio of the cast ingot and an upsetting rate in upsetting through hot press may be used to accomplish the present invention.

15 [0009] That is, the present invention provides a manufacturing method of a sputtering target material, which is an Fe-Co based alloy having an atomic ratio represented by a composition formula $((\text{Fe}_{100-X}\text{-Co}_X)_{100-Y}\text{-Ni}_Y)_{100-a}\text{-M1}_a$, where $5 \leq X \leq 95$, $0 \leq Y \leq 25$, $5 \leq a \leq 20$, and the M1 element is one or two or more elements selected from B, Zr, Hf, Ta, Nb and Y. The manufacturing method includes inserting a cylindrical cast ingot
20 having a diameter/height ratio up to 0.5-2 into a pressure mold, and upsetting by hot press with an upsetting rate of 30%-70% at a temperature in a range of 900°C-1250°C, so as to obtain a target material.

[0010] Furthermore, in the manufacturing method of the present invention, the

sputtering target material may contain an M2 element less than or equal to 15 atom% which is one or two or more elements selected from titanium (Ti), vanadium (V), chromium (Cr), molybdenum (Mo), tungsten (W), aluminum (Al) and silicon (Si).

[0011] Furthermore, in the present invention, preferably, a diameter of the cast ingot is greater than or equal to 100 mm, and a diameter of the target material is less than or equal to 200 mm.

[0012] [Effect of the invention]

[0013] The present invention provides an Fe-Co based alloy sputtering target material for forming a soft magnetic film of a perpendicular magnetic recording medium capable of stably performing magnetron sputtering, so the present invention is an extremely effective technology in manufacturing the perpendicular magnetic recording medium.

[0014] In order to make the aforementioned and other objectives, features and advantages of the present invention comprehensible, embodiments accompanied with figures are described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

[0016] FIG. 1 is a structural view of an example of the shape of a sputtering target material in the present invention.

DESCRIPTION OF THE EMBODIMENTS

[0017] Reference will now be made in detail to the present embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

[0018] The most important feature of the present invention lies in that, it is found that a target material may be manufactured stably by upsetting by hot press with a controlled upsetting rate after a diameter/height ratio of an cast ingot of an Fe-Co based alloy having an atomic ratio represented by a composition formula $((\text{Fe}_{100-X}\text{-Co}_X)_{100-Y}\text{-Ni}_Y)_{100-a}\text{-M1}_a$, where $5 \leq X \leq 95$, $0 \leq Y \leq 25$, $5 \leq a \leq 20$, and the M1 element is one or two or more elements selected from B, Zr, Hf, Ta, Nb, and Y is controlled.

[0019] First, an alloy composition of a sputtering target material in the present invention is an Fe-Co based alloy having an atomic ratio represented by a composition formula $((\text{Fe}_{100-X}\text{-Co}_X)_{100-Y}\text{-Ni}_Y)_{100-a}\text{-M1}_a$, where $5 \leq X \leq 95$, $0 \leq Y \leq 25$, $5 \leq a \leq 20$, and the M1 element is formed of one or two or more elements selected from B, Zr, Hf, Ta, Nb and Y. The purpose of the alloy composition is to obtain an amorphous film or micro-crystallite film having magnetic characteristics essential to a soft magnetic film for perpendicular magnetic recording. Furthermore, an Fe-Co based alloy further containing one or two or more elements selected from Ti, V, Cr, Mo, W, Al and Si less than or equal to 15 atom% is also applicable to the alloy composition, because the magnetic characteristics of the soft magnetic film can be maintained while the corrosion resistance or amorphous-forming capability is improved by containing the one or two or

more elements selected from Ti, V, Cr, Mo, W, Al and Si.

[0020] An intermetallic compound having poor hot workability, for example, Fe_2Ta , Co_2Ta , Fe_3Zr , Fe_2B , or the like, exists in large amount in the cast ingot formed of the Fe-Co based alloy.

5 **[0021]** Therefore, in order to perform plastic working on the cast ingot of the Fe-Co based alloy so as to reduce casting defects or eliminate directional cast structures, upsetting by hot press is employed. Because the hot press can implement upsetting in which the cast ingot is heated at a high and constant temperature while being compressed at a high pressure, so that hot working can be performed with a high
10 upsetting rate greater than or equal to 30% without causing breakage or crack of a material having poor hot workability. Moreover, the reason of employing upsetting by hot press lies in that, the cast ingot has a processing strain while being dynamically recrystallized by performing heating and upsetting at the same time, so as to effectively eliminate the directional cast structures.

15 **[0022]** Furthermore, in the upsetting by hot press, the cast ingot before the hot press is made into a cylindrical shape having a diameter/height ratio of 0.5-2. The reason lies in that, if the diameter/height ratio of the cast ingot before the upsetting by hot press is less than 0.5, the possibility of buckling increases during the upsetting by hot press; if the diameter/height ratio is over 2, the friction between the cast ingot and a punch
20 forming a pressure mold causes an excessively large compression load at which the upsetting is performed in the hot press, which is unpractical.

[0023] In the hot press, the upsetting is performed with an upsetting rate of 30%-70%. When the upsetting rate is less than 30%, cast structures of the target material cannot be

sufficiently eliminated. Moreover, when the upsetting is required to be performed with an upsetting rate over 70%, the friction between the cast ingot and a punch forming a pressure mold causes an excessively large compression load at which the upsetting is performed in the hot press, which is impractical.

5 **[0024]** In addition, the temperature in the upsetting by hot press is set to be in the range of 900°C-1250°C. If the temperature is lower than 900°C, a deformation resistance of the cast ingot is large, and it is difficult for upsetting of the cast ingot, and if the temperature is higher than 1250°C, the Fe-Co based alloy in the present invention may be in a liquid phase. Moreover, when a carbon based material such as graphite is
10 used in a die or punch of a pressure mold of the hot press, in order to inhibit the reaction between Fe and carbon (C), ideally, the upsetting is performed at a temperature less than or equal to 1150°C, or a high melting point metal foil such as Mo, Nb, and Ta is lined as an anti-diffusion foil to prevent direct contact between the die or punch and the cast ingot.

15 **[0025]** Besides, hot workability may be improved through spheroidization of the intermetallic compound having poor hot workability by performing heat treatment on the cast ingot. Thus, it is effective to perform heat treatment for 1 hour or more in the range of 1000°C-1250°C before the upsetting by hot press. Furthermore, since the crystal grain coarsening in the cast ingot is significant in the case of a heat treatment
20 over 30 hours, the time of the heat treatment is ideally no more than 30 hours.

[0026] Furthermore, since plastic working is more difficult especially for the composition containing the M1 element greater than or equal to 15 atom%, heat

treatment is ideally performed on the cast ingot having such composition before the upsetting by hot press.

[0027] Furthermore, ideally, the target material obtained from the upsetting by hot press is sliced perpendicular to an upsetting direction, because the target material after the hot press may have a thickness twice or more of the desired size of the target material due to the diameter/height relationship. Thus, the target material may be sliced to acquire multiple pieces of target materials, thereby improving the manufacturing yield greatly.

[0028] Furthermore, ideally, a diameter of the cast ingot before the upsetting by hot press is greater than or equal to 100 mm, and a diameter of the target material after the hot press upsetting is less than or equal to 200 mm. The reason lies in that, if the diameter of the cast ingot before the hot press is less than 100 mm, the diameter/height ratio will become small, which causes a large possibility of buckling in the upsetting; if the diameter of the material after the hot press is over 200 mm, the required compression load will become excessively large due to the diameter/height ratio.

[0029] Furthermore, a die or punch forming the pressure mold in the hot press ideally uses graphite or carbon composite, but a die or punch of ceramics, a refractory metal or alloy thereof, or a cemented carbide may also be used. When the cast ingot is inserted into the pressure mold, the coefficient of friction between the punch or die and the cast ingot may be reduced and meanwhile the possibility that carbon as a component of the punch or die diffuses towards the cast ingot may be prevented by coating powder such as boron nitride. Then, a foil of Mo, Nb, Ta, stainless steel, and other materials are inserted between upper and lower surfaces of the cast ingot and the punch, which is

also effective in preventing the carbon contained in the punch from diffusing towards the cast ingot. When the foil is inserted, coating powder such as boron nitride on the foil is also effective in reducing the coefficient of friction.

[0030] [Embodiment 1]

- 5 [0031] Vacuum melting and casting are performed on a molten alloy of an Fe-Co based alloy having an atomic ratio represented by $(\text{Fe}_{40}\text{-Co}_{60})_{90}\text{-(Ta}_{50}\text{-Zr}_{50})_8\text{-(Al}_{50}\text{-Cr}_{50})_2$ to obtain a cylindrical cast ingot shown in Table 1. The cast ingot is inserted into a pressure mold formed of a punch and a die (an inner diameter ϕ is 10 mm) made of graphite, and upsetting by hot press is performed under conditions shown in Table 1.
- 10 Furthermore, boron nitride is coated on the cast ingot when the upsetting by hot press is performed.

- [0032] In addition, a shape and a diameter/height ratio of a target material obtained by upsetting on each cast ingot through hot press are determined, as shown in Table 2. Furthermore, the upsetting rate shown in Table 2 is a value calculated by ((height of the
- 15 cast ingot - height of the target material)/height of the cast ingot $\times$ 100).

[0033] [Table 1]

Sample No.	Cast ingot		Hot press condition	Remarks
	Shape (mm)	Diameter/height ratio		
1	$\phi 7 \times 8.4$	0.83	Temperature: 1100°C Load: 2350 N Time: 3 h	Example of the present invention
2	$\phi 7 \times 5$	1.40	Temperature: 1100°C Load: 2350 N Time: 3 h	Example of the present invention
3	$\phi 7 \times 4$	1.75	Temperature: 1100°C Load: 2350 N Time: 3 h	Example of the present invention
4	$\phi 7 \times 3$	2.33	Temperature: 1100°C Load: 2350 N Time: 3 h	Comparative example
5	$\phi 7 \times 2$	3.50	Temperature: 1100°C Load: 2350 N Time: 3 h	Comparative example
6	$\phi 7 \times 1$	7.00	Temperature: 1100°C Load: 2350 N Time: 3 h	Comparative example

[0034] [Table 2]

Sample No.	Target material		Upsetting rate	Remarks
	Shape (mm)	Diameter/height ratio		
1	$\phi 10 \times 4.1$	2.44	51%	Example of the present invention
2	$\phi 10 \times 2.5$	4.08	50%	Example of the present invention
3	$\phi 10 \times 2.0$	5.10	50%	Example of the present invention
4	$\phi 8.2 \times 2.2$	3.75	27%	Comparative example
5	$\phi 7 \times 2$	3.50	0%	Comparative example
6	$\phi 7 \times 1$	7.00	0%	Comparative example

[0035] As can be known from Tables 1 and 2, sufficient plastic working can be realized for Samples 1-3 in the examples of the present invention through upsetting by hot press at a load of 2350 N that can be applied in view of the strength of the die made of graphite of the pressure mold. Moreover, according to observation on test pieces
5 collected from materials of Samples 1, 2, and 3, casting defects are reduced and directional cast structures eliminated.

[0036] On the other hand, as shown by Samples 4-6, sufficient upsetting cannot be performed for the cylindrical cast ingot having a diameter/height ratio over 2 through hot press, and according to observation on test pieces collected from sources materials
10 of Samples 4, 5, and 6, cast structures are not eliminated.

[0037] [Embodiment 2]

[0038] Vacuum melting and casting are performed on a molten alloy of an Fe-Co based alloy having an atomic ratio represented by $(\text{Fe}_{65}\text{-Co}_{35})_{88}\text{-Ta}_{12}$ to obtain a cylindrical cast ingot shown in Table 3. The cast ingot is inserted into a pressure mold
15 formed of a punch and a die (an inner diameter ϕ is 10 mm) made of graphite, and upsetting by hot press is performed under conditions shown in Table 3. Furthermore, boron nitride is coated on the cast ingot when the upsetting by hot press is performed.

[0039] Moreover, a shape and a diameter/height ratio of a target material obtained by upsetting on each cast ingot through hot press are determined, as shown in Table 4.

20 Furthermore, the upsetting rate shown in Table 4 is a value calculated by $((\text{height of the cast ingot} - \text{height of the target material}) / \text{height of the cast ingot} \times 100)$.

[0040] [Table 3]

Sample No.	Cast ingot		Hot press condition	Remarks
	Shape (mm)	Diameter/height ratio		
7	$\phi 7 \times 8.4$	0.83	Temperature: 1100°C Load: 2350 N Time: 3 h	Example of the present invention

[0041] [Table 4]

Sample No.	Target material		Upsetting rate	Remarks
	Shape (mm)	Diameter/height ratio		
7	$\phi 9.8 \times 4.3$	2.28	49%	Example of the present invention

[0042] As can be known from Tables 3 and 4, sufficient plastic working can be realized for Sample 7 in the example of the present invention through upsetting by hot press at a load of 2350 N that can be applied in view of the strength of the die made of graphite of the pressure mold. Moreover, according to observation on test pieces collected from the material of Sample 7, casting defects are reduced and directional cast structures are eliminated.

[0043] [Embodiment 3]

[0044] Vacuum melting and casting are performed on a molten alloy of an Fe-Co based alloy having an atomic ratio represented by $(\text{Fe}_{40}\text{-Co}_{60})_{90}\text{-(Ta}_{50}\text{-Zr}_{50})_8\text{-(Al}_{50}\text{-Cr}_{50})_2$ to obtain a cylindrical cast ingot shown in Table 5. The cast ingot is inserted into a pressure mold formed of a punch and a die (an inner diameter ϕ is 190 mm) made of graphite, and upsetting by hot press is performed under conditions shown in Table 5. Furthermore, when the upsetting by hot press is performed, a stainless steel foil is inserted between the cast ingot and the punch made of graphite, and boron nitride is

coated on the cast ingot.

[0045] Moreover, a shape and a diameter/height ratio of a target material obtained by upsetting on each cast ingot through hot press are determined, as shown in Table 6.

[0046] Furthermore, the upsetting rate shown in Table 6 is a value calculated by
 5 $((\text{height of the cast ingot} - \text{height of the target material}) / \text{height of the cast ingot} \times 100)$.

[0047] The target material of Sample 8 obtained through hot press is sliced and machined to manufacture multiple pieces of sputtering target materials with a diameter of 180 mm and a thickness of 8 mm, as shown in FIG. 1.

[0048] [Table 5]

Sample No.	Cast ingot		Hot press condition	Remarks
	Shape (mm)	Diameter/height ratio		
8	φ120×200	0.60	Temperature: 1100°C Load: 843400 N Time: 3 h	Example of the present invention
9	φ165×7	23.57	Temperature: 1100°C Load: 843400 N Time: 3 h	Comparative example

10

[0049] [Table 6]

Sample No.	Target material		Upsetting rate	Remarks
	Shape (mm)	Diameter/height ratio		
8	φ190×80	2.38	60%	Example of the present invention
9	φ165×7	23.57	0%	Comparative example

[0050] As can be known from Tables 5 and 6, sufficient plastic working can be realized for Sample 8 in the example of the present invention through upsetting by hot

press at a load of 843400 N that can be applied in view of the strength of the die made of graphite of the pressure mold. Moreover, according to observation on test pieces collected from the target material of Sample 8, casting defects are reduced and directional cast structures are eliminated.

5 [0051] In another aspect, as shown by Sample 9, sufficient upsetting cannot be realized for the cylindrical cast ingot having a diameter/height ratio over 2 through hot press. As a result, if the upsetting rate is 0%, the material cannot be compressed.

[0052] [Embodiment 4]

[0053] Vacuum melting and casting are performed on a molten alloy of an Fe-Co
10 based alloy system having an atomic ratio represented by $(\text{Fe}_{62.5}\text{-Co}_{37.5})_{80}\text{-B}_{12}\text{-Cr}_8$ to obtain a cylindrical cast ingot shown in Table 7. The cast ingot is inserted into a pressure mold in the same manner as that in Embodiment 3, and upsetting is performed through hot press under conditions shown in Table 7. Determination results of a shape and a diameter/height ratio of a target material obtained by upsetting on the cast ingot of
15 Sample 10 through hot press are shown in Table 8.

[0054] Moreover, the target material of Sample 10 obtained through hot press is sliced and machined to manufacture multiple pieces of sputtering target material with a diameter of 180 mm and a thickness of 8 mm, as shown in FIG. 1.

[0055] [Table 7]

Sample No.	Cast ingot		Hot press condition	Remarks
	Shape (mm)	Diameter/height ratio		
10	$\phi 125 \times 180$	0.69	Temperature: 1050°C Load: 843400 N Time: 5 h	Example of the present invention

[0056] [Table 8]

Sample No.	Target material		Upsetting rate	Remarks
	Shape (mm)	Diameter/height ratio		
10	$\phi 190 \times 78$	2.44	57%	Example of the present invention

[0057] As can be known from Tables 7 and 8, sufficient plastic working can be realized for Sample 10 in the example of the present invention through upsetting by hot press at a load of 843400 N that can be applied in view of the strength of the die made of graphite of the pressure mold. Moreover, according to observation on test pieces collected from the target material of Sample 10, casting defects are reduced and directional cast structures are eliminated.

[0058] [Embodiment 5]

[0059] Vacuum melting and casting are performed on a molten alloy of each Fe-Co based alloy system shown in Table 9 to obtain a cylindrical cast ingot of $\phi 7 \text{ mm} \times 8.4 \text{ mm}$ (diameter/height ratio=0.83). The cast ingot is inserted into a pressure mold formed of a punch and a die (an inner diameter ϕ is 10 mm) made of graphite, and upsetting by hot press is performed under conditions shown in Table 9. Furthermore, boron nitride is coated on the cast ingot when the upsetting by hot press is performed.

[0060] Moreover, a shape and a diameter/height ratio of a target material obtained by upsetting on each cast ingot through hot press are determined, as shown in Table 10. Furthermore, the upsetting rate shown in Table 10 is a value calculated by ((height of the cast ingot - height of the target material)/height of the cast ingot $\times 100$).

[0061] [Table 9]

Sample No.	Cast ingot composition (at%)	Hot press condition	Remarks
11	$(\text{Fe}_{30}\text{-Co}_{70})_{90}\text{-(Ta}_{50}\text{-Zr}_{50})_8\text{-Ti}_2$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
12	$(\text{Fe}_{30}\text{-Co}_{70})_{90}\text{-(Ta}_{50}\text{-Zr}_{50})_8\text{-Si}_2$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
13	$(\text{Fe}_{30}\text{-Co}_{70})_{90}\text{-(Ta}_{50}\text{-Zr}_{50})_8\text{-V}_2$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
14	$(\text{Fe}_{30}\text{-Co}_{70})_{90}\text{-(Ta}_{50}\text{-Zr}_{50})_8\text{-Al}_2$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
15	$(\text{Fe}_{30}\text{-Co}_{70})_{90}\text{-(Ta}_{50}\text{-Zr}_{50})_8\text{-Cr}_2$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
16	$(\text{Fe}_{30}\text{-Co}_{70})_{90}\text{-(Ta}_{50}\text{-Zr}_{50})_8\text{-W}_2$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
17	$(\text{Fe}_{25}\text{-Co}_{75})_{88}\text{-(Ta}_{33}\text{-B}_{66})_{12}$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
18	$((\text{Fe}_{50}\text{-Co}_{50})_{95}\text{-Ni}_5)_{86}\text{-Ta}_{14}$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
19	$((\text{Fe}_{50}\text{-Co}_{50})_{95}\text{-Ni}_5)_{92}\text{-(Ta}_{40}\text{-Zr}_{60})_8$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
20	$((\text{Fe}_{50}\text{-Co}_{50})_{95}\text{-Ni}_5)_{90}\text{-(Ta}_{50}\text{-Zr}_{50})_{10}$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
21	$((\text{Fe}_{50}\text{-Co}_{50})_{95}\text{-Ni}_5)_{88}\text{-(Nb}_{70}\text{-Zr}_{30})_{12}$	Temperature: 1100°C	Example of the present invention

		Load: 2350 N Time: 2 h	
22	$((\text{Fe}_{10}\text{-Co}_{90})_{90}\text{-Ni}_{10})_{90}\text{-(Nb}_{50}\text{-Zr}_{50})_{10}$	Temperature: 1100°C Load: 2350 N Time: 2 h	Example of the present invention
23	$((\text{Fe}_{10}\text{-Co}_{90})_{90}\text{-Ni}_{10})_{90}\text{-(Nb}_{50}\text{-Zr}_{50})_{10}$	Temperature: 850°C Load: 2350 N Time: 2 h	Comparative example

[0062] [Table 10]

Sample No.	Target material		Upsetting rate	Remarks
	Shape (mm)	Diameter/height ratio		
11	φ10×4.1	2.44	51%	Example of the present invention
12	φ10×4.1	2.44	51%	Example of the present invention
13	φ10×4.1	2.44	51%	Example of the present invention
14	φ10×4.1	2.44	51%	Example of the present invention
15	φ10×4.1	2.44	51%	Example of the present invention
16	φ9.9×4.2	2.36	50%	Example of the present invention
17	φ9.9×4.2	2.36	50%	Example of the present invention
18	φ10×4.1	2.44	51%	Example of the present invention
19	φ10×4.1	2.44	51%	Example of the present invention
20	φ9.9×4.2	2.36	50%	Example of the present invention
21	φ10×4.1	2.44	51%	Example of the present invention
22	φ10×4.1	2.44	51%	Example of the present invention
23	φ7×8.4	0.83	0%	Comparative example

[0063] As can be known from Tables 9 and 10, sufficient plastic working can be realized for Samples 11-22 in the examples of the present invention through upsetting by hot press at a load of 2350 N that can be applied in view of the strength of the die made of graphite of the pressure mold in the range of 900-1250°C.

5 [0064] In another aspect, as shown by Sample 23, sufficient upsetting cannot be performed because the temperature in the upsetting by hot press is 850°C. As a result, if the upsetting rate is 0%, the material cannot be compressed.

[0065] [Embodiment 6]

[0066] Vacuum melting is performed on a molten alloy of an Fe-Co based alloy
10 system having an atomic ratio represented by $(\text{Fe}_{65}\text{-Co}_{35})_{85}\text{-(Ta}_{70}\text{-Zr}_{30})_{15}$, and after a heat treatment shown in Table 11, a cylindrical cast ingot of $\phi 7 \text{ mm} \times 8.4 \text{ mm}$ (diameter/height ratio=0.83) is obtained. The cast ingot is inserted into a pressure mold formed of a punch and a die (an inner diameter ϕ is 10 mm) made of graphite shown in Table 11, and upsetting by hot press is performed under conditions shown in
15 Table 11. Furthermore, boron nitride is coated on the cast ingot when the upsetting by hot press is performed.

[0067] Moreover, a shape and a diameter/height ratio of a target material obtained by upsetting on the cast ingot through hot press are determined, as shown in Table 12. Furthermore, the upsetting rate shown in Table 12 is a value calculated by ((height of the
20 cast ingot - height of the target material)/height of the cast ingot $\times 100$).

[0068] [Table 11]

Sample No.	Target material		Heat treatment condition	Hot press condition	Remarks
	Shape (mm)	Diameter/height ratio			
24	$\phi 7 \times 8.4$	0.83	1200 °C $\times 20$ h	Temperature: 1100°C Load: 2350 N Time: 3 h	Example of the present invention

[0069] [Table 12]

Sample No.	Target material		Upsetting rate	Remarks
	Shape (mm)	Diameter/height ratio		
24	$\phi 9.9 \times 4.2$	2.36	50%	Example of the present invention

[0070] As can be known from Tables 11 and 12, the example of the present invention can still realize sufficient plastic working in the hot press upsetting by performing the heat treatment at appropriate temperature and for appropriate time before the upsetting even in the composition in which upsetting is difficult for the Fe-Co based alloy composition containing a large amount of M1 element (of 15 atom%).

[0071] [Embodiment 7]

[0072] Vacuum melting and casting are performed on a molten alloy of an Fe-Co based alloy having an atomic ratio represented by $((\text{Fe}_{30}\text{-Co}_{70})_{90}\text{-Ni}_{10})_{90}\text{-(Nb}_{50}\text{-Zr}_{50})_{10}$ to obtain a cylindrical cast ingot shown in Table 13. The cast ingot is inserted into a pressure mold formed of a punch and a die (an inner diameter ϕ is 190 mm) made of graphite, and upsetting by hot press is performed under conditions shown in Table 13. Furthermore, when the upsetting by hot press is performed, a molybdenum foil is inserted between the cast ingot and the punch made of graphite, and boron nitride is coated on the cast ingot.

[0073] Moreover, a shape and a diameter/height ratio of a target material obtained by upsetting on each cast ingot through hot press are determined, as shown in Table 14.

[0074] Furthermore, the upsetting rate shown in Table 14 is a value calculated by $((\text{height of the cast ingot} - \text{height of the target material}) / \text{height of the cast ingot} \times 100)$.

5 [0075] The target material of Sample 25 obtained through hot press is sliced and machined to manufacture multiple pieces of sputtering target material with a diameter of 180 mm and a thickness of 8 mm shown in FIG. 1.

[0076] [Table 13]

Sample No.	Cast ingot		Hot press condition	Remarks
	Shape (mm)	Diameter/height ratio		
25	$\phi 125 \times 180$	0.69	Temperature: 1100°C Load: 843400 N Time: 3 h	Example of the present invention

10 [0077] [Table 14]

Sample No.	Target material		Upsetting rate	Remarks
	Shape (mm)	Diameter/height ratio		
25	$\phi 190 \times 78$	2.44	57%	Example of the present invention

[0078] As can be known from Tables 13 and 14, sufficient plastic working can be realized for Sample 25 in the example of the present invention through upsetting by hot press at a load of 843400 N that can be applied in view of the strength of the die made of graphite of the pressure mold. Moreover, according to observation on test pieces
15 collected from the target material of Sample 25, casting defects are reduced and

directional cast structures are eliminated.

[0079] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.

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WHAT IS CLAIMED IS:

1. A manufacturing method of a sputtering target material, wherein the sputtering target material is an Fe-Co based alloy with an atomic ratio represented by a composition formula $((\text{Fe}_{100-X}\text{-Co}_X)_{100-Y}\text{-Ni}_Y)_{100-a}\text{-M1}_a$, where $5 \leq X \leq 95$, $0 \leq Y \leq 25$,
5 $5 \leq a \leq 20$, and the M1 element in the composition formula is one or two or more elements selected from B, Zr, Hf, Ta, Nb and Y, the manufacturing method comprising:
inserting a cylindrical cast ingot with a diameter/height ratio up to 0.5-2 into a pressure mold; and
upsetting by hot press with an upsetting rate of 30%-70% at a
10 temperature in a range of 900°C-1250°C, so as to obtain a target material.
2. The manufacturing method of a sputtering target material according to claim 1, wherein the sputtering target material is an Fe-Co based alloy further comprising one or two or more elements selected from Ti, V, Cr, Mo, W, Al and Si as an M2 element and with an atomic ratio represented by a composition formula
15 $((\text{Fe}_{100-X}\text{-Co}_X)_{100-Y}\text{-Ni}_Y)_{100-a-b}\text{-M1}_a\text{-M2}_b$, where $5 \leq X \leq 95$, $0 \leq Y \leq 25$, $5 \leq a \leq 20$, and $b \leq 15$.
3. The manufacturing method of a sputtering target material according to claim 1 or 2, wherein a diameter of the cast ingot is greater than or equal to 100 mm.
4. The manufacturing method of a sputtering target material according to
20 any one of claims 1 to 3, wherein a diameter of the target material is less than or equal to 200 mm.