

ALUMINUM SUBSTRATE FOR MAGNETIC RECORDING MEDIUM AND METHOD FOR PRODUCING SAME

TECHNICAL FIELD

[0001]

The present invention relates to an aluminum substrate having a film formed thereon, which is suitable as a substrate for a magnetic recording medium, and also relates to a method for producing the same.

BACKGROUND ART

[0002]

An A5086 alloy as prescribed in JIS H4000-2014 is almost exclusively used as an aluminum substrate for a magnetic recording medium. In sole use, this alloy is insufficient in surface smoothness, surface defect-free properties, flaw resistance or the like, suited for magnetic recording media, and therefore, electroless Ni-P plating is applied as a surface treatment.

[0003]

By applying the electroless Ni-P plating, a crystallized product or an inclusion appearing on the surface is covered up, thereby enabling the surface defect-free properties to be realized. In addition, by covering the grain boundary, high smoothness can be realized by means of polishing. Furthermore, by increasing the surface hardness, the flaw resistance can be improved.

[0004]

However, when the conventionally used Ni-P plating is heat-treated at 300°C or higher, it is crystallized so that not only the smoothness of the surface is deteriorated, but also ferromagnetism is revealed, thereby making the resultant inappropriate as a substrate for a magnetic recording medium.

Meanwhile, a high recording density is demanded as a performance for the magnetic recording medium, and in order to satisfy such a demand, relaxation of a temperature condition during the magnetic layer deposition is demanded.

[0005]

Patent Document 1 proposes Ni-P-W plating for the purpose of suppressing revealment of magnetism of the Ni-P plating to be caused due to the heat treatment at a temperature of 300°C or higher.

As other surface treatments than the Ni-P plating, for example, Patent Document 2 proposes a surface treatment method of an alumite substrate by coating the alumite substrate with silicon oxide and performing a heat treatment, thereby making the alumite substrate surface smooth.

[0006]

In addition, in order to achieve a high recording density, it is also important to suppress the generation of a flaw following collision of a recording head with the substrate surface. In magnetic recording, a recording and reproducing head moves at a high speed in a height of several nm on the surface of the recording medium, and it is important to prevent deformation of the substrate surface to be caused due to collision of the head with the substrate. For that reason, Ni-P plating having a thickness of about 10 μm is adopted. The hardness required for the substrate surface is demanded for the purpose of realizing the flaw resistance.

Patent Document 3 discloses a magnetic disk substrate having a continuous thin film of silicon nitride on an aluminum substrate. As for a production method of the subject substrate, Patent Document 3 discloses that the aluminum substrate is coated with an inorganic polysilazane and then the aluminum substrate is heat-treated in the atmosphere at 200°C for 1 hour, whereby higher hardness and smoothness than those of a nickel-phosphorus plated substrate can be realized in a thickness of about 1 μm .

CITATION LIST

PATENT DOCUMENTS

[0007]

Patent Document 1: JP-A-2012-195021

Patent Document 2: JP-A-H02-73520

Patent Document 3: JP-A-H04-252420

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0008]

However, even when the Ni-P-W plating described in Patent Document 1 is used, the heat-resistant temperature is limited to 320°C. In addition, Patent Document 2 discloses that by coating the alumite-processed aluminum substrate with an organosiloxane solution and baking it at 150°C to 350°C, the alumite surface can be made smooth. That is, Patent Document 2 discloses that by coating irregularities or fine pores of the surface produced by an anodic oxidation treatment with an organic silicon and performing the heat treatment, smoothening can be achieved. However, Patent Document 2 does not mention at all the heat resistance or flaw resistance that is especially important as the substrate for a magnetic recording medium. In addition, Patent Document 2 does not mention at all a composition, physical properties and the like suited as the organic silicon to be coated.

[0009]

In addition, as for the magnetic disk substrate described in Patent Document 3, even if a film having high hardness is formed on the aluminum substrate, in the case where the thickness is 1 μm , its flaw resistance is greatly inferior as compared with the case of an Ni-P plated substrate (thickness: up to 10 μm) which is currently widely used.

[0010]

In view of the foregoing circumstances, the present invention has been made, and an object thereof is to provide an aluminum substrate for a magnetic recording medium having excellent flaw resistance and heat resistance.

SOLUTION TO PROBLEM

[0011]

The present inventor made extensive and intensive investigations. As a result, it has been found that an aluminum substrate for a magnetic recording medium having excellent flaw resistance and heat resistance is obtained by forming an anodic oxide film having a specified thickness on at least one surface of an aluminum alloy and further forming a specified silica-converted film thereon, leading to accomplishment of the present invention.

[0012]

That is, the present invention provides the following [1] to [9].

[1] An aluminum substrate for a magnetic recording medium, comprising: an aluminum substrate; an anodic oxide film having a thickness of 7 μm or more and 25 μm or less formed on the aluminum substrate; and a silica-converted film on the anodic oxide film, the silica-converted film being prepared by coating the anodic oxide film with a polysilazane solution containing methylhydropolysilazane in an amount at which a leveling effect is revealed.

[2] The aluminum substrate for a magnetic recording medium according to [1], wherein the polysilazane solution containing methylhydropolysilazane is a mixture of methylhydropolysilazane and an inorganic polysilazane.

[3] The aluminum substrate for a magnetic recording medium according to [2], wherein a blending ratio of the methylhydropolysilazane to the inorganic polysilazane in the mixture is in a range of from 10/0 to 2/8 in a weight ratio.

[4] The aluminum substrate for a magnetic recording medium according to any one of [1] to [3], wherein the silica-converted film is a silica layer having a thickness of 0.2 μm or more.

[5] A method for producing an aluminum substrate for a magnetic recording medium, the method comprising:

forming an anodic oxide film having a thickness of 7 μm or more and 25 μm or less on an aluminum substrate; and

coating the anodic oxide film with a polysilazane solution containing methylhydropolysilazane in an amount at which a leveling effect is revealed and then undergoing silica conversion by heating, thereby forming a silica-converted film on the anodic oxide film.

[6] The method for producing an aluminum substrate for a magnetic recording medium according to [5], wherein the anodic oxide film is formed with an anodic oxidation treatment solution containing at least oxalic acid.

[7] The method for producing an aluminum substrate for a magnetic recording medium according to [5] or [6], wherein the polysilazane solution containing methylhydropolysilazane is a mixture of methylhydropolysilazane and an inorganic polysilazane.

[8] The method for producing an aluminum substrate for a magnetic recording medium according to [7], wherein a blending ratio of the methylhydropolysilazane to the inorganic polysilazane in the mixture is in a range of from 10/0 to 2/8 in a weight ratio.

[9] The method for producing an aluminum substrate for a magnetic recording medium according to any one of [5] to [8], wherein the silica-converted film is a silica layer having a thickness of 0.2 μm or more.

ADVANTAGEOUS EFFECTS OF INVENTION

[0013]

In the present invention, it is possible to provide an aluminum substrate for a magnetic recording medium having very excellent heat resistance and flaw resistance.

BRIEF DESCRIPTION OF DRAWINGS

[0014]

FIG. 1 is a graph showing ATR spectra of characteristic vibration regions of Si-O-Si and Si-CH₃ of silica films.

FIG. 2 is a graph showing the load dependence of a flaw depth of anodic oxide film for every thickness of the film.

FIG. 3 is a graph showing the load dependence of a flaw depth by a combination of an anodic oxide film with a silica film for every thickness of the film.

FIG. 4 is a graph showing the load dependence of a flaw depth by a combination of an anodic oxide film with a silica film for every thickness of the film.

FIG. 5 is a graph showing the load dependence of a flaw depth by a combination of an anodic oxide film with a silica film for every thickness of the film.

DESCRIPTION OF EMBODIMENTS

[0015]

The aluminum substrate for a magnetic recording medium in the present invention includes an aluminum substrate; an anodic oxide film having a thickness of 7 μm or more and 25 μm or less formed on the aluminum substrate; and a silica-converted film on the anodic oxide film, the silica-converted film being prepared by

coating the anodic oxide film with a polysilazane solution containing methylhydropolysilazane in an amount at which a leveling effect is revealed.

[0016]

<Aluminum substrate>

An aluminum alloy (which will be also referred to simply as "aluminum" in some cases) which is used as the substrate in the present invention is not particularly limited so long as, with respect to a chemical component composition thereof, it has a strength necessary for the magnetic recording medium and is useful for the formation of an anodic oxide film. Examples thereof may include an aluminum alloy containing 3.5 wt.% or more and 6 wt.% or less of Mg, 0.02 wt.% or more and 0.5 wt.% or less of Cu, 0.05 wt.% or less of Si, and 0.05 wt.% or less of Fe and further containing at least one selected from the group consisting of 0.05 wt.% or more and 0.6 wt.% less of Cr, 0.05 wt.% or more and 1.5 wt.% or less of Mn, and 0.05 wt.% or more and 0.6 wt.% or less of Zr, with the remainder being Al and inevitable impurities, and having a maximum length of intermetallic compounds on the surface thereof of 10 μm or less and having a number of intermetallic compounds having a maximum length per mm^2 of the substrate surface of 5 μm or more of 1 or less; and the like.

[0017]

<Anodic oxide film>

The anodic oxide film in the present invention is an anodic oxide film formed on the aluminum substrate and having a thickness of 7 μm or more and 25 μm or less, and the entire surface of an aluminum alloy base material is covered with this anodic oxide film.

[0018]

As an anodic oxidation treatment solution to be used for forming an anodic oxide film, it is preferred to use an anodic oxidation treatment solution containing at least oxalic acid. This is because in view of the fact that the anodic oxide film forms an oxalic acid-based film on the aluminum alloy base material, it is possible to increase the hardness and to enhance the high-temperature crack resistance.

That is, examples of general anodic oxidation treatment solutions include organic acids such as oxalic acid and formic acid, and inorganic acids such as phosphoric acid, chromic acid and sulfuric acid; however, from the viewpoints of

increasing the hardness and remarkably reducing the generation of a crack at a high temperature, it is preferred to use an anodic oxidation treatment solution containing at least oxalic acid. A concentration of oxalic acid in the anodic oxidation treatment solution may be properly controlled such that a desired operation/working-effect may be effectively exhibited. A lower limit of the concentration of oxalic acid in the anodic oxidation treatment solution is preferably 10 g/L, and more preferably 15 g/L. An upper limit of the concentration of oxalic acid is preferably 50 g/L, and more preferably 40 g/L.

[0019]

As a method of thickening the anodic oxide film or accelerating the film formation, it is preferred to perform the anodic oxidation treatment with a mixed acid solution containing at least oxalic acid (anodic oxidation treatment solution). Other acid solution which may be mixed with oxalic acid at that time is not particularly limited. Examples thereof include organic acids such as formic acid, inorganic acids such as chromic acid, sulfuric acid, phosphoric acid, and the like. One or more acid solutions chosen therefrom can be used. In this way, by using a solution containing at least oxalic acid (anodic oxidation treatment solution), the formed porous anodic oxide film becomes a film which is less in dissolution with the treatment solution, makes it possible to achieve thickening of the anodic oxide film, and is excellent in crack resistance (characteristics free from the generation of a crack).

[0020]

The above-described anodic oxidation treatment with a mixed acid solution (solution containing oxalic acid) is not particularly prescribed with respect to concentrations of various acids, treatment temperature, electrolytic voltage, and current density, and treatment conditions may be properly chosen.

[0021]

Other anodic oxidation treatment conditions are also not particularly prescribed. However, for example, the temperature on performing the anodic oxidation treatment may be set within a range where the productivity is not impaired, and dissolution of the anodic oxide film is not remarkably caused, and it is preferred to set the temperature to approximately 0 to 50°C. A treatment time on performing the

anodic oxidation treatment may be similarly properly set and is not particularly limited; and the treatment may be performed, for example, for 10 to 300 minutes.

[0022]

The electrolytic voltage (anodic oxide film-forming voltage) and the current density on performing the anodic oxidation treatment may be properly regulated so as to obtain a desired anodic oxide film. Of these, so far as the electrolytic voltage is concerned, when the electrolytic voltage is low, the current density is small so that the deposition rate becomes slow, whereas when the electrolytic voltage is too high, there is a tendency that an anodic oxide film is not formed because of dissolution of the film to be caused due to a large current. The influence by the electrolytic voltage is also related to the composition of the used electrolytic treatment solution (anodic oxidation treatment solution), the temperature at which the anodic oxidation treatment is performed, and the like, and therefore, it may be properly set. Specifically, the electrolytic voltage during the anodic oxidation treatment is preferably about 5 V to 150 V, and more preferably about 20 V to 120 V. The current density to be flown during the anodic oxidation treatment is preferably 100 A/dm² or less, more preferably 50 A/dm² or less, and still more preferably 30 A/dm² or less.

[0023]

A thickness of the thus formed anodic oxide film is an important factor bearing the flaw resistance, and from the viewpoint of obtaining favorable flaw resistance, the thickness is preferably 7 μm or more, more preferably 9 μm or more, and still more preferably 12 μm or more. In the case of the anodic oxide film alone, when the thickness of the anodic oxide film is 15 μm or more, the flaw resistance equal to that in the Ni-P plating is obtained. However, in the present invention, in view of a combination with a silica-converted film (silica film), the above-described effect may be obtained so far as the thickness of the anodic oxide film is 7 μm or more.

[0024]

Meanwhile, when the thickness of the anodic oxide film is too thick, the costs increase, and the flaw resistance is rather lowered. Thus, the thickness of the anodic oxide film is preferably 25 μm or less, and more preferably 20 μm or less.

[0025]

<Silica-converted film>

The above-described anodic oxide film is further coated with a polysilazane solution containing methylhydropolysilazane in an amount at which a leveling effect is revealed, thereby forming a silica-converted film (silica film).

After coating with the polysilazane solution, the resultant is heat-treated in an atmosphere containing water vapor, thereby achieving silica conversion.

In view of the fact that pits originated from pores of the anodic oxide film or a crystallized product or an inclusion in the alloy may be clogged by the silica film, a defect-free smooth surface may be realized, and the flaw resistance may be improved. [0026]

When the polysilazane solution contains methylhydropolysilazane, the flaw resistance is improved as compared with the case of using an anodic oxide alone. From the standpoint that the strength of the film may be more enhanced, the polysilazane solution is preferably a mixture of methylhydropolysilazane and an inorganic polysilazane. A blending ratio of the inorganic polysilazane to the methylhydropolysilazane is in the range of preferably from 0/10 to 8/2 (weight ratio), and more preferably from 2/8 to 5/5 (weight ratio). [0027]

As a suitable example of the inorganic polysilazane, perhydropolysilazane is exemplified. However, it is conventional that the perhydropolysilazane reacts with water vapor to convert into SiO_2 . In this case, Si-O-Si is connected through a three-dimensional network to form a structure analogous to molten quartz, so that the resulting film is hard and lacks in flexibility.

On the other hand, when the methylhydropolysilazane in which a methyl group is bonded to a silicon atom is allowed to react with water vapor, the skeleton of Si-O-Si is not able to form a hard structure due to the methyl group, so that the resulting film has flexibility. When the both are mixed in an appropriate proportion and allowed to react with water vapor, a silica skeleton having flexibility, in which a part of the three-dimensional network of Si-O-Si is terminated with a methyl group, may be formed.

The film having appropriate flexibility relieves a stress to be caused due to a difference of heat expansion from the aluminum substrate, and therefore, an improvement of the heat resistance is expected.

[0028]

The amount at which a leveling effect is revealed means an amount at which the smoothness may be ensured to some extent. Although the subject amount is varied depending upon a thickness of the anodic oxide film, a concentration of the polysilazane solution, an organic/inorganic mixing ratio, a coating method and the like, in general, it is preferably 0.15 mg/cm^2 or more, more preferably 0.2 mg/cm^2 or more, and still more preferably 0.4 mg/cm^2 or more in terms of an amount of the polysilazane coated per unit area of the substrate. An upper limit of the amount of the polysilazane coated is determined by not the revealment of the leveling effect but such a restriction that the thickness of the film in a silica-converted state is within $3 \text{ }\mu\text{m}$.

A coating amount of the polysilazane may be determined from a difference between the substrate weight before coating and the substrate weight after coating and an area calculated from inside and outside diameters of the substrate.

[0029]

The silica film is a silica layer having a thickness of preferably $0.2 \text{ }\mu\text{m}$ or more, and more preferably $0.3 \text{ }\mu\text{m}$ or more. The thickness is preferably $3 \text{ }\mu\text{m}$ or less, and more preferably $2 \text{ }\mu\text{m}$ or less.

It is preferred that the thickness of the silica-converted film may be measured by observing a cross section of the film by a scanning electron microscope (SEM) and performing elemental mapping. In the case where the anodic oxide film is porous, the polysilazane solution may be impregnated in the pores, thereby achieving the silica conversion.

[0030]

<Production method of aluminum substrate for magnetic recording medium>

A method for producing an aluminum substrate for a magnetic recording medium in the present invention includes a step of forming an anodic oxide film having a thickness of $7 \text{ }\mu\text{m}$ or more and $25 \text{ }\mu\text{m}$ or less on an aluminum substrate and a step of coating the anodic oxide film with a polysilazane solution containing methylhydropolysilazane in an amount at which a leveling effect is revealed and then undergoing silica conversion by heating, thereby forming a silica-converted film. Although the anodic oxide film and the silica film may be formed on/above at least one surface of the aluminum substrate, from the standpoint of efficient use of the substrate

surface, it is preferred that the anodic oxide film and the silica film are formed on/above the both surfaces of the aluminum substrate.

[0031]

The preferred aluminum substrate, anodic oxide film, and silica film are those as described previously.

Although the step of forming an anodic oxide film on an aluminum substrate may be performed by a conventional method, the anodic oxide film may be formed by, for example, energizing an aluminum alloy as the substrate in a solution containing an organic acid such as oxalic acid or formic acid, an inorganic acid such as phosphoric acid, chromic acid or sulfuric acid, or the like. In this case, it is possible to regulate the thickness of the anodic oxide film by an energization time.

Here, as described previously, from the viewpoint of enhancing the voltage resistance while remarkably reducing the generation of a crack at a high temperature, it is preferred to use an anodic oxidation treatment solution containing at least oxalic acid.

[0032]

On coating the anodic oxide film with the polysilazane solution, the coating may be performed by means of dip coating, spray coating, spin coating or the like. Above all, spin coating is preferred from the standpoint that a uniform thickness of the film may be realized.

As a solvent which is used for regulating the concentration of the polysilazane solution, an alcohol containing a hydroxyl group (-OH) in a molecular structure thereof is not usable because it reacts with the polysilazane. A petroleum-based solvent, an aromatic solvent such as xylene, an alkyl ether such as dibutyl ether, and the like are preferred. Although the concentration may be set within an appropriate range depending on a coating method or condition, it is generally 20 wt.% to 60 wt.% in terms of a polysilazane concentration. When the concentration is high, the viscosity is high so that the coating is hardly achieved. On the other hand, when the concentration is too low, a sufficient thickness of the film may not be obtained after drying the solvent.

[0033]

After coating, the resulting polysilazane solution may be converted into silica (SiO_2) by heating, thereby forming a silica film.

For the silica conversion of polysilazane, the reaction with water is necessary, and water vapor may be introduced into a heating atmosphere. A heating temperature is preferably 200 to 370°C from the standpoint of efficiently advancing the silica conversion. A heating time is preferably 20 minutes to 2 hours from the standpoints of sufficient silica conversion and productivity.

[0034]

In the case of forming the anodic oxide film and the silica-converted film on/above the both surfaces of the aluminum substrate, the aluminum alloy may be immersed in the anodic oxidation treatment solution and energization may be performed to form the anodic oxide film on the both surfaces of the aluminum substrate; and thereafter, one of the surfaces may be coated with the polysilazane solution containing methylhydropolysilazane and silica conversion may be performed by a heat treatment; and subsequently, the other surface may be coated and subjected to silica conversion by a heat treatment in the same manner.

In addition, the silica conversion may be achieved at once on the both surfaces by coating one of the surfaces with the polysilazane solution and then drying, and also coating the other surface with the polysilazane solution and then performing a heat treatment. Furthermore, the silica conversion may also be achieved by coating the both surfaces with the polysilazane solution at once and then performing a heat treatment.

EXAMPLES

[0035]

The present invention is hereunder specifically described by reference to Examples and Comparative Examples, but it should not be construed that the present invention is limited to these Examples. The present invention can be carried out after appropriate modifications or variations within a range meeting the gist of the present invention, all of which are included in the technical scope of the present invention.

[0036]

<Silica film>

A mixture of methylhydropolysilazane and perhydropolysilazane (NL120A-20 and HTA1500, available from Merck Performance Materials (formerly AZ Electronic Materials)) having a composition ratio shown in the following Table 1 was prepared, and an anodic oxide film having a thickness of 10 μm was coated with the mixture, followed by heat-treating in an atmosphere containing water vapor at 300°C for 1 hour to perform silica conversion, followed by applying heat hysteresis at each temperature for 15 minutes. The anodic oxide film having a thickness of 10 μm was formed by energizing an aluminum alloy in a solution containing 30 g/L of oxalic acid at 30°C. The thickness of the anodic oxide film can be regulated by an energization time.

A temperature at which neither crack nor exfoliation of the film was perceived through visual inspection and optical microscopic observation was defined as a heat-resistant temperature. The results are shown in Table 1. According to the results shown in Table 1, a difference was not confirmed between the case where the thickness of the silica film was 0.3 μm and the case where the thickness of the silica film was 2 μm . In addition, in the table, “PHPS” means perhydropolysilazane, and “MHPS” means methylhydropolysilazane.

[0037]

The ratio of methylhydropolysilazane to perhydropolysilazane in the silica film can be determined by the ATR (Attenuated Total Reflection) method.

That is, in the ATR method, the methyl group bonded to the Si atom exhibits sharp characteristic absorption at a wavelength of around 1,270 to 1,280 cm^{-1} . In addition, strong characteristic absorption caused due to skeletal vibration of Si-O-Si is observed at a wavelength of around 1,030 to 1,050 cm^{-1} . Since the amount of the methyl group in the silica skeleton can be evaluated from a ratio in a peak height of the both, the ratio of methylhydropolysilazane to perhydropolysilazane can be determined.

[0038]

(Measurement condition of ATR spectrum)

Device: Spectrum Spotlight 400, available from PerkinElmer, Inc.

Measurement method: Single reflection ATR, Ge crystal, incident angle: 48°

Resolution: 4 cm^{-1}

Absorption amount: Expressed in terms of absorbance

[0039]

(Measurement condition of ATR spectrum and analysis method)

With respect to the measured spectrum, both points at wavelengths of 870 cm^{-1} and $1,300\text{ cm}^{-1}$ are connected to each other with a straight line, and a ratio of a value " $I_{(\text{Si-O-Si})}$ " from the straight line of a characteristic absorption peak originated from the skeletal vibration of Si-O-Si appearing at a wavelength of around $1,030$ to $1,050\text{ cm}^{-1}$ and a value " $I_{(\text{Si-CH}_3)}$ " from the straight line of a peak of the characteristic absorption of Si-CH₃ appearing at a wavelength of $1,265$ to $1,280\text{ cm}^{-1}$ is determined. The resulting ATR spectrum is shown in FIG. 1. In view of the fact that the case where this value is 0.02 corresponds to the case where a blending ratio of inorganic polysilazane (PHPS) to methylhydropolysilazane (MHPS) is 0/10 (weight ratio), and the case where the subject value is 0.25 corresponds to the case where a blending ratio of PHPS to MHPS is 8/2 (weight ratio), it may be said that the subject value is preferably 0.02 or more and 0.25 or less.

In FIG. 1, the ratio (weight ratio) of PHPS to MHPS is 8/2 in HD-208, 6/4 in HD-210, 4/6 in HD-212, and 2/8 in HD-214, respectively.

[0040]

Table 1: Heat resistance of PHPS/MHPS blend material

Sample No.	PHPS/MHPS (weight ratio)	Heat-resistant temperature
1	10/0	300°C
2	8/2	350°C
3	6/4	375°C
4	4/6	400°C
5	2/8	425°C
6	0/10	450°C

[0041]

<Anodic oxide film>

On an aluminum substrate, an anodic oxide film was formed in a thickness of $5\text{ }\mu\text{m}$, $10\text{ }\mu\text{m}$, $15\text{ }\mu\text{m}$, $20\text{ }\mu\text{m}$, and $30\text{ }\mu\text{m}$, respectively and the flaw resistance was evaluated.

The results are shown in FIG. 2. Even when an anodic oxide film was used alone, in a case where the thickness is $15\text{ }\mu\text{m}$ or more, the flaw resistance is improved

as compared with the case of a conventional Ni-P plating treatment (thickness: 10 μm). That is, it means that the anodic oxidation treatment is effective for improving the flaw resistance of the aluminum substrate. In the case of using the anodic oxide film alone, when the thickness is 30 μm , the flaw resistance tends to be deteriorated even slightly as compared with the case where the thickness is 20 μm . This may be conjectured to be caused due to the matter that the anodic oxidation treatment time became long, and the neighborhood of the surface of the initially formed film was corroded with the electrolytic solution.

As the aluminum substrate, an aluminum alloy containing 5.5 wt.% of Mg, 0.04 wt.% of Cu, 0.01 wt.% of Si, 0.015 wt.% of Fe, 0.3 wt.% of Mn, and 0.5 wt.% of Cr, with the remainder being Al and inevitable impurities, was used and was energized in a solution containing 30 g/L of oxalic acid at 30°C, thereby forming an anodic oxide film. The thickness of the anodic oxide film was regulated by an energization time.

The thickness of the anodic oxide film was measured with an eddy current type film thickness meter. On the measurement, the same place was measured five times, and an average value thereof was defined as the thickness of the film of the subject place.

[0042]

The flaw resistance was evaluated through measurement with a continuous loading scratching intensity tester, TYPE 18, available from Shinto Scientific Co., Ltd. On the measurement, a conical scratch needle having an R-processed tip and using a diamond ball having a radius of 0.1 mm as an indenter was loaded with a weight of 10 g, 20 g (or 25 g), 50 g, 70 g, and 100 g, respectively and travelled at a distance of 10 mm on the surface of a test piece. After travelling, a depth of the flaw formed on the surface of the test piece was measured.

The flaw depth was measured with an Alpha-Step meter, available from KLA-Tencor.

In FIG. 2, the terms “5 μm ”, “10 μm ”, “15 μm ”, “20 μm ”, and “30 μm ” express the thickness of the anodic oxide film, respectively; the term “G-SUB” expresses an aluminum substrate having a ground surface, which was not subjected to a surface treatment; and the term “NPP” expresses an aluminum substrate in which after grinding, Ni-P plating was applied, followed by surface polishing.

[0043]

<Combination of anodic oxide film with silica film>

The thickness of the anodic oxide film was 10 μm and 15 μm , respectively, and among the PHPS/MHPS blend materials shown in Table 1, the solutions having a PHPS/MHPS (weight ratio) of 8/2, 6/4, 4/6, 2/8, and 0/10 were each applied to the anodic oxide film, followed by heat-treating in an atmosphere containing water vapor at 300°C for 1 hour to perform silica conversion, thereby obtaining silica films having a thickness of 0.6 μm and 1.2 μm , respectively. The thickness of the film was determined through SEM observation of a cross section of the test piece prepared under the same condition. The prepared samples are summarized in Table 2.

[0044]

The evaluation of the flaw resistance of each of the samples was performed by the same method as in the preceding evaluation of flaw resistance of the anodic oxide film. The results are shown in FIGs. 3 to 5. FIG. 3 shows the results of Nos. 7 to 10 in Table 2 (symbols 8:2-2, 6:4-2, 4:6-2, and 2:8-2); FIG. 4 shows the results of Nos. 11 to 13 in Table 2 (symbols: 6:4-1, 4:6-1, and 0:10-1); and FIG. 5 shows the results of Nos. 14 to 17 in Table 2 (symbols 6:4-1, 6:4-2, 4:6-1, and 4:6-2). In FIGs. 3 to 5, the term "NPP" is concerned with the results of the nickel-phosphorus plated substrate as a reference; the term "Anodic Oxidation: 10 μm " is concerned with the results of flaw resistance of the anodic oxide film alone having a thickness of 10 μm ; and the term "Anodic Oxidation: 15 μm " is concerned with the results of flaw resistance of the anodic oxide film alone having a thickness of 15 μm .

In the case where the thickness of the silica coating is 0.1 μm or less, regardless of the blending ratio of PHPS to MHPS, when the indentation load exceeded 25 gf, a meaningful difference from the case of the anodic oxide film alone was not observed.

[0045]

Table 2

No.	Symbol	Thickness of anodic oxide film	Blending ratio (PHPS/MHPS)	Thickness of silica coating
7	8:2-2	10 μm	8/2	1 μm
8	6:4-2	10 μm	6/4	1 μm
9	4:6-2	10 μm	4/6	1 μm
10	2:8-2	10 μm	2/8	1 μm
11	6:4-1	10 μm	6/4	0.3 μm
12	4:6-1	10 μm	4/6	0.3 μm
13	0:10-1	10 μm	0/10	0.3 μm
14	6:4-1	15 μm	6/4	0.3 μm
15	6:4-2	15 μm	6/4	1 μm
16	4:6-1	15 μm	4/6	0.3 μm
17	4:6-2	15 μm	4/6	1 μm

[0046]

From the foregoing results, an aluminum substrate having excellent heat resistance and flaw resistance can be obtained by coating the anodic oxide film with a silica precursor of MHPS alone or a silica precursor having PHPS mixed with MHPS and then performing silica conversion.

CLAIMS

1. An aluminum substrate for a magnetic recording medium, comprising: an aluminum substrate; an anodic oxide film having a thickness of 7 μm or more and 25 μm or less formed on the aluminum substrate; and a silica-converted film on the anodic oxide film, the silica-converted film being prepared by coating the anodic oxide film with a polysilazane solution containing methylhydropolysilazane in an amount at which a leveling effect is revealed,

wherein the silica-converted film is a silica layer having a thickness of 0.2 μm or more, and

the silica-converted film includes a silica skeleton in which a part of a three-dimensional network of Si-O-Si is terminated with a methyl group.

2. The aluminum substrate for a magnetic recording medium according to claim 1, wherein the polysilazane solution containing methylhydropolysilazane is a mixture of methylhydropolysilazane and an inorganic polysilazane.

3. The aluminum substrate for a magnetic recording medium according to claim 2, wherein a blending ratio of the methylhydropolysilazane to the inorganic polysilazane in the mixture is in a range of from 8/2 to 2/8 in a weight ratio.

4. A method for producing an aluminum substrate for a magnetic recording medium, the method comprising:

forming an anodic oxide film having a thickness of 7 μm or more and 25 μm or less on an aluminum substrate; and

coating the anodic oxide film with a polysilazane solution containing methylhydropolysilazane in an amount at which a leveling effect is revealed and then undergoing silica conversion by heating, thereby forming a silica-converted film on the anodic oxide film,

wherein the polysilazane solution containing methylhydropolysilazane is a mixture of methylhydropolysilazane and an inorganic polysilazane, and

the silica-converted film is a silica layer having a thickness of 0.2 μm or more.

5. The method for producing an aluminum substrate for a magnetic recording medium according to claim 4, wherein the anodic oxide film is formed with an anodic oxidation treatment solution containing at least oxalic acid.

6. The method for producing an aluminum substrate for a magnetic recording medium according to claim 4, wherein a blending ratio of the methylhydropolysilazane to the inorganic polysilazane in the mixture is in a range of from 8/2 to 2/8 in a weight ratio.