

IRON-COBALT-TANTALUM-ZIRCONIUM ALLOY SPUTTERING TARGET AND METHOD FOR MANUFACTURING THE SAME

1. Field of the Invention

5 The present invention relates to an iron-cobalt-tantalum-zirconium (Fe-Co-Ta-Zr) alloy sputtering target, and more particularly to a Fe-Co-Ta-Zr alloy sputtering target for forming a soft magnetic layer of magnetic recording media. In addition, the present invention also relates to a method for manufacturing the Fe-Co-Ta-Zr alloy sputtering target.

10 2. Description of the Prior Arts

 With the improvement of science and technology, the magnetic recording media with high recording density become a necessity when large amount of information and important files are backed up and stored automatically by systems. Conventionally longitudinal magnetic recording (LMR) media are mainly adopted.

15 However, LMR media have encountered a recording limit. Subsequently, perpendicular magnetic recording (PMR) media with another laminated structure have been developed.

 PMR media comprise a substrate, an adhesive layer, a soft magnetic layer, a seed layer, an intermediate layer, a recording layer, a cover layer and a lubricant layer.

20 Introducing the soft magnetic layer into PMR media enhances the writing efficiency and reduces the intensity of demagnetizing field, and thereby the thermal stability of the recording layer is improved. For providing improved characteristics of the soft magnetic layer, a soft magnetic layer consisting of amorphous soft magnetic alloy with a coercive force less than 20 Oe is typically used. For example, common amorphous

25 soft magnetic alloys include iron-cobalt-boron (Fe-Co-B) based alloys,

cobalt-zirconium-niobium (Co-Zr-Nb) based alloys or cobalt-iron-zirconium (Co-Fe-Zr) based alloys, etc. Among them, Co-Fe-Ta based alloys are especially valued in the magnetic recording field.

Magnetron sputtering technique is a physical vapor deposition, which allows 5 electrons to travel in a spiral movement around a line of magnetic force under a magnetic field. The collision rate between electrons and gaseous molecules is thus increased, thereby enhancing the ionization density of molecules and improving the sputtering yield. Furthermore, magnetron sputtering technique can be conducted under a lower pressure to ensure the quality of magnetic film. Electrons are strayed from the 10 substrate, such that a substrate with a lower temperature is provided. Therefore, magnetron sputtering technique is favorable to deposit a magnetic film on a substrate that cannot endure high temperature, and becomes a popular method for depositing a magnetic film with excellent performance.

However, a sputtering target comprising amorphous soft magnetic alloys 15 induces magnetic shielding effect under a magnetic field. The magnetic forces from magnets under the sputtering target are blocked and cannot pass through the sputtering target, and fail to undergo a normal sputtering process. Besides, focused magnetic forces will erode and form a recess in the surface of the sputtering target, and lower the utility of the sputtering target. The abovementioned effects are influenced by the 20 PTF of the sputtering target, and thus increasing the PTF is one solution to overcome these problems.

As used herein, “pass through flux (PTF)” indicates a ratio of transmitted magnetic field to applied magnetic field. A measurement technique of PTF can be referred to ASTM Standard F1761 “standard test method for pass through flux of 25 circular magnetic sputtering targets”. An inverse correlation typically exists between

PTF and maximum permeability, that is, a PTF of 100% indicates a non-magnetic material.

Conventional processes for manufacturing magnetic sputtering targets comprise powder metallurgy process and melting and casting process. The powder metallurgy process is more complicated and hardly controls the uniformity among multiple different components. Although the melting and casting process has overcome the abovementioned problems and limitations about size and shape, an iron-cobalt-tantalum-zirconium (Co-Fe-Ta-Zr) based alloy sputtering target with specific composition, for example, Fe-30Co-8Ta-5Zr alloy sputtering target, having a required PTF, cannot be produced by the melting and casting process, and the sputtering performance and sputtering utility of the Co-Fe-Ta-Zr based alloy sputtering target are deteriorated.

JP publication No. 2010-059540A discloses a method for manufacturing an iron-cobalt based alloy sputtering target. A mixture composed of Co-containing alloy powder and Fe-containing alloy powder is used as a raw material and then sintered to obtain the sputtering target. However, as both alloy powders have respective specific gravity and mobility, it is difficult to mix two kinds of alloy powders well. Therefore, the produced Fe-Co based alloy sputtering target has several shortcomings such as complicated process and non-uniform compositions.

In view of the shortcomings that the powder metallurgy process is more complicated and hardly controls the uniformity among multiple different components in the sputtering target and that the melting and casting process cannot make a sputtering target with a required PTF to undergo a sputtering process, the primary objective of the present invention is to provide an iron-cobalt-tantalum-zirconium

alloy sputtering target with high PTF and a uniform composition, which is manufactured by a simple powder metallurgy process. The iron-cobalt-tantalum-zirconium alloy sputtering target in accordance with the present invention can be applied for forming a soft magnetic layer of magnetic recording media.

To achieve the objective, the present invention provides a method for manufacturing an iron-cobalt-tantalum-zirconium alloy sputtering target, comprising the steps of: (a) providing a raw material containing iron (Fe), cobalt (Co), tantalum (Ta) and zirconium (Zr); (b) melting and casting the raw material containing Fe, Co, Ta and Zr to form a Fe-Co-Ta-Zr alloy; (c) making a pre-alloyed Fe-Co-Ta-Zr powder from the Fe-Co-Ta-Zr pre-alloy by atomization; (d) compacting the pre-alloyed Fe-Co-Ta-Zr powder to obtain a green compact; and (e) solidifying the green compact at a temperature ranging from 800°C to 950°C to obtain the iron-cobalt-tantalum-zirconium alloy sputtering target.

In accordance with the method of the present invention, the raw material containing Fe, Co, Ta and Zr may be composed of four pure metals of iron, cobalt, tantalum, and zirconium. Or, the raw material containing Fe, Co, Ta and Zr may be any combinations of pre-alloys composed of at least two aforementioned metals, for example, but not limited to a combination of Co-Fe pre-alloy and Ta-Zr pre-alloy, a combination of Fe-Ta pre-alloy and Co-Zr pre-alloy, a combination of pre-Fe-Zr alloy and Co-Ta pre-alloy.

Preferably, the raw material containing Fe, Co, Ta and Zr can be made into the Fe-Co-Ta-Zr pre-alloy by melting and casting process, such that the Fe-Co-Ta-Zr pre-alloy is provided to make the iron-cobalt-tantalum-zirconium alloy sputtering

target by powder metallurgy process.

Preferably, the atomization process is selected from a group consisting of gas atomization, vacuum atomization, water atomization, centrifugal atomization, plasma spraying, and sputtering.

5 In accordance with the method of the present invention, the iron-cobalt-tantalum-zirconium alloy sputtering target is essentially consisted of only one pre-alloyed Fe-Co-Ta-Zr powder, such that the iron-cobalt-tantalum-zirconium alloy sputtering target in accordance with the present invention has a more uniform composition.

10 In accordance with the method of the present invention, the pre-alloyed Fe-Co-Ta-Zr powder has a base phase containing iron-cobalt alloy. Soft magnetic metals such as iron and cobalt can be easily flipped over a direction with an external magnetic field, and thereby the iron-cobalt-tantalum-zirconium alloy sputtering target in accordance with the present invention has high PTF and provides an improved
15 sputtering performance and sputtering utility.

Preferably, the green compact is solidified under a pressure ranging from 300 bars to 650 bars in the step (e), in order to obtain the iron-cobalt-tantalum-zirconium alloy sputtering target with high PTF in accordance with the present invention.

Preferably, the green compact is solidified by hot pressing method, canning
20 method, hot isostatic pressing method or sintering method in the step (e) to obtain the iron-cobalt-tantalum-zirconium alloy sputtering target in accordance with the present invention.

Preferably, the iron-cobalt-tantalum-zirconium alloy sputtering target in accordance with the present invention has an individual content of iron not less than 5

atomic percentage (at%), an individual content of cobalt not less than 5at%, and a total content of iron and cobalt ranging from 75at% to 87at% relative to the total content of the iron-cobalt-tantalum-zirconium alloy sputtering target.

To achieve the objective, the present invention also provides an
5 iron-cobalt-tantalum-zirconium alloy sputtering target, which is essentially consisted of the pre-alloyed Fe-Co-Ta-Zr powder. The pre-alloyed Fe-Co-Ta-Zr powder has a base phase containing iron-cobalt alloy, and the iron-cobalt-tantalum-zirconium alloy sputtering target has an individual content of iron not less than 5 atomic percentage (at%), an individual content of cobalt not less than 5at%, and a total content of iron and
10 cobalt ranging from 75at% to 87at% relative to the total content of the iron-cobalt-tantalum-zirconium alloy sputtering target.

Preferably, the iron-cobalt-tantalum-zirconium alloy sputtering target in accordance with the present invention is manufactured by the aforementioned method.

Preferably, the iron-cobalt-tantalum-zirconium alloy sputtering target in
15 accordance with the present invention has a total content of tantalum and zirconium relative to the total content of the iron-cobalt-tantalum-zirconium alloy sputtering target ranging from 13at% to 25at%.

Preferably, the iron-cobalt-tantalum-zirconium alloy sputtering target in accordance with the present invention may further comprise at least one additive metal
20 selected from a group consisting of boron (B), aluminum (Al) and chromium (Cr).

Preferably, the at least one additive metal dissolves with iron, cobalt, tantalum and zirconium alloy.

Preferably, a total content of tantalum, zirconium and at least one additive metal relative to the total content of the iron-cobalt-tantalum-zirconium alloy

sputtering target may range from 5at% to 20at%. When the at least one additive metal is comprised in the iron-cobalt-tantalum-zirconium alloy sputtering target, the total content of tantalum and zirconium relative to the total content of the iron-cobalt-tantalum-zirconium alloy sputtering target is preferably not less than 8at%,
5 and more preferably ranges from 8at% to 20at%, and the total content of the additive metal relative to the total content of the iron-cobalt-tantalum-zirconium alloy sputtering target preferably ranges from 5at% to 17at%.

Preferably, the iron-cobalt-tantalum-zirconium alloy sputtering target with a thickness not more than 12 mm has a PTF not less than 20%. More preferably, the
10 iron-cobalt-tantalum-zirconium alloy sputtering target with a thickness not more than 12 mm has a PTF ranging from 20% to 25%, and further more preferably ranging from 30% to 35%.

In conclusion, by using the pre-alloyed Fe-Co-Ta-Zr powder having preferable contents of those soft magnetic components as a raw material for manufacturing a
15 sputtering target, the process for manufacturing an iron-cobalt-tantalum-zirconium alloy sputtering target for forming a soft magnetic layer can be simplified by the method in accordance with the present invention.

Furthermore, an iron-cobalt-tantalum-zirconium alloy sputtering target with a more uniform composition and essentially consisted of the pre-alloyed Fe-Co-Ta-Zr
20 powder is made by powder metallurgy process. Because the iron-cobalt-tantalum-zirconium alloy sputtering target has a base phase containing iron-cobalt alloy, the iron-cobalt-tantalum-zirconium alloy sputtering target can have high PTF and provides an improved sputtering performance and sputtering utility.

Other objectives, advantages and novel features of the invention will become

more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

IN THE DRAWINGS:

Fig. 1 is a block diagram of a method for manufacturing an
5 iron-cobalt-tantalum-zirconium alloy sputtering target in accordance with the present invention;

Figs. 2 and 3 are metallographic images of an iron-cobalt-tantalum-zirconium alloy sputtering target of Example 1 in accordance with the present invention;

Figs. 4 and 5 are metallographic images of an iron-cobalt-tantalum-zirconium
10 alloy sputtering target of Example 2 in accordance with the present invention;

Fig. 6 is a metallographic image of an iron-cobalt-tantalum-zirconium alloy sputtering target of Comparative Example 1 in accordance with the prior art;

Fig. 7 is a metallographic image of an iron-cobalt-tantalum-zirconium alloy sputtering target of Comparative Example 2 in accordance with the prior art;

15 Figs. 8 and 9 are metallographic images of an iron-cobalt-tantalum-zirconium alloy sputtering target of Comparative Example 3.

Hereinafter, one skilled in the arts can easily realize the advantages and effects of an iron-cobalt-tantalum-zirconium alloy sputtering target and a method for manufacturing the same in accordance with the present invention from the following
20 examples. Therefore, it should be understood that the descriptions proposed herein are just preferable examples only for the purpose of illustrations, not intended to limit the scope of the invention. Various modifications and variations could be made in order to practice or apply the present invention without departing from the spirit and scope of the invention.

Example 1

In the present example, the method for manufacturing the iron-cobalt-tantalum-zirconium alloy sputtering target was implemented as described in detail incorporating the block diagram as shown in Fig. 1.

5 18609 grams of cobalt metal, 15675 grams of iron metal, 12697 grams of tantalum metal and 3200 grams of zirconium metal were provided as a raw material. The four pure metals were melted and cast to form a Fe-Co-Ta-Zr pre-alloy.

Then, 50 kilograms of Fe-Co-Ta-Zr pre-alloy was atomized at an atomization temperature about 1650°C with a gas atomization equipment to obtain a pre-alloyed
10 Fe-Co-Ta-Zr powder. Herein, the obtained pre-alloyed Fe-Co-Ta-Zr powder has particle sizes ranging from 55 μm to 250 μm.

After that, 680 grams of the pre-alloyed Fe-Co-Ta-Zr powder was mixed well by roll-mixing machine for 20 minutes. The well-mixed pre-alloyed Fe-Co-Ta-Zr powder was filled into a graphite mold with even distribution, and then compacted
15 under a hydraulic press of 500 psi to obtain a green compact.

Finally, the graphite mold with the green compact was put into a hot-pressing furnace, and the green compact was sintered and solidified at 850°C under 500 bars for 60 minutes to obtain a 40Fe-45Co-10Ta-5Zr alloy sputtering target with a diameter about 96 mm and a thickness about 8 mm.

20 The PTF of the iron-cobalt-tantalum-zirconium alloy sputtering target was tested by ASTM Standard F1761 method. The result shows that the 40Fe-45Co-10Ta-5Zr alloy sputtering target with a thickness about 8 mm has a PTF up to 35%.

In addition, the metallographic microstructure of the

iron-cobalt-tantalum-zirconium alloy sputtering target was observed by scanning electron microscopy (Hitachi N-3400 SEM). With reference to Figs. 2 and 3, the black phase represents the continuous base phase of the iron-cobalt-tantalum-zirconium alloy sputtering target.

5 The components comprised in the black and white phases of the iron-cobalt-tantalum-zirconium alloy sputtering target were analyzed by energy dispersive spectrometer (HORIBA 7021-H EDS). As shown by Table 1, the iron-cobalt-tantalum-zirconium alloy sputtering target was essentially consisted of the pre-alloyed Fe-Co-Ta-Zr powder, and the black phase mainly contains iron-cobalt
10 alloy.

Table 1: components and contents in black phase and white phase of the iron-cobalt-tantalum-zirconium alloy sputtering target of Example 1 in accordance with the present invention

	Fe	Co	Ta	Zr
Black Phase	54.1 at%	44.4 at%	0.8 at%	0.7 at%
White Phase	31.0 at%	42.7 at%	19.9 at%	6.4 at%

Based on the results from scanning electron microscopy and electron
15 dispersive spectroscopy, the iron-cobalt-tantalum-zirconium alloy sputtering target of Example 1 was essentially consisted of the pre-alloyed Fe-Co-Ta-Zr powder, and the pre-alloyed Fe-Co-Ta-Zr powder has a base phase containing iron-cobalt alloy.

Example 2

In the present example, the method for manufacturing the
20 iron-cobalt-tantalum-zirconium alloy sputtering target was also implemented as described in detail incorporating the block diagram as shown in Fig. 1. A similar process was performed as Example 1. The difference between Examples 1 and 2 was

the sintering temperature for forming the sputtering target. Therefore, a simplified process of manufacturing the iron-cobalt-tantalum-zirconium alloy sputtering target was described below.

An identical green compact with Example 1 was obtained. The graphite mold
5 with the green compact of the present example was sintered and solidified at 950°C under 500 bars for 60 minutes to obtain a 40Fe-45Co-10Ta-5Zr alloy sputtering target with a diameter about 96 mm and a thickness about 8 mm.

According to the result tested by ASTM Standard F1761 method, the
40Fe-45Co-10Ta-5Zr alloy sputtering target manufactured by the method in
10 accordance with the present invention has a thickness about 8 mm and a PTF up to 30%. With reference to Figs. 4 and 5, the black phase represents the base phase of the iron-cobalt-tantalum-zirconium alloy sputtering target. The components comprised in the black and white phases of the iron-cobalt-tantalum-zirconium alloy sputtering target were analyzed by energy dispersive spectrometer (HORIBA 7021-H EDS). As
15 shown by Table 2, the iron-cobalt-tantalum-zirconium alloy sputtering target was essentially consisted of the pre-alloyed Fe-Co-Ta-Zr powder, and the black phase mainly contains iron-cobalt alloy.

Table 2: Components and contents in black phase and white phase of the
iron-cobalt-tantalum-zirconium alloy sputtering target of Example 2 in accordance
20 with the present invention

	Fe	Co	Ta	Zr
Black Phase	56.4 at%	42.0 at%	1.1 at%	0.5 at%
White Phase	32.5 at%	46.9 at%	16.3 at%	4.3 at%

Based on the results from scanning electron microscopy and electron
dispersive spectroscopy, the iron-cobalt-tantalum-zirconium alloy sputtering target of

Example 2 was essentially consisted of the pre-alloyed Fe-Co-Ta-Zr powder, and the pre-alloyed Fe-Co-Ta-Zr powder has a base phase containing iron-cobalt alloy.

Comparative Example 1

18609 grams of cobalt metal, 15675 grams of iron metal, 12697 grams of tantalum metal, and 3200 grams of zirconium metal were provided as a raw material.

The four pure metals were melted and cast in a pot to form a cast ingot.

Then, the cast ingot was processed by hot isostatic pressing method to eliminate the shrinkage in the cast ingot. Finally, the cast ingot was formed into a 40Fe-45Co-10Ta-5Zr alloy sputtering target with a diameter of 96 mm and a thickness of 8 mm by wire-cutting and lathe process.

The PTF of the iron-cobalt-tantalum-zirconium alloy sputtering target was tested by ASTM Standard F1761 method. The result shows that the 40Fe-45Co-10Ta-5Zr alloy sputtering target with a thickness about 8 mm only has a PTF about 28%.

The metallographic microstructure of the iron-cobalt-tantalum-zirconium alloy sputtering target was observed by scanning electron microscopy (Hitachi N-3400 SEM). With reference to Fig. 6, the black phase represents the continuous base phase of the iron-cobalt-tantalum-zirconium alloy sputtering target of the comparative example 1.

The components comprised in the black and white phases of the iron-cobalt-tantalum-zirconium alloy sputtering target were analyzed by energy dispersive spectrometer. As shown by Table 3, the black phase of the iron-cobalt-tantalum-zirconium alloy sputtering target mainly contains iron-cobalt alloy.

Table 3: Components and contents in black phase and white phase of the iron-cobalt-tantalum-zirconium alloy sputtering target of Comparative Example 1

	Fe	Co	Ta	Zr
Black Phase	55.4 at%	43.5 at%	0.7 at%	0.4 at%
White Phase	29.8 at%	44.3 at%	21.3 at%	4.8 at%

With reference to Fig. 6, the distribution of metallographic microstructure of black phase in the iron-cobalt-tantalum-zirconium alloy sputtering target produced by the melting and casting process was different from that produced by the powder metallurgy process (Figs. 2 to 5). The distribution of the black phase affects the flip ability of the soft magnetic components. Thus, the PTF of the iron-cobalt-tantalum-zirconium alloy sputtering target in the comparative example was reduced due to the distribution of black phase. As a result, the iron-cobalt-tantalum-zirconium alloy sputtering target with a same thickness produced by melting and casting process had a lower PTF, and thus the sputtering performance and sputtering utility of the sputtering target could not be improved.

Comparative Example 2

34467 grams of cobalt metal, 12464 grams of tantalum metal, and 3141 grams of zirconium metal were melted and cast to form a Co-10Ta-5Zr pre-alloy. Besides, 33850 grams of iron metal, 12903 grams of tantalum metal, and 3252 grams of zirconium metal were also melted and cast to form a Fe-10Ta-5Zr pre-alloy.

Then, 5 kilograms of Co-10Ta-5Zr pre-alloy and 5 kilograms of Fe-10Ta-5Zr pre-alloy were atomized at 1650°C with a gas atomization equipment to obtain a pre-alloyed Co-Ta-Zr powder and a pre-alloyed Fe-Ta-Zr powder. Herein, the obtained pre-alloyed Co-Ta-Zr powder and pre-alloyed Fe-Ta-Zr powder have particle sizes ranging from 55 μm to 250 μm .

Then, 366 grams of pre-alloyed Co-Ta-Zr powder and 314 grams of pre-alloyed Fe-Ta-Zr powder were mixed well by roll-mixing machine for 20 minutes. The well-mixed pre-alloyed Co-Ta-Zr powder and pre-alloyed Fe-Ta-Zr powder were filled into a graphite mold with even distribution, and then compacted under a 5 hydraulic press of 500 psi to obtain a green compact.

Finally, the graphite mold with the green compact was put into a hot-pressing furnace, and the green compact was sintered and solidified at 1100°C under 500 bars for 90 minutes to obtain a Fe-Co-Ta-Zr alloy sputtering target with a diameter about 96 mm and a thickness about 8 mm.

10 The PTF of the iron-cobalt-tantalum-zirconium alloy sputtering target was tested by ASTM Standard F1761 method. The result shows that the Fe-Co-Ta-Zr alloy sputtering target with a thickness about 8 mm has a PTF about 33%.

With reference to Fig. 7 and Table 4, the Fe-Co-Ta-Zr alloy sputtering target had two metallographic phases composed of pre-alloyed Co-10Ta-5Zr powder and 15 pre-alloyed Fe-10Ta-5Zr powder.

Table 4: components and contents in black phase and white phase of the iron-cobalt-tantalum-zirconium alloy sputtering target of Comparative Example 2

	Fe	Co	Ta	Zr
Black Phase	3.9at%	77.7at%	12.4at%	6.0at%
White Phase	84.3at%	NA	9.7at%	6.0at%

According to the results as shown by Table 4 and electron dispersive spectroscopy, two pre-alloyed powders comprised in the 20 iron-cobalt-tantalum-zirconium alloy sputtering target were respectively diffused from each other and distributed in different metallographic phases, and produced lots of internal pores. Hence, the density of the iron-cobalt-tantalum-zirconium alloy

sputtering target was reduced.

Comparative Example 3

18609 grams of cobalt metal, 15675 grams of iron metal, 12697 grams of tantalum metal and 3200 grams of zirconium metal were melted and cast to form a 5 Fe-Co-Ta-Zr pre-alloy.

Then, 50 kilograms of Fe-Co-Ta-Zr pre-alloy was atomized at 1650°C with a gas atomization equipment to obtain a pre-alloyed Fe-Co-Ta-Zr powder having particle sizes ranging from 55 µm to 250 µm.

After that, 680 grams of pre-alloyed Fe-Co-Ta-Zr powder was mixed well by 10 roll-mixing machine for 20 minutes. The well-mixed pre-alloyed Fe-Co-Ta-Zr powder was filled into a graphite mold, and then compacted under a hydraulic press of 500 psi to obtain a green compact.

Finally, the graphite mold with the green compact was put into a hot-pressing furnace, and the green compact was sintered and solidified at 1100°C under 500 bars 15 for 90 minutes to obtain a 40Fe-45Co-10Ta-5Zr alloy sputtering target with a diameter about 96 mm and a thickness about 8 mm.

PTF of the iron-cobalt-tantalum-zirconium alloy sputtering target was tested by ASTM Standard F1761 method. The result showed that the 40Fe-45Co-10Ta-5Zr alloy sputtering target with a thickness about 8 mm has a PTF of only 15%.

20 In addition, the metallographic microstructure of the iron-cobalt-tantalum-zirconium alloy sputtering target was observed by scanning electron microscopy (Hitachi N-3400 SEM). With reference to Figs. 8 and 9, the white phase represents the continuous base phase of the iron-cobalt-tantalum-zirconium alloy sputtering target.

The components comprised in the black and white phases of the iron-cobalt-tantalum-zirconium alloy sputtering target were analyzed by energy dispersive spectrometer. As shown by Table 5, white phase of the iron-cobalt-tantalum-zirconium alloy sputtering target mainly contains 5 iron-cobalt-tantalum-zirconium alloy, not iron-cobalt alloy. This is the main reason why the 40Fe-45Co-10Ta-5Zr alloy sputtering target has a reduced PTF.

Table 5: components and contents in black phase and white phase of the iron-cobalt-tantalum-zirconium alloy sputtering target of Comparative Example 3

	Fe	Co	Ta	Zr
Black Phase	55.6 at%	43.9 at%	0.4 at%	0.1 at%
White Phase	28.4 at%	45.5 at%	18.0 at%	8.1 at%

According to results from Examples 1 and 2 and the Comparative Example 3, 10 the sintering temperature in solidification process preferably ranges from 800°C to 950 °C to obtain an iron-cobalt-tantalum-zirconium alloy sputtering target with high PTF.

Based on the results from Examples 1 and 2 and Comparative Examples 1 to 3, the metallographic microstructure and its components can be effectively controlled by using the pre-alloyed Fe-Co-Ta-Zr powder as a raw material and solidifying the green 15 compact at a temperature from 800°C to 950°C. A continuous base phase mainly containing iron-cobalt alloy is formed. In comparison with the methods from Comparative Examples 1 to 3, the method for manufacturing the iron-cobalt-tantalum-zirconium alloy sputtering target with specific composition in accordance with the present invention is simpler by powder metallurgy process with 20 one single pre-alloyed powder as raw material. Thus, an iron-cobalt-tantalum-zirconium alloy sputtering target with high PTF for forming soft magnetic layer is successfully obtained.

Even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and features of the invention, the disclosure is illustrative only. Changes may be made in the details, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

CLAIMS

1. A method for manufacturing an iron-cobalt-tantalum-zirconium alloy sputtering target, comprising the steps of:
 - 5 (a) providing a raw material containing iron (Fe), cobalt (Co), tantalum (Ta) and zirconium (Zr);
 - (b) melting and casting the raw material containing Fe, Co, Ta and Zr to form a Fe-Co-Ta-Zr pre-alloy;
 - (c) making a pre-alloyed Fe-Co-Ta-Zr powder from the Fe-Co-Ta-Zr pre-alloy
10 by atomization;
 - (d) compacting the pre-alloyed Fe-Co-Ta-Zr powder to obtain a green compact; and
 - (e) solidifying the green compact at a temperature ranging from 800°C to 950°C to obtain the iron-cobalt-tantalum-zirconium alloy sputtering target.
- 15 2. The method as claimed in claim 1, wherein the iron-cobalt-tantalum-zirconium alloy sputtering target is essentially consisted of the pre-alloyed Fe-Co-Ta-Zr powder, and the pre-alloyed Fe-Co-Ta-Zr powder has a base phase containing iron-cobalt alloy.
- 20 3. The method as claimed in claim 1, wherein the iron-cobalt-tantalum-zirconium alloy sputtering target has an individual content of iron not less than 5at%, an individual content of cobalt not less than 5at%, and a total content of iron and cobalt ranging from 75at% to 87at% relative to a total content of the iron-cobalt-tantalum-zirconium alloy sputtering target.

4. The method as claimed in claim 1, wherein the step (e) comprises solidifying the green compact by hot pressing method, canning method, hot isostatic pressing method or sintering method.

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5. The method as claimed in claim 1, wherein the step (e) comprises solidifying the green compact under a pressure ranging from 300 barss to 650 barss.

6. An iron-cobalt-tantalum-zirconium alloy sputtering target, which is essentially
10 consisted of a pre-alloyed Fe-Co-Ta-Zr powder, wherein the pre-alloyed Fe-Co-Ta-Zr powder has a base phase containing iron-cobalt alloy, and the iron-cobalt-tantalum-zirconium alloy sputtering target has an individual content of iron not less than 5at%, an individual content of cobalt not less than 5at%, and a total content of iron and cobalt ranging from 75at% to 87at% relative to a total content of
15 the iron-cobalt-tantalum-zirconium alloy sputtering target.

7. The iron-cobalt-tantalum-zirconium alloy sputtering target as claimed in claim 6, wherein the iron-cobalt-tantalum-zirconium alloy sputtering target has a total content of tantalum and zirconium ranging from 13at% to 25at% relative to the total
20 content of the iron-cobalt-tantalum-zirconium alloy sputtering target.

8. The iron-cobalt-tantalum-zirconium alloy sputtering target as claimed in claim 6, wherein the iron-cobalt-tantalum-zirconium alloy sputtering target further comprises at least one additive metal selected from a group consisting of boron, aluminum and

chromium.

9. The iron-cobalt-tantalum-zirconium alloy sputtering target as claimed in claim 8, wherein the iron-cobalt-tantalum-zirconium alloy sputtering target has a total
5 content of tantalum and zirconium not less than 8at% and a total content of the at least one additive metal ranging from 5at% to 17at% relative to the total content of the iron-cobalt-tantalum-zirconium alloy sputtering target.

10. The iron-cobalt-tantalum-zirconium alloy sputtering target as claimed in claim
10 6, which is manufactured by the method as claimed in any one of claims 1 to 5.

11. The iron-cobalt-tantalum-zirconium alloy sputtering target as claimed in any one of claims 6 to 9, wherein the iron-cobalt-tantalum-zirconium alloy sputtering target has a PTF not less than 20% and a thickness not more than 12 mm.

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12. The iron-cobalt-tantalum-zirconium alloy sputtering target as claimed in claim 10, wherein the iron-cobalt-tantalum-zirconium alloy sputtering target has a PTF not less than 20% and a thickness not more than 12 mm.