

SPUTTERING TARGET AND POWDER FOR PRODUCING SPUTTERING TARGET

FIELD OF THE INVENTION

[0001]

The present disclosure relates to a sputtering target and a powder for producing the sputtering target. More particularly, it relates to a sputtering target containing Ru and a powder for producing the sputtering target.

BACKGROUND OF THE INVENTION

[0002]

In the field of magnetic recording media represented by hard disk drives, materials based on Co, Fe or Ni that is a ferromagnetic metal are used as materials of magnetic thin films being responsible for recording. For example, Co-Cr based or Co-Cr-Pt based ferromagnetic alloys containing Co as a main component have been used for recording layers of hard disks employing a longitudinal magnetic recording system.

[0003]

In recent years, the capacity of magnetic recording of hard disk drives and the like has been increasing. In order to realize the increased capacity, it is important to improve the separability of crystal grains in the magnetic recording layer, thereby reducing interaction between the crystal grains.

[0004]

Patent Literature 1 discloses a base layer of a Ru-xCoO alloy. Further, Patent Literature 1 discloses that crystal grain boundaries based on oxides are formed in a second base layer 150b to promote separability between the grains, and

crystal orientations of Ru and a main recording layer 160 forming the base layer 150 are improved.

[0005]

Patent Literature 2 discloses a perpendicular magnetic recording medium including non-magnetic intermediate layers and magnetic layers. Further, Patent Literature 2 discloses Ru as a first non-magnetic intermediate layer and a CoCr alloy as a second non-magnetic intermediate layer.

[0006]

Patent Literature 3 discloses a perpendicular magnetic recording medium provided with at least a perpendicular magnetic layer formed by alternately laminating a first magnetic layer and a second magnetic layer on a non-magnetic substrate via a base layer. Patent Literature 3 also discloses that the base layer comprises Ru containing oxygen.

[0007]

Patent Literature 4 discloses a sputtering target capable of forming a Ru film or a Ru oxide thin film that have higher adhesion to a substrate such as a plug and a barrier metal and have lower specific resistance when used as an electrode.

CITATION LIST

Patent Literatures

[0008]

[Patent Literature 1] Japanese Patent Application Publication No. 2012-009086 A

[Patent Literature 2] Japanese Patent Application Publication No. 2009-134804 A

[Patent Literature 3] Japanese Patent Application Publication No. 2005-243093 A

[Patent Literature 4] Japanese Patent Application Publication No. 2002-167668 A

SUMMARY OF THE INVENTION

Technical Problem

[0009]

The intermediate layer underlying the magnetic recording layer plays an important role in improving the separability. When Ru crystal grains are present in the intermediate layer, the crystal grains in the magnetic recording layer grow starting from the Ru crystal grains. Further, when an Ru oxide and Ru-B are used as the intermediate layer, the magnetic recording characteristics are improved. Based on these findings, the present inventors have examined a combination of Ru and boron oxide. The purpose of this is to obtain a structure in which a boron oxide is arranged around Ru crystal grains. Here, although a method of co-sputtering Ru and boron oxide can be considered, a single sputtering target containing both is more advantageous in terms of the production step.

[0010]

Therefore, the present inventors have first examined production of a sputtering target containing Ru and a boron oxide. As a result, the following points have been found. A material must be subjected to processing such as hot pressing (HP) and/or hot isotropic pressing (HIP) in order to produce a sputtering target. In this case, the material is exposed to elevated temperature. The present inventors have used B_2O_3 as the boron oxide. However, because of a lower melting point of B_2O_3 , the B_2O_3 has flowed out from the material by the HP and/or HIP processing. As a result, an amount of boron oxide remaining in a sintered body has been significantly decreased. Therefore, B_2O_3 could not be used in producing the sputtering target containing Ru and the boron oxide. In view of the above circumstances, an object of the present disclosure is to provide a sputtering target containing Ru and a boron oxide.

Solution to Problem

[0011]

As a result of further studies, the present inventors have found that when a specific composite boron oxide is used in place of B_2O_3 , boron remains in the sintered body. It is believed that a reason why it remains is that an amount lost during the HP and/or HIP processing could be reduced by using the boron oxide having a melting point higher than that of B_2O_3 .

[0012]

The present invention has been completed based on the above findings and includes the following inventions in one aspect.

(Invention 1)

A sputtering target containing Ru as a main component, wherein the sputtering target has a melting point higher than that of B_2O_3 and comprises a composite oxide containing boron.

(Invention 2)

The sputtering target according to Invention 1, wherein the sputtering target has a B content of 0.01 wt% or more.

(Invention 3)

The sputtering target according to Invention 1 or 2, wherein the sputtering target has a relative density of 90% or more.

(Invention 4)

The sputtering target according to any one of Inventions 1 to 3, further comprising one or more selected from Co, Cr, Mn, and Ti as constituent elements, in addition to Ru, B, and O.

(Invention 5)

The sputtering target according to any one of Inventions 1 to 4, wherein the composite oxide has a melting point of 750 °C or more.

(Invention 6)

The sputtering target according to any one of Inventions 1 to 5, wherein the composite oxide is one or more selected from the group consisting of $\text{Co}_2\text{B}_2\text{O}_5$, CrBO_3 , TiBO_3 and $\text{Mn}_3\text{B}_2\text{O}_6$.

(Invention 7)

A powder of a composite oxide for use in production of a sputtering target, wherein the composite oxide is a composite oxide having a melting point higher than that of B_2O_3 , the composite oxide containing boron.

(Invention 8)

The powder according to Invention 7, wherein the composite oxide has a melting point of 750 °C or more.

(Invention 9)

The powder according to Invention 7 or 8, wherein the composite oxide is one or more selected from the group consisting of $\text{Co}_2\text{B}_2\text{O}_5$, CrBO_3 , TiBO_3 and $\text{Mn}_3\text{B}_2\text{O}_6$.

(Invention 10)

The powder according to any one of Inventions 7 to 9, wherein the powder has a specific surface area of from 0.5 to 80 m^2/g , a particle size of from 0.3 to 15 μm , and/or an impurity concentration of 10000 wtppm or less.

Advantageous Effects of Invention

[0013]

In one aspect, the sputtering target according to the present disclosure contains Ru and B. This can eliminate the need for co-sputtering, which is advantageous in the production step.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

FIG. 1 is an SEM photograph of a target produced using Ru powder and $\text{Co}_2\text{B}_2\text{O}_5$ powder in an embodiment. The square part represents a part of oxides analyzed by EDS.

DETAILED DESCRIPTION OF THE INVENTION

[0015]

Hereinafter, specific embodiments for carrying out the invention according to the present disclosure will be described. The following descriptions are for facilitating the understanding of the invention according to the present disclosure. Therefore, they are not intended to limit the scope of the present invention.

[0016]

1. Sputtering Target

In an embodiment, the present disclosure relates to a sputtering target.

[0017]

1-1. Composition of Sputtering Target

In an embodiment, the sputtering target contains at least Ru and a composite oxide. The Ru is a main component of the sputtering target.

[0018]

As used herein, the main component refers to an element having the highest content (at%) among the metal elements. Typically, the main component may mean 50 at% or more.

[0019]

Further, the composite oxide is a compound containing boron and having a melting point higher than that of B_2O_3 . This can allow a larger amount of B to remain in a sintered body as compared with a case where the sputtering target is produced by using B_2O_3 . Therefore, crystal separability of Ru after sputtering is improved.

[0020]

In an embodiment, a content of Ru may be from 80.0 to 99.8 wt%. The content of Ru of 80.0 wt% or more can allow Ru crystal grains required for the growth of crystal grains in a recording layer to be sufficiently ensured in an intermediate layer after film formation. The content of Ru of 99.8 at% or less can allow the B content to be sufficient for separating the crystal grains of Ru to be ensured in the intermediate layer after the film formation. The lower limit of the Ru content is preferably 90.0 wt% or more, and more preferably 95 wt% or more. The upper limit of the Ru content is preferably 99.5 wt% or less, and more preferably 99.0 wt% or less.

[0021]

In an embodiment, a content of B is 0.01 wt% or more. The content of B of 0.01 wt% or more can allow the B content to be sufficient for separating the Ru crystal grains to be ensured in the intermediate layer after the film formation. The upper limit of the B content may be typically 3.0 wt% or less in terms of maintaining characteristics of Ru, although not particularly limited thereto. The lower limit of the B content may preferably be 0.05 wt% or more, and more preferably 0.15 wt% or more.

[0022]

In an embodiment, in addition to the Ru, B and O as described above, the sputtering target may contain one or more selected from Co, Cr, Mn, and Ti. Each of these elements can form a composite oxide with B. The composite oxide has a melting point higher than that of B_2O_3 . Therefore, it is less likely that it will be dissolved and lost by a heat treatment (e.g., HIP, HP, or the like) during production.

[0023]

The content of at least one element selected from Co, Cr, Mn, and Ti is preferably according to a stoichiometric ratio for forming the composite oxide with B, although not particularly limited thereto.

[0024]

Similarly, the content of O is preferably according to a stoichiometric ratio for forming the composite oxide with B, although not particularly limited thereto.

For example, when the composite oxide is $\text{Co}_2\text{B}_2\text{O}_5$, the Co content is 53.70 wt%, the B content is 9.85 wt%, and the O content is 36.45 wt%, based on the total weight of the composite oxide of 100%. Therefore, assuming that the total weight of the sputtering target is 100% and the B content in the entire sputtering target is 0.01 wt% or more, the Co content is 0.054 wt% or more, and the O content is 0.036 wt% or more.

[0025]

In an embodiment, the sputtering target may consist of the following elements:

Ru;

B;

at least one selected from Co, Cr, Mn, and Ti; and

O.

[0026]

In an embodiment, the sputtering target may contain inevitable impurities in addition to the elements as described above. The inevitable impurity content may be 10,000 wtpm or less, and preferably 5000 wtpm or less (the total amount of all inevitable impurity elements).

[0027]

Elemental analysis (and quantification) of the sputtering target can be carried out by methods known in the art, for example, by the following method. For

example, the sputtering target itself or waste materials of a sintered body (waste left when processed into a shape of the sputtering target) can be used as a sample.

First, about 5 g of the sample collected from a position as close to the center of the sputtering target as possible is powdered. For O, N, and C, the measurement can be carried out using an infrared absorption method (TC 600 from LECO) after heating the powder to gasifying it. For boron and metal elements, the powder is dissolved with an acid or the like and analyzed using an ICP emission spectroscopic analyzer (SPS 3100 HV from Hitachi High-Tech Corporation). Alternatively, the constituent elements may be analyzed by EDS (S-3700 N from Hitachi High-Tech Corporation) or EPMA (JXA-8500 F from JEOL Ltd.).

[0028]

1-2. Composite Oxide Containing Boron in Sputtering Target

In an embodiment, the composite oxide containing boron includes a composite oxide composed of B, O and a metal element(s). A reason for using such a composite oxide is that it has a melting point higher than that of B_2O_3 as described above and is less likely to be lost by a heat treatment. More preferably, the melting point of the composite oxide containing boron may be 750 °C or more (preferably 1000 °C or more). The upper limit of the melting point is typically 1300 °C or less, although not particularly limited thereto.

[0029]

The metal element for forming the composite oxide containing boron preferably includes, but not limited to, one or more selected from Co, Cr, Mn, and Ti. These metal elements are preferable because it is less likely that they would adversely affect the crystallinity of Ru. For example, Co presents an hcp crystal structure as with Ru, so that Co does not affect the crystallinity of Ru. In a case of Ru rich, Cr, Ti, and Mn do not react with Ru and do not affect the crystallinity of Ru.

[0030]

Specific examples of the composite oxide containing boron include, but not limited to, one or more selected from the group consisting of $\text{Co}_2\text{B}_2\text{O}_5$, CrBO_3 , TiBO_3 and $\text{Mn}_3\text{B}_2\text{O}_6$.

[0031]

The presence or absence of the composite oxide containing boron as described above can be confirmed by EDS or EPMA.

[0032]

1-3. Relative Density of Sputtering Target

In an embodiment, the sputtering target may have a relative density of 90% or more, and preferably 98% or more. This can allow arcing to be further suppressed. The relative density as used herein refers to a ratio of a measured density to a theoretical density. The measured density refers to a value measured by an Archimedes method using pure water as a solvent. The theoretical density is the sum of values obtained by multiplying each of individual densities of a raw materials by a mixed mass ratio, as described below:

Theoretical density = $\sum \{(\text{theoretical density of component } n \times \text{mixed mass ratio})\}$.

[0033]

In order to produce the sputtering target having the higher relative density, a pressure must be applied at a high temperature as described later. However, when the B compound having a lower melting point such as B_2O_3 is contained in the material, the B_2O_3 is melted and lost due to the heat treatment. On the other hand, if the pressure is decreased, the relative density will be lower and the required level of the product cannot be passed. Therefore, it is significant that the sputtering target containing B and having the higher relative density can be achieved.

[0034]

2. Powder for Sputtering Target powder

2-1. Properties of Powder

In an embodiment, the present disclosure relates to a powder for producing a sputtering target and the use of the powder. A component of the powder is a composite oxide containing boron. Preferably, the composite oxide containing boron has a melting point of 750 °C or more (more preferably 1000 °C or more). The upper limit is typically 1300 °C or less, although not particularly limited thereto. A metal element forming the complex oxide containing boron in the powder preferably includes, but not limited to, one or more selected from Co, Cr, Mn, and Ti. Specific examples of the composite oxide containing boron include, but not limited to, one or more selected from the group consisting of $\text{Co}_2\text{B}_2\text{O}_5$, CrBO_3 , TiBO_3 and $\text{Mn}_3\text{B}_2\text{O}_6$.

[0035]

In an embodiment, the powder may have a particle size D50 of from 0.3 to 15 μm . These sizes can allow a sputtering target having high quality to be produced. The lower limit of D50 is preferably 0.8 μm or more, and more preferably 1.0 μm or more. The upper limit of D50 is preferably 10 μm or less, and more preferably 5 μm or less.

[0036]

The particle size of the powder means a particle size at an integrated value of 50% (D50) based on a volume value in a particle size distribution obtained by a laser diffraction/scattering method. For example, the particle size can be determined by dispersing the powder in an ethanol solvent and measuring the particle size using a particle size distribution measuring device, model LA-920 from HORIBA.

[0037]

In an embodiment, the powder has a lower impurity concentration, because impurities adversely affect the sputtering target after production. For example, examples of impurities include Ti (limited to the case of the composite oxide of Co,

Cr, or Mn), Al, N, C, and the like. The total concentration of these impurities may be 10000 wtppm or less, and preferably 5000 wtppm or less. The impurity concentration can be analyzed by using the infrared absorption method, ICP emission spectroscopic analyzer, GDMS (glow discharge mass spectrometry) and the like, as described above.

[0038]

In an embodiment, the powder may have a specific surface area of from 0.5 to 80 m²/g. These specific surface areas can allow a sputtering target having high quality to be produced. The lower limit of the specific surface area is preferably 0.8 m²/g or more, and more preferably 1.5 m²/g or more. The upper limit of the specific surface area is preferably 50 m²/g or less, and more preferably 35 m²/g or less.

[0039]

The specific surface area as used herein refers to a value measured by the following procedure:

- degassing a target substance at 200 °C for 2 hours; and
- measuring the specific surface area by a BET method (one-point method) using a mixed gas of 70 at% of He and 30 at% of N₂ as an adsorbing gas with Monosorb from Quantachrome.

[0040]

2-2. Method for Producing Composite Oxide Powder Containing Boron

First, powder of an oxide containing at least one of Co, Cr, Ti and Mn, and powder of an oxide containing B are prepared. These powders may be commercially available products. These powders are preparing by mixing them together and then heating them at a temperature lower than or equal to their melting points. Further, in order to render the powder suitable for producing a sputtering target, a crushing step can be added after synthesis.

[0041]

The method of mixing and crushing is not particularly limited, and known means such as mortar mixing and ball mill may be used.

[0042]

The heating may be carried out using a known means.

[0043]

3. Method for Producing Sputtering Target

In an embodiment, the present disclosure relates to a method for producing a sputtering target. The method includes at least the following steps:

- a step of mixing Ru powder and powder of a composite oxide containing boron;
- and
- a step of sintering the mixed powder under pressure.

[0044]

3-1. Mixture

First, Ru powder and powder of the composite oxide containing boron are prepared. The Ru powder may employ a commercially available product. Preferably, powder suitable for producing a sputtering target is used (e.g., powder having lower impurities, and the like). On the other hand, the powder of the composite oxide containing boron may employ the composite oxide containing boron having a melting point of 750 °C or more (preferably 1000 °C or more), as described above.

[0045]

The method of mixing both is not particularly limited, and known means such as mortar mixing and ball mill may be used.

[0046]

3-2. Sintering under Pressure

The above mixed powder can be filled in a mold or the like and sintered.
Examples of the pressurizing method when sintering the mixed powder include hot pressing (HP) and/or hot isotropic pressing (HIP).

[0047]

A processing temperature during hot pressing may be from 750 to 1200 °C.
The lower limit of the processing temperature may be preferably 900 °C or more.
The upper limit of the processing temperature may be preferably 1100 °C or less.
A maintaining pressure during the sintering is preferably in a pressure range of 150 kgf/cm² or more.

[0048]

A processing temperature during hot isotropic pressing may be from 750 to 1200 °C. The lower limit of the processing temperature may be preferably 900 °C or more. The upper limit of the processing temperature may be preferably 1100 °C or less. A maintaining pressure during the sintering is preferably in a pressure range of 1000 kgf/cm² or more.

[0049]

3-3. Other

After undergoing the above mixing and sintering, machining may further be performed to finish it into a desired shape.

[0050]

4. Use of Sputtering Target

4-1. Film Formation

A film can be formed using the sputtering target obtained in the above step.
The sputtering conditions may employ those known in the art, typically as follows:
Sputtering Conditions
Sputtering device: C 3010 from Canon Anelva Corporation;
Input power: from 100 to 1 kW (for example, 1 kW);

Ar gas pressure: from 1 to 10 Pa (for example, 1.7 Pa); and

Pre-sputtering: from 0.5 to 2 kWhr (for example, 2 kWhr).

[0051]

4-2. Magnetic Recording Medium

Sputtering can be carried out under the above conditions to form an intermediate layer for a magnetic recording layer. Utilizing this, a magnetic recording medium can be produced.

For example, the magnetic recording medium can be produced by the following procedure. First, a substrate is prepared. Onto the substrate, a layer containing NiW or NiFeW as a component is formed. Then, onto the NiW layer or the NiFeW layer, a pure Ru layer is formed. Subsequently, the sputtering can be carried out using the above sputtering target to form a layer composed of Ru and the composite oxide containing boron as an intermediate layer. Then, onto the intermediate layer, a magnetic recording layer is formed. Onto the magnetic recording layer, layers known in the art such as a protective layer and a lubricating layer can be provided. Further, provided under the NiW layer can be layers known in the art such as an adhesion layer containing CrTi or NiTa as a main component, a soft magnetic layer containing FeCoTa, FeCoNb, FeCoMo or the like as a main component, and a Ru layer promoting an antiferromagnetic bond at the middle of the soft magnetic layer.

[0052]

The perpendicular magnetic recording medium obtained by the above method can have relatively less irregularities at boundaries between Ru and the recording layer, improved magnetic separation between the magnetic particles in the recording layer, and increased magnetic anisotropy of the magnetic particles. Therefore, it is possible to improve recording density of the HDD having the perpendicular magnetic recording medium.

EXAMPLES

[0053]

5. Examples

5-1. Production of Sputtering Target

Ruthenium powder (a purity of 99.9 wt%) and Powder of a composite oxide powder containing boron (a purity of 99 wt%) were prepared. For the composite oxide containing boron, four types of $\text{Co}_2\text{B}_2\text{O}_5$, CrBO_3 , TiBO_3 , and $\text{Mn}_3\text{B}_2\text{O}_6$ (Examples 1 to 4) and B_2O_3 (Comparative Example) were prepared. The ruthenium powder and the powder of the composite oxide containing boron were mixed such that the content of the composite oxide containing boron was "B Target Composition Value wt%" as shown in Table 1. The mixture was then filled in a carbon mold and hot-pressed. The hot pressing conditions were an Ar atmosphere, a sintering temperature of 1000 °C, a sintering pressure of 300 kg/cm², and a sintering time of 2 hours. A sintered body taken out from the hot pressing mold was subjected to hot isostatic pressing sintering (HIP). The conditions for hot isostatic pressing sintering were a maintaining temperature of 1100 °C and a maintaining time of 2 hours, and a gas pressure of an Ar gas was gradually increased from the start of increasing the temperature and pressurized at 1500 kgf/cm² while maintaining the temperature at 1100 °C. The resulting sintered body was cut into a desired size to obtain a disk-shaped sputtering target.

[0054]

Further, a sputtering target (Reference Example) was produced under the same conditions as above using only ruthenium powder (a purity of 99.9 wt%).

[0055]

Immediately after hot pressing and immediately after hot isostatic pressing sintering, the density of each sintered body was measured and the relative density was calculated.

[0056]

Further, an amount of boron was analyzed using an ICP emission spectroscopic analyzer (SPS 3100 HV from Hitachi High-Tech Corporation).

[0057]

The results are shown in Table 1.

Table 1

	Composition	Oxide Volume Fraction (%)	Theoretical Density (g/cm ³)	HP Temperature (°C)	Dimensional Density after HP (g/cm ³)	Relative Density after HP (%)	HIP Temperature (°C)	Archimedes Density after HIP (g/cm ³)	Relative Density after HIP (%)	B Target Composition Value (wt%)	B Analysis Value [ICP] (wt%)
Reference Example	Ru	–	12.06	1000	10.72	88.89	1100	11.53	95.61	–	–
Comparative Example	Ru-B ₂ O ₃	15	10.528	1000	10.51	99.83	1100	–	–	0.81	Not detected
Example 1	Ru-Co ₂ B ₂ O ₅	15	10.857	1000	10.62	97.82	1100	10.89	100.30	0.55	0.49
Example 2	Ru-CrBO ₃	15	10.948	1000	10.14	92.62	1100	10.97	100.20	0.55	0.48
Example 3	Ru-TiBO ₃	15	10.815	1000	8.77	81.09	1100	9.91	91.63	0.53	0.51
Example 4	Ru-Mn ₃ B ₂ O ₆	15	10.955	1000	10.12	92.38	1100	10.92	99.68	0.53	0.49

[0058]

In Example 1, the sputtering target was produced by mixing the powders such that the amount of B was 0.55 wt%. The B content in the resulting sputtering target was 0.49 wt%. Therefore, it was demonstrated that B remained even after undergoing hot pressing and hot isostatic pressing sintering. Similar trends were shown in Examples 2 to 4.

[0059]

5-2. Presence of Composite Oxide Containing Boron

For Examples 1 to 4, their sputtering target structures were observed by SEM (FIG. 1). Further, a part of the observed oxide (the square part in FIG. 1) was quantitatively analyzed using EDS (S-3700 N from Hitachi High-Tech Corporation). The results are shown in Table 2.

[0060]

Table 2

		EDS Quantification Results [wt%]					
		Co	Cr	Ti	Mn	B	O
Example 1	Ru-Co ₂ B ₂ O ₅	55.5	0	0	0	9.4	35.1
Example 2	Ru-CrBO ₃	0	47.6	0	0	10.2	42.2
Example 3	Ru-TiBO ₃	0	0	43.9	0	9.6	46.5
Example 4	Ru-Mn ₃ B ₂ O ₆	0	0	0	56.2	7.2	36.6

[0061]

In Example 1, Co, B and O were detected in the same compartment. Therefore, it was demonstrated that a composite oxide of Co₂B₂O₅ was present. Similarly, it was also demonstrated that the desired composite oxides (CrBO₃, TiBO₃ and Mn₃B₂O₆) were present in Examples 2 to 4.

[0062]

The specific embodiments according to the present invention have been described above. The above embodiments are merely specific examples of the

present invention, and the present invention is not limited to the above embodiments. For example, the technical features disclosed in one of the above embodiments may be applied to other embodiments. Further, unless otherwise specified, it is possible for a specific method to replace a part of steps with the order of other steps, and an additional step may be added between two specific steps. The scope of the present invention is defined by the claims.

CLAIMS

1. A sputtering target containing Ru as a main component, wherein the sputtering target has a melting point higher than that of B_2O_3 and comprises a composite oxide containing boron.
2. The sputtering target according to claim 1, wherein the sputtering target has a B content of 0.01 wt% or more.
3. The sputtering target according to claim 1 or 2, wherein the sputtering target has a relative density of 90% or more.
4. The sputtering target according to any one of claims 1 to 3, further comprising one or more selected from Co, Cr, Mn, and Ti as constituent elements, in addition to Ru, B, and O.
5. The sputtering target according to any one of claims 1 to 4, wherein the composite oxide has a melting point of 750 °C or more.
6. The sputtering target according to any one of claims 1 to 5, wherein the composite oxide is one or more selected from the group consisting of $Co_2B_2O_5$, $CrBO_3$, $TiBO_3$ and $Mn_3B_2O_6$.
7. A powder of a composite oxide for use in production of a sputtering target, wherein the composite oxide is a composite oxide having a melting point higher than that of B_2O_3 , the composite oxide containing boron.

8. The powder according to claim 7, wherein the composite oxide has a melting point of 750 °C or more.
9. The powder according to claim 7 or 8, wherein the composite oxide is one or more selected from the group consisting of $\text{Co}_2\text{B}_2\text{O}_5$, CrBO_3 , TiBO_3 and $\text{Mn}_3\text{B}_2\text{O}_6$.
10. The powder according to any one of claims 7 to 9, wherein the powder has a specific surface area of from 0.5 to 80 m^2/g , a particle size of from 0.3 to 15 μm , and/or an impurity concentration of 10000 wtppm or less.