

## DESCRIPTION

### SPUTTERING TARGET

#### 5 TECHNICAL FIELD

[0001] The present invention relates to a sputtering target that is used for forming a thin film of a magnetic recording medium. In particular the present invention relates to a sputtering target having a structure in which oxide phases are dispersed in metal phases having Co as the main component.

#### BACKGROUND ART

[0002] In the field of magnetic recording/reproduction devices as represented by hard disk devices, the perpendicular magnetic recording system of aligning the easy axis of magnetization in a vertical direction relative to the recording surface has been put into practical application. In particular, with a hard-disk medium adopting the perpendicular magnetic recording system, a magnetic thin film having a granular structure in which the magnetic crystal grains aligned in the vertical direction are surrounded by a nonmagnetic material and the magnetic interaction between the magnetic grains is reduced has been developed for achieving higher recording density and noise reduction.

[0003] Ferromagnetic alloys having Co as the main component are being used as the foregoing magnetic crystal grains, and oxides are being used as the nonmagnetic material. This kind of magnetic thin film having a granular structure is formed on a substrate by sputtering a target, which has a structure of oxide phases dispersed in metal phases, using a magnetron sputtering equipment.

[0004] However, during the sputtering process, there is a problem in that extraneous matter known as particles become adhered to the substrate with the thin film formed thereon. It is known that many of the particles that are generated during deposition are the oxides in the target. It is considered that the occurrence of an abnormal discharge on the sputtering surface of the target during sputtering, which causes oxides to fall off the sputtering surface of the target, and thereby causes the generation of particles. In recent years, with

hard disk drives, since the floating quantity of the magnetic head is becoming smaller pursuant to the increase in the recording density, the tolerable size and quantity of particles in a magnetic recording medium are becoming increasing stricter.

5 [0005] Various technologies are known with regard to sputtering targets having a structure in which oxide phases are dispersed in metal phases, and the production method thereof (for instance, Patent Documents 1 to 8). For example, Patent Document 1 discloses a method of: refining the target structure and reducing the generation of particles by incorporating a primary  
10 sintered compact powder, which was obtained by mixing, sintering and pulverizing a part of the raw material powders, when mixing and pulverizing the raw material powders with a ball mill or the like; and thereby inhibiting the aggregation of oxides.

[0006] Patent Document 1: Japanese Patent Application Publication No. 2011-208169

15 Patent Document 2: Japanese Patent Application Publication No. 2011-174174

Patent Document 3: Japanese Patent Application Publication No. 2011-175725

Patent Document 4: Japanese Patent Application No. 2011-536231

Patent Document 5: Japanese Patent Application Publication No. 2012-117147

Patent Document 6: Pamphlet of International Publication No. 2012/086388

20 Patent Document 7: Japanese Patent Application Publication No. 2006-299400

Patent Document 8: Japanese Patent Application Publication No. 2006-77323

## SUMMARY OF INVENTION

### 25 [Technical Problem]

[0007] Generally speaking, upon producing a sputtering target in which oxide phases are dispersed in metal phases, there are cases where the oxides become agglomerated, and such agglomerated oxides cause the particles during sputtering. The conventional technologies cause the oxide phases to  
30 be finely dispersed in the metal phases in order to inhibit the generation of particles.

[0008] Nevertheless, depending on the type of oxides, in certain cases the oxides still cause the generation of particles even when such oxides are finely dispersed. In light of the foregoing problem, an object of the present invention  
35 is to provide a sputtering target capable of minimizing the generation of

particles during sputtering.

[Solution to Problem]

[0009] In order to achieve the foregoing object, as a result of intense study, the present inventors discovered that the generation of particles can be effectively reduced by adding Mn to the metal phases and the oxide phases, respectively, and the yield during deposition can also be improved.

[0010] Based on the foregoing discovery, the present invention provides:

1) A sintered compact sputtering target having a structure in which metal phases and oxide phases are uniformly dispersed, wherein the metal phases contain Co, Pt and Mn as components, and the oxide phases contain an oxide having at least Mn as a constituent

2) The sputtering target according to 1) above, wherein some of the metal phases are Pt-Mn phases;

3) The sputtering target according to 1) or 2) above, wherein the oxide phases additionally contain an oxide having one or more elements selected from Al, B, Ba, Be, Bi, Ca, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Ho, La, Li, Lu, Mg, Mo, Nb, Nd, Ni, Pr, Sb, Sc, Si, Sm, Sn, Sr, Ta, Tb, Te, Ti, Tm, V, W, Y, Yb, Zn, and Zr as a constituent;

4) The sputtering target according to any one of 1) to 3) above, wherein the oxide phases are a composite oxide having Mn as one constituent;

5) The sputtering target according to any one of 1) to 4) above, wherein the metal phases additionally contain, as an additive component, one or more elements selected from Ag, Au, B, Cr, Cu, Fe, Ga, Ge, Mo, Nb, Ni, Pd, Re, Rh, Ru, Sn, Ta, W, V, and Zn; and

6) The sputtering target according to any one of 1) to 5) above, wherein a volume ratio of the oxide phases in the sputtering target is 10% or more and less than 55%.

[Advantageous Effects of Invention]

[0011] The sputtering target of the present invention yields superior effects of being able to reduce the amount of particles generated during sputtering and improve the yield during deposition.

## BRIEF DESCRIPTION OF DRAWINGS

[0012] [Fig. 1] This is an image when the element distribution is measured on the

polished surface of the sintered compact of Example 3 using an electron probe microanalyzer (EPMA).

## DESCRIPTION OF EMBODIMENTS

5

[0013] The sputtering target of the present is a sintered compact sputtering target having a structure in which metal phases and oxide phases are uniformly dispersed, wherein the metal phases contain Co, Pt and Mn as components, and the oxide phases contain an oxide having at least Mn as a constituent.

10

A Co-Pt-based alloy is a material conventionally known as magnetic crystal grains, and what is important in the present invention is that Mn, in addition to Co and Pt, is contained as a constituent of the metal phases, and the oxide phases contain an oxide having at least Mn as a constituent.

[0014] Since Mn exists as a thermodynamically stable oxide, and at the same time has a nature of being easily soluble in Pt as a component of the metal phases, Mn existing in both the metal phases and the oxide phases plays the role of increasing the adhesion between the metal phases and the oxide phases, and yields an extremely superior effect of being able to prevent the oxides from falling off the target during sputtering.

15

20 Note that Patent Documents 5 and 6 disclose that a Mn oxide is included as an inorganic material in a sintered compact sputtering target made from a ferromagnetic alloy and a non-metal inorganic material, but these technologies fail to teach that the adhesion can be improved by including Mn in both the metal phases and the oxide phases.

25 [0015] Moreover, the sputtering target of the present invention covers cases where some of the metal phases are Pt-Mn phases. A Pt-Mn phase is able to increase the adhesion with the oxide phases, and, because the Pt-Mn phase is a stable form, the Pt-Mn phase is effective for inhibiting the generation of particles since the Pt-Mn phase itself will not cause the generation of particles.

30 [0016] Moreover, with the sputtering target of the present invention, the content ratio of Mn in the metal phases is desirably adjusted to be 0.5% or more and 20% or less based on an atomic ratio in the metal phases. When the content ratio of Mn in the metal phases is less than 0.5%, the effect of increasing the adhesion with the oxide phases will deteriorate, and the generation of particles cannot be sufficiently inhibited. Meanwhile, when the content ratio of Mn in

35

the metal phases is more than 20%, the toughness of the sputtering target will deteriorate, and there is a problem in that the target may crack during sputtering.

[0017] Moreover, when the sputtering target of the present invention is used for depositing a recording layer of a hard-disk medium, the recording layer can obtain even more favorable magnetic properties by adjusting the composition of the metal phases to satisfy the following composition formula.

Composition:  $(100 - \alpha - \beta - \gamma)$  Co -  $\alpha$  Pt -  $\beta$  Mn -  $\gamma$  M (wherein, in the foregoing composition formula,  $\alpha$  satisfies the condition of  $5 \leq \alpha \leq 30$ ,  $\beta$  satisfies the condition of  $0.5 \leq \beta \leq 20$ ,  $\gamma$  satisfies the condition of  $0.5 \leq \gamma \leq 20$ , and M represents the additive metal element described later)

Note that the foregoing composition range is a range of improving the magnetic properties as the recording layer of a hard-disk medium, and even if the composition range is outside the foregoing range, it will not impair the superior effect of providing the properties as a recording layer and reducing the amount of particles that are generated during sputtering.

[0018] Moreover, the sputtering target of the present invention covers cases where the oxide phases additionally contain an oxide having one or more elements selected from Al, B, Ba, Be, Bi, Ca, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Ho, La, Li, Lu, Mg, Mo, Nb, Nd, Ni, Pr, Sb, Sc, Si, Sm, Sn, Sr, Ta, Tb, Te, Ti, Tm, V, W, Y, Yb, Zn, and Zr as a constituent. These elements may be suitably added in combination with Mn to match the intended magnetic properties in order to further improve the magnetic properties in comparison to the case of only adding Mn oxide.

[0019] Moreover, the sputtering target of the present invention covers cases where the oxide phases are a composite oxide having Mn as one constituent. While a Mn oxide can easily form a composite oxide with other oxides, in the foregoing case, the generation of particles can be more effectively inhibited since the adhesion between the metal phases and the oxide phases will be further increased.

[0020] Moreover, the sputtering target of the present invention also covers cases where the metal phases additionally contain, as an additive component, one or more elements selected from Ag, Au, B, Cr, Cu, Fe, Ga, Ge, Mo, Nb, Ni, Pd, Re, Rh, Ru, Sn, Ta, W, V, and Zn. These metal components may be suitably added to match the intended magnetic properties.

[0021] Moreover, the sputtering target of the present invention also covers cases where a volume ratio of the oxide phases in the sputtering target is 10% or more and less than 55%. By causing the volume ratio of the oxide phases to be 10% or more and less than 55%, the magnetic properties can be further improved in the deposited magnetic thin film. When the volume ratio of the oxide phases is less than 10%, the effect of the oxides blocking the magnetic interaction of the magnetic grains will deteriorate. Moreover, when the volume ratio of the oxide phases is 55% or more, since the dispersability of the oxide phases will deteriorate, there is a problem in that the amount of particles will increase.

[0022] Note that the volume ratio of the oxide phases can be obtained from the area ratio of the oxide phases in an arbitrary cut plane of the sputtering target. In the foregoing case, the volume ratio of the oxide phases in the sputtering target can also be referred to as the area ratio in a cut plane. In order to reduce the variation depending on the observed location, the area ratio may be obtained by observing regions of roughly 1 mm<sup>2</sup> or more, and taking the average thereof.

[0023] The sputtering target of the present invention can be prepared, for example, based on the following method. Foremost, a Co powder, a Pt powder, and a Mn powder are prepared as the metal powders. Here, in addition to using single element metal powders, alloy powders may also be used. The grain size of these metal powders is desirably within the range of 1 to 10 μm. More uniform mixture of the powders is enabled when the grain size is 1 to 10 μm, and the segregation and coarse crystallization in the sintered target can be prevented. When the metal powders are larger than 10 μm, there are cases where the oxide phases cannot be finely dispersed. Moreover, when the metal powders are smaller than 1 μm, there are cases where the influence from the oxidation of the metal powders may become a problem. Nevertheless, the foregoing grain size range is merely a preferred range, and it should be easy to understand that the deviation from the foregoing grain size range is not a condition for denying the present invention.

[0024] As the oxide powders, a Mn oxide powder and, as needed, oxide powders of other elements are prepared. As the Mn oxide powder, a Mn<sub>3</sub>O<sub>4</sub> powder or a Mn<sub>2</sub>O<sub>3</sub> powder may be used in addition to a MnO powder. The grain size of the oxide powders is desirably within the range of 0.2 to 5 μm. When the grain

size is 0.2 to 5  $\mu\text{m}$ , there is an advantage in that uniform mixture with the metal powders is facilitated. Meanwhile, when the average grain size of the oxide powders is larger than 5  $\mu\text{m}$ , there are cases where coarse oxide phases are generated after sintering, and when the average grain size of the oxide powders is smaller than 0.2  $\mu\text{m}$ , there are cases where the oxide powders become agglomerated. Nevertheless, the foregoing range is merely a preferred range, and it should be easy to understand that the deviation from the foregoing range is not a condition for denying the present invention.

[0025] Subsequently, the foregoing raw material powders are weighed to achieve the intended composition, and mixed and pulverized using a known means such as a ball mill. Here, it is desirable to seal inert gas in the pulverizing container in order to inhibit the oxidation of the raw material powders.

Subsequently, the thus obtained mixed powder is molded and sintered by the hot press method in a vacuum atmosphere or in an inert gas atmosphere. Moreover, in addition to the hot press method, various other pressure sintering methods such as the plasma discharge sintering method may also be used. In particular, the hot isostatic sintering method is effective for increasing the density of the sintered compact. The holding temperature of sintering will depend on the composition, but is often within the range of 700°C to 1100°C.

The sputtering target of the present invention can be prepared by processing the obtained sintered compact into an intended shape using a lathe.

[0026] The sputtering target of the present invention can be produced as described above. The thus produced sputtering target yields superior effects of being able to reduce the amount of particles that are generated during sputtering, and improve the yield during deposition.

#### [Examples]

[0027] The present invention is now explained based on the following Examples and Comparative Examples. Note that these Examples are merely exemplifications, and the present invention is not in any way limited by these Examples. In other words, the present invention is limited only by the scope of claims, and various modifications other than the following Examples in the present invention are also covered by this invention.

#### [0028] (Example 1)

A Co-Cr-Pt-Mn powder having an average grain size of 10  $\mu\text{m}$  produced by the gas atomization method was prepared as the metal powder, and a MnO

powder having an average grain size of 3  $\mu\text{m}$  and a  $\text{Y}_2\text{O}_3$  powder having an average grain size of 3  $\mu\text{m}$  were prepared as the oxide powders. These powders were weighed based on the following composition ratio to achieve a total weight of 2000 g.

5 Weighed composition (molecular ratio): 65Co-5Cr-15Pt-5Mn-5MnO-5 $\text{Y}_2\text{O}_3$

[0029] The weighed powders were sealed in a ball mill pot having a capacity of 10 liters together with zirconia balls as the grinding medium, and rotated for 8 hours for mixing. The mixed powder removed from the ball mill was filled in a carbon mold having a diameter of 190 mm, and sintered by hot pressing. The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1000°C, holding time of 2 hours, and pressure of 30 MPa was applied from the start of temperature increase up to the end of holding. After the end of holding, the product was left in the chamber for natural cooling.

10 [0030] Upon polishing the cut plane of the thus prepared sintered compact and observing the structure, a structure in which the metal phases and the oxide phases are mutually and uniformly dispersed was confirmed. In addition, the element distribution of the polished surface was measured using an electron probe microanalyzer. Consequently, it was confirmed that the metal phases were alloy phases having Co, Cr, Pt, and Mn as components. Moreover, it was confirmed that the oxide phases were Mn oxides and Y oxides.

15 [0031] Subsequently, the sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm to prepare a disk-shaped target. The disk-shaped target was mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

20 The sputtering conditions were as follows; namely, after performing 2 kWhr pre-sputtering at an applied power of 1 kW and Ar gas pressure of 1.7 Pa, film deposition onto a silicon substrate having a diameter of 4 inches was performed for 20 seconds. Subsequently, the number of particles that adhered on the substrate was measured using a particle counter. The number of particles in this case was 13 particles.

25 [0032] (Example 2)

30 A Co powder having an average grain size of 3  $\mu\text{m}$ , a Cr powder having an average grain size of 5  $\mu\text{m}$ , a Pt powder having an average grain size of 3  $\mu\text{m}$ ,

and a Pt-Mn powder (atomic ratio Pt:Mn = 60:40) having an average grain size of 10  $\mu\text{m}$  were prepared as the metal powders, and a MnO powder having an average grain size of 3  $\mu\text{m}$  and a  $\text{Y}_2\text{O}_3$  powder having an average grain size of 3  $\mu\text{m}$  were prepared as the oxide powders. These powders were weighed based on the following composition ratio to achieve a total weight of 2000 g.

Weighed composition (molecular ratio): 65Co-5Cr-15Pt-5Mn-5MnO-5 $\text{Y}_2\text{O}_3$

[0033] The weighed powders were sealed in a ball mill pot having a capacity of 10 liters together with zirconia balls as the grinding medium, and rotated for 8 hours for mixing. The mixed powder removed from the ball mill was filled in a carbon mold having a diameter of 190 mm, and sintered by hot pressing. The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1000°C, holding time of 2 hours, and pressure of 30 MPa was applied from the start of temperature increase up to the end of holding. After the end of holding, the product was left in the chamber for natural cooling.

[0034] Upon polishing the cut plane of the thus prepared sintered compact and observing the structure, a structure in which the metal phases and the oxide phases are mutually and uniformly dispersed was confirmed. In addition, the element distribution of the polished surface was measured using an electron probe microanalyzer. Consequently, it was confirmed that the metal phases were alloy phases having Co, Cr, Pt, and Mn as components. In addition, it was confirmed that some of the metal phases were Pt-Mn phases. Moreover, it was confirmed that the oxide phases were Mn oxides and Y oxides.

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

The sputtering conditions were as follows; namely, after performing 2 kWhr pre-sputtering at an applied power of 1 kW and Ar gas pressure of 1.7 Pa, film deposition onto a silicon substrate having a diameter of 4 inches was performed for 20 seconds. Subsequently, the number of particles that adhered on the substrate was measured using a particle counter. The number of particles in this case was 8 particles.

[0036] (Comparative Example 1)

A Co powder having an average grain size of 3  $\mu\text{m}$ , a Cr powder having an average grain size of 5  $\mu\text{m}$ , and a Pt powder having an average grain size of 3  $\mu\text{m}$  were prepared as the metal powders, and a  $\text{Y}_2\text{O}_3$  powder having an average grain size of 3  $\mu\text{m}$  was prepared as the oxide powder. These powders were weighed based on the following composition ratio to achieve a total weight of 1850 g.

Weighed composition (molecular ratio): 70Co-5Cr-15Pt-10Y<sub>2</sub>O<sub>3</sub>

[0037] The weighed powders were sealed in a ball mill pot having a capacity of 10 liters together with zirconia balls as the grinding medium, and rotated for 8 hours for mixing. The mixed powder removed from the ball mill was filled in a carbon mold having a diameter of 190 mm, and sintered by hot pressing. The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1000°C, holding time of 2 hours, and pressure of 30 MPa was applied from the start of temperature increase up to the end of holding. After the end of holding, the product was left in the chamber for natural cooling.

[0038] Upon polishing the cut plane of the thus prepared sintered compact and observing the structure, a structure in which the metal phases and the oxide phases are mutually and uniformly dispersed was confirmed. In addition, the element distribution of the polished surface was measured using an electron probe microanalyzer. Consequently, it was confirmed that the metal phases were alloy phases having Co, Cr, and Pt as components. The metal phases were a uniform alloy phase of Co-Cr-Pt. Moreover, it was confirmed that the oxide phases were Y oxides.

[0039] Subsequently, the sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm to prepare a disk-shaped target. The disk-shaped target was mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, after performing 2 kWhr pre-sputtering at an applied power of 1 kW and Ar gas pressure of 1.7 Pa, film deposition onto a silicon substrate having a diameter of 4 inches was performed for 20 seconds. Subsequently, the number of particles that adhered on the substrate was measured using a particle counter. The number of particles in this case was 52 particles, and increased in comparison to

Examples 1 and 2.

[0040] (Comparative Example 2)

A Co powder having an average grain size of 3  $\mu\text{m}$ , a Cr powder having an average grain size of 5  $\mu\text{m}$ , and a Pt powder having an average grain size of 3  $\mu\text{m}$  were prepared as the metal powders, and a MnO powder having an average grain size of 3  $\mu\text{m}$  and a  $\text{Y}_2\text{O}_3$  powder having an average grain size of 3  $\mu\text{m}$  were prepared as the oxide powders. These powders were weighed based on the following composition ratio to achieve a total weight of 2000 g.

Weighed composition (molecular ratio): 70Co-5Cr-15Pt-5MnO-5 $\text{Y}_2\text{O}_3$

[0041] The weighed powders were sealed in a ball mill pot having a capacity of 10 liters together with zirconia balls as the grinding medium, and rotated for 8 hours for mixing. The mixed powder removed from the ball mill was filled in a carbon mold having a diameter of 190 mm, and sintered by hot pressing. The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1000°C, holding time of 2 hours, and pressure of 30 MPa was applied from the start of temperature increase up to the end of holding. After the end of holding, the product was left in the chamber for natural cooling.

[0042] Upon polishing the cut plane of the thus prepared sintered compact and observing the structure, a structure in which the metal phases and the oxide phases are mutually and uniformly dispersed was confirmed. In addition, the element distribution of the polished surface was measured using an electron probe microanalyzer. Consequently, it was confirmed that the metal phases were alloy phases having Co, Cr, and Pt as components. Moreover, it was confirmed that the oxide phases were Mn oxides and Y oxides.

[0043] Subsequently, the sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm to prepare a disk-shaped target. The disk-shaped target was mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, after performing 2 kWhr pre-sputtering at an applied power of 1 kW and Ar gas pressure of 1.7 Pa, film deposition onto a silicon substrate having a diameter of 4 inches was performed for 20 seconds. Subsequently, the number of particles that adhered on the substrate was measured using a particle counter. The number

of particles in this case was 27 particles, and increased in comparison to Examples 1 and 2.

[0044] (Comparative Example 3)

5 A Co-Cr-Pt-Mn powder having an average grain size of 10  $\mu\text{m}$  produced by the gas atomization method was prepared as the metal powder, and a  $\text{Y}_2\text{O}_3$  powder having an average grain size of 3  $\mu\text{m}$  was prepared as the oxide powder. These powders were weighed based on the following composition ratio to achieve a total weight of 1850 g.

Weighed composition (molecular ratio): 65Co-5Cr-15Pt-5Mn-10 $\text{Y}_2\text{O}_3$

10 [0045] The weighed powders were sealed in a ball mill pot having a capacity of 10 liters together with zirconia balls as the grinding medium, and rotated for 8 hours for mixing. The mixed powder removed from the ball mill was filled in a carbon mold having a diameter of 190 mm, and sintered by hot pressing. The hot press conditions were as follows; namely, vacuum atmosphere, rate of  
15 temperature increase of 300°C/hour, holding temperature of 1000°C, holding time of 2 hours, and pressure of 30 MPa was applied from the start of temperature increase up to the end of holding. After the end of holding, the product was left in the chamber for natural cooling.

[0046] Upon polishing the cut plane of the thus prepared sintered compact and  
20 observing the structure, a structure in which the metal phases and the oxide phases are mutually and uniformly dispersed was confirmed. In addition, the element distribution of the polished surface was measured using an electron probe microanalyzer. Consequently, it was confirmed that the metal phases were alloy phases having Co, Cr, Pt and Mn as components. Moreover, it was  
25 confirmed that the oxide phases were Y oxides.

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

The sputtering conditions were as follows; namely, after performing 2 kWhr pre-sputtering at an applied power of 1 kW and Ar gas pressure of 1.7 Pa, film deposition onto a silicon substrate having a diameter of 4 inches was performed for 20 seconds. Subsequently, the number of particles that  
35 adhered on the substrate was measured using a particle counter. The number

of particles in this case was 82 particles, and increased in comparison to Examples 1 and 2.

[0048] (Example 3)

A Co powder having an average grain size of 3  $\mu\text{m}$ , a Cr powder having an average grain size of 5  $\mu\text{m}$ , a Pt powder having an average grain size of 3  $\mu\text{m}$ , and a Pt-Mn powder (atomic ratio Pt:Mn = 60:40) having an average grain size of 10  $\mu\text{m}$  were prepared as the metal powders, and a MnO powder having an average grain size of 3  $\mu\text{m}$  and a SiO<sub>2</sub> powder having an average grain size of 1  $\mu\text{m}$  were prepared as the oxide powders. These powders were weighed based on the following composition ratio to achieve a total weight of 2000 g.

Weighed composition (molecular ratio): 65Co-5Cr-15Pt-5Mn-5MnO-5SiO<sub>2</sub>

[0049] The weighed powders were sealed in a ball mill pot having a capacity of 10 liters together with zirconia balls as the grinding medium, and rotated for 8 hours for mixing. The mixed powder removed from the ball mill was filled in a carbon mold having a diameter of 190 mm, and sintered by hot pressing. The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1000°C, holding time of 2 hours, and pressure of 30 MPa was applied from the start of temperature increase up to the end of holding. After the end of holding, the product was left in the chamber for natural cooling.

[0050] Upon polishing the cut plane of the thus prepared sintered compact and observing the structure, a structure in which the metal phases and the oxide phases are mutually and uniformly dispersed was confirmed. In addition, the element distribution of the polished surface was measured using an electron probe microanalyzer. Consequently, it was confirmed that the metal phases were alloy phases having Co, Cr, Pt, and Mn as components. In addition, it was confirmed that some of the metal phases were Pt-Mn phases. Moreover, it was confirmed that the oxide phases were composite oxides having Mn and Si as components, and Si oxides.

[0051] Subsequently, the sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm to prepare a disk-shaped target. The disk-shaped target was mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, after performing 2 kWhr

pre-sputtering at an applied power of 1 kW and Ar gas pressure of 1.7 Pa, film deposition onto a silicon substrate having a diameter of 4 inches was performed for 20 seconds. Subsequently, the number of particles that adhered on the substrate was measured using a particle counter. The number of particles in this case was 12 particles.

[0052] (Example 4)

A Co powder having an average grain size of 3  $\mu\text{m}$ , a Cr powder having an average grain size of 5  $\mu\text{m}$ , a Pt powder having an average grain size of 3  $\mu\text{m}$ , a Mn powder having an average grain size of 20  $\mu\text{m}$ , and a Ru powder having an average grain size of 10  $\mu\text{m}$  were prepared as the metal powders, and a  $\text{Mn}_2\text{O}_3$  powder having an average grain size of 3  $\mu\text{m}$  and a  $\text{TiO}_2$  powder having an average grain size of 1  $\mu\text{m}$  were prepared as the oxide powders. These powders were weighed based on the following composition ratio to achieve a total weight of 2100 g.

Weighed composition (molecular ratio):

62.5Co-5Cr-15Pt-5Mn-5Ru-2.5 $\text{Mn}_2\text{O}_3$ -5 $\text{TiO}_2$

[0053] The weighed powders were sealed in a ball mill pot having a capacity of 10 liters together with zirconia balls as the grinding medium, and rotated for 8 hours for mixing. The mixed powder removed from the ball mill was filled in a carbon mold having a diameter of 190 mm, and sintered by hot pressing. The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1000°C, holding time of 2 hours, and pressure of 30 MPa was applied from the start of temperature increase up to the end of holding. After the end of holding, the product was left in the chamber for natural cooling.

[0054] Upon polishing the cut plane of the thus prepared sintered compact and observing the structure, a structure in which the metal phases and the oxide phases are mutually and uniformly dispersed was confirmed. In addition, the element distribution of the polished surface was measured using an electron probe microanalyzer. Consequently, it was confirmed that the metal phases were alloy phases having Co, Cr, Pt, Mn and Ru as components. In addition, it was confirmed that some of the metal phases were Pt-Mn phases. Moreover, it was confirmed that the oxide phases were composite oxides having Mn and Ti as components.

[0055] Subsequently, the sintered compact was machined with a lathe into a

shape having a diameter of 180.0 mm and a thickness of 5.0 mm to prepare a disk-shaped target. The disk-shaped target was 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, after performing 2 kWhr pre-sputtering at an applied power of 1 kW and Ar gas pressure of 1.7 Pa, film deposition onto a silicon substrate having a diameter of 4 inches was performed for 20 seconds. Subsequently, the number of particles that adhered on the substrate was measured using a particle counter. The number  
10 of particles in this case was 7 particles.

[0056] Moreover, upon polishing the cut plane of the sintered compact and observing the polished surface in a range of 1 mm<sup>2</sup>, the area ratio of the oxide phases was 21%. In other words, the volume ratio of the oxide phases in the target was 21%.

15 [0057] (Comparative Example 4)

A Co powder having an average grain size of 3 μm, a Cr powder having an average grain size of 5 μm, a Pt powder having an average grain size of 3 μm, a Mn powder having an average grain size of 20 μm, and a Ru powder having an average grain size of 10 μm were prepared as the metal powders, and a  
20 Mn<sub>2</sub>O<sub>3</sub> powder having an average grain size of 3 μm and a TiO<sub>2</sub> powder having an average grain size of 1 μm were prepared as the oxide powders. These powders were weighed based on the following composition ratio to achieve a total weight of 1650 g.

Weighed composition (molecular ratio):

25 37.5Co-5Cr-15Pt-5Mn-5Ru-2.5Mn<sub>2</sub>O<sub>3</sub>-30TiO<sub>2</sub>

[0058] The weighed powders were sealed in a ball mill pot having a capacity of 10 liters together with zirconia balls as the grinding medium, and rotated for 8 hours for mixing. The mixed powder removed from the ball mill was filled in a carbon mold having a diameter of 190 mm, and sintered by hot pressing. The  
30 hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1000°C, holding time of 2 hours, and pressure of 30 MPa was applied from the start of temperature increase up to the end of holding. After the end of holding, the product was left in the chamber for natural cooling.

35 [0059] Upon polishing the cut plane of the thus prepared sintered compact and

observing the structure, a structure in which the metal phases and the oxide phases are mutually dispersed was confirmed. In addition, the element distribution of the polished surface was measured using an electron probe microanalyzer. Consequently, it was confirmed that the metal phases were alloy phases having Co, Cr, Pt, Mn and Ru as components. In addition, it was confirmed that some of the metal phases were Pt-Mn phases. Moreover, it was confirmed that the oxide phases were composite oxides having Mn and Ti as components, and Ti oxides.

[0060] Subsequently, the sintered compact was machined with a lathe into a shape having a diameter of 180.0 mm and a thickness of 5.0 mm to prepare a disk-shaped target. The disk-shaped target was mounted on a magnetron sputtering equipment (C-3010 sputtering system manufactured by Canon Anelva) to perform sputtering.

The sputtering conditions were as follows; namely, after performing 2 kWhr pre-sputtering at an applied power of 1 kW and Ar gas pressure of 1.7 Pa, film deposition onto a silicon substrate having a diameter of 4 inches was performed for 20 seconds. Subsequently, the number of particles that adhered on the substrate was measured using a particle counter. The number of particles in this case was 82 particles.

[0061] Moreover, upon polishing the cut plane of the sintered compact and observing the polished surface in a range of 1 mm<sup>2</sup>, the area ratio of the oxide phases was 57%. In other words, the volume ratio of the oxide phases in the target was 57%. It was confirmed that the number of particles had considerably increased in comparison with Example 4 in which the volume ratio of the oxide phases was 21%.

[0062] (Example 5)

A Co-Pt-Mn powder having an average grain size of 10 μm produced by the gas atomization method was prepared as the metal powder, and a MnO powder having an average grain size of 3 μm and a Ta<sub>2</sub>O<sub>5</sub> powder having an average grain size of 3 μm were prepared as the oxide powders. These powders were weighed based on the following composition ratio to achieve a total weight of 2300 g.

Weighted composition (molecular ratio): 65Co-20Pt-5Mn-5MnO-5Ta<sub>2</sub>O<sub>5</sub>

[0063] The weighed powders were sealed in a ball mill pot having a capacity of 10 liters together with zirconia balls as the grinding medium, and rotated for 8

hours for mixing. The mixed powder removed from the ball mill was filled in a carbon mold having a diameter of 190 mm, and sintered by hot pressing. The hot press conditions were as follows; namely, vacuum atmosphere, rate of temperature increase of 300°C/hour, holding temperature of 1100°C, holding time of 2 hours, and pressure of 30 MPa was applied from the start of temperature increase up to the end of holding. After the end of holding, the product was left in the chamber for natural cooling.

[0064] Upon polishing the cut plane of the thus prepared sintered compact and observing the structure, a structure in which the metal phases and the oxide phases are mutually and uniformly dispersed was confirmed. In addition, the element distribution of the polished surface was measured using an electron probe microanalyzer. Consequently, it was confirmed that the metal phases were alloy phases having Co, Pt, and Mn as components. Moreover, it was confirmed that the oxide phases were Mn oxides and Ta oxides.

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

The sputtering conditions were as follows; namely, after performing 2 kWhr pre-sputtering at an applied power of 1 kW and Ar gas pressure of 1.7 Pa, film deposition onto a silicon substrate having a diameter of 4 inches was performed for 20 seconds. Subsequently, the number of particles that adhered on the substrate was measured using a particle counter. The number of particles in this case was 16 particles.

[0066] [Table 1]

|                       | Weighed Composition (mol%)                                                    | Metal phase (components) | Pt-Mn phases among metal phases | Oxide phase (components)          | Volume ratio of oxide phases (%) | Number of particles |
|-----------------------|-------------------------------------------------------------------------------|--------------------------|---------------------------------|-----------------------------------|----------------------------------|---------------------|
| Example 1             | 65Co-5Cr-15Pt-5Mn-5MnO-5Y <sub>2</sub> O <sub>3</sub>                         | Co, Cr, Pt, Mn           | not exist                       | Mn oxide and Y oxide              | 31                               | 13                  |
| Example 2             | 65Co-5Cr-15Pt-5Mn-5MnO-5Y <sub>2</sub> O <sub>3</sub>                         | Co, Cr, Pt, Mn           | exist                           | Mn oxide and Y oxide              | 31                               | 8                   |
| Example 3             | 65Co-5Cr-15Pt-5Mn-5MnO-5SiO <sub>2</sub>                                      | Co, Cr, Pt, Mn           | exist                           | MnSi composite oxide and Si oxide | 36                               | 12                  |
| Example 4             | 62.5Co-5Cr-15Pt-5Mn-5Ru-2.5Mn <sub>2</sub> O <sub>3</sub> -5TiO <sub>2</sub>  | Co, Cr, Pt, Mn, Ru       | exist                           | MnTi composite oxide              | 21                               | 7                   |
| Example 5             | 65Co-20Pt-5Mn-5MnO-5Ta <sub>2</sub> O <sub>5</sub>                            | Co, Pt, Mn               | not exist                       | Mn oxide and Ta oxide             | 33                               | 16                  |
| Comparative Example 1 | 70Co-5Cr-15Pt-10Y <sub>2</sub> O <sub>3</sub>                                 | Co, Cr, Pt               | not exist                       | Y oxide                           | 43                               | 52                  |
| Comparative Example 2 | 70Co-5Cr-15Pt-5MnO-5Y <sub>2</sub> O <sub>3</sub>                             | Co, Cr, Pt               | not exist                       | Mn oxide and Y oxide              | 33                               | 27                  |
| Comparative Example 3 | 65Co-5Cr-15Pt-5Mn-10Y <sub>2</sub> O <sub>3</sub>                             | Co, Cr, Pt, Mn           | not exist                       | Y oxide                           | 41                               | 82                  |
| Comparative Example 4 | 37.5Co-5Cr-15Pt-5Mn-5Ru-2.5Mn <sub>2</sub> O <sub>3</sub> -30TiO <sub>2</sub> | Co, Cr, Pt, Mn, Ru       | exist                           | MnTi composite oxide and Ti Oxide | 57                               | 82                  |

[0067] As described above, in all Examples it was possible to reduce the amount of particles that are generated during sputtering, and it was confirmed that Mn existing in the metal phases and the oxide phases plays an extremely important role in improving the yield during deposition.

5

#### INDUSTRIAL APPLICABILITY

[0068] The sputtering target of the present invention yields superior effects of being able to reduce the amount of particles generated during sputtering and improve the yield during deposition. Accordingly, the present invention is effective as a sputtering target for forming a magnetic thin film having a granular structure.

10

## CLAIMS

5 [Claim 1] (Amended) A sintered compact sputtering target having a structure in which metal phases and oxide phases are uniformly dispersed, wherein the metal phases contain Co, Pt and Mn as components, the oxide phases contain an oxide having at least Mn as a constituent, and a volume ratio of the oxide phases in the sputtering target is 10% or more and less than 55%.

10 [Claim 2] The sputtering target according to claim 1, wherein some of the metal phases are Pt-Mn phases.

15 [Claim 3] The sputtering target according to claim 1 or claim 2, wherein the oxide phases additionally contain an oxide having one or more elements selected from Al, B, Ba, Be, Bi, Ca, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Ho, La, Li, Lu, Mg, Mo, Nb, Nd, Ni, Pr, Sb, Sc, Si, Sm, Sn, Sr, Ta, Tb, Te, Ti, Tm, V, W, Y, Yb, Zn, and Zr as a constituent.

[Claim 4] The sputtering target according to any one of claims 1 to 3, wherein the oxide phases are a composite oxide having Mn as one constituent.

20 [Claim 5] The sputtering target according to any one of claims 1 to 4, wherein the metal phases additionally contain, as an additive component, one or more elements selected from Ag, Au, B, Cr, Cu, Fe, Ga, Ge, Mo, Nb, Ni, Pd, Re, Rh, Ru, Sn, Ta, W, V, and Zn.

[Claim 6] (Deleted)

25