

## **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 an arithmetic mean curvature Spc of peaks on a surface of the non-sputtering region is  $3200\text{ mm}^{-1}$  or more.

[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  $40\text{ }\mu\text{m}$ .

[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  $250\text{ }\mu\text{m}$ .

[5] The sputtering target f  
or 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  $\mu\text{m}$ .

[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 surface in the non-sputtering region having an arithmetic mean curvature  $S_{pc}$  of peaks of  $3200\text{ mm}^{-1}$  or more.

[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 an optical microscope photograph of the surface of the non-sputtering region of Example 3.

FIG.3(A) is a photograph of an appearance of the sample surface after lacquer spray application in Example 3. FIG.3(B) is a photograph of an appearance of the sample surface after cutting out a 1 mm square grid in Example 3. FIG.3(C) is a photograph of an appearance of the sample surface after a peel test in Example 3. FIG.3(D) is a photograph of an appearance of the sample surface after a peel test in Comparative Example 7.

## 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 Material>

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 non-sputtering region 12a of the sputtering target according to an embodiment of the present invention has an arithmetic mean curvature  $S_{pc}$  of peaks on the surface controlled to  $3200\text{ mm}^{-1}$  or more. A small arithmetic mean curvature  $S_{pc}$  of the peaks on the surface indicates that the points of contact with other

objects are rounded, while a large value indicates that the points of contact with other objects are sharp. When the arithmetic mean curvature  $Spc$  of the peaks on the surface of the non-sputtering region 12a is  $3200\text{ mm}^{-1}$  or more, the roughness of the non-sputtering region 12a is increased, improving the adhesion of the redeposited film formed in the non-sputtering region and effectively suppressing peeling of the redeposited film. As a result, particle contamination during sputtering is suppressed, improving the product yield. Furthermore, when the arithmetic mean curvature  $Spc$  of the peaks on the surface of the non-sputtering region 12a exceeds  $6000\text{ mm}^{-1}$ , the convex portions become too sharp, which may easily induce arcing. For this reason, the arithmetic mean curvature  $Spc$  of the peaks on the surface of the non-sputtering region 12a is preferably  $3200$  to  $6000\text{ mm}^{-1}$ . The arithmetic mean curvature  $Spc$  of the peaks on the surface of the non-sputtering region 12a is more preferably  $3500$  to  $5500\text{ mm}^{-1}$ , and even more preferably  $3700$  to  $5100\text{ mm}^{-1}$ . The arithmetic mean curvature  $Spc$  of the peaks on the surface of the non-sputtering region 12a can be measured using a laser microscope in accordance with ISO-25178.

[0020]

The developed area ratio  $Sdr$  of the surface of the non-sputtering region 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.

[0021]

The surface roughness Sa of the non-sputtering region 12a is preferably 10 to 40  $\mu\text{m}$ . When the surface roughness Sa of the non-sputtering region 12a is 10  $\mu\text{m}$  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  $\mu\text{m}$ , 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  $\mu\text{m}$ , and even more preferably 18 to 33  $\mu\text{m}$ . 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.

[0022]

The maximum height Sz of the non-sputtering region 12a is preferably 100 to 250  $\mu\text{m}$ . If the maximum height Sz of the non-sputtering region 12a is 100  $\mu\text{m}$  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  $\mu\text{m}$ , 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  $\mu\text{m}$ , and even more preferably 120 to 200  $\mu\text{m}$ . The maximum height Sz of the non-sputtering region 12a can be measured using a laser microscope in accordance with ISO-25178.

[0023]

The root-mean-square height Sq of the non-sputtering region 12a is preferably 3 to 45  $\mu\text{m}$ . 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  $\mu\text{m}$  or more. If the root-mean-square height Sq of the non-sputtering region 12a is 45  $\mu\text{m}$  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  $\mu\text{m}$ , 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  $\mu\text{m}$ , and even more preferably 18 to 39  $\mu\text{m}$ . The root-mean-square height Sq of the non-sputtering region 12a can be measured using a laser microscope in accordance with ISO-25178.

[0024]

The above-mentioned Spc, 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. 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  $\mu\text{m}$  x 672  $\mu\text{m}$ ) 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 areas 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

[0025]

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.

[0026]

#### <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.

[0027]

#### <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.

[0028]

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.

[0029]

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.

[0030]

The sintered body is then machined on a lathe to obtain a target of a desired shape. The surface roughness Ra after lathe processing is preferably set to 1  $\mu\text{m}$  or less so as not to affect laser machining.

[0031]

Next, under atmospheric pressure, a surface in which the above-mentioned S<sub>pc</sub>, S<sub>dr</sub>, S<sub>a</sub>, S<sub>z</sub>, and S<sub>q</sub> are controlled can be formed in the non-sputtering region of the sintered body by laser processing. The values of S<sub>pc</sub>, S<sub>dr</sub>, S<sub>a</sub>, S<sub>z</sub>, and S<sub>q</sub> can be appropriately adjusted by the laser irradiation output, the laser light scanning

speed, and multiple scanning of the same location. More specifically, by appropriately adjusting each condition in the following laser processing conditions, the Spc, Sdr, Sa, Sz, and Sq of the non-sputtering region of the sputtering target according to an embodiment of the present invention can be controlled to within the desired numerical range.

[0032]

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.

[0033]

(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.

[0034]

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  $\text{ZrO}_2$  and  $\text{SiC}$ . The presence of  $\text{ZrO}_2$  and  $\text{SiC}$  on the surface of the 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  $\text{ZrO}_2$  and  $\text{SiC}$  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  $\text{Al}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3$  is not present. The presence of  $\text{Al}_2\text{O}_3$  on the surface of the non-sputtering region 12a even when the composition of the sputtering target does not contain  $\text{Al}_2\text{O}_3$  means, for example, that elements of the blasting media are present on the surface of the non-sputtering region 12a. The absence of  $\text{Al}_2\text{O}_3$  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.

[0035]

### <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.

[0036]

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 arithmetic mean curvature  $Spc$  of the peaks on the surface of the non-sputtering region is controlled to  $3200\text{ mm}^{-1}$  or more., 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

[0037]

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.

[0038]

### <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, a surface with controlled Spc, Sdr, Sa, Sz, and Sq was formed in the non-sputtering region of the sintered body by laser processing. 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.

[0039]

(Laser Processing Conditions for Layer 1)

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

[0040]

(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

[0041]

<Comparative Examples 1-7>

- Producing Sputtering Target

The sputtering targets for Comparative 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, Si and O (Comparative Examples 1-4), powders containing Co, Fe, B and N (Comparative Example 5), powder containing Co, Pt, B, O, Ti and Si (Comparative Example 6), powder containing Co, Cr, Pt, B, O, Ti and Si (Comparative Example 7). The purity of each of these raw materials was 3N (99.9% by mass).

Next, the powders of these raw materials were pulverized in a media agitation mill using beads, and the mixture obtained by mixing was hot pressed to obtain a sintered body.

Next, the sintered body was machined using a lathe to obtain a disk-shaped target.

Next, under atmospheric pressure, a surface with controlled S<sub>pc</sub>, S<sub>dr</sub>, S<sub>a</sub>, S<sub>z</sub>, and S<sub>q</sub> was formed in the non-sputtering region of the sintered body by laser processing. For "Layer 1," the laser processing was performed by first drawing a cross pattern (angle 0°) with the laser, and then, for "Layer 2," a cross pattern rotated by 45° or 120° was drawn with a laser so as to overlap, thereby drawing a linear pattern every 45° or 120°. In Comparative Examples 1 and 2, only the laser processing was performed on Layer 1. In Comparative Example 7, only the lathe

processing described above was performed, and no laser processing was performed.

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

(Laser Processing Conditions for Layer 1)

- Laser Processing Power: 4.8-20 W
- Scanning Speed: 100-1000mm/s
- Number of Scans per Location: 1-6
- Frequency: 50-140 kHz
- Scanning Pitch: 0.2 mm

[0042]

(Laser Processing Conditions for Layer 2)

- Laser Processing Power: 4.8-20 W
- Scanning Speed: 100-500 mm/s
- Number of Scans per Location: 1-3
- Frequency: 50-140 kHz
- Scanning Pitch: 0.2 mm

[0043]

- Optical Microscope Photograph

An optical microscope photograph of the non-sputtering region of Example 3 was taken using a VK-X3000 laser microscope. FIG.2 shows the optical microscope photograph (magnification: 360x) for Example 3.

[0044]

- S<sub>pc</sub>, S<sub>dr</sub>, S<sub>a</sub>, S<sub>z</sub>, S<sub>q</sub>

For the sputtering targets of Examples 1 to 7 and Comparative Examples 1 to 7, the arithmetic mean curvature S<sub>pc</sub> of peaks, the developed area ratio S<sub>dr</sub>, the surface roughness S<sub>a</sub>, the maximum height S<sub>z</sub>, and the root-mean-square height S<sub>q</sub>

of the non-sputtering region, were measured using a laser microscope (Keyence VK-X3000). The measurement procedure was as described above.

[0045]

- 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 area 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.

The same test was also carried out on Comparative Example 7, and the peeled area was between 35 and 65%, and it was evaluated as a score of 2.

These results confirmed that Examples 1-5 effectively suppressed redeposited film peeling. As examples of the peel test method, FIG.3(A) shows a photograph of the appearance of the sample surface after lacquer spray application in Example 3, FIG.3(B) shows a photograph of the appearance of the sample surface after cutting out a 1 mm square grid in Example 3, FIG.3(C) shows a photograph of the appearance of the sample surface after the peel test in Example 3, and FIG.3(D) shows a photograph of the appearance of the sample surface after the peel test in Comparative Example 7.

Table 2 shows the evaluation results.

[0046]

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 <sub>2</sub> O <sub>3</sub> -TiO <sub>2</sub> -SiO <sub>2</sub> -CoO | 20                         | 200                   | 1                                    | cross   | 0         | 0.1                 | 180             |
| EX.2       | Co-Cr-Pt-B <sub>2</sub> O <sub>3</sub> -TiO <sub>2</sub> -SiO <sub>2</sub> -CoO | 20                         | 200                   | 1                                    | cross   | 0         | 0.1                 | 140             |
| EX.3       | Co-Cr-Pt-B <sub>2</sub> O <sub>3</sub> -TiO <sub>2</sub> -SiO <sub>2</sub> -CoO | 20                         | 400                   | 1                                    | cross   | 0         | 0.1                 | 220             |
| EX.4       | Co-Cr-Pt-B <sub>2</sub> O <sub>3</sub> -TiO <sub>2</sub> -SiO <sub>2</sub> -CoO | 20                         | 200                   | 1                                    | cross   | 0         | 0.1                 | 220             |
| EX.5       | Co-Cr-Pt-B <sub>2</sub> O <sub>3</sub> -TiO <sub>2</sub> -SiO <sub>2</sub> -CoO | 20                         | 400                   | 1                                    | cross   | 0         | 0.1                 | 200             |
| EX.6       | Co-Pt-B <sub>2</sub> O <sub>3</sub> -TiO <sub>2</sub> -SiO <sub>2</sub> -CoO    | 20                         | 200                   | 1                                    | cross   | 0         | 0.1                 | 180             |
| EX.7       | Co-Pt-Ru-TiO <sub>2</sub> -SiO <sub>2</sub> -CoO                                | 20                         | 200                   | 1                                    | cross   | 0         | 0.1                 | 140             |
| Comp. EX.1 | Co-Cr-SiO <sub>2</sub>                                                          | 20                         | 500                   | 6                                    | cross   | 0         | 0.2                 | 140             |
| Comp. EX.2 | Co-Cr-SiO <sub>2</sub>                                                          | 20                         | 1000                  | 2                                    | cross   | 0         | 0.2                 | 140             |
| Comp. EX.3 | Co-Cr-SiO <sub>2</sub>                                                          | 20                         | 500                   | 3                                    | cross   | 0         | 0.2                 | 140             |
| Comp. EX.4 | Co-Cr-SiO <sub>2</sub>                                                          | 20                         | 100                   | 1                                    | cross   | 0         | 0.2                 | 140             |
| Comp. EX.5 | Co-Fe-BN                                                                        | 12                         | 200                   | 1                                    | cross   | 0         | 0.2                 | 50              |
| Comp. EX.6 | Co-Pt-B <sub>2</sub> O <sub>3</sub> -TiO <sub>2</sub> -SiO <sub>2</sub> -CoO    | 4.8                        | 200                   | 1                                    | cross   | 0         | 0.2                 | 50              |
| Comp. EX.7 | Co-Cr-Pt-B <sub>2</sub> O <sub>3</sub> -TiO <sub>2</sub> -SiO <sub>2</sub> -CoO | -                          | -                     | -                                    | -       | -         | -                   | -               |

[0047]

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 <sup>-1</sup> ] | 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     | -                 |
| Comp. EX.1 | -                     | -                                    | -       | -         | -                   | -               | 25.9    | 151.9            | 2191.9                  | 5.0 | 29.7    | -                 |
| Comp. EX.2 | -                     | -                                    | -       | -         | -                   | -               | 4.4     | 28.0             | 1054.9                  | 0.1 | 5.1     | -                 |
| Comp. EX.3 | 500                   | 3                                    | cross   | 120       | 0.2                 | 140             | 20.0    | 107.6            | 2304.3                  | 2.9 | 22.9    | -                 |
| Comp. EX.4 | 100                   | 1                                    | cross   | 45        | 0.2                 | 140             | 28.4    | 209.7            | 3146.9                  | 4.7 | 35.2    | -                 |
| Comp. EX.5 | 200                   | 1                                    | cross   | 45        | 0.2                 | 50              | 5.0     | 58.9             | 1887.4                  | 0.6 | 6.5     | -                 |
| Comp. EX.6 | 200                   | 1                                    | cross   | 45        | 0.2                 | 50              | 6.8     | 83.5             | 2782.9                  | 1.5 | 8.9     | -                 |
| Comp. EX.7 | -                     | -                                    | -       | -         | -                   | -               | 0.8     | 11.62            | 1063.2                  | 0.2 | 1.0     | 2                 |

[0048]

#### <Discussion>

In all sputtering targets of Examples 1-5, the arithmetic mean curvature Spc of peaks on the surface of the non-sputtering region was  $3200\text{ mm}^{-1}$  or more. Therefore, the adhesion of the coating film formed in the non-sputtering region was improved, and peeling of the coating film was effectively suppressed. Furthermore, in Examples 6 and 7, as in Examples 1 to 5, the arithmetic mean curvature Spc of peaks on the surface of the non-sputtering region was  $3200\text{ mm}^{-1}$  or more, so it is believed that peeling of the coating film can be effectively suppressed in the same way. From this result, it is believed that peeling of the redeposited film can be effectively suppressed even during sputtering.

Furthermore, in the sputtering target of Comparative Example 7, the arithmetic mean curvature Spc of peaks on the surface of the non-sputtering region was less than  $3200\text{ mm}^{-1}$ , and therefore significant peeling was observed in the coating film in the peel test. Furthermore, the sputtering targets of Comparative Examples 1 to 6, like Comparative Example 7, all had the arithmetic mean curvature Spc of peaks on the surface of the non-sputtering region of less than  $3200\text{ mm}^{-1}$ . Therefore, similar to Comparative Example 7, significant peeling is thought to be observed in the coating film in the peel test. From these results, it is thought that the adhesion of the redeposited film formed in the non-sputtering region is reduced, and peeling of the redeposited film during sputtering cannot be effectively suppressed.

#### Description of Reference Numerals

10a, 10b: Sputtering target

11a, 11b: Sputtering region

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

## CLAIMS

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

wherein an arithmetic mean curvature  $S_{pc}$  of peaks on a surface of the non-sputtering region is  $3200\text{ mm}^{-1}$  or more.

[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  $S_{dr}$  of 4.5 or more.

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

wherein a surface roughness  $S_a$  of the non-sputtering region is 10 to  $40\text{ }\mu\text{m}$ .

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

wherein a maximum height  $S_z$  of the non-sputtering region is 100 to  $250\text{ }\mu\text{m}$ .

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

wherein a root-mean-square height  $S_q$  of the non-sputtering region is 3 to  $45\text{ }\mu\text{m}$ .

[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 surface in the non-sputtering region having an arithmetic mean curvature Spc of peaks of  $3200 \text{ mm}^{-1}$  or more.