

SINTERED COMPACT SPUTTERING TARGET

TECHNICAL FILED

5 [0001] The present invention relates to a sintered compact sputtering target used for depositing a nonmagnetic thin film of a magnetic recording medium, in particular, a nonmagnetic interlayer of a hard disk which employs the perpendicular magnetic recording system.

10 BACKGROUND ART

[0002] In the field of magnetic recording, technologies have been developed for improving magnetic properties by finely dispersing a nonmagnetic material into a magnetic material thin film. As an example, in a recording medium of a hard disk which employs the perpendicular magnetic recording system, various properties for a magnetic recording medium are known to be improved by using a granular film in which the magnetic interaction between magnetic grains in a magnetic recording film is blocked or weakened by a nonmagnetic material.

15 [0003] As one of the suitable materials for the granular film, Co-Cr-Pt-SiO₂ is known, for example (see Patent Literatures 1 to 4). A granular film of the Co-Cr-Pt-SiO₂ is manufactured by sputtering a ferromagnetic material target of a nonmagnetic grain-dispersed type in which SiO₂ as a nonmagnetic material is finely and uniformly dispersed in a base material of a ferromagnetic Co-Cr alloy having Co as a main component.

20 [0004] It is widely known that such a ferromagnetic material sputtering target may be manufactured by the powder metallurgy method. For example, a ferromagnetic material sputtering target may be manufactured by preparing a commercially available raw material powder for each component constituting the target, weighing out these raw material powders to give a desired composition, mixing by a known method such as a ball mill, and molding and sintering the mixed powder by hot press.

25 [0005] Meanwhile, in a recording medium of a hard disk which employs the perpendicular magnetic recording system, in addition to the magnetic recording layer described above, a nonmagnetic interlayer is present between the recording layer and an underlayer. A composition may need to be adjusted so

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that the interlayer, which has a structure in which a non-metal material such as SiO₂ is dispersed in a metal matrix of a Co-Cr alloy as in the recording layer, contains a large amount of Cr because it should be nonmagnetic unlike the recording layer.

5 [0006] However, as the content of Cr is being increased, a very fragile phase may be formed from which cracking may occur during sputtering. Such methods that warpage of the target is controlled by increasing the thickness of the target or making the target to be a bonding type, and low electric power is adopted as a sputtering condition have been used in order to prevent cracking in a target.
10 However, none of the methods is effective.

[0007] Further, in such a sputtering target, it might also be conceived that the strength of the target could be increased by decreasing the content of a relatively fragile non-metal material or replacing a metal portion with a more ductile material. However, these approaches can not be used because of
15 requirements for magnetic properties, for example, a film deposited by sputtering must be nonmagnetic.

[0008] Patent Literature 1: Japanese Patent Laid-Open No. 2010-255088
Patent Literature 2: Japanese Patent Laid-Open No. 2012-33247
Patent Literature 3: WO2009/119812
20 Patent Literature 4: WO2010/110033

SUMMARY OF INVENTION

[Technical Problem]

25 [0009] In view of the above problems, an object of the present invention is to provide a sintered compact sputtering target capable of providing stable sputtering by increasing the mechanical strength of the target to control cracking of the target during sputtering.

[Solution to Problem]

30 [0010] After conducting extensive studies to solve the above problems, the present inventor finds that a sintered compact sputtering target having a high mechanical strength which is capable of controlling cracking of the target during sputtering can be obtained by reducing fragile σ phases in a Co-Cr alloy present in a composition of the target as much as possible. Based on the
35 above finding, the present invention provides the followings:

1) A sintered compact sputtering target, comprising an alloy having a composition of 25 mol% to 40 mol% of Cr with the remainder being Co, and a non-metal material dispersed in the alloy, wherein the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy relative to the mean intensity of background is 1.30 or less.

2) The sintered compact sputtering target of 1), comprising, as the non-metal material, one or more materials selected from: an oxide of an element selected from Si, Al, B, Ba, Be, Ca, Ce, Cr, Dy, Er, Eu, Ga, Gd, Ho, Li, Mg, Mn, Nb, Nd, Pr, Sc, Sm, Sr, Ta, Tb, Ti, V, Y, Zn and Zr; C (carbon) or a carbide of an element selected from B, Ca, Nb, Si, Ta, Ti, W and Zr; and, a nitride of an element selected from Al, B, Ca, Nb, Si, Ta, Ti and Zr.

3) The sintered compact sputtering target of 1) or 2), comprising a total of 20 to 50 vol% of the non-metal material.

4) The sintered compact sputtering target of any one of 1) to 3), comprising, as an additive element to the alloy, a total of 0.5 mol% to 15 mol% of one or more elements selected from Pt, Ag, Au, B, Co, Cr, Cu, Ga, Ge, Mn, Mo, Nb, Ni, Pd, Re, Rh, Ru, Sn, Ta, W, V and Zn.

5) The sintered compact sputtering target of any one of 1) to 4), wherein the bending strength of the target is 700 MPa or more.

[Advantageous Effects of Invention]

[0011] Advantageously, the sputtering target according to the present invention can control cracking of the target during sputtering because of its high mechanical strength, leading to stable sputtering. Further, this can produce a significantly advantageous effect that a manufacturing yield can be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0012] Fig. 1 shows a SEM image of the structure of a polished surface of the target from Example 3.

Fig. 2 shows a SEM image of the structure of a polished surface of the target from Example 4.

DESCRIPTION OF EMBODIMENTS

[0013] The sintered compact sputtering target according to the present invention

comprises an alloy having a composition of 25 mol% to 40 mol% of Cr with the remainder being Co, and a non-metal material dispersed in the alloy, wherein the intensity ratio of the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy relative to the mean intensity of background is 1.30 or less. That is, the present invention satisfies: (the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy) / (the mean intensity of background) $\leq$ 1.30. This is a basis of the present invention.

[0014] The content of Cr in a target is 25 mol% to 40mol %. The content of Cr of less than 25 mol% is not preferred since a nonmagnetic film may not be obtained. The content of more than 40 mol% is not preferred since very fragile σ phases (sigma phases) in the Co-Cr alloy may increase.

[0015] For the X-ray diffraction peak intensity of σ phases in the above Co-Cr alloy, a peak cps value of the (410) plane which appears around $2\theta=42.4^\circ$ is used. Further, for the background strength, the mean of cps values over a width of 1.0° in an angle region at which no particular peak appears is used. For example, in a case of a Co-Cr-TiO₂ target, the mean of cps values at which 2θ is 50° or more and less than 51° is used. Note that measurement results obtained are used as-is without performing any processing for background reduction.

The intensity ratio of σ phases in the Co-Cr alloy of more than 1.30 is not preferred because the mechanical strength of the target is decreased, and cracking of the target and the like may occur during sputtering under sputtering conditions for an interlayer and a grain diameter-controlling layer of a perpendicular magnetic recording medium.

[0016] In the sputtering target according to the present invention, one or more materials selected from: an oxide of an element selected from Si, Al, B, Ba, Be, Ca, Ce, Cr, Dy, Er, Eu, Ga, Gd, Ho, Li, Mg, Mn, Nb, Nd, Pr, Sc, Sm, Sr, Ta, Tb, Ti, V, Y, Zn and Zr; C (carbon) or a carbide of an element selected from B, Ca, Nb, Si, Ta, Ti, W and Zr; and, a nitride of an element selected from Al, B, Ca, Nb, Si, Ta, Ti and Zr, may be used as a non-metal material. In a nonmagnetic thin film deposited by sputtering, these non-metal materials can insulate magnetic interactions between magnetic grains to provide good magnetic properties.

Further, a total content of 20 to 50 vol% is effective for the non-metal material. The content of the non-metal material in this range can provide a good granular structure in a nonmagnetic thin film deposited by sputtering.

[0017] Further, it is effective to add 0.5 to 15 mol% of one or more elements as an additive element to a Co-Cr alloy in the sputtering target according to the present invention, the one or more elements being selected from Pt, Ag, Au, B, Co, Cu, Ga, Ge, Mn, Mo, Nb, Ni, Pd, Re, Rh, Ru, Sn, Ta, W, V and Zn.

5 [0018] According to the present invention, the bending strength of a sputtering target of 700 MPa or more can be achieved. In a case where the bending strength of a target is 700 MPa or more, cracking of the target during sputtering can be significantly reduced.

10 [0019] The sputtering target according to the present invention may be manufactured, for example, by the following method. First, metal powders of Co, Cr and the like or an alloy powder such as Co-Cr are prepared. For these powders, a powder having a maximum grain size of 20 μm or less is preferred to be used. Further, for example, an oxide such as SiO_2 is prepared as a non-metal material powder. For the non-metal material powder, a powder
15 having a maximum grain size of 5 μm or less is preferred to be used. Further, a powder of metal such as Pt is prepared as an additive element to the alloy if desired. For the additive element powder, a powder having a maximum grain size of 20 μm or less is preferred to be used. These powders are weighed to give a desired composition, and then mixed and ground using a known
20 technique such as a ball mill.

[0020] A carbon mold is filled with the mixed powder obtained thereby, and then molded and sintered by hot press (HP). Other than hot press, various pressurized sintering methods such as the plasma discharge sintering method may be used. Moreover, performing hot isostatic sintering (HIP) after the
25 powder sintering treatment such as hot press is particularly effective because a locally reduced density can be prevented and the mechanical strength of the target can be enhanced in the whole region. The sputtering target of the present invention can be manufactured by processing thus-obtained sintered compact into a desired shape with a lathe.

30 [Examples]

[0021] Below, the present invention will be described based on Examples and Comparative Examples. Note that Examples are presented for merely illustrative purposes, and the present invention shall in no way be limited to these. That is, the present invention is only defined by the claims, and shall
35 encompass various modifications other than those in Examples included in the

present invention.

(Example 1)

[0022] As raw material powders, a Co powder having a mean grain diameter of 1 μm , a Cr powder having a mean grain diameter of 2 μm and a SiO_2 powder having a mean grain diameter of 1 μm were prepared. These raw powders were weighed to give a composition of 90(65Co-35Cr)-10 SiO_2 (mol%). At this time, the volume ratio of SiO_2 was 31%.

Then, the weighed powders were sealed together with zirconia balls as grinding media in a ball mill pot with a 10 liters capacity using Ar gas, and subjected to mixing by mechanically rotating the ball mill for 40 hours. A carbon mold was filled with the resulting mixed powder, and hot press (HP) was performed in a vacuum atmosphere under the following conditions: a sintering temperature of 1050°C, a holding time of 2 hours and a pressure of 30 MPa to manufacture a sintered compact.

[0023] A portion of the sintered compact was cut out, and a cut surface thereof was polished to obtain a sample for X-ray diffraction measurements. Measurements of the sample for X-ray diffraction profiles were performed by the $\theta/2\theta$ method using an X-ray diffractometer (UltimaIV, Rigaku). The CuK α line was used as an X-ray source. Measurement conditions were as follows: a tube voltage of 40 kV, a tube current of 30 mA, a scan rate of 50°/min with a step of 0.01°. Results showed that (the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy) / (the mean intensity of background) was 1.14.

Next, the sintered compact was subjected to cutting work with a lathe to obtain a disk-shaped target with a diameter of 180.0 mm and a thickness of 5.0 mm. This target was placed in a magnetron sputtering system (a C-3010 sputtering system, Canon Anelva Corporation) to perform sputtering with an input power of 0.8 kW and an Ar gas pressure of 1.7 Pa. Results showed that cracking did not occur in the target when sputtering was performed at 5 kW/hr.

Further, a three-point bending test was performed using a small piece cut out from the target after sputtering. Results showed that the bending strength was as high as 908 MPa.

(Comparative Example 1)

[0024] As raw material powders, a Co powder having a mean grain diameter of 1 μm , a Cr powder having a mean grain diameter of 2 μm and a SiO_2 powder having a mean grain diameter of 1 μm were prepared. These raw powders

were weighed to give a composition of 90(52Co-48Cr)-10SiO₂ (mol%). At this time, the volume ratio of SiO₂ was 31%.

Then, the weighed powders were sealed together with zirconia balls as grinding media in a ball mill pot with a 10 liters capacity using Ar gas, and subjected to mixing by mechanically rotating the ball mill for 40 hours. A carbon mold was filled with the resulting mixed powder, and hot press (HP) was performed in a vacuum atmosphere under the following conditions: a sintering temperature of 1050°C, a holding time of 2 hours and a pressure of 30 MPa to manufacture a sintered compact.

[0025] A portion of the sintered compact was cut out, and a cut surface thereof was polished to obtain a sample for X-ray diffraction measurements. Measurements of the sample for X-ray diffraction profiles were performed under similar conditions as in Example 1 using an X-ray diffractometer. Results showed that (the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy) / (the mean intensity of background) was 1.54.

Next, the sintered compact was subjected to cutting work with a lathe to obtain a disk-shaped target with a diameter of 180.0 mm and a thickness of 5.0 mm. This target was placed in a magnetron sputtering system (a C-3010 sputtering system, Canon Anelva Corporation) to perform sputtering under similar conditions as in Example 1. Results showed that cracking occurred in the target, when sputtering was performed at 1.0 kWh.

Further, a three-point bending test was performed using a small piece cut out from the target after sputtering. Results showed that the bending strength was 533 MPa.

(Comparative Example 2)

[0026] As raw material powders, a Co powder having a mean grain diameter of 1 μ m, a Cr powder having a mean grain diameter of 2 μ m and a SiO₂ powder having a mean grain diameter of 1 μ m were prepared. These raw powders were weighed to give a composition of 90(55Co-45Cr)-10SiO₂ (mol%). At this time, the volume ratio of SiO₂ was 31%.

Then, the weighed powders were sealed together with zirconia balls as grinding media in a ball mill pot with a 10 liters capacity using Ar gas, and subjected to mixing by mechanically rotating the ball mill for 40 hours. A carbon mold was filled with the resulting mixed powder, and hot press (HP) was performed in a vacuum atmosphere under the following conditions: a sintering

temperature of 1050°C, a holding time of 2 hours and a pressure of 30 MPa to manufacture a sintered compact.

[0027] A portion of the sintered compact was cut out, and a cut surface thereof was polished to obtain a sample for X-ray diffraction measurements. Measurements of the sample for X-ray diffraction profiles were performed under similar conditions as in Example 1 using an X-ray diffractometer. Results showed that (the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy) / (the mean intensity of background) was 1.32.

Next, the sintered compact was subjected to cutting work with a lathe to obtain a disk-shaped target with a diameter of 180.0 mm and a thickness of 5.0 mm. This target was placed in a magnetron sputtering system (a C-3010 sputtering system, Canon Anelva Corporation) to perform sputtering under similar conditions as in Example 1. Results showed that cracking occurred in the target, when sputtering was performed at 4.0 kWh.

Further, a three-point bending test was performed using a small piece cut out from the target after sputtering. Results showed that the bending strength was 641 MPa.

(Example 2)

[0028] As raw material powders, a Co powder having a mean grain diameter of 1 μm , a Cr powder having a mean grain diameter of 2 μm , a SiO_2 powder having a mean grain diameter of 1 μm and a Cr_2O_3 powder having a mean grain diameter of 0.6 μm were prepared. These raw material powders were weighed to give a composition of 89(60Co-40Cr)-8 SiO_2 -3 Cr_2O_3 (mol%). At this time, the total volume ratio of SiO_2 and Cr_2O_3 was 33%.

Then, the weighed powders were sealed together with zirconia balls as grinding media in a ball mill pot with a 10 liters capacity using Ar gas, and subjected to mixing by mechanically rotating the ball mill for 40 hours. A carbon mold was filled with the resulting mixed powder, and hot press (HP) was performed in a vacuum atmosphere under the following conditions: a sintering temperature of 1050°C, a holding time of 2 hours and a pressure of 30 MPa to manufacture a sintered compact.

[0029] A portion of the sintered compact was cut out, and a cut surface thereof was polished to obtain a sample for X-ray diffraction measurements. Measurements of the sample for X-ray diffraction profiles were performed under similar conditions as in Example 1 using an X-ray diffractometer. Results

showed that (the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy) / (the mean intensity of background) was 1.16.

Next, the sintered compact was subjected to cutting work with a lathe to obtain a disk-shaped target with a diameter of 180.0 mm and a thickness of 5.0 mm. This target was placed in a magnetron sputtering system (a C-3010 sputtering system, Canon Anelva Corporation) to perform sputtering under similar conditions as in Example 1. Results showed that cracking did not occur in the target when sputtering was performed at 5 kWhr.

Further, a three-point bending test was performed using a small piece cut out from the target after sputtering. Results showed that the bending strength was as high as 783 MPa.

(Comparative Example 3)

[0030] As raw material powders, a Co powder having a mean grain diameter of 1 μm , a Cr powder having a mean grain diameter of 2 μm , a SiO_2 powder having a mean grain diameter of 1 μm and a Cr_2O_3 powder having a mean grain diameter of 0.6 μm were prepared. These raw material powders were weighed to give a composition of 89(55Co-45Cr)-8 SiO_2 -3 Cr_2O_3 (mol%). At this time, the total volume ratio of SiO_2 and Cr_2O_3 was 33%.

Then, the weighed powders were sealed together with zirconia balls as grinding media in a ball mill pot with a 10 liters capacity using Ar gas, and subjected to mixing by mechanically rotating the ball mill for 40 hours. A carbon mold was filled with the resulting mixed powder, and hot press (HP) was performed in a vacuum atmosphere under the following conditions: a sintering temperature of 1050°C, a holding time of 2 hours and a pressure of 30 MPa to manufacture a sintered compact.

[0031] A portion of the sintered compact was cut out, and a cut surface thereof was polished to obtain a sample for X-ray diffraction measurements. Measurements of the sample for X-ray diffraction profiles were performed under similar conditions as in Example 1 using an X-ray diffractometer. Results showed that (the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy) / (the mean intensity of background) was 1.35.

Next, the sintered compact was subjected to cutting work with a lathe to obtain a disk-shaped target with a diameter of 180.0 mm and a thickness of 5.0 mm. This target was placed in a magnetron sputtering system (a C-3010 sputtering system, Canon Anelva Corporation) to perform sputtering under

similar conditions as in Example 1. Results showed that cracking occurred in the target when sputtering was performed at 3.5 kWhr.

Further, a three-point bending test was performed using a small piece cut out from the target after sputtering. Results showed that the bending strength was 627 MPa.

(Example 3)

[0032] As raw material powders, a Co powder having a mean grain diameter of 1 μm , a Cr powder having a mean grain diameter of 2 μm , a Pt powder having a mean grain diameter of 2 μm , a SiO_2 powder having a mean grain diameter of 1 μm and a Cr_2O_3 powder having a mean grain diameter of 0.6 μm were prepared. These raw material powders were weighed to give a composition of 70(75Co-25Cr)-15Pt-10 SiO_2 -5 Cr_2O_3 (mol%). At this time, the total volume ratio of SiO_2 and Cr_2O_3 was 41%.

Then, the weighed powders were sealed together with zirconia balls as grinding media in a ball mill pot with a 10 liters capacity using Ar gas, and subjected to mixing by mechanically rotating the ball mill for 10 hours. A carbon mold was filled with the resulting mixed powder, and hot press (HP) was performed in a vacuum atmosphere under the following conditions: a sintering temperature of 1050°C, a holding time of 2 hours and a pressure of 30 MPa to manufacture a sintered compact.

[0033] A portion of the sintered compact was cut out, and a cut surface thereof was polished to obtain a sample for X-ray diffraction measurements. Measurements of the sample for X-ray diffraction profiles were performed under similar conditions as in Example 1 using an X-ray diffractometer. Results showed that (the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy) / (the mean intensity of background) was 1.14.

Next, the sintered compact was subjected to cutting work with a lathe to obtain a disk-shaped target with a diameter of 180.0 mm and a thickness of 5.0 mm. This target was placed in a magnetron sputtering system (a C-3010 sputtering system, Canon Anelva Corporation) to perform sputtering under similar conditions as in Example 1. Results showed that cracking did not occur in the target when sputtering was performed at 8.0 kWhr.

Moreover, a polished surface of the target before sputtering was observed with a scanning electron microscope (SEM). An image of the structure is shown in Fig. 1. Those finely dispersed in Fig. 1 are non-metal materials SiO_2

grains and Cr_2O_3 grains. The mean area of each grain of these oxide phases was $2.4 \mu\text{m}^2$.

Further, a three-point bending test was performed using a small piece cut out from the target after sputtering. Results showed that the bending strength was 710 MPa.

(Example 4)

[0034] As raw material powders, a Co powder having a mean grain diameter of $1 \mu\text{m}$, a Cr powder having a mean grain diameter of $2 \mu\text{m}$, a Pt powder having a mean grain diameter of $2 \mu\text{m}$, a SiO_2 powder having a mean grain diameter of $1 \mu\text{m}$ and a Cr_2O_3 powder having a mean grain diameter of $0.6 \mu\text{m}$ were prepared. These raw material powders were weighed to give a composition of 70(75Co-25Cr)-15Pt-10 SiO_2 -5 Cr_2O_3 (mol%). At this time, the total volume ratio of SiO_2 and Cr_2O_3 was 41%.

Then, the weighed powders were sealed together with zirconia balls as grinding media in a ball mill pot with a 10 liters capacity using Ar gas, and subjected to mixing by mechanically rotating the ball mill for 40 hours. A carbon mold was filled with the resulting mixed powder, and hot press (HP) was performed in a vacuum atmosphere under the following conditions: a sintering temperature of 1050°C , a holding time of 2 hours and a pressure of 30 MPa to obtain a sintered compact.

[0035] A portion of the sintered compact was cut out, and a cut surface thereof was polished to obtain a sample for X-ray diffraction measurements. Measurements of the sample for X-ray diffraction profiles were performed under similar conditions as in Example 1 using an X-ray diffractometer. Results showed that (the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy) / (the mean intensity of background) was 1.14.

Next, the sintered compact was subjected to cutting work with a lathe to obtain a disk-shaped target with a diameter of 180.0 mm and a thickness of 5.0 mm. This target was placed in a magnetron sputtering system (a C-3010 sputtering system, Canon Anelva Corporation) to perform sputtering under similar conditions as in Example 1. Results showed that cracking did not occur in the target when sputtering was performed at 10.0 kWhr.

Moreover, a polished surface of the target before sputtering was observed with a scanning electron microscope (SEM). An image of the structure is shown in Fig. 2. Those finely dispersed in Fig. 2 are non-metal materials SiO_2

grains and Cr_2O_3 grains. The mean area of each grain of these oxide phases was $0.9 \mu\text{m}^2$.

Further, a three-point bending test was performed using a small piece cut out from the target after sputtering. Results showed that the bending strength was as high as 930 MPa. Thus, further enhancement of bending strength was possible by micronizing the grains as oxide phases.

(Example 5)

[0036] As raw material powders, a Co powder having a mean grain diameter of $1 \mu\text{m}$, a Cr powder having a mean grain diameter of $2 \mu\text{m}$, a Ru powder having a mean grain diameter of $2 \mu\text{m}$, a TiO_2 powder having a mean grain diameter of $1 \mu\text{m}$ and a Cr_2O_3 powder having a mean grain diameter of $0.6 \mu\text{m}$ were prepared. These raw material powders were weighed to give a composition of 82(57Co-43Cr)-3Ru-5 TiO_2 -10 Cr_2O_3 (mol%). At this time, the total volume ratio of TiO_2 and Cr_2O_3 was 40%.

Then, the weighed powders were sealed together with zirconia balls as grinding media in a ball mill pot with a 10 liters capacity using Ar gas, and subjected to mixing by mechanically rotating the ball mill for 40 hours. A carbon mold was filled with the resulting mixed powder, and hot press (HP) was performed in a vacuum atmosphere under the following conditions: a sintering temperature of 1050°C , a holding time of 2 hours and a pressure of 30 MPa to manufacture a sintered compact.

[0037] The relative density was 96.8% when a density after hot press was measured by the Archimedes method. Note that the relative density presents a value obtained by dividing back a measured density of a target by a calculated density (also referred to as a theoretical density). Further, the calculated density represents a density when components of a target are assumed to be present in a mixture without diffusing or reacting each other, and is calculated with the following equation.

Equation: Calculated density = Σ (molecular weight of component x molar ratio of component) / Σ (molecular weight of component x molar ratio of component / literature value for density of component), wherein Σ means all components in the target are summed up.

A portion of the sintered compact was cut out, and a cut surface thereof was polished to obtain a sample for X-ray diffraction measurements. Measurements of the sample for X-ray diffraction profiles were performed under

similar conditions as in Example 1 using an X-ray diffractometer. Results showed that (the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy) / (the mean intensity of background) was 1.29.

Next, the sintered compact was subjected to cutting work with a lathe to obtain a disk-shaped target with a diameter of 180.0 mm and a thickness of 5.0 mm. This target was placed in a magnetron sputtering system (a C-3010 sputtering system, Canon Anelva Corporation) to perform sputtering under similar conditions as in Example 1. Results showed that cracking did not occur in the target when sputtering was performed at 8.0 kWhr.

Further, a three-point bending test was performed using a small piece cut out from the target after sputtering. Results showed that the bending strength was 700 MPa.

(Example 6)

[0038] As raw material powders, a Co powder having a mean grain diameter of 1 μm , a Cr powder having a mean grain diameter of 2 μm , a Ru powder having a mean grain diameter of 2 μm , a TiO_2 powder having a mean grain diameter of 1 μm and a Cr_2O_3 powder having a mean grain diameter of 0.6 μm were prepared. These raw material powders were weighed to give a composition of 82(57Co-43Cr)-3Ru-5 TiO_2 -10 Cr_2O_3 (mol%). At this time, the total volume ratio of TiO_2 and Cr_2O_3 was 40%.

Then, the weighed powders were sealed together with zirconia balls as grinding media in a ball mill pot with a 10 liters capacity using Ar gas, and subjected to mixing by mechanically rotating the ball mill for 40 hours. A carbon mold was filled with the resulting mixed powder, and hot press (HP) was performed in a vacuum atmosphere under the following conditions: a sintering temperature of 1050°C, a holding time of 2 hours and a pressure of 30 MPa.

This was further treated by the hot isostatic pressing method (HIP) under the following conditions: a temperature of 1050°C, a holding time of 2 hours and a pressure of 150 MPa to manufacture a sintered compact.

[0039] The relative density was 98.1% when a density after the HIP treatment was measured by the Archimedes method. Note that the relative density was calculated using the method described above.

A portion of the sintered compact was cut out, and a cut surface thereof was polished to obtain a sample for X-ray diffraction measurements. Measurements of the sample for X-ray diffraction profiles were performed under

similar conditions as in Example 1 using an X-ray diffractometer. Results showed that (the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy) / (the mean intensity of background) was 1.30.

5 Next, the sintered compact was subjected to cutting work with a lathe to obtain a disk-shaped target with a diameter of 180.0 mm and a thickness of 5.0 mm. This target was placed in a magnetron sputtering system (a C-3010 sputtering system, Canon Anelva Corporation) to perform sputtering under similar conditions as in Example 1. Results showed that cracking did not occur in the target when sputtering was performed at 8.0 kWhr.

10 Further, a three-point bending test was performed using a small piece cut out from the target after sputtering. Results showed that the bending strength was 720 MPa. Thus, further enhancement of mechanical strength was possible by performing the HIP treatment. The reason behind this appears that defectives such as pores present in the sintered compact were removed by the HIP treatment.

15 [0040] The results described above are shown in Tables 1 to 3. As shown in Tables 1 to 3, all sputtering targets according to the present invention in Examples show fewer σ phases, which are very fragile, in the Co-Cr alloys, and have a mechanical strength of 700 MPa or more, showing no cracking in the targets during sputtering. Moreover, further enhancement of mechanical strength of the targets was possible by finely dispersing non-metal materials in the target, and increasing the relative density by the HIP treatment.

20 [0041] [Table 1]

No.	Composition of Target	Composition ratio (atomic number ratio)	Volume ratio of non-metallic material (vol%)	(X-ray diffraction peak intensity of σ phases in Co-Cr alloy) / (Mean intensity of background)	Bending strength (MPa)	Cracking of target
Example 1	58.5Co-31.5Cr-10SiO ₂	90(65Co-35Cr)-10SiO ₂	31	1.14	908	None
Comparative Example 1	46.8Co-43.2Cr-10SiO ₂	90(52Co-48Cr) — 10SiO ₂	31	1.54	533	Yes
Comparative Example 2	49.5Co-40.5Cr-10SiO ₂	90(55Co-45Cr)-10SiO ₂	31	1.32	641	Yes
Example 2	53.4Co-35.6Cr-8SiO ₂ -3Cr ₂ O ₃	89(60Co-40Cr)-8SiO ₂ -3Cr ₂ O ₃	33	1.16	783	None
Comparative Example 3	48.95Co-40.05Cr-8SiO ₂ -3Cr ₂ O ₃	89(55Co-45Cr)-8SiO ₂ -3Cr ₂ O ₃	33	1.35	627	Yes

[0042] [Table 2]

No.	Composition of Target	Composition ratio (atomic number ratio)	Volume ratio of non-metallic material (vol%)	(X-ray diffraction peak intensity of σ phases in Co-Cr alloy) / (Mean intensity of background)	Mean area of oxide phase (μm^2)	Bending strength (MPa)	Cracking of target
Example 3	52.5Co-17.5Cr-15Pt-10SiO ₂ -5Cr ₂ O ₃	70(75Co-25Cr)-15Pt-10SiO ₂ -5Cr ₂ O ₃	41	1.14	2.4	710	None
Example 4	52.5Co-17.5Cr-15Pt-10SiO ₂ -5Cr ₂ O ₃	70(75Co-25Cr)-15Pt-10SiO ₂ -5Cr ₂ O ₃	41	1.14	0.9	930	None

[0043]

[Table 3]

No.	Composition of Target	Composition ratio (atomic number ratio)	Volume ratio of non-metallic material (vol%)	(X-ray diffraction peak intensity of σ phases in Co-Cr alloy) / (Mean intensity of background)	Relative density (%)	Bending strength (MPa)	Cracking of target
Example 5	46.74Co-35.26Cr-3Ru-5TiO ₂ -10Cr ₂ O ₃	82(57Co-43Cr)-3Ru-5TiO ₂ -10Cr ₂ O ₃	40	1.29	96.8	700	None
Example 6	46.74Co-35.26Cr-3Ru-5TiO ₂ -10Cr ₂ O ₃	82(57Co-43Cr)-3Ru-5TiO ₂ -10Cr ₂ O ₃	40	1.30	98.1	720	None

INDUSTRIAL APPLICABILITY

[0044] The sputtering target according to the present invention can provide stable sputtering because it has a high mechanical strength such that cracking of the target during sputtering can be controlled. In particular, the sputtering target according to the present invention is useful for depositing a nonmagnetic interlayer of a hard disk which employs the perpendicular magnetic recording system.

10

CLAIMS

- [Claim 1] A sintered compact sputtering target, comprising an alloy having a composition of 25 mol% to 40 mol% of Cr with the remainder being Co, and a non-metal material dispersed in the alloy, wherein the intensity ratio of the X-ray diffraction peak intensity of σ phases in the Co-Cr alloy relative to the mean intensity of background is 1.30 or less.
- [Claim 2] The sintered compact sputtering target of claim 1, comprising, as the non-metal material, one or more materials selected from: an oxide of an element selected from Si, Al, B, Ba, Be, Ca, Ce, Cr, Dy, Er, Eu, Ga, Gd, Ho, Li, Mg, Mn, Nb, Nd, Pr, Sc, Sm, Sr, Ta, Tb, Ti, V, Y, Zn and Zr; C (carbon) or a carbide of an element selected from B, Ca, Nb, Si, Ta, Ti, W and Zr; and, a nitride of an element selected from Al, B, Ca, Nb, Si, Ta, Ti and Zr.
- [Claim 3] The sintered compact sputtering target of claim 1 or 2, comprising a total of 20 to 50 vol% of the non-metal material.
- [Claim 4] The sintered compact sputtering target of any one of claims 1 to 3, comprising, as an additive element to the alloy, a total of 0.5 mol% to 15 mol% of one or more elements selected from Pt, Ag, Au, B, Co, Cu, Ga, Ge, Mn, Mo, Nb, Ni, Pd, Re, Rh, Ru, Sn, W, V and Zn.
- [Claim 5] The sintered compact sputtering target of any one of claims 1 to 4, wherein the bending strength of the target is 700 MPa or more.