

Co-Fe-Nb-based Sputtering Target

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a Co-Fe-based sputtering target, more particularly to a Co-Fe-Nb-based sputtering target.

2. Description of the Prior Arts

With the increasing demand for the information storage capacity of the magnetic recording medium, how to improve the recording quality of magnetic recording media has been an active research topic. According to the magnetization direction of a magnetic head, the conventional magnetic recording media can be classified into horizontal magnetic recording media and vertical magnetic recording media. The vertical magnetic recording media include a substrate, an adhesion layer, a soft under layer, a seed layer, an intermediate layer, a magnetic recording layer, a cover layer, and a lubricating layer from bottom to top.

The conventional soft under layer is mainly composed of cobalt and iron, and doped with silicon, boron, and additive elements such as molybdenum, chromium, and niobium. Niobium component was incorporated to improve the corrosion resistance of the soft under layer, trying to improve the quality of the magnetic recording media.

In the preparation of a soft under layer material including cobalt, iron, and niobium, the raw materials such as cobalt, iron, and niobium were melted to form a Co-Fe-Nb-based sputtering target, and then sputtered by DC sputtering, RF sputtering, or magnetron sputtering to form a soft under layer

with good film quality as expected.

However, when the Co-Fe-Nb-based sputtering target includes niobium, such highly active element will be oxidized during the melting process and a large amount of niobium oxide inclusions will be precipitated, leading to the falling of particles, abnormal arcing, and splash during sputtering. Said problems not only deteriorate sputtering quality of the Co-Fe-Nb-based sputtering target, but also fail to guarantee the film quality of the soft magnetic layer sputtered by the Co-Fe-Nb-based sputtering target.

SUMMARY OF THE INVENTION

Based on the above, the objective of the present invention is to effectively suppress the precipitation of niobium oxides in the Co-Fe-Nb-based sputtering target and to reduce the amount of inclusions, and thereby solving the problems of particles falling, abnormal arcing, and splash in the sputtering process of Co-Fe-Nb-based sputtering target.

To achieve the aforementioned objective, the present invention provides a Co-Fe-Nb-based sputtering target, which includes cobalt (Co), iron (Fe), an active element, a first additive, and a second additive. The active element includes niobium (Nb). The first additive may include tungsten (W), molybdenum (Mo), vanadium (V), zirconium (Zr), titanium (Ti), yttrium (Y), manganese (Mn), aluminum (Al), copper (Cu), nickel (Ni), phosphorus (P), gallium (Ga), germanium (Ge), tin (Sn), or any combinations thereof. The second additive may include magnesium (Mg), carbon (C), boron (B), chromium (Cr), calcium (Ca), or any combinations thereof. Based on the total amount of cobalt, iron, the active element, and the first and second additives in

the Co-Fe-Nb-based sputtering target, the total amount of the active element is more than 0 at% and no more than 20 at%, the total amount of the active element and the first additive is more than 0 at% and no more than 25 at%, and the total amount of the second additive is more than 0 at% and no more than 0.5 at%. The Co-Fe-Nb sputtering target has niobium oxides, the ratio of niobium oxide particles to a surface of the Co-Fe-Nb-based sputtering target is less than 35 counts/mm².

By means of adding specific first and second additives to the Co-Fe-Nb-based sputtering target and controlling the total amount of the active element, the total amount of the active element and the first additive, and the total amount of the second additive in the Co-Fe-Nb-based sputtering target, the precipitation of niobium oxides can be effectively suppressed and the amount of inclusions can be reduced in the Co-Fe-Nb-based sputtering target, resulting in the ratio of niobium oxide particles to the surface of the Co-Fe-Nb-based sputtering target being less than 35 counts/mm². Accordingly, the technical means of the present invention is effective to avoid particles falling, abnormal arcing, and splash while sputtering the Co-Fe-Nb-based sputtering target.

In accordance with the present invention, the Co-Fe-Nb-based sputtering target may be prepared by vacuum induction melting (VIM) or powder sintering process, wherein VIM is preferred for reducing the oxygen content thereof. The Co-Fe-Nb-based sputtering target prepared by VIM generally has an oxygen content less than 100 ppm, which is lower than that prepared by powder sintering process, and thus is beneficial to overcome the

problem of abnormal arcing. In addition, controlling the total amount of the second additive at no more than 0.5 at% inhibits the generation of undesired compound phase, *e.g.*, boride or carbide, in the Co-Fe-Nb-based sputtering target, and thereby being beneficial to suppress the falling of the compound particles during sputtering the Co-Fe-Nb-based sputtering target.

Preferably, based on the total amount of cobalt, iron, the active element, the first additive, and the second additive in the Co-Fe-Nb-based sputtering target, the total amount of cobalt and iron is no less than 74.5 at% and no more than 85 at%, the total amount of the active element and the first additive is no less than 14.5 at% and no more than 25 at%, and the total amount of the second additive is no less than 0.01 at% and no more than 0.5 at%. More preferably, based on the total amount of cobalt, iron, the active element, the first additive, and the second additive in the Co-Fe-Nb-based sputtering target, the total amount of cobalt and iron is no less than 74.5 at% and less than 80 at%, the total amount of the active element and the first additive is no less than 19.5 at% and no more than 25 at%, and the total amount of the second additive is no less than 0.01 at% and no more than 0.5 at%.

In one embodiment, the active element is composed of niobium, the total amount of the active element, *i.e.*, the individual amount of niobium, is more than 0 at% and no more than 14 at%. In another embodiment, the active element may include both niobium and tantalum, the total amount of the active element, *i.e.*, the sum of the individual amount of niobium and the individual amount of tantalum, is more than 0 at% and no more than 20 at%; in this case, the individual amount of niobium is more than 0 at% and no more than 14 at%

and the individual amount of tantalum is more than 0 at% and no more than 19 at%.

In accordance with the present invention, the total amount of the active element is preferably no less than 1 at% and no more than 20 at%, and more
5 preferably no less than 8 at% and no more than 19 at%.

Preferably, the first additive is tungsten, molybdenum or any combinations thereof. In accordance with the present invention, the total amount of the first additive is preferably more than 0 at% and no more than 20 at%, more preferably no less than 4 at% and no more than 20 at%, and still
10 more preferably no less than 4 at% and no more than 15 at%.

In accordance with the present invention, the total amount of the active element and the first additive is preferably no less than 15 at% and no more than 24.95 at%, and more preferably no less than 18 at% and no more than 24.95 at%.

15 In accordance with the present invention, the total amount of the second additive is preferably no less than 0.01 at% and no more than 0.5 at%, more preferably no less than 0.1 at% and no more than 0.5 at%, still more preferably no less than 0.15 at% and no more than 0.4 at%, and still further more preferably no less than 0.3 at% and no more than 0.4 at%.

20 Preferably, the second additive may be carbon, boron or any combinations thereof. The total amount of the second additive is preferably no less than 0.3 at% and no more than 0.4 at%.

In accordance with the present invention, the ratio of the amount of cobalt to the amount of iron is preferably between 0.25 and 4, and more

preferably between 0.3 and 3. In one embodiment, the amount of cobalt may be more than the amount of iron; in this case, the ratio of the amount of cobalt to the amount of iron may be between 1.5 and 2.5. In another embodiment, the amount of iron may be more than the amount of cobalt; in this case, the ratio of the amount of cobalt to the amount of iron may be no less than 0.5 and less than 1.

In the present specification, the term “the ratio of niobium oxide particles to the surface of the Co-Fe-Nb-based sputtering target” means that the ratio of the count of niobium oxide particles precipitated in the Co-Fe-Nb-based sputtering target relative to an area of a surface of the Co-Fe-Nb-based sputtering target. As the Co-Fe-Nb-based sputtering target is a homogeneous target, the less the count of niobium oxide particles in the Co-Fe-Nb-based sputtering target, the less the occurrence of particles falling, abnormal arcing, and splash during sputtering.

In the present specification, the term “the total amount of the first additive” means that the sum of the individual amount(s) of every element of the first additive. In the case that the first additive includes multiple different elements, the total amount of the first additive is the sum of the individual amounts of every element. In the case that the first additive includes a single element, the total amount of the first additive is just the individual amount of said single element. For example, in the case that the first additive includes tungsten and molybdenum, the total amount of the first additive is the sum of the individual amount of tungsten and the amount of molybdenum. In the case that the first additive includes only tungsten, the total amount of the first

additive is the individual amount of tungsten.

Similarly, the term "the total amount of the second additive" means that the sum of the individual amount(s) of every element of the second additive. In the case that the second additive includes multiple different elements, the total amount of the second additive is the sum of the individual amounts of every element. In the case that the second additive includes a single element, the total amount of the second additive is just the individual amount of said single element. For example, in the case that the second additive includes boron and carbon, the total amount of the second additive is the sum of the individual amount of boron and the individual amount of carbon. In the case that the second additive includes only boron, the total amount of the second additive is the individual amount of boron.

In the present specification, the term "the total amount of the active element and the first additive" means the sum of the foresaid total amount of the active element and the foresaid total amount of the first additive.

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.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A to Fig. 1E are respectively optical microscope images of Co-Fe-Nb-based sputtering targets of Example 1 to Example 5.

Fig. 2A and Fig. 2B are respectively optical microscope images of Co-Fe-Nb-based sputtering targets of Comparative Example 1 and Comparative Example 2.

Fig. 3 is a schematic top view of a Co-Fe-Nb-based sputtering target. The top view is marked with horizontal lines and vertical lines to form 12 observation areas, in order to illustrate the method of calculating the ratio of niobium oxide particles to the surface of the Co-Fe-Nb-based sputtering target in the test example.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In order to verify the effect of the composition of the Co-Fe-Nb-based sputtering target on the density of niobium oxide contained in the target, several examples of the Co-Fe-Nb-based sputtering target of different compositions are exemplified to illustrate the implementation of the present invention. The person skilled in the art can easily realize the advantages and effects of the present invention in accordance with the contents of the specification. 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.

Preparation of Co-Fe-Nb-based sputtering target

The Co-Fe-Nb-based sputtering target materials of Examples 1 to 13 and Comparative Examples 1 to 11 were each obtained by applying an appropriate amount of raw materials such as cobalt, iron, niobium, tantalum, tungsten, molybdenum, magnesium, carbon, boron, chromium, and calcium in accordance with the process described below. The purity of each of the foresaid raw materials was 3N5. Herein, tungsten and molybdenum acted as the first additive, and magnesium, carbon, boron, chromium and calcium acted as the second additive to suppress the generation of niobium oxide particles. In Table

1, the amount of the components in the Co-Fe-Nb-based sputtering target are expressed in atomic percent (at%).

In the preparation process of the Co-Fe-Nb-based sputtering target, the raw materials were weighed according to the composition in Table 1, and then
5 crushed until the particle size was less than 10 μm . Then the foresaid mixture of the raw materials was added with alcohol and then cleaned by an ultrasonic treatment and dried for 2 hours. The dried mixed raw material was put into an oxide crucible.

Subsequently, the oxide crucible packed with the mixed raw material
10 was placed in a reaction chamber. The reaction chamber was first evacuated to below 1 mtorr, then supplied with argon to raise the degree of vacuum to 400 mtorr. Then the mixed raw material was subjected to a vacuum induction melting process at 1780°C for 40 minutes. After the raw material was melted, the reaction chamber was evacuated to below 1 mtorr for depressurization, so
15 as to obtain a melt alloy.

Finally, the foresaid melt alloy was cast into a mold at a pouring temperature of 1590°C, and then cooled below 300°C to form an alloy ingot. The alloy ingot was taken out from the mold, and followed by the steps of wire cutting, lathing, grinding, and polishing to form a disk shape Co-Fe-Nb-based
20 sputtering target with a diameter of 180 mm and a thickness of 8 mm.

Test Example: Precipitation of Niobium Oxides

In the present test example, the oxide particles precipitated in the Co-Fe-Nb-based sputtering target of Examples 1 to 13 and Comparative Examples 1 to 11 were observed by an optical microscope. Take observation

results of Examples 1 to 5 and Comparative Examples 1 and 2 as representative examples for illustration, as the comparison results of Figs. 1A to 1E, Figs. 2A and 2B indicated, only a few niobium oxide particles (as shown by dark spot in Figs. 1A to 1E) were participated in the Co-Fe-Nb-based sputtering targets of Examples 1 to 5; however, significantly more niobium oxide particles were participated in the Co-Fe-Nb-based sputtering targets of Comparative Example 1 and Comparative Example 2. Furthermore, the size of the niobium oxide particles precipitated in the Co-Fe-Nb-based sputtering target of Comparative Example 1 and Comparative Example 2 was also apparently larger than that of Examples 1 to 5. In other words, the observation results from optical microscope preliminarily verified that controlling the composition of the Co-Fe-Nb-based sputtering target can effectively suppress the precipitation of niobium oxide particles in the Co-Fe-Nb-based sputtering target.

In addition, to further analyze the precipitation of niobium oxide particles in the Co-Fe-Nb-based sputtering target, a horizontal line L1 and a vertical line L2 through the center of the Co-Fe-Nb-based sputtering target were marked on the surface of each Co-Fe-Nb-based sputtering target, the horizontal line L1 and the vertical line L2 are perpendicular to each other, thereby dividing four quadrants on the Co-Fe-Nb-based sputtering target, as shown in Fig 3.

Subsequently, in the first quadrant, an observation region was defined by moving upward 0.2 mm from the horizontal line L1 and moving rightward 20 mm from the vertical line L2. Repeating the foregoing steps, three successive observation regions were defined from the vertical line L2 to the

right side. Similarly, in the second quadrant, an observation unit was defined by moving leftward 0.2 mm from the vertical line L2 and moving upward 20 mm from the horizontal line L1, and three successive observation regions were defined from the horizontal line L1 to the upside. In the third quadrant, an
5 observation unit was defined by moving downward 0.2 mm from the horizontal line L1 and moving leftward 20 mm from the vertical line L2, and three successive observation regions were defined from the vertical line L2 to the left side. In the fourth quadrant, an observation unit was defined by moving rightward 0.2 mm from the vertical line L2 and moving downward 20 mm from
10 the horizontal line L1, and three successive observation regions were defined from the horizontal line L1 to the bottom side. Accordingly, each of the four quadrants of the Co-Fe-Nb-based sputtering target was defined with three rectangular observation regions. Each observation region was 20 mm in length D1 and 0.2 mm in width D2, and the area of each observation region was 4
15 mm².

Twelve observation regions of the Co-Fe-Nb-based sputtering target were observed at a magnification of 500 times. After that, the number of niobium oxide particles in each observation region was counted and summed. The total count of niobium oxide particles in the 12 observation regions was
20 divided by the total area, *i.e.*, 48 mm², to obtain the ratio of the niobium oxide particles to the surface of the Co-Fe-Nb-based sputtering target (unit: particle counts per square millimeter (counts/mm²)).

According to the above observation and analysis method, the ratio of niobium oxide particles to the surface of the Co-Fe-Nb-based sputtering target

of each example and comparative example was shown in Table 1 below. The ratio of niobium oxide particles to the surface of the Co-Fe-Nb-based sputtering target was abbreviated as “average precipitation of niobium oxides” in Table 1.

Table 1: The composition of Co-Fe-Nb-based sputtering target, the average precipitation of niobium oxides in Co-Fe-Nb-based sputtering target, the unit content of each element is atomic percent (at%).

	Co	Fe	Active Element		First Additive			Second Additive					average precipitation of niobium oxides (counts/mm ²)
			Nb	Ta	W	Mo	Mg	C	B	Cr	Ca		
Example 1	55.92	23.96	9.98	0	9.99	0	0.15	0	0	0	0	27.7	
Example 2	55.83	23.92	9.97	0	9.97	0	0	0.31	0	0	0	15	
Example 3	55.81	23.92	9.96	0	9.97	0	0	0	0.34	0	0	22.3	
Example 4	55.97	23.98	9.99	0	9.99	0	0	0	0	0.07	0	31.9	
Example 5	55.95	23.98	9.99	0	9.99	0	0	0	0	0	0.09	23.8	
Example 6	52.82	21.92	1	18.93	0	4.98	0	0.35	0	0	0	30	
Example 7	52.78	21.92	1	18.93	0	4.98	0	0	0.39	0	0	29.3	
Example 8	52.85	21.94	13.96	0	0	10.97	0	0.28	0	0	0	27.7	
Example 9	52.83	21.94	13.96	0	0	10.96	0	0	0.31	0	0	29.2	
Example 10	52.83	21.93	9.97	4.98	4.98	4.99	0	0.32	0	0	0	26.3	
Example 11	52.82	21.92	9.96	4.98	4.98	4.99	0	0	0.35	0	0	29.5	
Example 12	52.83	21.93	9.96	9.97	4.98	0	0	0.33	0	0	0	31.1	
Example 13	52.81	21.92	9.96	9.96	4.98	0	0	0	0.37	0	0	33.6	
Comparative Example 1	56	24	10	0	10	0	0	0	0	0	0	67.4	
Comparative Example 2	52.84	20.93	1	20.94	0	3.99	0	0	0.30	0	0	72.5	
Comparative Example 3	52.84	19.94	15.95	0	0	10.97	0	0	0.30	0	0	53.3	
Comparative Example 4	52.94	18.98	9.99	7.99	5.00	5.00	0	0	0	0	0.10	38.6	
Comparative Example 5	53.00	22.00	10.00	10.00	5.00	0	0	0	0	0	0	73.6	

Comparative Example 6	52.94	21.98	12.99	7.99	4.00	0	0	0	0	0	0	0.10	41.2
Comparative Example 7	52.84	19.94	24.93	0	1.99	0	0.30	0	0	0	0	0	66.6
Comparative Example 8	29.92	25.92	9.97	9.97	11.96	11.96	0.30	0	0	0	0	0	126.7
Comparative Example 9	52.62	21.86	24.82	0	0	0	0	0	0	0	0.70	0	84.3
Comparative Example 10	52.85	21.94	24.93	0	0	0	0	0.28	0	0	0	0	62.3
Comparative Example 11	54.81	14.95	9.97	14.95	4.98	0	0	0	0.34	0	0	0	97.4

As shown in Table 1, when the Co-Fe-Nb-based sputtering target was mixed with a second additive of magnesium, carbon, boron, chromium, calcium or any combinations thereof, the total amount of the active element (niobium) was no more than 20 at%, and the total amount of the active element and the first additive (tungsten, molybdenum or any combinations thereof) was no more than 25 at%, and the total amount of the second additive was no more than 0.5 at%, the precipitation of niobium oxide particles in the Co-Fe-Nb-based sputtering target was effectively suppressed, and thus the ratio of niobium oxide particles to the surface of the Co-Fe-Nb-based sputtering target (*i.e.*, the average precipitation as shown in Table 1) of Examples 1 to 13 was reduced to 35 counts/mm².

In contrast with Comparative Example 1 and Comparative Example 5, no magnesium, carbon, boron, chromium or calcium was mixed in the Co-Fe-Nb-based sputtering target of Comparative Example 1 and Comparative Example 5, such that the average niobium oxide precipitated in the Co-Fe-Nb-based sputtering target was still more than 65 counts/mm². In particular, the composition of Comparative Example 5 and its results indicated that simply controlling the total amount of the active element and the total amount of the active element and the first additive being exactly 20 at% and 25 at% but mixing none of magnesium, carbon, boron, chromium or calcium in the target certainly failed to suppress the precipitation of niobium oxide particles.

As the composition of Comparative Example 9 and its results indicated, although chromium was contained in the Co-Fe-Nb-based sputtering

target and served as a second additive, the second additive failed to suppress the precipitation of niobium oxide particles if the Co-Fe-Nb-based sputtering target of Comparative Example 9 contained excessive amount of the second additive and was free of first additive. As a result, the average niobium oxide
5 precipitated in the Co-Fe-Nb-based sputtering target of Comparative Example 9 was still over 80 counts/mm².

As the total amount of the active element and the first additive in each of the Co-Fe-Nb-based sputtering targets of Comparative Examples 2 to 4, 7, 8 and 11 exceeded 25 at%, the niobium oxides particles in the Co-Fe-Nb-based
10 sputtering target of Comparative Examples 2 to 4, 7, 8 and 11, even if containing second additive, were precipitated more severely than those of the Examples 1 to 13. Besides, as the total amount of the active element in each of the Co-Fe-Nb-based sputtering targets of Comparative Examples 2, 6, 7 and 9 to 11 exceeded 20 at%, even if containing second additive, the average niobium
15 oxide precipitated in each of the Co-Fe-Nb-based sputtering targets of Comparative Examples 2, 6, 7 and 9 to 11 was still as many as 40 counts/mm² or more.

To further study the effect of the individual amount of the active element, the compositions of Co-Fe-Nb-based sputtering targets of
20 Comparative Examples 3, 7, 9, and 10 and their results were further analyzed. As the individual amount of niobium was more than 14 at%, the average niobium oxide precipitated in each of the Co-Fe-Nb-based sputtering targets of Comparative Examples 3, 7, 9 and 10 was also as many as 50 counts/mm² or more. In addition, as the individual amount of tantalum was more than 19 at %,

resulting in the average niobium oxide precipitated in the Co-Fe-Nb-based sputtering target of Comparative Examples 2 was also as many as 70 counts/mm² or more.

To further study the total amount of the first additive in the Co-Fe-Nb-based sputtering target, as the individual amount of the first additive in the Co-Fe-Nb-based sputtering target of Comparative Example 8 was more than 20 at%, the average niobium oxide precipitated in the Co-Fe-Nb-based sputtering target of Comparative Example 8 was even more than 125 counts/mm².

To further study the ratio of the amount of cobalt to the amount of iron in the Co-Fe-Nb-based sputtering target, the ratio of the amount of cobalt to the amount of iron of each of the Co-Fe-Nb-based sputtering target of Examples 1 to 13 was between 1.5 and 2.5, but the ratio of the amount of cobalt to the amount of iron in the Co-Fe-Nb-based sputtering target of Comparative Example 11 was beyond the above range, resulting in the average niobium oxide precipitated in the Co-Fe-Nb-based sputtering target of Comparative Examples 11 was as many as 90 counts/mm².

Based on the above test results, controlling the composition of the Co-Fe-Nb-based sputtering target can effectively suppress the precipitation of niobium oxide particles in the Co-Fe-Nb-based sputtering target, and reduces the ratio of niobium oxide particles to the surface of the Co-Fe-Nb-based sputtering target to less than 35 counts/mm² from 120 counts/mm².

Accordingly, the technical means provided by the present invention can reduce the amount of inclusions, and thus overcomes the problems of particles falling,

abnormal arcing, and splash during sputtering the Co-Fe-Nb-based sputtering target, so as to effectively enhance the sputtering quality of Co-Fe-Nb-based sputtering target.

Even though numerous characteristics and advantages of the present
5 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
10 claims are expressed.

WHAT IS CLAIMED IS:

1. A Co-Fe-Nb-based sputtering target, which includes cobalt, iron,
an active element, a first additive, and a second additive, the active element
5 including niobium, the first additive including tungsten, molybdenum,
vanadium, zirconium, titanium, yttrium, manganese, aluminum, copper, nickel,
phosphorus, gallium, germanium, tin, or any combinations thereof, and the
second additive including magnesium, carbon, boron, chromium, calcium, or
any combinations thereof;
- 10 wherein based on the total amount of the Co-Fe-Nb-based sputtering
target, the total amount of the active element is more than 0 at% and no more
than 20 at%, the total amount of the active element and the first additive is
more than 0 at% and no more than 25 at%, and the total amount of the second
additive is more than 0 at% and no more than 0.5 at%;
- 15 wherein the Co-Fe-Nb-based sputtering target has niobium oxide
particles, and the ratio of niobium oxide particles to the surface of the
Co-Fe-Nb-based sputtering target is less than 35 counts/mm².
2. The Co-Fe-Nb-based sputtering target as claimed in claim 1,
20 wherein the active element is composed of niobium, and the total amount of the
active element is more than 0 at% and no more than 14 at%.

3. The Co-Fe-Nb-based sputtering target as claimed in claim 1,
wherein the active element includes tantalum, the individual amount of
niobium is more than 0 at% and no more than 14 at%, and the individual
amount of tantalum is more than 0 at% and no more than 19 at%.

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4. The Co-Fe-Nb-based sputtering target as claimed in claim 1,
wherein the total amount of the active element is no less than 1 at% and no
more than 20 at%.

10 5. The Co-Fe-Nb-based sputtering target as claimed in claim 1,
wherein the total amount of the first additive is more than 0 at% and no more
than 20 at%.

6. The Co-Fe-Nb-based sputtering target as claimed in claim 1,
15 wherein the total amount of the active element and the first additive is no less
than 15 at% and no more than 24.95 at%.

7. The Co-Fe-Nb-based sputtering target as claimed in claim 1,
wherein the total amount of the second additive is no less than 0.01 at% and no
20 more than 0.5 at%.

8. The Co-Fe-Nb-based sputtering target as claimed in claim 1,
wherein the ratio of the amount of cobalt to the amount of iron is between 0.25
and 4.

9. The Co-Fe-Nb-based sputtering target as claimed in claim 1,
wherein based on the total amount of cobalt, iron, the active element, the first
additive, and the second additive in the Co-Fe-Nb-based sputtering target, the
5 total amount of cobalt and iron is no less than 74.5 at% and no more than 85
at%, the total amount of the active element and the first additive is no less than
14.5 at% and no more than 25 at%, and the total amount of the second additive
is no less than 0.01 at% and no more than 0.5 at%.

10. The Co-Fe-Nb-based sputtering target as claimed in claim 1,
wherein based on the total amount of cobalt, iron, the active element, the first
additive, and the second additive in the Co-Fe-Nb-based sputtering target, the
total amount of cobalt and iron is no less than 74.5 at% and less than 80 at%,
the total amount of the active element and the first additive is no less than 19.5
15 at% and no more than 25 at%, and the total amount of the second additive is no
less than 0.01 at% and no more than 0.5 at%.