

SPECIFICATION

TITLE OF THE INVENTION : SPUTTERING TARGET FOR MAGNETIC MATERIALS, SPUTTERING TARGET ASSEMBLY FOR MAGNETIC MATERIALS, AND METHOD FOR PRODUCING SPUTTERING TARGET FOR MAGNETIC MATERIALS

FIELD OF THE INVENTION

[0001]

The present invention relates to a sputtering target for magnetic materials, a sputtering target assembly for magnetic materials, and a method for producing a sputtering target for magnetic materials, and mainly relates to a sputtering target for producing films for HDDs.

BACKGROUND OF THE INVENTION

[0002]

For example, the layers of hard disks that employ perpendicular magnetic recording systems are made of materials based on ferromagnetic metals such as Co, Fe, and Ni, and recording layers are often made of composite materials consisting of ferromagnetic alloys, such as Co-Cr, Co-Pt, Co-Cr-Pt, and Fe-Pt, which have Co or Fe as their main components, and non-magnetic inorganic materials. Thin films for magnetic recording media such as hard disks are often produced by sputtering targets containing the above materials, due to their high productivity.

[0003]

Sputtering is a technique for forming a thin film on the surface of a substrate by sputtering the surface of a sputtering target, which serves as the sputtering source, with accelerated argon ions, releasing particles (sputter particles) from the

sputtering target and depositing the sputter particles on the surface of a substrate that has been placed in an opposing position.

[0004]

Some of the sputtered particles may redeposit at specific locations on the sputtering target to form a laminate (also called a redeposited film). If this redeposited film peels off from the sputtering target, it can cause arcing (abnormal discharge) during sputtering, increase the number of particles during sputtering, and cause problems such as contamination of the thin film, resulting in a lower product yield.

[0005]

To address this problem, Patent Literature 1 discloses that the region of the sputtering target where the redeposited film is formed is roughened by blasting with glass beads. It also discloses that this makes it possible to prevent the redeposited film from peeling off from the roughened surface. Patent Literature 2 also discloses that the sputtering target is roughened. Patent Literature 2 also discloses that the region to be roughened is within a range from the outer periphery (0%) of the sputtering target to a position 2 to 13% in the center direction, and/or within a range from the center (0%) to a position 12 to 33% in the outer periphery direction.

CITATION LIST

Patent Literatures

[0006]

[Patent Literature 1] Japanese Unexamined Patent Application Publication No. 4-301074

[Patent Literature 2] Japanese Unexamined Patent Application Publication No. 2018-141202

SUMMARY OF THE INVENTION

[0007]

Both Patent Literatures 1 and 2 merely mention controlling the arithmetic mean roughness Ra, and there is room for improvement in terms of suppressing peeling of the redeposited film.

[0008]

Therefore, an object of an embodiment of the present invention is to provide a sputtering target for magnetic materials, a sputtering target assembly for magnetic materials, and a method for producing a sputtering target for magnetic materials that can effectively suppress peeling of a redeposited film.

[0009]

The above problems are solved by the present invention, which is specified as follows.

[1] A sputtering target for magnetic materials having a sputtering region and a non-sputtering region,

wherein a surface of the non-sputtering region has a plurality of rounded convex portions,

wherein the plurality of convex portions include convex portions connected via connecting portions and/or convex portions not connected via connecting portions.

[2] The sputtering target for magnetic materials according to [1],

wherein the surface of the non-sputtering region has a developed area ratio Sdr of 4.5 or more.

[3] The sputtering target for magnetic materials according to [1] or [2],

wherein a surface roughness Sa of the non-sputtering region is 10 to 40 μm .

[4] The sputtering target for magnetic materials according to any one of [1] to [3],

wherein a maximum height Sz of the non-sputtering region is 100 to 250 μm .

[5] The sputtering target for magnetic materials according to any one of [1] to [4],

wherein a root mean square height S_q of the non- sputtering region is 3 to 45 μm .

[6] The sputtering target for magnetic materials according to any one of [1] to [5],

wherein a composition of the sputtering target comprises at least one element selected from the group consisting of Co, Pt, Fe, Ru, Cr, Ti, Si, Zr, B, C, N, Al, O, Mg, Zn, Ag, Cu, Ni, Ta, Nb, V, W, Mn, Bi, Ge, and Ir.

[7] A sputtering target assembly for magnetic materials, comprising:
the sputtering target for magnetic materials according to any one of [1] to [6];
and

a backing plate bonded to the sputtering target for magnetic materials.

[8] A method for producing a sputtering target for magnetic materials having a sputtering region and a non-sputtering region,

comprising forming a plurality of rounded convex portions on the surface of the non-sputtering region,

wherein the plurality of convex portions include convex portions connected via connecting portions and/or convex portions not connected via connecting portions.

[0010]

According to the present invention, it is possible to provide a sputtering target for magnetic materials, a sputtering target assembly for magnetic materials, and a method for producing a sputtering target for magnetic materials that can effectively suppress peeling of a redeposited film.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG.1(A) and FIG.1(B) are plan views each schematically showing a disk-shaped sputtering target.

FIG.2 is a SEM photograph of the surface of a non-sputtering region illustrating first convex portions, second convex portions, and connecting portions.

FIG.3(A) and FIG.3(B) are schematic diagrams of an example of a structure including first convex portions, second convex portions, and connecting portions, respectively.

FIG.4(A) and FIG.4(B) are schematic diagrams of an example of a structure including first convex portions, second convex portions, third convex portions, and connecting portions, respectively.

FIG.5(A) and FIG.5(B) are schematic diagrams of an example of a structure including first convex portions, second convex portions, third convex portions, fourth convex portions, and connecting portions, respectively.

FIG.6 is a SEM photograph of the surface of a non-sputtering region illustrating a first convex portions and second convex portions.

FIG.7 is a schematic diagrams of an example of first convex portion and second convex portion.

FIG.8(A) is a SEM photograph of the non-sputtering region surface of Example 1. FIG.8(B) is a SEM photograph of the non-sputtering region surface of Example 2. FIG.8(C) is a SEM photograph of the non-sputtering region surface of Example 3. FIG.8(D) is a SEM photograph of the non-sputtering region surface of Example 4. FIG.8(E) is a SEM photograph of the non-sputtering region surface of Example 5.

FIG.9(A) is a SEM photograph of an appearance of the sample surface after lacquer spray application in Example 3. FIG.9(B) is a SEM photograph of an appearance of the sample surface after cutting out a 1 mm square grid in Example 3. FIG.9(C) is a SEM photograph of an appearance of the sample surface after a peel test in Example 3.

DETAILED DESCRIPTION OF THE INVENTION

[0012]

Next, embodiments of the present invention will be described in detail with reference to the drawings. It should be understood that the present invention is not limited to the following embodiments, and that appropriate design changes and improvements may be made based on the ordinary knowledge of those skilled in the art without departing from the spirit of the present invention.

[0013]

<Sputtering Target for Magnetic Materials>

The shape of the sputtering target for magnetic materials according to embodiments of the present invention is not particularly limited, but may be flat (including disc-shaped or rectangular plate-shaped), cylindrical, or any other shape. Note that, throughout this specification, the sputtering target for magnetic materials may also be referred to simply as the sputtering target.

[0014]

The sputtering target according to this embodiment is used, for example, to form magnetic recording layers and thin films in HDDs. The material of the sputtering target according to this embodiment is not particularly limited, but may include at least one element selected from the group consisting of Co, Pt, Fe, Ru, Cr, Ti, Si, Zr, B, C, N, Al, O, Mg, Zn, Ag, Cu, Ni, Ta, Nb, V, W, Mn, Bi, Ge, and Ir. Alternatively, the sputtering target may include an alloy containing at least one element selected from the group consisting of Co, Pt, Fe, Ru, Cr, Ti, Si, Zr, B, C, N, Al, Mg, Zn, Ag, Cu, Ni, Ta, Nb, V, W, Mn, Bi, Ge, and Ir. The sputtering target may also be made of a material containing an alloy particle phase and a non-magnetic material. The non-magnetic material may be one or more selected from carbon, oxides, nitrides, and carbides.

[0015]

The sputtering target according to the embodiment of the present invention mainly has a front surface, a back surface, and a side surface. The front surface is

subjected to a roughening treatment described below. Therefore, the front surface has a sputtering region and a non-sputtering region. The sputtering region is a region on the surface of the sputtering target that is sputtered by bombarding accelerated argon ions, and the non-sputtering region is a region on the surface of the sputtering target other than the sputtering region. This non-sputtering region is a region where some of the sputtered particles redeposit to form a redeposited film, and in order to effectively suppress peeling of the redeposited film, the sputtering target according to the embodiment of the present invention is subjected to a very distinctive roughening treatment.

[0016]

Specific examples of the sputtering region and the non-sputtering region of the sputtering target according to the embodiment of the present invention are shown in FIG.1(A) and FIG.1(B), which are plan views schematically showing sputtering targets 10a and 10b formed in a disk shape, respectively.

[0017]

In the sputtering target 10a shown in FIG.1(A), only the peripheral portion of the surface of the sputtering target 10a, where the redeposited film is formed, is a non-sputtering region 12a, while the remaining regions, including the central portion, are sputtering regions 11a. The peripheral non-sputtering region 12a is preferably formed with a uniform width of a predetermined size along the circumferential direction of the surface of the sputtering target 10a. The area ratio of the peripheral non-sputtering region 12a is not particularly limited as long as it covers at least the position where the redeposited film is formed. Furthermore, the sputtering target 10a may have a non-sputtering region that is roughened not only on the peripheral portion of the surface as described above, but also on the entire or part of the side surface. Even in this case, the entire or part of the side surface non-sputtering region has the same characteristics as the non-sputtering region described below.

[0018]

In the sputtering target 10b shown in FIG.1(B), the peripheral portion of the surface of the sputtering target 10b where the redeposited film is formed is a non-sputtering region 12b, and the central portion of the surface is also a non-sputtering region 13b. The area other than these non-sputtering regions 12b and 13b is a sputtering region 11b. The peripheral non-sputtering region 12b is preferably formed with a uniform width of a predetermined size along the circumferential direction of the surface of the sputtering target 10b. The area ratios of the central non-sputtering region 13b and the peripheral non-sputtering region 12b are not particularly limited as long as they cover at least the position where the redeposited film is formed. Furthermore, only the central portion of the surface of the sputtering target 10b may be roughened. Furthermore, the sputtering target 10b may have a non-sputtering region where the entire surface or a portion of the side surface is roughened, in addition to the peripheral and central portions of the surface as described above. In this case, the entire surface or a portion of the side surface has the same characteristics as the non-sputtering region described below.

[0019]

The surface of the non-sputtering region of the sputtering target according to an embodiment of the present invention has a plurality of rounded convex portions, and the plurality of convex portions includes convex portions connected via connecting portions and/or convex portions not connected via connecting portions. This configuration allows for the formation of favorable irregularities on the surface of the non-sputtering region, ensuring a sufficient surface area. This improves the adhesion of the redeposited film formed in the non-sputtering region, effectively suppressing peeling of the redeposited film. As a result, particle contamination during sputtering is suppressed, improving the product yield. The plurality of convex portions and connecting portions will be described in detail below with reference to the drawings.

[0020]

FIG.2 shows a SEM photograph (magnification: 100x) of the surface of the non-sputtering region of a sputtering target according to Example 1, which will be described later, as an example of a sputtering target according to an embodiment of the present invention. Here, first and second convex portions are described as the multiple convex portions, but there are also multiple other convex portions. The surface of the non-sputtering region has a rounded first convex portion 21 and a rounded second convex portion 22, and the first convex portion 21 and the second convex portion 22 are connected via a connecting portion 23. A plurality of structures including the first convex portion 21, the second convex portion 22, and the connecting portion 23 are formed on the surface of the non-sputtering region. The structures including the first convex portion 21, the second convex portion 22, and the connecting portion 23 are formed by laser processing the surface of the sputtering target, as will be described later, and are structures in which the first convex portion 21, the second convex portion 22, and the connecting portion 23 are continuous with each other. The multiple structures including the first convex portion 21, the second convex portion 22, and the connecting portion 23 may exist singly, multiple structures may be adjacent to each other, the structures may partially overlap each other, or a combination thereof may be used. The shape of the first convex portion 21 may be the same as or different from the shape of the second convex portion 22. The structures may be formed on a portion of the surface of the non-sputtering region. Furthermore, if multiple structures are formed over the entire surface of the non-sputtering region while partially overlapping each other, this is preferable because the surface area of the non-sputtering region is further increased and the adhesion of the redeposited film formed on the non-sputtering region is further improved.

[0021]

The first convex portion 21 and the second convex portion 22 each have a rounded shape. The first convex portion 21 and the second convex portion 22 may

have a rounded shape like a sphere, a rounded shape like an ellipsoid or an elongated ellipsoid (prolate ellipsoid), or another rounded shape, or may have a plurality of rounded shapes formed by combining a plurality of spheres.

[0022]

The shape and size of the connecting portion 23 are not particularly limited as long as it has a shape that connects the first convex portion 21 and the second convex portion 22, and it may be a shape that extends with a uniform thickness, or a shape that extends with an uneven thickness, may extend in a straight line, may extend in a curved line, may extend in two or three directions, or may extend in more directions.

[0023]

FIG.3(A) and FIG.3(B) are schematic diagrams showing an example of a structure including the first convex portion 21, the second convex portion 22, and the connecting portion 23 when observing the surface of a non-sputtering region of a sputtering target according to an embodiment of the present invention. In FIG.3(A), the first convex portion 21 and the second convex portion 22 have similar shapes, while in FIG.3(B), the first convex portion 21 and the second convex portion 22 have different shapes or sizes. In FIG.3(A) and FIG.3(B), the structure including the first convex portion 21, the second convex portion 22, and the connecting portion 23 has a shape in which the first convex portion 21 and the second convex portion 22, which have a rounded shape such as a sphere or an ellipse, are integrally formed at the end of the connecting portion 23.

[0024]

The surface of the non-sputtering region of the sputtering target according to an embodiment of the present invention may further include a third convex portion. FIG.4(A) and FIG.4(B) are schematic diagrams illustrating an example of a structure including the first convex portion 21, the second convex portion 22, the third convex portion 24, and the connecting portion 23, as observed from the surface of the non-

sputtering region. In FIG.4(A) and FIG.4(B), the structure including the first convex portion 21, the second convex portion 22, the third convex portion 24, and the connecting portion 23 has a shape in which the first convex portion 21, the second convex portion 22, and the third convex portion 24, each having a rounded shape such as a spherical or elliptical shape, are integrally formed at the end of the connecting portion 23. In FIG.4(A), the connecting portion 23 is a single piece, with the first convex portion 21 integrally formed at one end and the second convex portion 22 and the third convex portion 24 integrally formed at the other end. In FIG.4(B), the connecting portion 23 branches off midway to have a total of three ends, and the first convex portion 21, the second convex portion 22, and the third convex portion 24 are integrally formed at each end.

[0025]

The surface of the non-sputtering region of the sputtering target according to an embodiment of the present invention may further include a fourth convex portion. FIG.5(A) and FIG.5(B) are schematic diagrams illustrating an example of a structure including the first convex portion 21, the second convex portion 22, the third convex portion 24, a fourth convex portion 25, and the connecting portion 23, as observed from the surface of the non-sputtering region. In FIG.5(A) and FIG.5(B), the structure including the first convex portion 21, the second convex portion 22, the third convex portion 24, the fourth convex portion 25, and the connecting portion 23 has a shape in which the first convex portion 21, the second convex portion 22, the third convex portion 24, and the fourth convex portion 25, each having a rounded shape such as a spherical or elliptical shape, are integrally formed at the end of the connecting portion 23. In FIG.5(A), the connecting portion 23 is a single piece, with the first convex portion 21 and the fourth convex portion 25 integrally formed at one end and the second convex portion 22 and the third convex portion 24 integrally formed at the other end. In FIG.5(B), the connecting portion 23 branches off midway to form a total of four ends, with the first convex portion 21, the second convex

portion 22, the third convex portion 24, and the fourth convex portion 25 integrally formed at each end. Furthermore, the shapes are not limited to those shown in FIG.3(A) to FIG.5(B), and the structure may have even more convex portions, such as a fifth convex portion, a sixth convex portion, etc. With this configuration, various types of irregularities are formed on the surface of the non-sputtering region, further increasing the surface area. This further improves the adhesion of the redeposited film formed in the non-sputtering region, making it possible to better suppress peeling of the redeposited film.

[0026]

The size of the convex portions, such as the first convex portion 21 and the second convex portion 22, is not particularly limited, but the longest diameter is preferably 10 μm or more, and more preferably 30 μm or more. The size of the convex portions, such as the first convex portion 21 and the second convex portion 22, is typically 10 to 100 μm . The longest diameter of the convex portions, such as the first convex portion 21 and the second convex portion 22, can be measured by observing the non-sputtering region at 100x magnification using a scanning electron microscope (Hitachi High-Tech S-3700N). When a straight line is drawn through the convex portion on the acquired SEM photograph, the longest diameter can be defined as the length on the convex portion of the longest line passing through the convex portion. When measuring with a scanning electron microscope, the accelerating voltage, current value (irradiation current value), brightness, and contrast can be adjusted to clearly visualize the image.

[0027]

The distance between the convex portions, such as the distance between the first convex portion 21 and the second convex portion 22, is not particularly limited, but may typically be 10 to 100 μm , or may be 20 to 80 μm . The distance between the convex portions can be measured by taking an SEM photograph, similar to the size of the convex portions described above. The distance between the convex

portions can be defined as the length of a straight line connecting the centers of the circumscribing circles of the convex portions on the acquired SEM photograph.

[0028]

FIG. 6 shows a SEM photograph (magnification: 100x) of the surface of the non-sputtering region of a sputtering target according to Example 5, which will be described later, as another example of the sputtering target according to an embodiment of the present invention. The surface of the non-sputtering region has the rounded first convex portion 21 and the rounded second convex portion 22. The first convex portion 21 and the second convex portion 22 are not connected via a connecting portion, and the shape of the first convex portion 21 is different from the shape of the second convex portion 22. A plurality of structures including such first convex portions 21 and second convex portions 22 are formed on the surface of the non-sputtering region. Unlike the embodiment shown in FIG.2, these convex portions are not connected to each other via a connecting portion, and exist independently on the surface of the non-sputtering region. Furthermore, the surface of the non-sputtering region may be configured such that the convex portions exist independently, or such independently existing convex portions may be mixed with structures formed by convex portions connected to each other via a connecting portion. With this configuration, the surface area of the non-sputtering region increases, improving the adhesion of the redeposited film formed on the non-sputtering region.

[0029]

FIG.7 is a schematic diagram of an example of the first convex portion 21 and the second convex portion 22 when observing the surface of the non-sputtering region for the example shown in FIG.6. As shown in FIG.7, the rounded first convex portion 21 and the rounded second convex portion 22 are adjacent to each other, the first convex portion 21 and the second convex portion 22 are not connected via

a connecting portion, and the shape of the first convex portion 21 is different from the shape of the second convex portion 22.

[0030]

The sizes of the independently existing first convex portions 21 and second convex portions 22 are not particularly limited, but each preferably has the longest diameter of 10 μm or more, more preferably 30 μm or more. Furthermore, the sizes of the independently existing first convex portions 21 and second convex portions 22 are typically 10 to 100 μm . Furthermore, the distance between the independently existing first convex portions 21 and second convex portions 22 is not particularly limited, but may typically be 10 to 100 μm , or 20 to 80 μm , between adjacent convex portions.

[0031]

The developed area ratio Sdr of the surface of the non-sputtering 12a is preferably 4.5 or more. The developed area ratio Sdr represents the degree to which the developed area (surface area) of a given region has increased relative to the area of that given region; for example, the developed area ratio Sdr of a completely flat surface is 0. If the developed area ratio Sdr of the surface of the non-sputtering region 12a is 4.5 or more, the roughness of the non-sputtering region 12a is further increased, thereby increasing the contact area with the redeposited film and improving the adhesion of the redeposited film. The developed area ratio Sdr of the surface of the non-sputtering region 12a is more preferably 5.0 or more. There is no particular upper limit to the developed area ratio Sdr of the surface of the non-sputtering region 12a, but it may be 10.0 or less, or even 9.0 or less. The developed area ratio Sdr of the surface of the non-sputtering region 12a can be measured using a laser microscope in accordance with ISO-25178.

[0032]

The surface roughness Sa of the non-sputtering region 12a is preferably 10 to 40 μm . When the surface roughness Sa of the non-sputtering region 12a is 10 μm

or more, the roughness of the non-sputtering region 12a is further increased, thereby improving the adhesion of the redeposited film. When the surface roughness Sa of the non-sputtering region 12a exceeds 40 μm , this means that there are too many protruding portions, which are portions that protrude away from the surface of the sputtering target. The increased number of protruding portions may induce arcing. The surface roughness Sa of the non-sputtering region 12a is more preferably 15 to 35 μm , and even more preferably 18 to 33 μm . The surface roughness Sa of the non-sputtering region 12a can be measured using a laser microscope in accordance with ISO-25178. Furthermore, while the average surface roughness Ra is evaluated using a "line," the surface roughness Sa is evaluated using a "plane." When measuring average roughness Ra, the measurement results vary depending on which part is set as the measurement target. For example, if the measurement target is set along a predetermined area and Ra is measured, Ra will be smaller than when the measurement target is set across the predetermined area. Therefore, by using surface roughness Sa, the variation in Sa depending on the setting position of the measurement target is reduced, thereby improving the accuracy of control of the surface shape of the sputtering target. As a result, the quality stability of the sputtering target can be improved.

[0033]

The maximum height Sz of the non-sputtering region 12a is preferably 100 to 250 μm . If the maximum height Sz of the non-sputtering region 12a is 100 μm or more, the difference in elevation of the non-sputtering region 12a becomes large, and when a redeposited film is formed in the non-sputtering region 12a, the redeposited film is more likely to be secured at high and low positions in the non-sputtering region 12a. Therefore, the redeposited film is less likely to peel off from the non-sputtering region. If the maximum height Sz of the non-sputtering region 12a exceeds 250 μm , there is a high possibility that very large convex portions will be present. This may therefore be a factor in inducing arcing during sputtering. The

maximum height Sz of the non-sputtering region 12a is more preferably 110 to 210 μm , and even more preferably 120 to 200 μm . The maximum height Sz of the non-sputtering 12a can be measured using a laser microscope in accordance with ISO-25178.

[0034]

The root-mean-square height Sq of the non-sputtering region 12a is preferably 3 to 45 μm . Since Sq represents the standard deviation of roughness, a small Sq indicates small roughness itself. Therefore, it is preferable that the root-mean-square height Sq of the non-sputtering region 12a be 3 μm or more. If the root-mean-square height Sq of the non-sputtering region 12a is 45 μm or less, it indicates a small standard deviation of surface roughness, indicating uniform unevenness, and is advantageous in terms of preventing arcing. If the root-mean-square height Sq of the non-sputtering region 12a exceeds 45 μm , it indicates large variation in surface height, making it more likely that specifically high positions will exist. This increases the likelihood of arcing. The root-mean-square height Sq of the non-sputtering region 12a is more preferably 15 to 40 μm , and even more preferably 18 to 39 μm . The root mean square height Sq of the non-sputtering region 12a can be measured using a laser microscope in accordance with ISO-25178.

[0035]

The above-mentioned Sdr, Sa, Sz, and Sq can be measured using a laser microscope (Keyence VK-X3000, head model VK-X3100). The procedure is as follows:

With the VK-X3000, a 10x objective lens, 1.5x digital zoom, and 24x screen magnification are used to acquire a 360x (10x x 1.5x x 24x) image. Laser confocal is selected as the measurement method. The analysis software used is the multi-file analysis application version 3.3.1.85 included with the VK-X3000.

First, select surface roughness measurement as the measurement mode, and then select the desired roughness parameters and area. When selecting the

area, specify a range (896 μm x 672 μm) from the acquired image (360x image). The above-mentioned area is determined by performing this range specification operation on the laser microscope. Next, the analysis is performed with the following filter settings. When setting the surface shape correction, use "plane tilt correction." Note that "plane tilt correction" is also used when measuring non-sputtering region on either the surface or side of the sputtering target.

<Filter Settings>

Filter Type: Gaussian

S-Filter: None

F-Operation: Enabled

L-Filter: None

End Effect Correction: Checked

Note that the surface area is measured using the volumetric area measurement function under the following conditions.

<Surface Area Measurement Conditions>

Measurement Mode: Convex

Height Threshold Setting: Set this to include all irregularities within the measurement field of view. Select the height threshold setting button on the Keyence VK-X3000's operation screen, then drag the bar on the screen upwards until it covers the entire spectrum shown in black. This allows you to set this to include all irregularities within the measurement field of view.

Ignore Minor Irregularities: None

Ignore Minor Areas: Enabled

Include Top and Bottom Surfaces in Surface Area Calculation: None

[0036]

The configuration of the non-sputtering region described above has been described for non-sputtering region 12a of sputtering target 10a shown in FIG.1(A), but is not limited to this and may also be included in non-sputtering regions 12b and

13b of sputtering target 10b shown in FIG.1(B), or in non-sputtering regions of sputtering targets according to other embodiments of the present invention.

[0037]

<Sputtering Target Assembly>

The sputtering target according to the present invention may be bonded to a backing plate as needed to form a sputtering target assembly. The sputtering target assembly can be mounted in a sputtering apparatus for use. Indium or indium tin can be used as the brazing filler material. The sputtering target according to the present invention may also be mounted directly in a sputtering apparatus without using a backing plate. The backing plate material is not particularly limited, and examples include Cu, Ti, Mo, and alloys containing at least one of these (e.g., Cu-Ni-Si alloys (e.g., C18000), CuZn alloys, and CuCr alloys). It is preferable for the backing plate material to have high thermal conductivity; from this perspective, Cu is preferred.

[0038]

<Method for Producing Sputtering Target>

The following describes in detail a method for producing a sputtering target according to an embodiment of the present invention. In the method for producing a sputtering target according to an embodiment of the present invention, first, raw materials for forming a sintered body are prepared. The raw materials for the sintered body may be a powder containing at least one element selected from the group consisting of Co, Pt, Fe, Ru, Cr, Ti, Si, Zr, B, C, N, Al, O, Mg, Zn, Ag, Cu, Ni, Ta, Nb, V, W, Mn, Bi, Ge, and Ir, or may be a powder containing an alloy containing at least one element selected from the group consisting of Co, Pt, Fe, Ru, Cr, Ti, Si, Zr, B, C, N, Al, Mg, Zn, Ag, Cu, Ni, Ta, Nb, V, W, Mn, Bi, Ge, and Ir or ceramic. The raw materials for the sintered body may also be a powder containing an alloy particle phase and a non-magnetic material. The purity of these raw materials is typically 2N (99% by mass) or higher, preferably 3N (99.9% by mass) or higher, and

even more preferably 4N (99.99% by mass) or higher. If the purity is lower than 2N, the sintered compact will contain a large number of impurities, which can lead to problems such as an inability to achieve the desired physical properties (e.g., a decrease in the transmittance of the formed thin film, an increase in resistance, and the generation of particles due to arcing). These raw materials can be appropriately prepared based on the desired composition and purity of the sintered compact.

[0039]

Next, the raw material powders are crushed and mixed. A ball mill using ceramic balls can be used to crush and mix the raw material powders.

[0040]

The mixture obtained by mixing and crushing as described above is then hot-pressed to obtain a sintered body. Sintering conditions can be appropriately selected depending on the composition of the sintered body.

[0041]

The sintered body is then machined on a lathe to obtain a target of a desired shape. The surface roughness Ra after lathe machining is preferably set to 1 μm or less so as not to affect laser machining.

[0042]

Next, under atmospheric pressure, a non-sputtering region of the sintered body is laser processed to form a surface having a rounded first convex portion and a rounded second convex portion in the non-sputtering region, the first convex portion and the second convex portion being connected via a connecting portion, or the first convex portion and the second convex portion not being connected via a connecting portion, and the shape of the first convex portion being different from the shape of the second convex portion.

[0043]

Furthermore, in the non-sputtering region of the sintered body, the shape, size, number, and surface Sdr, Sa, Sz, and Sq of the first convex portions, the

second convex portions, and the connecting portions can be appropriately adjusted by the output of the laser irradiation, the scanning speed of the laser light, multiple scanning of the same location, etc. More specifically, by appropriately adjusting each condition in the following laser processing conditions, the shape, size, number, and surface Sdr, Sa, Sz, and Sq of the first convex portions, second convex portions, and connecting portions in the non-sputtering region of the sputtering target according to an embodiment of the present invention can be controlled to a desired configuration.

[0044]

In this embodiment, the sintered body is not heated using a separate heating device during the roughening treatment (laser irradiation). This is because the roughening treatment is performed under atmospheric pressure, and heating would facilitate oxidation of the sputtering target. Furthermore, it is not anticipated that any particular treatment will be performed to remove residual stress in the sputtering target before, after, or during the roughening treatment. Furthermore, the back surface of the sputtering target is not roughened. This is because performing the roughening treatment on the back surface could reduce the strength of the sputtering target.

[0045]

(Laser Processing Conditions)

- Laser processing power: 15-25 W
- Scanning speed: 150-1000 mm/s
- Number of scans per location: 1-10
- Frequency: 140-400 kHz
- Scanning pitch: 0.05-0.18 mm

Also, based on the above conditions, laser processing can be performed by first drawing a cross pattern (0° angle) as "Layer 1," and then, as "Layer 2," drawing a cross pattern without rotation (0° rotation) or rotated by a predetermined angle,

overlapping the laser, to draw a linear pattern at 0° or a predetermined angle.

Further laser processing can be performed as many times as desired.

Sputtering targets according to embodiments of the present invention can be produced in this manner. However, since the above conditions fundamentally depend on the target composition (due to differences in thermal conductivity and melting points), trial and error is required to determine the conditions for the target composition.

[0046]

In this embodiment, further roughening of the non-sputtering region after roughening treatment is not anticipated. For example, physical roughening methods such as bead blasting or chemical roughening methods such as chemical etching are not anticipated. For example, further bead blasting of the non-sputtering region after roughening treatment would result in residual blasting media. Note that, as long as the desired surface condition can be achieved, roughening of the non-sputtering region may be performed by other methods than laser irradiation. However, roughening the non-sputtering region by laser irradiation can achieve a surface of the non-sputtering region 12a that is free of ZrO_2 and SiC. The presence of ZrO_2 and SiC on the surface of non-sputtering region 12a means, for example, that elements of the blasting media are present on the surface of the non-sputtering region 12a. The absence of ZrO_2 and SiC on the surface of the non-sputtering region 12a prevents elements of the blasting media from being mixed into the thin film and suppresses arcing during sputtering. Furthermore, if the composition of the sputtering target does not contain Al_2O_3 , Al_2O_3 is not present. The presence of Al_2O_3 on the surface of the non-sputtering region 12a even when the composition of the sputtering target does not contain Al_2O_3 means, for example, that elements of the blasting media are present on the surface of the non-sputtering region 12a. The absence of Al_2O_3 on the surface of the non-sputtering region 12a can prevent

elements of the blasting media from being mixed into the thin film and can also suppress arcing during sputtering.

[0047]

<Film Forming Method Using Sputtering Target>

The sputtering target according to an embodiment of the present invention can be used to form thin films, primarily for use in magnetic recording media. Specifically, a sputtering device is used to sputter the surface of the sputtering target with accelerated argon ions, releasing particles (sputtered particles) from the sputtering target. These particles are then deposited on the surface of a substrate previously positioned opposite the sputtering target, forming a thin film on the substrate. Sputtering conditions can be appropriately set based on the desired film thickness and composition.

[0048]

A portion of the sputtered particles redeposits on the non-sputtering region of the sputtering target to form a redeposited film. In the sputtering target according to an embodiment of the present invention, the surface of the non-sputtering region has a plurality of rounded convex portions, and the plurality of convex portions includes convex portions that are connected via connecting portions and/or convex portions that are not connected via connecting portions, so that the adhesion of the redeposited film formed on the non-sputtering region is improved and peeling of the redeposited film is effectively suppressed.

EXAMPLES

[0049]

Examples of the present invention are given below, but these examples are provided for a better understanding of the present invention and its advantages, and are not intended to limit the invention.

[0050]

<Examples 1-7>

- Producing Sputtering Target

The sputtering targets for Examples 1-7 were produced using the following producing method.

First, the raw materials for the sintered body were prepared. The raw materials for the sintered body were powders containing Co, Cr, Pt, B, O, Ti, and Si (Examples 1-5), powders containing Co, Pt, B, O, Ti, and Si (Example 6), and powders containing Co, Pt, Ru, Ti, O, and Si (Example 7). The purity of each of these raw materials was 3N (99.9% by mass).

Next, these raw material powders were crushed using a ball mill with beads, and the resulting mixture was hot-pressed to obtain a sintered body.

The sintered body was then machined using a lathe to obtain a disk-shaped target.

Next, under atmospheric pressure, laser processing was performed on the non-sputtering regions of the sintered body to form a surface having a rounded first convex portion and a rounded second convex portion, where the first convex portion and the second convex portion are connected via a connecting portion, or the first convex portion and the second convex portion are not connected via a connecting portion, and the shape of the first convex portion is different from the shape of the second convex portion. For "Layer 1," the laser processing was performed by first drawing a cross pattern (angle 0°) with the laser, and then, for "Layer 2," drawing an overlapping cross pattern with the laser either not rotated (0° rotation) or rotated 45°, thereby drawing a linear pattern every 0° or 45°. Note that in Example 4, only Layer 1 was laser processed.

The laser processing conditions for Layers 1 and 2 are shown below. Tables 1 and 2 show the laser processing conditions for each example.

[0051]

(Laser Processing Conditions for Layer 1)

- Laser Processing Power: 20 W
- Scanning Speed: 200-400 mm/s
- Number of Scans per Location: 1
- Frequency: 140-220 kHz
- Scanning Pitch: 0.1 mm

[0052]

(Laser Processing Conditions for Layer 2)

- Laser Processing Power: 20 W
- Scanning Speed: 200-800 mm/s
- Number of Scans per Location: 1
- Frequency: 140-220 kHz
- Scanning Pitch: 0.1-0.131 mm

[0053]

- SEM Photographs

SEM photographs of the non-sputtering regions of Examples 1-7 were taken using a Hitachi High-Tech S-3700N. The SEM photographs confirmed that the surfaces of the non-sputtering regions of Examples 1-7 each had multiple rounded convex portions, including convex portions connected via connecting portions and/or convex portions not connected via connecting portions.

FIGs.8(A)-8(E) show SEM photographs (magnification: 100x) for Examples 1-5, respectively. When taking the SEM photograph in FIG.8, the accelerating voltage was set to 15 kV, and the current value (irradiation current value) was set to 84,000 nA.

[0054]

- Sdr, Sa, Sz, Sq

For the sputtering targets of Examples 1 to 7, the developed area ratio Sdr, the surface roughness Sa, the maximum height Sz, and the root-mean-square height Sq of the non-sputtering region, were measured using a laser microscope

(Keyence VK-X3000, head model VK-X3100). The measurement procedure was as described above.

[0055]

- Peel Test

A peel test was conducted on Examples 1-5 to confirm the adhesion of the redeposited film. The peel test was conducted in accordance with JIS-K5400 (checkerboard tape method). A commercially available lacquer spray was applied to each non-sputtering region and allowed to dry for at least six hours. The coating film formed by the lacquer spray was then cut with a cutter to create one hundred 1 mm square grids. Cellophane tape was then applied to the cut surface of the coating film. When the tape was peeled off, the degree of grid peeling was evaluated on a scale of 0 to 10 according to JIS-K5400.

In all of Examples 1-5, each cut was fine and smooth on both sides. No peeling was observed at the intersections of the cuts or between the individual squares. Therefore, a score of 10 was given.

These results confirmed that Examples 1-5 effectively suppressed redeposited film peeling. As examples of the peel test method, FIG.9(A) shows a photograph of the appearance of the sample surface after lacquer spray application in Example 3, FIG.9(B) shows a photograph of the appearance of the sample surface after cutting out a 1 mm square grid in Example 3, and FIG.9(C) shows a photograph of the appearance of the sample surface after the peel test in Example 3.

Table 2 shows the evaluation results.

[0056]

Table 1

	Compositional Varieties	Laser Processing Power [W]	Layer 1					
			Scanning Speed [mm/s]	Number of Scans per Location [times]	Pattern	Angle [°]	Scanning Pitch [mm]	Frequency [kHz]
EX.1	Co-Cr-Pt-B ₂ O ₃ -TiO ₂ -SiO ₂ -CoO	20	200	1	cross	0	0.1	180
EX.2	Co-Cr-Pt-B ₂ O ₃ -TiO ₂ -SiO ₂ -CoO	20	200	1	cross	0	0.1	140
EX.3	Co-Cr-Pt-B ₂ O ₃ -TiO ₂ -SiO ₂ -CoO	20	400	1	cross	0	0.1	220
EX.4	Co-Cr-Pt-B ₂ O ₃ -TiO ₂ -SiO ₂ -CoO	20	200	1	cross	0	0.1	220
EX.5	Co-Cr-Pt-B ₂ O ₃ -TiO ₂ -SiO ₂ -CoO	20	400	1	cross	0	0.1	200
EX.6	Co-Pt-B ₂ O ₃ -TiO ₂ -SiO ₂ -CoO	20	200	1	cross	0	0.1	180
EX.7	Co-Pt-Ru-TiO ₂ -SiO ₂ -CoO	20	200	1	cross	0	0.1	140

[0057]

[0058]

Table 2

	Layer 2							Laser microscope					Peel test results
	Scanning Speed [mm/s]	Number of Scans per Location [times]	Pattern	Angle [°]	Scanning Pitch [mm]	Frequency [kHz]		Sa [μm]	Sz [μm]	Spc [mm ⁻¹]	Sdr	Sq [μm]	Score (JIS-K5400)
EX.1	200	1	cross	45	0.131	180		32.3	179.0	4117.4	7.7	37.0	10
EX.2	200	1	cross	45	0.131	140		33.1	202.8	4495.84	8.4	38.4	10
EX.3	800	1	cross	0	0.131	220		15.9	115.0	4843.70	4.6	18.6	10
EX.4	-	-	-	-	-	-		25.0	146.6	3658.00	5.7	29.2	10
EX.5	400	1	cross	45	0.131	200		19.7	127.5	4518.73	5.2	22.7	10
EX.6	200	1	cross	45	0.1	180		30.1	195.8	5127.33	7.7	35.4	-
EX.7	200	1	cross	0	0.1	140		27.7	169.4	3885.40	7.6	3.2	-

<Discussion>

In all sputtering targets in Examples 1-5, the surface of the non-sputtering region had multiple rounded convex portions, some of which were connected via connecting portions and/or some of which were not connected via connecting portions. This enabled the formation of favorable irregularities on the surface of the non-sputtering region, ensuring sufficient surface area, improving the adhesion of the redeposited film formed in the non-sputtering region and effectively suppressing peeling of the redeposited film. Furthermore, in Examples 6 and 7, similar to Examples 1-5, the surface of the non-sputtering region had multiple rounded convex portions, some of which were connected via connecting portions and/or some of which were not connected via connecting portions, and therefore it is believed that this also effectively suppresses peeling of the redeposited film.

Description of Reference Numerals

10a, 10b: Sputtering target

11a, 11b: Sputtering region

12a, 12b, 13b: Non-sputtering region

21: First convex portion

22: Second convex portion

23: Connecting portion

24: Third convex portion

25: Fourth convex portion

CLAIMS

[Claim 1] A sputtering target for magnetic materials having a sputtering region and a non-sputtering region,

wherein a surface of the non-sputtering region has a plurality of rounded convex portions,

wherein the plurality of convex portions include convex portions connected via connecting portions and/or convex portions not connected via connecting portions.

[Claim 2] The sputtering target for magnetic materials according to claim 1,

wherein the surface of the non-sputtering region has a developed area ratio Sdr of 4.5 or more.

[Claim 3] The sputtering target for magnetic materials according to claim 1 or 2,

wherein a surface roughness Sa of the non-sputtering region is 10 to 40 μm .

[Claim 4] The sputtering target for magnetic materials according to claim 1 or 2,

wherein a maximum height Sz of the non-sputtering region is 100 to 250 μm .

[Claim 5] The sputtering target for magnetic materials according to claim 1 or 2,

wherein a root mean square height Sq of the non-sputtering region is 3 to 45 μm .

[Claim 6] The sputtering target for magnetic materials according to claim 1 or 2,

wherein a composition of the sputtering target comprises at least one element selected from the group consisting of Co, Pt, Fe, Ru, Cr, Ti, Si, Zr, B, C, N, Al, O, Mg, Zn, Ag, Cu, Ni, Ta, Nb, V, W, Mn, Bi, Ge, and Ir.

[Claim 7] A sputtering target assembly for magnetic materials, comprising:
the sputtering target for magnetic materials according to claim 1 or 2; and
a backing plate bonded to the sputtering target for magnetic materials.

[Claim 8] A method for producing a sputtering target for magnetic materials having a sputtering region and a non-sputtering region,
comprising forming a plurality of rounded convex portions on the surface of the non-sputtering region,
wherein the plurality of convex portions include convex portions connected via connecting portions and/or convex portions not connected via connecting portions.