

DESCRIPTION

SPUTTERING TARGET FOR FORMING MAGNETIC RECORDING FILM,
AND CARBON RAW MATERIAL USED FOR PRODUCTION OF SAID
TARGET

TECHNICAL FIELD

[0001] The present invention relates to a sputtering target that is used for the deposition of a granular magnetic thin film in a magnetic recording medium, and a carbon raw material that is used for the production of such a target.

BACKGROUND ART

[0002] In the field of magnetic recording as represented with hard disk drives, a material based on Co, Fe or Ni as ferromagnetic metals is being used as the material of the magnetic thin film in a magnetic recording medium. For example, Co-Cr-based or Co-Cr-Pt-based ferromagnetic alloys having Co as its main component are used for the magnetic thin film of hard disks adopting the longitudinal magnetic recording system. Moreover, composite materials made from Co-Cr-Pt-based ferromagnetic alloys having Co as its main component and nonmagnetic inorganic substance grains are often used for the magnetic thin film of hard disks adopting the perpendicular magnetic recording system which was recently put into practical application. In addition, the foregoing magnetic thin film is often produced by sputtering a target having the foregoing materials as its components using a DC magnetron sputtering equipment in light of its high productivity.

[0003] The recording density of hard disks is rapidly increasing year by year, and the current surface density of 600 Gbit/in² is expected to reach 1 Tbit/in² in the future. When the recording density reaches 1 Tbit/in², the size of the recording bit will fall below 10 nm. In such a case, it is anticipated that the super-paramagnetization caused by thermal fluctuation will become a problem, and it is further anticipated that the material currently used for a magnetic recording medium; for instance, a material with higher magnetic crystalline anisotropy obtained by adding Pt to a Co-Cr-based alloy, will no longer be

sufficient. This is because, for grains to stably behave ferromagnetically at a size of 10 nm or less, the magnetic grains need to possess even higher magnetic crystalline anisotropy.

[0004] Due to the foregoing reasons, an FePt phase having an L1₀ structure is attracting attention as a material for use in an ultrahigh-density recording medium. Since an FePt phase having a L1₀ structure exhibits high crystal magnetic anisotropy and yields superior corrosion resistance and oxidation resistance, it is expected to become a material that can be suitably applied for a magnetic recording medium. Furthermore, in connection with using the FePt phase as a material for use in an ultrahigh-density recording medium, demanded is the development of technology for dispersing the ordered FePt magnetic grains, in a magnetically isolated state, while densely aligning the orientation thereof as much as possible.

[0005] In light of the foregoing circumstances, a magnetic thin film having a granular structure in which the FePt magnetic grains having an L1₀ structure are isolated through the interposition of nonmagnetic materials such as oxide and carbon is being proposed for use in a magnetic recording medium of next-generation hard disks adopting the thermally assisted magnetic recording system. This magnetic thin film has a granular structure in which the magnetic grains are magnetically insulated from each other through the interposition of nonmagnetic substances. Documents related to magnetic recording mediums having a granular magnetic thin film and other related publications include, for example, Patent Document 1, Patent Document 2, Patent Document 3, Patent Document 4, and Patent Document 5 listed below.

[0006] As a magnetic thin film having a granular structure with the foregoing FePt phase having the L1₀ structure, a magnetic thin film containing C as a nonmagnetic substance at a volume ratio of 10 to 50% is particularly attracting attention from its high magnetic properties. It is known that this type of magnetic thin film having a granular structure is produced by simultaneously sputtering an Fe target, a Pt target, and a C target, or simultaneously sputtering an Fe-Pt alloy target, and a C target. Nevertheless, an expensive cosputtering equipment is required for simultaneously sputtering the foregoing sputtering targets.

[0007] Moreover, generally speaking, when a sputtering target, in which an alloy contains a nonmagnetic material, is sputtered with a sputtering equipment,

there is a problem in that the nonmagnetic material becomes inadvertently detached during sputtering or abnormal discharge occurs with the holes included in the sputtering target as the origin, and particles (foreign particles that become adhered to the substrate) are generated. In order to resolve this problem, the adhesion between the nonmagnetic material and the base metal alloy needs to be increased, and the high densification of the sputtering target is required. Generally speaking, a material of a sputtering target in which a nonmagnetic material is contained in an alloy is prepared by a powder sintering method. However, when a large amount of C is contained in Fe-Pt, since C is a sintering-resistant material, it is difficult to obtain a high-density sintered compact.

[0008] Moreover, the present inventors previously proposed a technology of producing a high-density sputtering target by finely and uniformly dispersing C grains, which are a nonmagnetic material, in a base metal to obtain an Fe-Pt-based sputtering target with C grains dispersed therein (Patent Document 6). According to this technology, while it is possible to inhibit the agglomeration of the C grains, so as long as the C grains are a sintering-resistant material, it was difficult to improve the sinterability of the C grains themselves. Moreover, while Patent Documents 7 and 8 describe a technology of inhibiting the abnormal discharge during sputtering and location-dependent differences in the sputter rate by dispersing a C phase in an FePt alloy phase in a sputtering target for forming a thin-film magnetic recording medium, they make no reference to improving the sinterability of C (carbon).

[0009] Patent Document 1: Japanese Patent Application Publication No. 2000-306228
Patent Document 2: Japanese Patent Application Publication No. 2000-311329
Patent Document 3: Japanese Patent Application Publication No. 2008-59733
Patent Document 4: Japanese Patent Application Publication No. 2008-169464
Patent Document 5: Japanese Patent Application Publication No. 2004-152471
Patent Document 6: Pamphlet of International Publication No. 2012/086335
Patent Document 7: Japanese Patent Application Publication No. 2012-102387
Patent Document 8: Japanese Patent Application Publication No. 2012-214874

SUMMARY OF INVENTION

[Technical Problem]

[0010] An object of this invention is to provide an Fe-Pt-based sputtering target with C grains dispersed therein which enables the production of a magnetic thin film having a granular structure without using an expensive cosputtering equipment, and the reduction in the amount of particles that are generated during sputtering.

[Solution to Problem]

[0011] In order to achieve the foregoing object, as a result of intense study, the present inventors discovered that the sintering resistance of carbon can be remedied by adjusting the fluorine content in a carbon raw material, which is a nonmagnetic material. Moreover, since the thus produced sputtering target can prevent the carbon from becoming detached and reduce the amount of particles that are generated, the present inventors discovered that the deposition yield can also be improved.

[0012] Based on the foregoing discovery, the present invention provides:

- 1) A carbon powder for use in producing a sputtering target for forming a magnetic recording film, wherein a fluorine content is 50 wtpm or more;
- 2) The carbon powder according to 1) above, wherein a median size is 0.1 to 20 μm
- 3) A sputtering target for forming a magnetic recording film, wherein the carbon powder according to 1) or 2) above is used as a raw material of the target, and the target is prepared by a powder sintering method;
- 4) The sputtering target for forming a magnetic recording film according to 3) above, wherein a fluorine content is less than 0.05 wtpm;
- 5) A method of producing a sputtering target for forming a magnetic recording film, wherein raw material powders including the carbon powder according to 1) or 2) above are mixed, the mixed powder is molded and sintered, and the obtained sintered compact is additionally subject to hot isostatic pressing and thereafter processed into a target shape.

[Advantageous Effects of Invention]

[0013] The Fe-Pt-based sputtering target with C grains dispersed therein according to the present invention yields a superior effect of enabling the deposition of a magnetic thin film having a granular structure without using an expensive cosputtering equipment, and the reduction in the amount of particles that are generated during sputtering.

DESCRIPTION OF EMBODIMENTS

[0014] The present invention is characterized in that the fluorine (F) content in the carbon powder, which is used for producing a sputtering target for forming a magnetic recording film, is caused to be 50 wtppm or more. Since a carbon powder contains fluorine (F) as an impurity, a raw material with low impurity content is generally used.

Here, while the fluorine in the carbon raw material exists in the form of being bound to carbon, a reaction of such bond to be broken (defluorination reaction) occurs by exposure to a high temperature. Here, a reaction that carbon becomes bound to another carbon via a leftover atomic bonding hand will occur. According to the present invention, by using a carbon raw material powder that preliminarily contains a relatively large amount of fluorine, the binding reaction between carbon grains during the defluorination reaction can be promoted, and the sintering resistance of carbon can thereby be remedied.

[0015] Moreover, the present invention additionally covers a case where the median size of the carbon raw material powder, which is used for producing the sputtering target for forming a magnetic recording film, is 0.1 to 20 μm . In order to promote the binding reaction between grains of the carbon raw material by the foregoing defluorination reaction, preferably, the surfaces of grains of the carbon powder having the carbon-fluorine bond are in contact with each other as much as possible. If the median size of the carbon raw material powder is less than 0.1 μm , there are cases where the fluorine content relative to the number of carbon grains becomes insufficient. Meanwhile, when the median size of the carbon raw material powder exceeds 20 μm , the carbon raw material itself could become the cause of an abnormal discharge, which is undesirable. Accordingly, the median size of the carbon raw material powder is preferably 0.1 to 20 μm .

[0016] Moreover, the present invention is characterized in producing a sputtering target for forming a magnetic recording film by using a carbon raw material powder having a fluorine (F) content of 50 wtppm or more and, as needed, a median size of 0.1 to 20 μm to perform sintering. Since the sintering of carbon can be promoted by using this kind of carbon raw material powder, it is possible to inhibit the carbon from becoming detached from the target upon sputtering

and consequently generating particles. Note that the present invention is unique with regard to the fluorine content in the carbon raw material powder and other features, and it should be easy to understand that publicly known means may be used as the sintering means.

5 [0017] Moreover, the present invention additionally covers a case where the fluorine content in the sputtering target for forming a magnetic recording film is less than 0.05 wtppm. The amount of fluorine contained in the carbon raw material powder will decrease due to the defluorination reaction as a result of exposure to a high temperature during sintering. This implies that, on the
10 other hand, the bonding (sintering) of the carbon grains is promoted. Accordingly, by adjusting the fluorine content in the carbon raw material powder and the fluorine content in the target, it is possible to quantitatively control the bonding amount of carbon. If the fluorine content in the target is 0.05 wtppm or more, the fluorine may become the cause of an abnormal discharge and
15 induce the generation of particles, which is undesirable.

[0018] Moreover, in the present invention, a publicly known composition may be used for the sputtering target for forming a magnetic recording film. For example, used may be an Fe-Pt alloy-based target with C grains dispersed therein in which the Pt content is 20 or more and 50 or less based on atomic
20 ratio, and the C content is 20 or more and 50 or less based on atomic ratio. Moreover, in the present invention, one or more metal elements selected from Ag, Cu, Au, B, Ru, and Mn may be added as an additive material, and oxides or nitrides of one or more elements selected from Si, Ti, Cr, Co, Fe, B, Ta, Ga, Mn, Zn, Nb, Al, Mg, Zr, Y, and Ca may also be added as an additive material. The
25 thus produced magnetic thin film can thereby yield favorable magnetic properties.

[0019] The sputtering target of the present invention is produced by the powder sintering method. Upon producing the sputtering target of the present invention, respective raw material powders (Fe powder, Pt powder, C powder and the like) are prepared. Here, as the C powder, it is important to use a C
30 power containing a predetermined amount of fluorine, a C powder that was preliminarily subject to fluorination treatment, or a mixed powder containing a C powder that was subject to fluorination treatment and another carbon raw material.

35 The C powder desirably has a grain size of 0.1 μm or more and 20 μm or

less. If the grain size of the raw material C powder is too small, there is a problem in that the fluorine content may become insufficient. Meanwhile, if the grain size of the raw material powder is too large, it will be difficult for the C grains to become finely dispersed in the alloy, and may become the cause of an abnormal discharge. Desirably, the other raw material powders also have a grain size of 0.1 μm or more and 20 μm or less.

In addition, an alloy powder (Fe-Pt powder or the like) may be used as the raw material powder. In particular, while this also depends on the composition, an alloy powder containing Pt is effective for reducing the oxygen content in the raw material powder. When using an alloy powder, it is also desirable to use an alloy powder having a grain size of 0.1 μm or more and 20 μm or less.

[0020] Subsequently, the foregoing powders are weighed to achieve the intended composition, and mixed using a publicly known means such as a mortar. The thus obtained mixed powder is molded and sintered by being subject to hot pressing. The plasma discharge sintering method and the hot isostatic sintering method may also be used in addition to the hot press method. While this will also depend on the composition of the sputtering target, the holding temperature during sintering is, in most cases, within a temperature range of 900 to 1400°C.

[0021] Subsequently, the sintered compact removed from the hot press is subject to hot isostatic pressing. The hot isostatic pressing is effective in increasing the density of the sintered compact. While this will also depend on the composition of the sintered compact, the holding temperature during hot isostatic pressing is, in most cases, within a temperature range of 900 to 1400°C. Moreover, the pressure is set to 100 Mpa or more.

By processing the thus obtained sintered compact into an intended shape using a lathe or the like, the sputtering target of the present invention can be produced.

[0022] Based on the above, it is possible to produce a sputtering target for forming a magnetic recording film in which the sintering resistance of carbon is remedied. The sputtering target of the present invention produced as described above generates few particles during sputtering, and is effective as a sputtering target for use in the deposition of a magnetic thin film having a granular structure.

[Examples]

[0023] The present invention is now explained in detail with reference to the Examples and Comparative Examples. Note that these Examples are merely illustrative, and the present invention shall in no way be limited thereby. In other words, various modifications and other embodiments are covered by the present invention, and the present invention is limited only by the scope of its claims.

[0024] (Example 1)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , and a C powder having an average grain size of 1 μm . As the C powder, natural graphite containing 150 wtppm of fluorine was used. Moreover, the median size (D50) of the C powder was 6.1 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

Note that the fluorine content was analyzed with a GDMS (Glow Discharge Mass Spectrometry). The same applies to the following Examples and Comparative Examples.

[0025] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1400°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian

method, and the calculated relative density was 96.1%.

[0026] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 130 particles.

[0027] (Comparative Example 1)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , and a C powder having an average grain size of 1 μm . As the C powder, carbon black having a fluorine content of 1 wtppm and a median size (D50) of 0.05 μm was used. These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

[0028] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1400°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding,

the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 94.8%.

5 [0029] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

10 The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by
15 KLA-Tencor). The number of particles in this case was 4530 particles.

[0030] (Comparative Example 2)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , and a C powder having an average grain size of 1 μm . As the C powder,
20 graphite having a fluorine content of 5 wtppm and a median size (D50) of 6.3 μm was used. These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

[0031] Subsequently, the weighed powders were placed in a mortar having a
25 capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1400°C,
30 and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as
35 follows; namely, rate of temperature increase of 300°C/hour, holding

temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

5 The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 94.3%.

[0032] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

10 The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 1121 particles.

[0033] (Example 2)

20 As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , and a C powder having an average grain size of 1 μm . As the C powder, used was a product obtained by adding fluorinated graphite (fluorine content ratio of 40%) having an average grain size of 5 μm to the raw material of Comparative Example 3 described later until the fluorine content reached 60 wtppm, and mixing this powder with a mortar. Moreover, the median size (D50) of the C powder was 19.8 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

30 [0034] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

35 The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1400°C,

and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 96.3%.

[0035] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 327 particles.

[0036] (Comparative Example 3)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , and a C powder having an average grain size of 1 μm . As the C powder, graphite having a fluorine content of 5 wtppm and a median size (D50) of 20.2 μm was used. These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

[0037] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot

pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1400°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 94.8%.

[0038] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 2534 particles.

[0039] (Example 3)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , and a C powder having an average grain size of 1 μm . As the C powder, used was a product obtained by adding fluorinated graphite (fluorine content ratio of 40%) having an average grain size of 10 μm to the raw material of Comparative Example 4 described later until the fluorine content reached 200 wtppm, and mixing this powder with a mortar. Moreover, the median size (D50) of the C

powder was 13.4 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

[0040] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1400°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 96.1%.

[0041] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 86 particles.

[0042] (Comparative Example 4)

As the raw material powders, prepared were an Fe powder having an

average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , and a C powder having an average grain size of 1 μm . As the C powder, graphite having a fluorine content of 5 wtppm and a median size (D50) of 13.9 μm was used. These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

[0043] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1200°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 94.6%.

[0044] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 1062 particles.

[0045] (Example 4)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , and a C powder having an average grain size of 1 μm . As the C powder, natural graphite containing 40 wtppm of fluorine was used. Moreover, the median size (D50) of the C powder was 0.11 μm . These powders were

weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

[0046] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1400°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 96.3%.

[0047] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 432 particles.

[0048] (Comparative Example 5)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm ,

and a C powder having an average grain size of 1 μm . As the C powder, a product obtained by calcinating the raw material of Example 4 in the atmosphere at 600°C for defluorination was used. This C powder had a fluorine content of less than 0.05 wtpm and a median size (D50) of 0.13 μm .
5 These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

[0049] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed
10 powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1400°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the
15 start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding
20 temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than
25 0.05 wtpm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 94.2%.

[0050] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering
30 system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kWhr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of
35 0.2 to 3.0 μm that adhered on the substrate was measured with a surface

contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 3237 particles.

[0051] (Example 5)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , and a C powder having an average grain size of 1 μm . As the C powder, used was a product obtained by adding fluorinated graphite (fluorine content ratio of 40%) having an average grain size of 5 μm to the raw material of Comparative Example 6 described later until the fluorine content reached 15000 wtppm, and mixing this powder with a mortar. Moreover, the median size (D50) of the C powder was 5.6 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

[0052] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1400°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 96.0%.

[0053] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering

system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 78 particles.

[0054] (Comparative Example 6)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , and a C powder having an average grain size of 1 μm . As the C powder, graphite having a fluorine content of 5 wtppm and a median size (D50) of 5.9 μm was used. These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-30Pt-40C

[0055] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1400°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 94.7%.

[0056] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

5 The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 1680 particles.

[0057] (Example 6)

15 As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , a Ag powder having an average grain size of 5 μm , and a C powder having an average grain size of 1 μm . As the C powder, natural graphite containing 150 wtppm of fluorine was used. Moreover, the median size (D50) of the C powder was 6.1 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

20 Atomic ratio: Fe-25Pt-5Ag-40C

[0058] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

25 The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 950°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

30 Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 950°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 950°C. After the end of holding,

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the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 97.2%.

5 [0059] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

10 The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 45 particles.

15 [0060] (Comparative Example 7)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , a Ag powder having an average grain size of 5 μm , and a C powder having an average grain size of 1 μm . As the C powder, a product obtained by calcinating the raw material of Example 6 in the atmosphere at 600°C for defluorination was used. This C powder had a fluorine content of less than 0.05 wtppm and a median size (D50) of 6.1 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

25 Atomic ratio: Fe-25Pt-5Ag-40C

[0061] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

30 The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 950°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

35 Subsequently, the sintered compact removed from the hot press mold was

subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 950°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 950°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 96.1%.

[0062] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 289 particles.

[0063] (Example 7)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , a C powder having an average grain size of 1 μm , and a SiO_2 powder having an average grain size of 1 μm . As the C powder, natural graphite containing 150 wtppm of fluorine was used. Moreover, the median size (D50) of the C powder was 6.1 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-36Pt-15C-8 SiO_2

[0064] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1090°C,

and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 98.8%.

[0065] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 22 particles.

[0066] (Comparative Example 8)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , a C powder having an average grain size of 1 μm , and a SiO_2 powder having an average grain size of 1 μm . As the C powder, a product obtained by calcinating the raw material of Example 7 in the atmosphere at 600°C for defluorination was used. This C powder had a fluorine content of less than 0.05 wtppm and a median size (D50) of 6.1 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-36Pt-15C-8 SiO_2

[0067] Subsequently, the weighed powders were placed in a mortar having a

capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1090°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 1100°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 97.6%.

[0068] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 108 particles.

[0069] (Example 8)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , a Cu powder having an average grain size of 3.5 μm , and a C powder having an average grain size of 1 μm . As the C powder, natural graphite containing 150 wtppm of fluorine was used. Moreover, the median size (D50) of the C

powder was 6.1 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-25Pt-5Cu-40C

[0070] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1060°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 950°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 950°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 97.1%.

[0071] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 28 particles.

[0072] (Comparative Example 9)

As the raw material powders, prepared were an Fe powder having an

average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , a Cu powder having an average grain size of 3.5 μm , and a C powder having an average grain size of 1 μm . As the C powder, a product obtained by calcinating the raw material of Example 6 in the atmosphere at 600°C for defluorination was used. This C powder had a fluorine content of less than 0.05 wtppm and a median size (D50) of 6.1 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-25Pt-5Cu-40C

[0073] Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1060°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 950°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 950°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 96.5%.

[0074] Subsequently, the obtained sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW/hr, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of

0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 265 particles.

[0075] (Example 9)

5 As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , a Ag powder having an average grain size of 5 μm , a BN powder having an average grain size of 10 μm , and a C powder having an average grain size of 1 μm . As the C powder, natural graphite containing 150 wtppm of fluorine was
10 used. Moreover, the median size (D50) of the C powder was 6.1 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-25Pt-5Ag-20BN-20C

[0076] Subsequently, the weighed powders were placed in a mortar having a
15 capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 950°C, and
20 holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as
25 follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 950°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 950°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

30 The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 97.3%.

[0077] Subsequently, the obtained sintered compact was machined with a lathe
35 into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering

system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kW, film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 34 particles.

[0078] (Comparative Example 10)

As the raw material powders, prepared were an Fe powder having an average grain size of 3 μm , a Pt powder having an average grain size of 3 μm , a Ag powder having an average grain size of 5 μm , a BN powder having an average grain size of 10 μm , and a C powder having an average grain size of 1 μm . As the C powder, a product obtained by calcinating the raw material of Example 6 in the atmosphere at 600°C for defluorination was used. This C powder had a fluorine content of less than 0.05 wtppm and a median size (D50) of 6.1 μm . These powders were weighed to attain a total weight of 2600 g based on the following atomic ratio.

Atomic ratio: Fe-25Pt-5Ag-20BN-20C

Subsequently, the weighed powders were placed in a mortar having a capacity of 10 liters, and mixed by agitation therein for 4 hours. The mixed powder removed from the mortar was thereafter filled in a carbon mold and hot pressed.

The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 950°C, and holding time of 2 hours, and a pressure of 30 MPa was applied from the start of temperature increase to the end of holding. After the end of holding, the resultant product was naturally cooled as is in the chamber.

Subsequently, the sintered compact removed from the hot press mold was subject to hot isostatic pressing. The hot isostatic pressing conditions were as follows; namely, rate of temperature increase of 300°C/hour, holding temperature of 950°C, and holding time of 2 hours, and the Ar gas pressure was gradually increased from the start of temperature increase, and a pressure of 150 MPa was applied during the holding at 950°C. After the end of holding, the resultant product was naturally cooled as is in the furnace.

The fluorine content of the thus produced sintered compact was less than 0.05 wtppm. Moreover, the density was measured by the Archimedian method, and the calculated relative density was 96.3%.

[0080] Subsequently, the obtained sintered compact was machined with a lathe
5 into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm, thereafter mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, input power of 1 kW and Ar gas pressure of 1.7 Pa, and after performing pre-sputtering at 2 kWhr,
10 film deposition was performed onto a silicon substrate having a 4-inch diameter for 20 seconds. Subsequently, the number of particles having a diameter of 0.2 to 3.0 μm that adhered on the substrate was measured with a surface contamination inspection system (Surfscan 6420 manufactured by KLA-Tencor). The number of particles in this case was 326 particles.

[0081] The foregoing results are summarized in Table 1. As shown in Table 1,
15 the sputtering target of the present invention was able to maintain a high density in all of the Examples, and the number of particles that were generated during sputtering was 500 particles or less, and considerably fewer in comparison to the Comparative Examples.

[0082] [Table 1]
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	Type of carbon raw material	Median size (D50) of carbon raw material	Fluorine content of carbon raw material	Mixing method	Sintered compact composition (mol%)	Sintered compact density	Fluorine content of sintered compact	Number of particles
Example 1	Graphite	6.1 μm	150 wtppm	Mortar	Fe-30Pt-40C	96.1%	Less than 0.05 wtppm	130 particles
Example 2	Graphite	19.8 μm	60 wtppm	Mortar	Fe-30Pt-40C	96.3%	Less than 0.05 wtppm	327 particles
Example 3	Graphite	13.4 μm	200 wtppm	Mortar	Fe-30Pt-40C	96.1%	Less than 0.05 wtppm	86 particles
Example 4	Graphite	0.11 μm	40 wtppm	Mortar	Fe-30Pt-40C	96.3%	Less than 0.05 wtppm	432 particles
Example 5	Graphite	5.6 μm	15000 wtppm	Mortar	Fe-30Pt-40C	96.0%	Less than 0.05 wtppm	78 particles
Example 6	Graphite	6.1 μm	150 wtppm	Mortar	Fe-25Pt-5Ag-40C	97.2%	Less than 0.05 wtppm	45 particles
Example 7	Graphite	6.1 μm	150 wtppm	Mortar	Fe-36Pt-15C-8SiO ₂	98.8%	Less than 0.05 wtppm	22 particles
Example 8	Graphite	6.1 μm	150 wtppm	Mortar	Fe-25Pt-5Cu-40C	97.1%	Less than 0.05 wtppm	28 particles
Example 9	Graphite	6.1 μm	150 wtppm	Mortar	Fe-25Pt-5Ag-20BN-20C	97.3%	Less than 0.05 wtppm	34 particles
Comparative Example 1	Carbon black	0.05 μm	1 wtppm	Mortar	Fe-30Pt-40C	94.8%	Less than 0.05 wtppm	4530 particles
Comparative Example 2	Graphite	6.3 μm	5 wtppm	Mortar	Fe-30Pt-40C	94.3%	Less than 0.05 wtppm	1121 particles
Comparative Example 3	Graphite	20.2 μm	5 wtppm	Mortar	Fe-30Pt-40C	94.8%	Less than 0.05 wtppm	2534 particles
Comparative Example 4	Graphite	13.9 μm	5 wtppm	Mortar	Fe-30Pt-40C	94.6%	Less than 0.05 wtppm	1062 particles
Comparative Example 5	Graphite	0.13 μm	Less than 0.05 wtppm	Mortar	Fe-30Pt-40C	94.2%	Less than 0.05 wtppm	3237 particles
Comparative Example 6	Graphite	5.9 μm	5 wtppm	Mortar	Fe-30Pt-40C	94.7%	Less than 0.05 wtppm	1680 particles
Comparative Example 7	Graphite	6.1 μm	Less than 0.05 wtppm	Mortar	Fe-25Pt-5Ag-40C	96.1%	Less than 0.05 wtppm	289 particles
Comparative Example 8	Graphite	6.1 μm	Less than 0.05 wtppm	Mortar	Fe-36Pt-15C-8SiO ₂	97.6%	Less than 0.05 wtppm	108 particles
Comparative Example 9	Graphite	6.1 μm	Less than 0.05 wtppm	Mortar	Fe-25Pt-5Cu-40C	96.5%	Less than 0.05 wtppm	265 particles
Comparative Example 10	Graphite	6.1 μm	Less than 0.05 wtppm	Mortar	Fe-25Pt-5Ag-20BN-20C	96.3%	Less than 0.05 wtppm	326 particles

INDUSTRIAL APPLICABILITY

[0083] The present invention yields a superior effect of being able to provide a high-density Fe-Pt-based sputtering target with C grains dispersed therein which enables the deposition of a magnetic thin film having a granular structure without using an expensive cosputtering equipment, and the reduction in the amount of particles that are generated during sputtering. Accordingly, the present invention is effective as a sputtering target for depositing a magnetic thin film having a granular structure.

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CLAIMS

[Claim 1] A carbon powder for use in producing a sputtering target for forming a magnetic recording film, wherein a fluorine content is 50 wtpm or more.

[Claim 2] The carbon powder according to claim 1, wherein a median size is 0.1 to 20 μm .

[Claim 3] A sputtering target for forming a magnetic recording film, wherein the carbon powder according to claim 1 or claim 2 is used as a raw material of the target, and the target is prepared by a powder sintering method.

[Claim 4] The sputtering target for forming a magnetic recording film according to claim 3, wherein a fluorine content is less than 0.05 wtpm.

[Claim 5] A method of producing a sputtering target for forming a magnetic recording film, wherein raw material powders including the carbon powder according to claim 1 or claim 2 are mixed, the mixed powder is molded and sintered, and the obtained sintered compact is additionally subject to hot isostatic pressing and thereafter processed into a target shape.