

Fe-Pt Based Target And Preparation Method Thereof

The present invention relates to an Fe-Pt based target and a preparation method thereof, more particularly to an Fe-Pt based target and a preparation method thereof for magnetic recording media.

5 Magnetic recording media refers to using the hysteresis characteristics of magnetic material to store data in the recording media. Nowadays, the magnetic recording media is classified into longitudinal magnetic recording (LMR) media and perpendicular magnetic recording (PMR) media, and the primary requirement of the magnetic recording media is high thermal stability
10 for the purpose of data storage. Besides, as the demand for higher storage capacities of the magnetic recording media increases, how to increase the storage density of the magnetic recording media has become a main focus of researches in the related fields. Nevertheless, as the storage density of LMR media is closely approaching the physical limit, PMR media, which can extend
15 the limit of the superparamagnetic effect and thus enable reaching higher storage density, becomes a solution of increasing the storage density of the magnetic recording media.

 In general, the PMR media comprises, from bottom to top, a substrate, an adhesion layer, a soft underlayer, a seed layer, an intermediate layer, a
20 magnetic recording layer, a cover layer and a lubricating layer, and the magnetic recording layer usually adopts a cobalt-chromium-platinum based (Co-Cr-Pt based) system as the main component. However, as the development of PMR media gradually matures, the PMR media adopting the Co-Cr-Pt magnetic recording layer is also approaching the limit of the storage density.

Accordingly, an iron-platinum based (Fe-Pt based) system is adopted to form the magnetic recording layer suitable for heat-assisted magnetic recording (HAMR) media, so as to pursue superior storage density of PMR media.

Briefly, in the HAMR system, during recording, the magnetic particles of the recording area are heated to the temperature over Curie temperature of the magnetic particles, which can reduce the magnetic coercivity of the magnetic particles temporarily. Besides, the size of the magnetic particles of the Fe-Pt based alloy can be smaller than that of the Co-Cr-Pt based alloy; therefore, adopting the Fe-Pt based alloy can further increase the storage density of the magnetic recording media. However, heat repeatedly acts on the same area during recording in the HAMR system, and therefore the composite magnetic materials of the magnetic recording layer requires high thermal stability. At present, boron nitride (BN), which has high thermal stability, is added into the Fe-Pt based system to form a barrier and reduce the magnetic coupling effect among grains of the Fe-Pt alloys.

Nevertheless, BN particles with reduced sizes are easy to agglomerate and hard to disperse well. That is, when BN is directly added into the Fe-Pt based system to form an Fe-Pt based target, obvious agglomerations of BN will be found in a metallography of the Fe-Pt based target, which causes many shortcomings, such as poor bending strength, occurrence of abnormal discharges during sputtering and severe particulate contamination of a magnetic recording layer formed by sputtering the Fe-Pt based target, thereby affecting the quality and yield of the magnetic recording layer.

In view of the aforementioned shortcomings, the objective of the present invention is to enhance the bending strength of the Fe-Pt based target, reduce the occurrence of abnormal discharges during sputtering, and mitigate particulate contamination, thereby improving the quality and yield of the magnetic recording layer formed from the Fe-Pt based target.

To achieve the aforementioned objective, the present invention provides an Fe-Pt based target comprising iron (Fe), platinum (Pt), and boron nitride (BN), and based on a total amount of the Fe-Pt based target, an amount of BN is more than 0 atomic percent (at%) and less than or equal to 50 at%. A metallography of the Fe-Pt based target comprises multiple black phases, an average size of the black phases is less than 3 micrometers (μm), and a dispersion uniformity of the black phases is less than 5×10^{-4} , wherein the dispersion uniformity is obtained by the following equation:

$$\frac{(\text{a total area of the black phases in the metallography}/\text{an area of the metallography})}{\text{a total number of the black phases}}.$$

By controlling the amount of BN, the average size of the black phases and the dispersion uniformity of the black phases of the Fe-Pt based target within a specific range, the phase composition of the Fe-Pt based target has good dispersion uniformity, which can effectively enhance the bending strength of the Fe-Pt based target, and also can reduce the occurrence of abnormal discharges during sputtering and mitigate particulate contamination simultaneously.

In accordance with the present invention, a size of each black phase indicates the maximum length through the center point of each black phase in

the metallography of the Fe-Pt based target, and an average of multiple data of
foresaid size of each black phase represents the average size of the black
phases.

In accordance with the present invention, the dispersion uniformity of
5 the black phases means that on the average, the proportion of the area of one
single black phase to the total area of the metallography of the Fe-Pt based
target. For example, when the total area of all of the black phases and the total
area of the metallography remain unchanged, the more the total number of the
black phases is, the less the proportion of the area of one single black phase to
10 the total area of the metallography, which indicates that every black phase is
more likely to disperse uniformly in the metallography. In brief, when the value
of the dispersion uniformity of the black phases is less, the black phases
disperse more uniformly in the metallography.

In accordance with the present invention, said BN may be, but is not
15 limited to, hexagonal boron nitride (h-BN), cubic boron nitride (c-BN),
wurtzite boron nitride (w-BN) or any combination thereof.

Preferably, based on the total amount of the Fe-Pt based target, the
amount of BN is more than or equal to 3 at% and less than or equal to 30 at%.
More preferably, based on the total amount of the Fe-Pt based target, the
20 amount of BN is more than or equal to 5 at% and less than or equal to 25 at%.
By controlling the amount of BN within the specific ranges mentioned above, a
film layer formed by sputtering the Fe-Pt based target can have a better
magnetic property.

Preferably, based on the total amount of the Fe-Pt based target, an amount of Pt is more than or equal to 10 at% and less than or equal to 45 at%.

Preferably, based on the total amount of the Fe-Pt based target, an amount of Fe is more than or equal to 5 at% and less than or equal to 84 at%.

5 In some embodiments of the present invention, the Fe-Pt based target further comprises a first component selected from the group consisting of: an oxide, a carbide, a nitride and any combination thereof; wherein based on the total amount of the Fe-Pt based target, an amount of the first component is more than 0 at% and less than or equal to 50 at%, and a sum of the amount of
10 the first component and the amount of BN is more than or equal to 6 at% and less than or equal to 50 at%. Preferably, based on the total amount of the Fe-Pt based target, the amount of the first component is more than or equal to 5 at% and less than or equal to 35 at%, and the sum of the amount of the first
15 component and the amount of BN is more than or equal to 6 at% and less than or equal to 50 at%.

 In some embodiments of the present invention, the Fe-Pt based target further comprises carbon (C), and based on the total amount of the Fe-Pt based target, an amount of C is more than or equal to 2 at% and less than or equal to 40 at%. Preferably, based on the total amount of the Fe-Pt based target, the
20 amount of C is more than or equal to 2 at% and less than or equal to 35 at%.

 In some embodiments of the present invention, the black phases in the metallography of the Fe-Pt based target comprise BN; in another embodiment of the present invention, the black phases in the metallography of the Fe-Pt based target comprise BN and the first component; in another embodiment of

the present invention, the black phases in the metallography of the Fe-Pt based target comprise BN and C; in another embodiment of the present invention, the black phases in the metallography of the Fe-Pt based target comprise BN, the first component and C.

5 Preferably, the oxide may be, but is not limited to, silicon dioxide (SiO_2), titanium(IV) oxide (TiO_2), chromium(III) oxide (Cr_2O_3), tantalum(V) oxide (Ta_2O_5), cobalt(II) oxide (CoO), manganese(III) oxide (Mn_2O_3), boron trioxide (B_2O_3), hafnium(IV) oxide (HfO_2), magnesium oxide (MgO), aluminum oxide (Al_2O_3), zirconium(IV) oxide (ZrO_2), niobium(V) oxide
10 (Nb_2O_5), vanadium(V) oxide (V_2O_5), tungsten(VI) oxide (WO_3), iron(III) oxide (Fe_2O_3), zinc oxide (ZnO) or any combination thereof.

 Preferably, the nitride may be, but is not limited to, aluminum nitride (AlN), titanium nitride (TiN), chromium nitride (CrN), zirconium nitride (ZrN), tantalum nitride (TaN), hafnium nitride (HfN), silicon nitride (Si_3N_4), titanium
15 carbon nitride (TiCN), tungsten nitride (WN) or any combination thereof. In this specification, the nitride does not comprise BN, which is an essential component in the Fe-Pt based target. That is, the description “a sum of the amount of the first component and the amount of BN is more than or equal to 6 at% and less than or equal to 50 at%” indicates that the sum of the amount of
20 the first component, such as AlN mentioned above, and the amount of BN is more than or equal to 6 at% and less than or equal to 50 at%.

 Preferably, the carbide may be, but is not limited to, silicon carbide (SiC), boron carbide (B_4C), titanium carbide (TiC), tungsten carbide (WC), tantalum carbide (TaC), hafnium carbide (HfC), zirconium carbide (ZrC),

vanadium carbide (VC), niobium carbide (NbC), chromium carbide (Cr_3C_2) or any combination thereof.

In another embodiment of the present invention, the Fe-Pt based target further comprises a second component selected from the group consisting of:

5 silver (Ag), gold (Au), germanium (Ge), copper (Cu), nickel (Ni), cobalt (Co), aluminum (Al), magnesium (Mg), manganese (Mn), silicon (Si), strontium (Sr) and any combination thereof; wherein based on the total amount of the Fe-Pt based target, an amount of the second component is more than or equal to 2 at% and less than or equal to 40 at%. Preferably, based on the total amount of
10 the Fe-Pt based target, the amount of the second component is more than or equal to 2 at% and less than or equal to 20 at%; more preferably, the amount of the second component is more than or equal to 2 at% and less than or equal to 10 at%. By means of adding the second component into the Fe-Pt based target, the Fe-Pt based target can further enhance the relative density.

15 In another embodiment of the present invention, the Fe-Pt based target further comprises the second component and C, and based on the total amount of the Fe-Pt based target, an amount of the second component is more than or equal to 2 at% and less than or equal to 40 at% and an amount of C is more than or equal to 2 at% and less than or equal to 20 at%. Preferably, based on the
20 total amount of the Fe-Pt based target, the amount of C is more than or equal to 2 at% and less than or equal to 10 at%.

In another embodiment of the present invention, the Fe-Pt based target further comprises the first component and the second component, and based on the total amount of the Fe-Pt based target, an amount of the first component is

more than 0 at% and less than or equal to 50 at% and a sum of the amount of the first component and the amount of BN is more than or equal to 6 at% and less than or equal to 50 at%; and an amount of the second component is more than or equal to 2 at% and less than or equal to 40 at%.

5 In another embodiment of the present invention, the Fe-Pt based target further comprises the first component, the second component and C, and based on the total amount of the Fe-Pt based target, an amount of the first component is more than 0 at% and less than or equal to 50 at% and a sum of the amount of the first component and the amount of BN is more than or equal to 6 at% and
10 less than or equal to 50 at%; an amount of the second component is more than or equal to 2 at% and less than or equal to 40 at%; and an amount of C is more than or equal to 2 at% and less than or equal to 20 at%. Preferably, based on the total amount of the Fe-Pt based target, the amount of C is more than or equal to 2 at% and less than or equal to 10 at%.

15 In the first embodiment of the present invention, the Fe-Pt based target comprises Fe, Pt and BN; in this embodiment, an amount of BN is more than or equal to 0.1 at% and less than or equal to 50 at%.

 In the second embodiment of the present invention, the Fe-Pt based target comprises Fe, Pt, BN and C; in this embodiment, an amount of BN is
20 more than or equal to 1 at% and less than or equal to 30 at% and an amount of C is more than or equal to 1 at% and less than or equal to 40 at%. Specifically, the amount of C is more than or equal to 2 at% and less than or equal to 40 at%.

 In the third embodiment of the present invention, the Fe-Pt based target

comprises Fe, Pt, BN and the first component; in this embodiment, an amount of BN is more than or equal to 1 at% and less than or equal to 50 at% and an amount of the first component is more than or equal to 4 at% and less than or equal to 30 at%.

5 In the fourth embodiment of the present invention, the Fe-Pt based target comprises Fe, Pt, BN and the second component; in this embodiment, an amount of BN is more than or equal to 10 at% and less than or equal to 50 at% and an amount of the second component is more than or equal to 1 at% and less than or equal to 20 at%. Specifically, the amount of the second component is
10 more than or equal to 2 at% and less than or equal to 20 at%.

 In the fifth embodiment of the present invention, the Fe-Pt based target comprises Fe, Pt, BN, the first component and the second component; in this embodiment, an amount of BN is more than or equal to 2 at% and less than or equal to 30 at%, an amount of the first component is more than or equal to 5
15 at% and less than or equal to 30 at% and an amount of the second component is more than or equal to 5 at% and less than or equal to 50 at%. Specifically, the amount of the second component is more than or equal to 5 at% and less than or equal to 40 at%.

 In the sixth embodiment of the present invention, the Fe-Pt based target
20 comprises Fe, Pt, BN, the first component and C; in this embodiment, an amount of BN is more than or equal to 1 at% and less than or equal to 20 at%, an amount of the first component is more than or equal to 10 at% and less than or equal to 50 at% and an amount of C is more than or equal to 2 at% and less than or equal to 20 at%.

In the seventh embodiment of the present invention, the Fe-Pt based target comprises Fe, Pt, BN, the second component and C; in this embodiment, an amount of BN is more than or equal to 1 at% and less than or equal to 30 at%, an amount of the second component is more than or equal to 1 at% and less than or equal to 20 at%, specifically, the amount of the second component is more than or equal to 2 at% and less than or equal to 20 at%, and an amount of C is more than or equal to 5 at% and less than or equal to 40 at%.

In the eighth embodiment of the present invention, the Fe-Pt based target comprises Fe, Pt, BN, the first component, the second component and C; in this embodiment, an amount of BN is more than or equal to 1 at% and less than or equal to 30 at%, an amount of the first component is more than or equal to 5 at% and less than or equal to 50 at%, specifically, the amount of the first component is more than or equal to 5 at% and less than or equal to 40 at%, an amount of the second component is more than or equal to 2 at% and less than or equal to 20 at% and an amount of C is more than or equal to 2 at% and less than or equal to 15 at%. In the foresaid first, third, fourth and fifth embodiments, the Fe-Pt based target selectively may not comprise C.

Preferably, a bending strength of the Fe-Pt based target is more than or equal to 700 MPa. More preferably, the bending strength of the Fe-Pt based target is more than or equal to 700 MPa and less than or equal to 1600 MPa.

To achieve the aforementioned objective, the present invention also provides a preparation method of an Fe-Pt based target, comprising the following steps: step (a): mixing raw materials of Fe, Pt, and BN to obtain a raw material mixture, wherein an average particle size of the raw material of

BN is less than 5 μm ; step (b): grinding the raw material mixture for 4 hours to 12 hours, and then sieving the raw material mixture through a sieve having more than or equal to 800 meshes and less than or equal to 1200 meshes, taking remaining matters above the sieve and then repeating the processes of grinding
 5 and sieving to obtain a raw material mixture of the Fe-Pt based target; and step (c): sintering the raw material mixture of the Fe-Pt based target to obtain the Fe-Pt based target; wherein, based on a total amount of the Fe-Pt based target, an amount of the raw material of BN is more than 0 at% and less than or equal to 50 at%; wherein a metallography of the Fe-Pt based target comprises
 10 multiple black phases, and an average size of the black phases is less than 3 μm , and a dispersion uniformity of the black phases is less than 5×10^{-4} , wherein the dispersion uniformity is obtained by the following equation:

$$\frac{(\text{a total area of the black phases in the metallography}/\text{an area of the metallography})}{\text{a total number of the black phases}} .$$

By controlling the average size and the amount of the raw material of
 15 BN in the raw material mixture of the Fe-Pt based target, and also by adopting the technical means of sieving, the Fe-Pt based target prepared by the method can have a specific range of the average size of the black phases and a specific range of the dispersion uniformity of the black phases, such that the Fe-Pt based target can have improved bending strength, the occurrence of abnormal
 20 discharges during sputtering can be reduced, and particulate contamination can be mitigated simultaneously.

In accordance with the present invention, in the step (a), said mixing may adopt any ways capable of mixing raw materials uniformly. For example,

said mixing may be, but is not limited to, placing raw materials into a mixer for the purpose of mixing raw materials uniformly.

In accordance with the present invention, in the step (a), a reduction step may be conducted after a completion of said mixing step. Said reduction
5 step may adopt any ways capable of reducing oxidized raw materials. For example, said reduction step may be, but is not limited to, hydrogen reduction, vacuum reduction, carbon reduction or zinc reduction. Preferably, said reduction step is hydrogen reduction.

In accordance with the present invention, in the step (b), a prepressing
10 step may be conducted after the raw material mixture is obtained. Said prepressing step may adopt any ways capable of pressing the raw material mixture of the Fe-Pt based target into a fixed shape. For example, said prepressing may be, but is not limited to, placing the raw material mixture of the Fe-Pt based target into an oil hydraulic press for prepressing under pressure
15 of about 250 pounds per square inch (psi) to 350 psi.

Preferably, based on the total amount of the raw material mixture of the Fe-Pt based target, an amount of the raw material of Pt is more than or equal to 10 at% and less than or equal to 45 at%.

Preferably, based on the total amount of the raw material mixture of the
20 Fe-Pt based target, the amount of the raw material of BN is more than or equal to 3 at% and less than or equal to 30 at%. More preferably, based on the total amount of the raw material mixture of the Fe-Pt based target, the amount of the raw material of BN is more than or equal to 5 at% and less than or equal to 25 at%.

Preferably, based on the total amount of the raw material mixture of the Fe-Pt based target, an amount of the raw material of Fe is more than or equal to 5 at% and less than or equal to 84 at%.

Preferably, in the step (b), said repeating the processes of the grinding and sieving is repeating at least three times to obtain the raw material mixture of the Fe-Pt based target. Specifically, said repeating the processes of grinding and sieving refers to that after the raw material mixture is ground and sieved, the remaining matters above the sieve are taken and then subjected to next grinding and sieving processes under identical conditions as foresaid.

In some embodiments of the present invention, the raw material mixture of the Fe-Pt based target further comprises a first component selected from the group consisting of: a raw material of oxide, a raw material of carbide, a raw material of nitride and any combination thereof; wherein based on the total amount of the raw material mixture of the Fe-Pt based target, an amount of the first component is more than 0 at% and less than or equal to 50 at%, and a sum of the amount of the first component and the amount of the raw material of BN is more than or equal to 6 at% and less than or equal to 50 at%.

Preferably, based on the total amount of the raw material mixture of the Fe-Pt based target, the amount of the first component is more than or equal to 5 at% and less than or equal to 35 at%, and the sum of the amount of the first component and the amount of the raw material of BN is more than or equal to 6 at% and less than or equal to 50 at%.

In some embodiments of the present invention, the raw material mixture of the Fe-Pt based target may further comprise a raw material of C, and

based on the total amount of the raw material mixture of the Fe-Pt based target, an amount of the raw material of C is more than or equal to 2 at% and less than or equal to 40 at%. Preferably, based on the total amount of the raw material mixture of the Fe-Pt based target, the amount of the raw material of C is more
5 than or equal to 2 at% and less than or equal to 35 at%.

In another embodiment of the present invention, the raw material mixture of the Fe-Pt based target may further comprise a second component selected from the group consisting of: a raw material of Ag, a raw material of Au, a raw material of Ge, a raw material of Cu, a raw material of Ni, a raw
10 material of Co, a raw material of Al, a raw material of Mg, a raw material of Mn, a raw material of Si, a raw material of Sr and any combination thereof; wherein based on the total amount of the raw material mixture of the Fe-Pt based target, an amount of the second component is more than or equal to 2 at% and less than or equal to 40 at%.

15 Preferably, in the step (c), a temperature of sintering is more than or equal to 600°C and less than or equal to 1200°C, and a pressure of sintering is more than or equal to 350 bar and less than or equal to 1800 bar.

In one of the embodiments of the present invention, in the step (c), a duration of sintering is more than or equal to 5 minutes and less than or equal
20 to 4 hours. More preferably, in the step (c), the temperature of sintering is more than or equal to 700°C and less than or equal to 1100°C, and the pressure of sintering is more than or equal to 380 bar and less than or equal to 1750 bar. In one of the embodiments of the present invention, in the step (c), the duration of sintering may be 3 hours.

In accordance with the present invention, said sintering may be hot pressing (HP), hot isostatic pressing (HIP) or spark plasma sintering (SPS). For example, when said sintering is performed by HP, the temperature of sintering may be, but is not limited to, ranging from 800°C to 1100°C, the pressure of sintering may be, but is not limited to, ranging from 350 bar to 400 bar, and the duration of sintering may be, but is not limited to, ranging from 2 hours to 4 hours; when said sintering is performed by HIP, the temperature of sintering may be, but is not limited to, ranging from 800°C to 1100°C, the pressure of sintering may be, but is not limited to, ranging from 1700 bar to 1800 bar, and the duration of sintering may be, but is not limited to, ranging from 2 hours to 4 hours; when said sintering is performed by SPS, the sintering temperature may be, but is not limited to, ranging from 700°C to 1100°C, the pressure of sintering may be, but is not limited to, ranging from 450 bar to 550 bar, and the duration of sintering may be, but is not limited to, ranging from 5 minutes to 1 hour.

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 metallographic image of an Fe-Pt based target of Example 5 obtained by scanning electron microscopy (SEM) at 2000-fold magnification.

FIG. 2 is a metallographic image of an Fe-Pt based target of Comparative Example 3 obtained by SEM at 2000-fold magnification.

FIG. 3 is a metallographic image of an Fe-Pt based target of Example

22 obtained by SEM at 2000-fold magnification.

FIG. 4 is a metallographic image of an Fe-Pt based target of Comparative Example 17 obtained by SEM at 2000-fold magnification.

In order to verify the influences of the amount of BN, the average size
5 of the black phases and the dispersion uniformity of the black phases to the Fe-Pt based target, several Fe-Pt based targets are provided as examples below 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 specification. Various modifications and variations could
10 be made in order to practice or apply the present invention without departing from the spirit and scope of the invention.

Examples 1 to 5: Fe-Pt based target

According to the compositions of the Fe-Pt based targets listed in the following Table 1, suitable amount of Fe powders with an average particle size
15 less than 100 μm , Pt powders with an average particle size less than 20 μm and BN powders with an average particle size less than 5 μm were placed in a mixer for mixing uniformly to obtain a powdered mixture. Afterward, the powdered mixture was reduced by a hydrogen reduction to obtain a reduced powdered mixture. Then, the reduced powdered mixture was ground for 4
20 hours to 12 hours by a high-speed grinder, and then followed by sieving with a sieve having more than or equal to 800 meshes and less than or equal to 1200 meshes. The remaining matters above the sieve were taken and subjected to the repeated processes of said grinding and said sieving for three times to obtain a powdered mixture of the Fe-Pt based target.

Next, the powdered mixture of the Fe-Pt based target was prepressed with a pressure of about 300 psi by an oil hydraulic press, and followed by sintering to obtain the Fe-Pt based targets of Examples 1 to 5. The sintering method and the temperature of sintering were listed in the following Table 1, and when said sintering was performed by HP, the pressure of sintering was about 380 bar and the duration of sintering was about 3 hours; when said sintering was performed by SPS, the pressure of sintering was about 500 bar and the duration of sintering was about 10 minutes.

In the following Table 1, the compositions of the Fe-Pt based targets of Examples 1 to 5 can be presented by a general formula “aFe-bPt-cBN”, wherein “a” represents the amount of Fe in atomic percent relative to the total amount of the Fe-Pt based target; “b” represents the amount of Pt in atomic percent relative to the total amount of the Fe-Pt based target; and “c” represents the amount of BN in atomic percent relative to the total amount of the Fe-Pt based target.

Examples 6 to 7: Fe-Pt based target (comprising C)

The preparation methods of Examples 6 to 7 were similar to those of Examples 1 to 5, that is, the preparation methods of Examples 6 to 7 also comprised similar steps such as adopting suitable amount of different kinds of powder and mixing, reducing, grinding, sieving, prepressing and sintering to obtain the Fe-Pt based targets of Examples 6 to 7. The sintering methods and temperature of sintering of Examples 6 to 7 were listed in the following Table 1, and when said sintering was performed by HP, the pressure of sintering was about 380 bar and the duration of sintering was about 3 hours; when said

sintering was performed by SPS, the pressure of sintering was about 500 bar and the duration of sintering was about 10 minutes.

The main differences between Examples 6 to 7 and Examples 1 to 5 were the steps of adopting suitable amount of Fe powders with an average particle size less than 100 μm , Pt powders with an average particle size less than 20 μm , BN powders with an average particle size less than 5 μm and C powders with an average particle size less than 10 μm , and then mixing in a mixer according to the compositions of the Fe-Pt based targets listed in the following Table 1.

In the following Table 1, the compositions of the Fe-Pt based targets of Examples 6 to 7 can be presented by a general formula “aFe-bPt-cBN-d1C”, wherein “a”, “b”, and “c” respectively represent the amount of Fe, of Pt and of BN in atomic percent relative to the total amount of the Fe-Pt based target as defined above; “d1” represents the amount of C in atomic percent relative to the total amount of the Fe-Pt based target.

Examples 8 to 13: Fe-Pt based target (comprising the first component)

The preparation methods of Examples 8 to 13 were similar to those of Examples 1 to 5, which comprised steps such as adopting suitable amount of different kinds of powder and mixing, reducing, grinding, sieving, prepressing and sintering to obtain the Fe-Pt based targets of Examples 8 to 13. The sintering methods and temperature of sintering of Examples 8 to 13 were listed in the following Table 1, and when said sintering was performed by HP, the pressure of sintering was about 380 bar and the duration of sintering was about

3 hours; when said sintering was performed by SPS, the pressure of sintering was about 500 bar and the duration of sintering was about 10 minutes; when said sintering was performed by HIP, the pressure of sintering was about 1750 bar and the duration of sintering was about 3 hours.

5 The main differences between Examples 8 to 13 and Examples 1 to 5 were the steps of adopting suitable amount of Fe powders with an average particle size less than 100 μm , Pt powders with an average particle size less than 20 μm , BN powders with an average particle size less than 5 μm and the first component with an average particle size less than 10 μm , and then mixing
10 in a mixer according to the compositions of the Fe-Pt based targets listed in the following Table 1. Here, the first component may be B_4C powders, SiO_2 powders, AlN powders, TiO_2 powders, TaC powders, Ta_2O_5 powders, TiN powders and Cr_3C_2 powders or any combination thereof.

In the following Table 1, the compositions of the Fe-Pt based targets of
15 Examples 8 to 13 can be presented by a general formula “ $a\text{Fe}-b\text{Pt}-c\text{BN}-d_2\text{B}_4\text{C}-d_3\text{SiO}_2-d_4\text{AlN}-d_5\text{TiO}_2-d_6\text{TaC}-d_7\text{Ta}_2\text{O}_5-d_8\text{TiN}-d_9\text{Cr}_3\text{C}_2$ ”, wherein “a”, “b”, and “c” respectively represent the amount of Fe, of Pt and of BN in atomic percent relative to the total amount of the Fe-Pt based target as defined above; “d2”, “d3”, “d4”, “d5”, “d6”, “d7”, “d8” and “d9” respectively represent the
20 amount of B_4C , of SiO_2 , of AlN , of TiO_2 , of TaC , of Ta_2O_5 , of TiN and of Cr_3C_2 in atomic percent relative to the total amount of the Fe-Pt based target.

In this specification, said “a sum of the amount of the first component and the amount of BN” indicates the sum of “c”, “d2”, “d3”, “d4”, “d5”, “d6”, “d7”, “d8” and “d9”.

Example 14: Fe-Pt based target (comprising the second component)

The preparation method of Example 14 was similar to those of Examples 1 to 5, which comprised steps such as adopting suitable amount of different kinds of powder and mixing, reducing, grinding, sieving, prepressing and sintering to obtain the Fe-Pt based target of Example 14. The sintering method and temperature of sintering of Example 14 were listed in the following Table 1, and in Example 14, said sintering was performed by HP, the pressure of sintering was about 380 bar and the duration of sintering was about 3 hours.

The main differences between Example 14 and Examples 1 to 5 were the steps of adopting suitable amount of Fe powders with an average particle size less than 100 μm , Pt powders with an average particle size less than 20 μm , BN powders with an average particle size less than 5 μm and the second component with an average particle size less than 20 μm , and then mixing in a mixer according to the composition of the Fe-Pt based target listed in the following Table 1. Here, the second component was Ag powders.

In the following Table 1, the compositions of the Fe-Pt based targets of Example 14 can be presented by a general formula “ $a\text{Fe}-b\text{Pt}-c\text{BN}-e1\text{Ag}$ ”, wherein “ a ”, “ b ”, and “ c ” respectively represent the amount of Fe, of Pt and of BN in atomic percent relative to the total amount of the Fe-Pt based target as defined above; “ $e1$ ” represents the amount of Ag in atomic percent relative to the total amount of the Fe-Pt based target.

Examples 15 to 25: Fe-Pt based target (comprising the first component and the second component)

The preparation methods of Examples 15 to 25 were similar to those of Examples 1 to 5, which comprises steps such as adopting suitable amount of different kinds of powder and mixing, reducing, grinding, sieving, prepressing and sintering to obtain the Fe-Pt based targets of Examples 15 to 25. The sintering methods and temperature of sintering of Examples 15 to 25 were listed in the following Table 1, and when said sintering was performed by HP, the pressure of sintering was about 380 bar and the duration of sintering was about 3 hours; when said sintering was performed by SPS, the pressure of sintering was about 500 bar and the duration of sintering was about 10 minutes; when said sintering was performed by HIP, the pressure of sintering was about 1750 bar and the duration of sintering was about 3 hours.

The main differences between Examples 15 to 25 and Examples 1 to 5 were the steps of adopting suitable amount of Fe powders with an average particle size less than 100 μm , Pt powders with an average particle size less than 20 μm , BN powders with an average particle size less than 5 μm , the first component with an average particle size less than 20 μm and the second component with an average particle size less than 20 μm , and then mixing in a mixer according to the compositions of the Fe-Pt based targets listed in the following Table 1. Here, the first component may be SiC powders, Cr_2O_3 powders, CoO powders, AlN powders, MgO powders, Mn_2O_3 powders, SiO_2 powders, TiO_2 powders, Al_2O_3 powders, TiN powders, B_2O_3 powders, HfO_2 powders or any combination thereof; the second component may be Ag powders,

Cu powders, Mg powders, Mn powders, Co powders, Ge powders, Al powders, Ni powders, Si powders, Sr powders, Au powders or any combination thereof.

Besides, according to the compositions of the Fe-Pt based targets of Examples 15, 16, 20 and 23 listed in the following Table 1, a suitable amount of C powders with an average particle size less than 20 μm was also mixed with Fe powders, Pt powders, BN powders, the first component and the second component mentioned above in said mixer.

In the following Table 1, the compositions of the Fe-Pt based targets of Examples 15 to 25 can be presented by a general formula “aFe-bPt-cBN-d1C-d3SiO₂-d4AlN-d5TiO₂-d8TiN-d10SiC-d11Cr₂O₃-d12CoO-d13MgO-d14Mn₂O₃-d15Al₂O₃-d16B₂O₃-d17HfO₂-e1Ag-e2Cu-e3Mg-e4Mn-e5Co-e6Ge-e7Al-e8Ni-e9Si-e10Sr-e11Au”, wherein “a”, “b”, and “c” respectively represent the amount of Fe, of Pt and of BN in atomic percent relative to the total amount of the Fe-Pt based target as defined above; “d1”, “d3”, “d4”, “d5”, “d8”, “d10”, “d11”, “d12”, “d13”, “d14”, “d15”, “d16” and “d17” respectively represent the amount of C, of SiO₂, of AlN, of TiO₂, of TiN, of SiC, of Cr₂O₃, of CoO, of MgO, of Mn₂O₃, of Al₂O₃, of B₂O₃ and of HfO₂ in atomic percent relative to the total amount of the Fe-Pt based target; “e1”, “e2”, “e3”, “e4”, “e5”, “e6”, “e7”, “e8”, “e9”, “e10” and “e11” respectively represent the amount of Ag, of Cu, of Mg, of Mn, of Co, of Ge, of Al, of Ni, of Si, of Sr and of Au in atomic percent relative to the total amount of the Fe-Pt based target.

In this specification, said “an amount of the second component” indicates the sum of “e1”, “e2”, “e3”, “e4”, “e5”, “e6”, “e7”, “e8”, “e9”, “e10” and “e11”.

Comparative Examples 1 to 20: Fe-Pt based target

The preparation methods of Comparative Examples 1 to 20 were similar to Examples. The main differences were that in Comparative Examples 1 to 20, the average particle size of BN was not less than 5 μm and the reduced powdered mixture was not sieved after the step of grinding, but the rest of the preparing processes were the same as Examples to obtain the Fe-Pt based targets of Comparative Examples 1 to 20. The compositions of the Fe-Pt based targets of Comparative Examples 1 to 20 and the amount in atomic percent of each component of the Fe-Pt based targets of Comparative Examples 1 to 20 were listed in the following Table 1. The Fe-Pt based targets of Comparative Examples 1 to 20 can also be represented by the general formula as denoted in Examples, and the expression of the amount of each component in the general formula is same as the definition of Examples.

Comparative Examples 21 to 22: Fe-Pt based target

Diamond powders and a plurality of grinding balls having a diameter of 5 minimeters (mm) were placed in a ball mill jar and then were subjected to high-energy ball milling for 3 hours to obtain ground diamond powders having an average particle size of 0.5 μm . After that, BN powders were sieved with a sieve having 400 meshes to obtain sieved BN powders. Afterward, adopting suitable amount of Fe powders, Pt powders, the ground diamond powders and the sieved BN powders according to the compositions listed in the following Table 1, and then mixing those powders to obtain a powdered mixture. Then, the powdered mixture was subjected to high-energy ball milling for 3 hours to obtain Fe-Pt based powders, and then sintering the Fe-Pt based powders

according to the sintering methods and the temperature of sintering listed in the following Table 1 to obtain the Fe-Pt based targets of Comparative Examples 21 to 22. The compositions of the Fe-Pt based targets of Comparative Examples 21 to 22 and the amount in atomic percent of each component of the Fe-Pt based targets of Comparative Examples 21 to 22 were listed in the following Table 1. The Fe-Pt based targets of Comparative Examples 21 to 22 can also be represented by the general formula as denoted in Examples, and the expression of the amount of each component in the general formula is same as the definition of Examples.

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Table 1: the compositions, sintering methods and the temperature of sintering of the Fe-Pt based targets of Examples 1 to 25 and Comparative Examples 1 to 22

Sample No.	Compositions of Fe-Pt based target	Sintering method	Temperature of sintering
Example 1	59.9Fe-40Pt-0.1BN	HP	1100°C
Example 2	53Fe-45Pt-2BN	HP	1100°C
Example 3	80Fe-10Pt-10BN	SPS	1000°C
Example 4	35Fe-35Pt-30BN	HP	1000°C
Example 5	26Fe-24Pt-50BN	HP	1000°C
Example 6	18Fe-42Pt-5BN-35C	HIP	800°C
Example 7	50Fe-44Pt-1BN-5C	SPS	950°C
Example 8	50Fe-40Pt-5BN-5B ₄ C	SPS	1100°C
Example 9	35Fe-35Pt-10BN-20SiO ₂	HP	1000°C
Example 10	50Fe-25Pt-5BN-20AlN	HIP	1000°C
Example 11	47Fe-35Pt-3BN-15TiO ₂	HIP	1100°C
Example 12	45Fe-30Pt-5BN-5TaC-10Ta ₂ O ₅ -5TiN	HIP	1050°C
Example 13	40Fe-10Pt-40BN-10Cr ₃ C ₂	HP	1100°C
Example 14	30Fe-27Pt-40BN-3Ag	HP	1000°C

Example 15	40Fe-30Pt-3BN-5SiC-10Cr ₂ O ₃ -5CoO-2C-5Cu	HP	1000°C
Example 16	25Fe-20Pt-1BN-5AlN-39MgO-5C-5Mg	HP	1100°C
Example 17	40Fe-10Pt-30BN-10Mn ₂ O ₃ -10Mn	HP	1000°C
Example 18	25Fe-40Pt-10BN-5SiO ₂ -5TiO ₂ -10Co-5Ge	HIP	850°C
Example 19	37Fe-30Pt-3BN-15TiO ₂ -5Mg-5Mn-5Sr	HIP	1000°C
Example 20	40Fe-10Pt-24BN-7C-12Cu-7Ag	SPS	900°C
Example 21	35Fe-20Pt-5BN-20AlN-5Al-10Ni-5Si	HIP	1000°C
Example 22	25Fe-25Pt-5BN-5Al ₂ O ₃ -30Co-5Al-5Sr	SPS	800°C
Example 23	50Fe-24Pt-1BN-5C-5Au-10Ag-5Cu	SPS	950°C
Example 24	20Fe-15Pt-10BN-20SiO ₂ -30Co-5Ge	HP	1000°C
Example 25	5Fe-40Pt-2BN-5TiN-5B ₂ O ₃ -3HfO ₂ -20Si-20Ni	HIP	900°C
Comparative Example 1	22Fe-18Pt-60BN	HIP	1100°C
Comparative Example 2	20Fe-50Pt-30BN	SPS	1000°C
Comparative Example 3	35Fe-35Pt-30BN	HP	1000°C
Comparative Example 4	35Fe-35Pt-30C	HP	950°C
Comparative Example 5	45Fe-30Pt-5BN-5TaC-10Ta ₂ O ₅ -5TiN	HIP	1050°C
Comparative Example 6	50Fe-40Pt-5BN-5B ₄ C	SPS	1100°C
Comparative Example 7	55Fe-40Pt-1BN-4TiC	HP	1100°C
Comparative Example 8	58Fe-40Pt-1BN-1C	HP	1100°C
Comparative Example 9	10Fe-35Pt-50BN-5WC	SPS	1100°C
Comparative Example 10	20Fe-10Pt-30BN-40C	HIP	1100°C
Comparative Example 11	30Fe-27Pt-40BN-3Ag	HP	1000°C

Comparative Example 12	40Fe-30Pt-3BN-5SiC-10Cr ₂ O ₃ -5CoO-2C-5Cu	HP	1000°C
Comparative Example 13	25Fe-20Pt-1BN-5AlN-39MgO-5C-5Mg	HP	1100°C
Comparative Example 14	40Fe-10Pt-30BN-10Mn ₂ O ₃ -10Mn	HP	1000°C
Comparative Example 15	25Fe-40Pt-10BN-5SiO ₂ -5TiO ₂ -10Co-5Ge	HIP	850°C
Comparative Example 16	40Fe-10Pt-24BN-7C-12Cu-7Ag	SPS	900°C
Comparative Example 17	25Fe-25Pt-5BN-5Al ₂ O ₃ -30Co-5Al-5Sr	SPS	800°C
Comparative Example 18	5Fe-40Pt-2BN-5TiN-5B ₂ O ₃ -3HfO ₂ -20Si-20Ni	HIP	900°C
Comparative Example 19	34Fe-20Pt-8BN-37C-1Co	HIP	900°C
Comparative Example 20	20Fe-10Pt-10BN-10AlN-50Co	HIP	800°C
Comparative Example 21	45Fe-30Pt-5BN-20C	HIP	900°C
Comparative Example 22	40Fe-30Pt-8BN-22C	HIP	900°C

Analysis 1: metallographic microstructure of the Fe-Pt based target

Analysis 1-1: the distribution and morphology of black phases in the metallography

The Fe-Pt based targets of Examples 1 to 25 and Comparative Examples 1 to 22 were further processed by wire cutting and turning to obtain a disc-shaped Fe-Pt based target with diameter of 2 inches and thickness of 3 mm. Then, a 10 mm×10 mm sample was taken from each of the disc-shaped Fe-Pt based targets of Examples 1 to 25 and Comparative Examples 1 to 22 at its half-radius ($r/2$).

Next, the metallographic images of the samples were each obtained by SEM (manufacturer: HITACHI, model: SE-3400) at 2000-fold magnification, and the images of Example 5, Comparative Example 3, Example 22 and Comparative Example 17 are chosen for exemplary explanation and shown in FIG. 1 to FIG. 4 respectively.

In comparison of the images between FIG. 1 and FIG. 2, and between FIG. 3 and FIG. 4, the black phases of the Fe-Pt based targets of Examples 5 and 22 obviously showed a dot-like pattern with an even distribution. However, the black phases of the Fe-Pt based targets of Comparative Examples 3 and 17 showed a large, island-like shaped pattern, which leads to the appearance of uneven distribution of the black phases.

Analysis 1-2: the average size of the black phases in the metallography

A commercially-available image analysis software Image J was used to analyze the metallography of the samples obtained from the Fe-Pt based targets of Examples 1 to 25 and Comparative Examples 1 to 22. Like Analysis 1-1, each of the metallographic images of the samples were obtained by SEM at 2000-fold magnification; in this analysis, each of the samples were taken five metallographic images from five random areas, and then the average size of the black phases of those five metallographic images was analyzed with the built-in function of Image J for measuring the average size called “Feret’s Diameter”. Afterward, the five sets of data of the average size of the black phases were further averaged to represent the average size of the black phases of the Fe-Pt based target, and the results were listed in the following Table 2.

Analysis 1-3: the dispersion uniformity of the black phases in the metallography

The metallographic images of Examples 1 to 25 and Comparative Examples 1 to 22 analyzed in Analysis 1-2 were further analyzed by the built-in function of Image J for measuring the area called “Area” to obtain the total area of the metallographic image, the total area of the black phases in the metallographic image and the total number of the black phases. Then, the dispersion uniformity of the black phases of the five metallographic images was obtained according to the equation for the dispersion uniformity of the black phases defined in this specification. Afterward, the five sets of data of the dispersion uniformity of the black phases were further averaged to represent the dispersion uniformity of the black phases of the Fe-Pt based target, and the results were listed in the following Table 2.

Analysis 2: evaluation of the relative density and the bending strength

The Fe-Pt based targets of Examples 1 to 25 and Comparative Examples 1 to 22 were further processed by wire cutting and turning to obtain a sample with thickness of 3 mm, width of 4 mm and length of 5mm. Then, the relative density of the Fe-Pt based targets of Examples 1 to 25 and Comparative Examples 1 to 22 were obtained according to Archimedes’ principle, and the results were listed in the following Table 2.

Next, the samples of Examples 1 to 25 and Comparative Examples 1 to 22 were placed on an universal testing machine for three-points flexural test. Specifically, the samples were placed on a jig of the three-points flexural test,

and the maximum load was measured under conditions of 20 mm span of the jig and 0.008 mm per second of the rate of pressurization right before the samples were broken. Then, with the equation: the bending strength = $(3 \times \text{the maximum load} \times \text{the span of jig}) / (2 \times \text{the width of sample} \times \text{the thickness of sample} \times \text{the thickness of sample})$, the bending strength of the Fe-Pt based targets of Examples 1 to 25 and Comparative Examples 1 to 22 were obtained, and the results were listed in the following Table 2.

Analysis 3: evaluation of the quality during sputtering

The Fe-Pt based targets of Examples 1 to 25 and Comparative Examples 1 to 22 were further processed by wire cutting and turning to obtain a disc-shaped Fe-Pt based target with diameter of 2 inches and thickness of 3 mm. Then, the target was placed in a magnetic sputtering machine (manufacturer: Kao Duen Technology Corporation), and the magnetic sputtering machine was continuously aerated of argon with amount of 50 sccm (Standard Cubic Centimeter per Minute) and had vacuum environment with pressure of 0.001 torr to 0.01 torr. Afterward, the target was pre-sputtered at power of 200 W for 600 seconds to remove dirt on the surface of the target, and thus a cleaned target ready for evaluating the quality during sputtering was provided.

Next, the cleaned target was placed in a sputtering environment with pressure of 0.001 torr to 0.01 torr and continuously aerated of argon with amount of 50 sccm, and then the cleaned target was sputtered at power of 50 W to 150 W for 300 seconds. During the sputtering, the occurrence of abnormal discharges and the number of falling particles were monitored and measured,

and the results were listed in the following Table 2. The number of falling particles was obtained by detecting the particulates having particle size over 0.5 μm with KLA-Tencor Surfsacn 6420.

Table 2: the compositions, relative density, average size of the black phases, dispersion uniformity of the black phases, bending strength, occurrence of abnormal discharges and number of falling particles of the Fe-Pt based targets of Examples 1 to 25 and Comparative Examples 1 to 22

Sample No.	Compositions of Fe-Pt based target	Relative density (%)	Average size of the black phases (μm)	Dispersion uniformity of the black phases	Bending strength (MPa)	Occurrence of abnormal discharges (times)	Number of falling particles (pieces)
Example 1	59.9Fe-40Pt-0.1BN	98.02	0.34	5.31×10^{-6}	1476	0	1
Example 2	53Fe-45Pt-2BN	97.96	0.41	7.64×10^{-6}	1403	1	1
Example 3	80Fe-10Pt-10BN	97.83	0.37	5.27×10^{-5}	1325	1	3
Example 4	35Fe-35Pt-30BN	97.15	1.43	2.83×10^{-4}	911	11	20
Example 5	26Fe-24Pt-50BN	97.06	1.45	2.80×10^{-4}	871	15	36
Example 6	18Fe-42Pt-5BN-35C	97.02	1.06	6.28×10^{-5}	806	3	6
Example 7	50Fe-44Pt-1BN-5C	97.71	0.31	1.32×10^{-5}	1264	2	3
Example 8	50Fe-40Pt-5BN-5B ₄ C	98.27	0.79	4.01×10^{-5}	963	4	9
Example 9	35Fe-35Pt-10BN-20SiO ₂	97.64	2.38	3.85×10^{-4}	710	16	39
Example 10	50Fe-25Pt-5BN-20AlN	97.32	1.22	2.78×10^{-4}	868	8	11
Example 11	47Fe-35Pt-3BN-15TiO ₂	98.15	1.16	2.43×10^{-4}	937	7	14
Example 12	45Fe-30Pt-5BN-5TaC-10Ta ₂ O ₅ -5TiN	97.93	1.26	1.37×10^{-4}	882	11	17

Example 13	40Fe-10Pt-40BN-10Cr ₃ C ₂	97.56	1.94	4.14×10^{-5}	721	23	41
Example 14	30Fe-27Pt-40BN-3Ag	98.65	1.17	2.72×10^{-4}	836	10	13
Example 15	40Fe-30Pt-3BN-5SiC-10Cr ₂ O ₃ -5CoO-2C-5Cu	98.34	1.76	2.88×10^{-4}	822	12	32
Example 16	25Fe-20Pt-1BN-5AlN-39MgO-5C-5Mg	98.16	2.17	3.24×10^{-4}	712	15	37
Example 17	40Fe-10Pt-30BN-10Mn ₂ O ₃ -10Mn	98.90	1.95	3.16×10^{-4}	763	11	29
Example 18	25Fe-40Pt-10BN-5SiO ₂ -5TiO ₂ -10Co-5Ge	99.03	1.34	1.92×10^{-4}	974	6	18
Example 19	37Fe-30Pt-3BN-15TiO ₂ -5Mg-5Mn-5Sr	98.96	1.04	1.39×10^{-4}	959	6	16
Example 20	40Fe-10Pt-24BN-7C-12Cu-7Ag	99.47	1.02	8.03×10^{-5}	936	9	21
Example 21	35Fe-20Pt-5BN-20AlN-5Al-10Ni-5Si	99.97	1.21	2.69×10^{-4}	916	6	10
Example 22	25Fe-25Pt-5BN-5Al ₂ O ₃ -30Co-5Al-5Sr	99.74	0.83	4.03×10^{-5}	1051	2	8
Example 23	50Fe-24Pt-1BN-5C-5Au-10Ag-5Cu	98.43	0.37	1.47×10^{-5}	1391	3	5
Example 24	20Fe-15Pt-10BN-20SiO ₂ -30Co-5Ge	99.38	2.43	3.96×10^{-4}	785	15	42
Example 25	5Fe-40Pt-2BN-5TiN-5B ₂ O ₃ -3HfO ₂ -20Si-20Ni	99.81	1.58	9.93×10^{-5}	978	5	12
Comparative Example 1	22Fe-18Pt-60BN	95.24	17.91	9.12×10^{-3}	467	103	1666
Comparative Example 2	20Fe-50Pt-30BN	97.23	8.28	7.59×10^{-3}	852	95	862
Comparative Example 3	35Fe-35Pt-30BN	97.41	8.59	7.68×10^{-3}	812	106	895

Comparative Example 4	35Fe-35Pt-30C	95.13	8.94	6.04×10^{-3}	824	226	1394
Comparative Example 5	45Fe-30Pt-5BN-5TaC-10Ta ₂ O ₅ -5TiN	97.63	5.79	7.65×10^{-4}	698	68	534
Comparative Example 6	50Fe-40Pt-5BN-5B ₄ C	97.35	6.43	6.55×10^{-4}	877	49	352
Comparative Example 7	55Fe-40Pt-1BN-4TiC	98.37	6.14	6.29×10^{-4}	893	47	366
Comparative Example 8	58Fe-40Pt-1BN-1C	98.24	5.37	6.51×10^{-4}	945	54	379
Comparative Example 9	10Fe-35Pt-50BN-5WC	95.41	10.26	9.04×10^{-3}	482	95	1147
Comparative Example 10	20Fe-10Pt-30BN-40C	96.98	26.55	1.01×10^{-2}	326	323	2719
Comparative Example 11	30Fe-27Pt-40BN-3Ag	98.32	6.82	9.42×10^{-4}	614	72	681
Comparative Example 12	40Fe-30Pt-3BN-5SiC-10Cr ₂ O ₃ -5CoO-2C-5Cu	98.15	7.69	5.97×10^{-3}	698	80	1054
Comparative Example 13	25Fe-20Pt-1BN-5AlN-39MgO-5C-5Mg	98.09	8.92	8.15×10^{-3}	587	86	1277
Comparative Example 14	40Fe-10Pt-30BN-10Mn ₂ O ₃ -10Mn	99.11	8.27	6.01×10^{-3}	644	62	842
Comparative Example 15	25Fe-40Pt-10BN-5SiO ₂ -5TiO ₂ -10Co-5Ge	99.16	6.22	1.17×10^{-3}	841	49	219

Comparative Example 16	40Fe-10Pt-24BN-7C-12Cu-7Ag	98.82	5.86	6.41×10^{-4}	775	54	667
Comparative Example 17	25Fe-25Pt-5BN-5Al ₂ O ₃ -30Co-5Al-5Sr	99.84	5.51	6.46×10^{-4}	907	36	105
Comparative Example 18	5Fe-40Pt-2BN-5TiN-5B ₂ O ₃ -3HfO ₂ -20Si-20Ni	99.77	6.93	8.58×10^{-4}	853	41	157
Comparative Example 19	34Fe-20Pt-8BN-37C-1Co	96.13	8.91	6.12×10^{-3}	462	109	1236
Comparative Example 20	20Fe-10Pt-10BN-10AlN-50Co	95.20	9.5	6.23×10^{-3}	621	117	1344
Comparative Example 21	45Fe-30Pt-5BN-20C	97.54	5.43	6.33×10^{-4}	736	56	694
Comparative Example 22	40Fe-30Pt-8BN-22C	97.26	6.07	6.71×10^{-4}	722	67	717

Discussion of the experimental results

According to the preparing methods of Examples and the results listed in Table 2, by controlling the average particle size and the amount of BN powders within a specific range as well as sieving, the amount of BN of the prepared Fe-Pt based target is less than or equal to 50 at%, the average size of the black phases of the prepared Fe-Pt based alloy target is less than 3 μm and the dispersion uniformity of the black phases of the prepared Fe-Pt based target is less than 5×10^{-4} . Accordingly, all of the Fe-Pt based targets of Examples 1 to 25 can have the bending strength more than or equal to 700 MPa, bring abnormal discharges less than 30 times, and produce less than 50 falling particles during sputtering. In contrast, Comparative Examples do not control the average particle size and the amount of BN powders within specific ranges and sieve the reduced powdered mixture after grinding at the same time. Accordingly, the amount of BN, the average size of the black phases and the dispersion uniformity of the black phases of the Fe-Pt based targets of Comparative Examples are not within the desired ranges, such that the bending strength of the target cannot be enhanced effectively, and the occurrence of abnormal discharges (still 36 times for the lowest result) and the number of falling particles (still 105 pieces for the lowest result) cannot be reduced effectively, either.

Further referring to the results of Example 1, Example 5, Comparative Example 1 and Comparative Example 4, in comparison with Comparative Example 1 (the amount of BN equals to 60 at%) and Comparative Example 4 (the amount of BN equals to 0 at%), the amount of BN of Example 1 (the

amount of BN equals to 0.1 at%) and Example 5 (the amount of BN equals to 50 at%) are both within the specific range as claimed by the present invention (more than 0 at% and less than or equal to 50 at%). Therefore, both of Example 1 and Example 5 have better results in the bending strength (1476 MPa and 871 MPa respectively), the occurrence of abnormal discharges (0 time and 15 times respectively) and the number of falling particles (1 piece and 36 pieces respectively) compared to the results of Comparative Example 1 and Comparative Example 4 whose bending strength are 467 MPa and 824 MPa respectively; occurrence of abnormal discharges are 103 times and 226 times respectively; and numbers of falling particles are 1666 pieces and 1394 pieces, respectively. Accordingly, controlling the amount of BN within a specific range actually can contribute to enhancing the bending strength of the target, reducing the occurrence of abnormal discharges and also reducing the number of falling particles.

Further referring to the results of Example 4 and Comparative Example 3, although the compositions of the Fe-Pt based targets of Example 4 and Comparative Example 3 are the same, *i.e.*, the amount of BN of Comparative Example 3 is within the range as claimed by the present invention, the average size of the black phases and the dispersion uniformity of the black phases are not within the range as claimed by the present invention. Accordingly, in Example 4, the results of the bending strength (911 MPa), the occurrence of abnormal discharges (11 times) and the number of falling particles (20 pieces) are all much better than the results in Comparative Example 3 (812 MPa for the bending strength, 106 times for the occurrence of abnormal discharges and 895

pieces of the number of falling particles). Accordingly, in addition to controlling the amount of BN within the specific range as claimed by the present invention, the average size of the black phases and the dispersion uniformity of the black phases should also be controlled within the specific
5 range as claimed by the present invention, so as to enhance the bending strength of the target and reduce the occurrence of abnormal discharges and the number of falling particles simultaneously.

Besides, according to the results of Examples 8 to 13, as the Fe-Pt based targets further comprise the first component, and the amount of BN, the
10 sum of the amount of the first component and the amount of BN, the average size of the black phases and the dispersion uniformity of the black phases are all within the specific range as claimed by the present invention, the Fe-Pt based targets of Examples 8 to 13 can also have effects of enhancing the bending strength of the target, reducing the occurrence of abnormal discharges
15 and reducing the number of falling particles. Further referring to the results of Examples 8 and 12, and Comparative Examples 5 and 6, although the compositions of the Fe-Pt based targets between Example 8 and Comparative Example 6, and between Example 12 and Comparative Example 5 are the same, the average size of the black phases and the dispersion uniformity of the
20 black phases of Comparative Examples 5 and 6 are not within the specific range as claimed by the present invention. Therefore, Comparative Examples 5 and 6 still have severe problems of occurrence of abnormal discharges and particulate contamination.

Further referring to the results of Examples 14 to 25, the Fe-Pt based targets of Examples 14 to 25 further comprise the second component.

Accordingly, in comparison with the results of the relative density of Examples 1 to 13, the results of the relative density of Examples 14 to 25 are obviously

5 enhanced, showing all the relative density over 98%, and 99.97% as the highest result. Therefore, further comprising the second component in the Fe-Pt based target can actually enhance the relative density of the Fe-Pt based target. In

contrast, although the compositions of the Fe-Pt based alloy targets of

Comparative Examples 11 to 18 and Examples 14, 15, 16, 17, 18, 20, 22 and 25

10 are the same respectively, the average size of the black phases and the

dispersion uniformity of the black phases of Comparative Examples 11 to 18

are not within the specific range as claimed by the present invention, which

leads to severe problems of occurrence of abnormal discharges and particulate

contamination. Besides, further referring to the results of Comparative

15 Examples 19 and 20, not only the average size of the black phases and the

dispersion uniformity of the black phases are not within the desired range, but

also the amount of the second component is not within the specific range of 2

at% to 40 at% as claimed by the present invention. Therefore, the results of

Comparative Examples 19 and 20 show more occurrence of abnormal

20 discharges (109 times and 117 times respectively) and larger numbers of falling

particles (1236 pieces and 1344 pieces respectively), and also show obviously

worse relative density of the Fe-Pt based target (96.13% and 95.20%

respectively).

In conclusion, by controlling the amount of BN in the Fe-Pt based target, and the average size of the black phases and the dispersion uniformity of the black phases in the metallography of the Fe-Pt based target, the bending strength of the Fe-Pt based target can be enhanced, the occurrence of abnormal discharges during sputtering the Fe-Pt based target can be reduced and the particulate contamination of the magnetic recording layer can be mitigated at the same time, thereby improving the quality and yield of the magnetic recording layer formed from the Fe-Pt based target.

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. An Fe-Pt based target comprising iron, platinum and boron nitride, wherein based on a total amount of the Fe-Pt based target, an amount of boron nitride is more than 0 atomic percent and less than or equal to 50 atomic percent; a metallography of the Fe-Pt based target comprises multiple black phases, an average size of the black phases is less than 3 μm , and a dispersion uniformity of the black phases is less than 5×10^{-4} , wherein the dispersion uniformity is obtained by the following equation:

$$\frac{\text{(a total area of the black phases in the metallography/an area of the metallography)}}{\text{a total number of the black phases}}.$$

2. The Fe-Pt based target as claimed in claim 1, wherein based on the total amount of the Fe-Pt based target, the amount of boron nitride is more than or equal to 3 atomic percent and less than or equal to 30 atomic percent.

3. The Fe-Pt based target as claimed in claim 1, wherein based on the total amount of the Fe-Pt based target, the amount of boron nitride is more than or equal to 5 atomic percent and less than or equal to 25 atomic percent.

4. The Fe-Pt based target as claimed in claim 1, wherein based on the total amount of the Fe-Pt based target, an amount of platinum is more than or equal to 10 atomic percent and less than or equal to 45 atomic percent.

5. The Fe-Pt based target as claimed in claim 1, wherein the Fe-Pt based target further comprises a first component, and the first component is

selected from the group consisting of: an oxide, a carbide, a nitride and any combination thereof; wherein based on the total amount of the Fe-Pt based target, an amount of the first component is more than 0 atomic percent and less than or equal to 50 atomic percent, and a sum of the amount of the first
5 component and the amount of boron nitride is more than or equal to 6 atomic percent and less than or equal to 50 atomic percent.

6. The Fe-Pt based target as claimed in claim 1, wherein the Fe-Pt based target further comprises carbon, and based on the total amount of the Fe-
10 Pt based target, an amount of carbon is more than or equal to 2 atomic percent and less than or equal to 40 atomic percent.

7. The Fe-Pt based target as claimed in claim 5, wherein the oxide comprises silicon dioxide, titanium(IV) oxide, chromium(III) oxide,
15 tantalum(V) oxide, cobalt(II) oxide, manganese(III) oxide, boron trioxide, hafnium(IV) oxide, magnesium oxide, aluminum oxide, zirconium(IV) oxide, niobium(V) oxide, vanadium(V) oxide, tungsten(VI) oxide, iron(III) oxide, zinc oxide or any combination thereof.

20 8. The Fe-Pt based target as claimed in claim 5, wherein the nitride comprises aluminum nitride, titanium nitride, chromium nitride, zirconium nitride, tantalum nitride, hafnium nitride, silicon nitride, titanium carbon nitride, tungsten nitride or any combination thereof.

9. The Fe-Pt based target as claimed in claim 5, wherein the carbide comprises silicon carbide, boron carbide, titanium carbide, tungsten carbide, tantalum carbide, hafnium carbide, zirconium carbide, vanadium carbide, niobium carbide, chromium carbide or any combination thereof.

5

10. The Fe-Pt based target as claimed in claim 1, wherein the Fe-Pt based target further comprises a second component, and the second component is selected from the group consisting of: silver, gold, germanium, copper, nickel, cobalt, aluminum, magnesium, manganese, silicon, strontium and any combination thereof; wherein based on the total amount of the Fe-Pt based target, an amount of the second component is more than or equal to 2 atomic percent and less than or equal to 40 atomic percent.

10

11. The Fe-Pt based target as claimed in claim 10, wherein the Fe-Pt based target further comprises carbon, and based on the total amount of the Fe-Pt based target, an amount of carbon is more than or equal to 2 atomic percent and less than or equal to 20 atomic percent.

15

12. The Fe-Pt based target as claimed in claim 5, wherein the Fe-Pt based target further comprises a second component, and the second component is selected from the group consisting of: silver, gold, germanium, copper, nickel, cobalt, aluminum, magnesium, manganese, silicon, strontium and any combination thereof; wherein based on the total amount of the Fe-Pt based target, an amount of the second component is more than or equal to 2 atomic percent and less than or equal to 40 atomic percent.

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13. The Fe-Pt based target as claimed in claim 12, wherein the Fe-Pt based target further comprises carbon, and based on the total amount of the Fe-Pt based target, an amount of carbon is more than or equal to 2 atomic percent
5 and less than or equal to 20 atomic percent.

14. The Fe-Pt based target as claimed in any of claims 1 to 13, wherein a bending strength of the Fe-Pt based target is more than or equal to 700 MPa.
10

15. A preparation method of an Fe-Pt based target, comprising steps as follows:

step (a): mixing raw materials of iron, platinum, and boron nitride to obtain a raw material mixture, wherein an average particle size of the raw
15 material of boron nitride is less than 5 μm ;

step (b): grinding the raw material mixture for 4 hours to 12 hours, and then sieving the raw material mixture through a sieve having more than or equal to 800 meshes and less than or equal to 1200 meshes, taking remaining matters above the sieve and then repeating the processes of grinding and
20 sieving to obtain a raw material mixture of the Fe-Pt based target; and

step (c): sintering the raw material mixture of the Fe-Pt based target to obtain the Fe-Pt based target;

wherein, based on a total amount of the Fe-Pt based target, an amount of the raw material of boron nitride is more than 0 atomic percent and less than
25 or equal to 50 atomic percent;

wherein a metallography of the Fe-Pt based target comprises multiple black phases, and an average size of the black phases is less than 3 μm , and a dispersion uniformity of the black phases is less than 5×10^{-4} , wherein the dispersion uniformity is obtained by the following equation:

5

$$\frac{(\text{a total area of the black phases in the metallography}/\text{an area of the metallography})}{\text{a total number of the black phases}} .$$

16. The preparation method as claimed in claim 15, wherein based on the total amount of the raw material mixture of the Fe-Pt based target, an
10 amount of the raw material of platinum is more than or equal to 10 atomic percent and less than or equal to 45 atomic percent.

17. The preparation method as claimed in claim 15, wherein the raw material mixture of the Fe-Pt based target further comprises a first component,
15 and the first component is selected from the group consisting of: a raw material of oxide, a raw material of carbide, a raw material of nitride and any combination thereof; wherein based on the total amount of the raw material mixture of the Fe-Pt based target, an amount of the first component is more than 0 atomic percent and less than or equal to 50 atomic percent, and a sum of
20 the amount of the first component and the amount of the raw material of boron nitride is more than or equal to 6 atomic percent and less than or equal to 50 atomic percent.

18. The preparation method as claimed in claim 15, wherein the raw material mixture of the Fe-Pt based target further comprises a raw material of carbon, and based on the total amount of the raw material mixture of the Fe-Pt based target, an amount of the raw material of carbon is more than or equal to 2
5 atomic percent and less than or equal to 40 atomic percent.

19. The preparation method as claimed in claim 15, wherein the raw material mixture of the Fe-Pt based target further comprises a second component, and the second component is selected from the group consisting of:
10 a raw material of silver, a raw material of gold, a raw material of germanium, a raw material of copper, a raw material of nickel, a raw material of cobalt, a raw material of aluminum, a raw material of magnesium, a raw material of manganese, a raw material of silicon, a raw material of strontium and any combination thereof; wherein based on the total amount of the raw material
15 mixture of the Fe-Pt based target, an amount of the second component is more than or equal to 2 atomic percent and less than or equal to 40 atomic percent.

20. The preparation method as claimed in claim 15, wherein in the step (c), a temperature of sintering is more than or equal to 600°C and less than
20 or equal to 1200°C, and a pressure of sintering is more than or equal to 350 bar and less than or equal to 1800 bar.