

Description

Title of Invention

ALUMINUM SUBSTRATE FOR MAGNETIC RECORDING MEDIUM, AND METHOD FOR PRODUCING SAME

Technical Field

[0001] The present invention relates to an aluminum substrate having formed thereon a coating film that is suitable as a substrate for magnetic recording medium, and to a method for producing the aluminum substrate.

Background Art

[0002] In magnetic recording media that are used in various electronic devices such as computers, a magnetic film that constitutes a recording layer is formed on a non-magnetic substrate. Substrates for magnetic recording media are required to be lightweight and to have high hardness, and also to have a smooth surface and scratch resistance. Accordingly, aluminum sheets are used as materials that are non-magnetic, are lightweight, and allow obtaining easily a smooth surface through mirror-finishing or the like. Substrates having a Ni-P plating film formed thereon (hereafter also referred to as “Ni-P plated aluminum substrates”) are widely used as substrates for magnetic recording media, in order to secure hardness and scratch resistance in the surface of an aluminum sheet.

[0003] To perform Ni-P plating, the oxide layer naturally formed on the surface of the aluminum sheet is removed and a zincate treatment is carried out, as a pretreatment, in order to achieve good plating adhesion. In this case, however, the smoothness of the aluminum sheet might be impaired in some instances. Defects such as pits become formed on the surface of a Ni-P plating film on account of crystallized intermetallic compounds that are unavoidably present in the aluminum sheet, and thus the smoothness of the Ni-P plated aluminum substrate might be thus impaired.

[0004] Such being the case, for instance amorphous SiO₂ films such as those disclosed in Patent Literature 1 and 2 have been studied as coating films that can constitute alternatives to Ni-P plating films. Attention has been given to SiO₂ films on account of the properties thereof, which include being non-magnetic and having high hardness and excellent heat resistance.

[0005] For instance, Patent Literature 1 discloses a surface treatment method of an alumite substrate for magnetic recording, the method involving performing an alumite treatment on the surface of an aluminum substrate, coating thereafter the surface of the resulting alumite film with silicon oxide, and performing a thermal treatment, to thereby smooth the surface of the alumite film. Patent Literature 1 indicates that the smoothness of the surface of the alumite film becomes thus improved to a very significant degree.

[0006] Patent Literature 2 discloses a substrate for magnetic recording medium having a SiO₂ film formed on the surface. Patent Literature 2 indicates that the SiO₂ film is preferably formed from a coating solution having a polysilazane as a main component. Patent Literature 2 indicates that surface roughness smaller than the surface roughness of a substrate can be achieved by forming a SiO₂ film on the surface of that substrate.

Citation List

Patent Literature

[0007] Patent Literature 1: Japanese Unexamined Patent Publication No. H2-73520

Patent Literature 2: Japanese Unexamined Patent Publication No. H9-147344

Summary of Invention

[0008] It is an object of the present invention to provide an aluminum substrate for magnetic recording medium, the aluminum substrate having both excellent smoothness and scratch

resistance, and to provide a method for producing the aluminum substrate.

[0009] One aspect of the present invention is an aluminum substrate for magnetic recording medium comprising an aluminum sheet and a coating film formed on the surface of the aluminum sheet, wherein the coating film is a multilayer film including an anodized film and a SiO₂ film in this order from the side of the aluminum sheet, the anodized film has a thickness of 7 μm to 45 μm, and the SiO₂ film has a thickness of 1 μm to 5 μm.

[0010] Another aspect of the present invention is a method for producing the above aluminum substrate for magnetic recording medium, the method including: a step of forming an anodized film on an aluminum sheet; and a step of forming the SiO₂ film on the anodized film by coating the surface of the anodized film with an inorganic polysilazane-containing solution, followed by heating to thereby convert the inorganic polysilazane to SiO₂.

[0011] The above and other objects, features and advantages of the present invention will be apparent from the following detailed description and the accompanying drawings.

Brief Description of Drawings

[0012] [Fig. 1] Fig. 1 is a schematic cross-sectional diagram illustrating an aluminum substrate according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a micrograph of No. 3-1 in Experiment 3.

[Fig. 3] Fig. 3 is a drawing-replacing photograph illustrating surface smoothness of No. 3-1 in Experiment 3.

[Fig. 4] Fig. 4 is a micrograph of No. 3-2 in Experiment 3.

[Fig. 5] Fig. 5 is a drawing-replacing photograph illustrating surface smoothness of No. 3-2 in Experiment 3.

[Fig. 6] Fig. 6 is a micrograph of No. 3-3 in Experiment 3.

[Fig. 7] Fig. 7 is a drawing-replacing photograph illustrating surface smoothness of

No. 3-3 in Experiment 3.

Description of Embodiments

[0013] In studies by the inventors a SiO₂ film having sufficient hardness and heat resistance failed to be formed using the organosiloxane that is utilized as silicon oxide in Patent Literature 1. Moreover, the aluminum substrate covered with the anodized film did not have sufficient scratch resistance.

[0014] In Patent Literature 2 there occurred problems such as cracking of the SiO₂ film, or peeling of the SiO₂ film off the aluminum sheet, depending on the thermal history during the production process or during usage, when the SiO₂ film was made thicker in order to secure scratch resistance.

[0015] The present invention is contrived in consideration of the above circumstances and its object is to provide an aluminum substrate for magnetic recording medium that combines excellent smoothness and scratch resistance. Specifically, it is an object of the present invention to provide an aluminum substrate for magnetic recording medium in which there is formed a coating film that combines excellent smoothness and scratch resistance. It is a further object of the present invention to provide a method for producing the aluminum substrate for magnetic recording medium.

[0016] The inventors conducted extensive research on aluminum substrates having a hardness of 4.0 to 8.0 GPa, comparable to that of glass, and having excellent smoothness and scratch resistance. The lead-up to the present invention was as follows.

[0017] From the viewpoint of securing hardness and scratch resistance, a first approach by the inventors involved increasing the thickness of the SiO₂ film that is formed on the surface of the aluminum sheet, using an inorganic polysilazane as a starting material. As a result, the inventors found that it is difficult to control water, ammonia and so forth, indispensable in the formation process of the SiO₂ film, and that forming films having a thickness over 5 μm in an

industrial scale was likewise difficult. In aluminum sheets provided with a SiO₂ film having a thickness of about 5 μm, scratches and dents occurred and sufficient scratch resistance failed to be obtained when the aluminum sheet suffered impacts during production or during use.

[0018] The use of a coating film that can be made thicker easily was considered, from the viewpoint of enhancing scratch resistance, and it was found that anodized films are readily amenable to thickening. However, it was found that the thickness of the anodized film must be 20 μm or greater in order to secure sufficient scratch resistance. It was moreover found that in this case the anodized film develops a porous structure, whereby surface roughness becomes significantly impaired and smoothness cannot be secured.

[0019] As a result of further diligent research directed at securing scratch resistance and smoothness, the inventors found that adopting a multilayer structure of predetermined thickness and having an anodized film and an SiO₂ film is effective in order to secure smoothness and scratch resistance while suppressing deterioration of the surface roughness of the anodized film, and arrived at the present invention on the basis of that finding.

[0020] Specifically, the aluminum substrate for magnetic recording medium according to one embodiment of the present invention has an aluminum sheet and a coating film formed on the aluminum sheet. The coating film is a multilayer film including an anodized film and a SiO₂ film in this order from the side of the aluminum sheet. The anodized film has a thickness of 7 μm to 45 μm and the SiO₂ film has a thickness of 1 μm to 5 μm. By virtue of having such a coating film, the aluminum substrate for magnetic recording medium can combine both smoothness and scratch resistance. Specifically, an aluminum substrate for magnetic recording medium is obtained in which there is formed a coating film that combines excellent smoothness and scratch resistance. This is deemed to arise specifically from the following.

[0021] To secure scratch resistance using an anodized film alone it was necessary to make

the anodized film thicker, as described above. However, covering the anodized film with a SiO_2 film having hardness comparable to that of glass allows securing herein sufficient scratch resistance even if the anodized film is thin. In particular, it is deemed that if a SiO_2 precursor is caused to penetrate into the porous structure of the anodized film during formation of the SiO_2 film, the anodized film develops a composite structure with SiO_2 , whereby adhesion is enhanced, and sufficient scratch resistance can be secured even in a thin film.

[0022] Further, making the anodized film thinner allows suppressing deterioration of surface roughness of the former, and accordingly yet better smoothness is obtained through covering with the SiO_2 film.

[0023] A trend is observed whereby scratch resistance cannot be secured if the thickness of the anodized film is not sufficient. The thickness of the anodized film is 7 μm or greater, preferably 8 μm or greater and more preferably 9 μm or greater. When on the other hand the anodized film is made excessively thick, costs tend to increase and the effect of enhancing scratch resistance tends to level off. Further, a greater film thickness tends to entail worse surface roughness of the anodized film, and a decrease in smoothness. A thicker film tends to result in a higher likelihood of breakage or peeling of the anodized film and in impaired heat resistance, derived from differences in thermal expansion between the anodized film and the aluminum sheet or the SiO_2 film depending on the thermal history. The thickness of the anodized film is 45 μm or smaller, preferably 40 μm or smaller, and more preferably 35 μm or smaller. From the above it follows that a coating film that combines excellent smoothness and scratch resistance is obtained by forming a SiO_2 film on the surface of an anodized film having a thickness lying in the above ranges.

[0024] A trend is observed whereby smoothness cannot be secured if the thickness of the SiO_2 film is not sufficient. The thickness of the SiO_2 film is 1 μm or greater, preferably 1.5

μm or greater and more preferably $2\ \mu\text{m}$ or greater. Although making the SiO_2 film thick is desirable in terms of securing smoothness, excessive thickness tends to give rise to impaired heat resistance in the form of breakage or peeling of the SiO_2 film, caused by differences in thermal expansion between the anodized film and the SiO_2 film depending on the thermal history. The thickness of the SiO_2 film is $5\ \mu\text{m}$ or smaller, preferably $4\ \mu\text{m}$ or smaller and more preferably $3\ \mu\text{m}$ or smaller. From the above it follows that a coating film that combines excellent smoothness and scratch resistance is obtained by forming a SiO_2 film having a thickness within the above ranges, on an anodized film.

[0025] Fig. 1 is a schematic cross-sectional diagram illustrating an aluminum substrate according to the present embodiment. The above coating film is not particularly limited, so long as it is a multilayer film obtained through overlaying of the anodized film and the SiO_2 film in this order from the aluminum sheet. Specifically, it suffices that the coating film be a multilayer film including the anodized film and the SiO_2 film in this order from the side of the aluminum sheet; the coating film may be herein a stack formed of the anodized film and the SiO_2 film, as illustrated in Fig. 1. It suffices herein that the coating film has the anodized film and the SiO_2 film, but the coating film may include also other layers (layers other than the anodized film and the SiO_2 film). Examples of the film structure of the coating film include, for instance, a two-layer structure made up of an anodized film 2 formed on the surface of an aluminum sheet 1, and a SiO_2 film 3 formed on the surface of the anodized film 2, as illustrated in Fig. 1. As described above, the coating film may include other layers, but preferably consist of the anodized film and the SiO_2 film, with the anodized film and the SiO_2 film in contact with each other. By virtue of the fact that the anodized film and the SiO_2 film are in contact with each other, the coating film exhibits a composite structure of an anodized film and SiO_2 such as the one described above. It is deemed that this allows enhancing adhesion and securing sufficient scratch resistance even in a thin film.

[0026] The thickness of the multilayer film is not particularly limited, and it suffices that the thicknesses of the anodized film and the thickness of the SiO₂ film lie within the above ranges; further, the thicknesses may be adjusted as appropriate, within the above ranges, in such a manner that the desired smoothness and scratch resistance are obtained.

[0027] The aluminum substrate according to the present embodiment, in which a multilayer film having an anodized film and a SiO₂ film is formed on the surface of an aluminum sheet, has excellent smoothness, preferably, for instance, the aluminum substrate has a center line average roughness Ra of 1.0 nm or less, and more preferably 0.8 nm or less, according to JIS B 0601-2001.

[0028] The aluminum substrate according to the present embodiment is also excellent in scratch resistance, and has scratch resistance comparable to, and preferably better than, that of a Ni-P plating film. The scratch resistance entails for instance a scratch depth of preferably 0.28 μm or less, more preferably 0.20 μm or less, in accordance with the test method in the below-described working examples.

[0029] A method for producing the aluminum substrate for magnetic recording medium according to another embodiment of the present invention will be explained next.

[0030] Film formation conditions are not particularly limited in the present embodiment so long as a multilayer film of an anodized film and of a SiO₂ film, having a predetermined thickness, can be formed on the surface of an aluminum sheet.

[0031] As a method for producing an aluminum substrate having excellent smoothness and scratch resistance according to the present embodiment there is recommended a production method that has a step of forming an anodized film on an aluminum sheet, and step of forming a SiO₂ film on an anodized film by coating the surface of the anodized film surface with an inorganic polysilazane-containing solution, removing thereafter the solvent through heating, and converting thereafter the inorganic polysilazane to SiO₂.

[0032] The aluminum sheet that is used as a base material in the present embodiment is not particularly limited; herein it suffices that the aluminum sheet contains aluminum, and the sheet may be a pure aluminum sheet or an aluminum alloy sheet. As the aluminum sheet there can be used various known pure aluminum sheets and aluminum alloy sheets widely utilized for magnetic recording media. Preferred aluminum alloy substrates include, for instance, sheets of 5D86 alloy produced by Kobe Steel, Ltd., sheets of 5086 alloy and sheets of 2219 alloy according to JIS H 4000-2006 as well as the aluminum alloy substrate disclosed in Japanese Patent No. 5325869. The aluminum alloy substrate disclosed in Japanese Patent No. 5325869 “is an aluminum alloy sheet containing 3.5 mass% to 6 mass% of Mg, the balance being made up of Al and unavoidable impurities, wherein stack annealing is performed under conditions that involve raising the temperature to 360°C or above at a rate of temperature rise of 2°C/minute or less and holding the temperature at 360°C or above for 2 hours or longer, followed by cooling at a temperature lowering rate of 2°C/minute or less, such that the variation in flatness before and after heating at 500°C for 10 seconds is 5 μ m or less and the variation in average grain size before and after heating at 500°C for 10 seconds is 10 μ m or less”. More preferably, the aluminum sheet is the above sheet of 5D86 alloy, sheet of 2219 alloy or the above aluminum alloy substrate disclosed in Japanese Patent No. 5325869, all of which have excellent high-temperature resistance.

[0033] The thickness of the aluminum sheet is not particularly limited, so long as the thickness is as required for magnetic recording media. For instance, the thickness of the aluminum sheet lies in the range of 1.2 mm to 1.8 mm in an aluminum substrate for magnetic recording medium having a diameter of 3.5 inches, but the value of thickness is not limited thereto.

[0034] It is recommended that the aluminum sheet be punched to a desired shape and be subjected to an annealing treatment. Performing an annealing treatment allows fixing the

shape of the aluminum sheet and removing residual stress. The annealing treatment may be performed for instance at a temperature of 300°C or higher.

[0035] A surface altered layer derived from rolling and so forth becomes formed on the aluminum sheet surface; accordingly, it is preferable to remove the rolled surface, as needed, through grinding or turning of the surface altered layer. The working method involved is not particularly limited, and generally wet grinding using a polyvinyl alcohol (PVA) grindstone or turning using a diamond bite can be resorted to herein. Wet grinding using a polyvinyl alcohol grindstone may be performed after turning.

[0036] The surface roughness of the aluminum sheet is preferably 1.0 nm or less, and more preferably 0.8 nm or less, expressed as center line average roughness Ra according to JIS B 0601-2001.

[0037] Preferably, the aluminum sheet surface is cleaned as needed by performing a known degreasing treatment or desmutting treatment.

[0038] The step of forming the anodized film on the aluminum sheet is not particularly limited, and may be a step of anodizing the aluminum sheet using an ordinary anodizing solution. The conditions for forming the anodized film on the aluminum sheet surface are not particularly limited. Examples of ordinary anodizing solutions include, for instance, organic acids such as oxalic acid and formic acid, and inorganic acids such as phosphoric acid, chromic acid and sulfuric acid. Among the foregoing it is preferable to use an anodizing solution that contains oxalic acid, from the viewpoint of reducing the occurrence of cracks at high temperature. The concentration of oxalic acid in the anodizing solution is not particularly limited, but generally the oxalic acid concentration is preferably controlled to be 10 g/L or higher, more preferably 20 g/L or higher, and preferably 50 g/L or lower and more preferably 40 g/L or lower.

[0039] The upper limit temperature (hereafter also referred to as “liquid temperature”) at the

time of the anodization treatment may be set to lie within a range such that dissolution of the anodized film does not progress at an excessive rate, while securing productivity, and is preferably 50°C or lower, more preferably 40°C or lower. Although a low-temperature treatment is also possible herein, the lower limit temperature is preferably 15°C or higher, more preferably 20°C or higher, in terms of heat resistance, since cracks occur when the treatment temperature is excessively low.

[0040] The electrolysis voltage and the current density at the time of the anodization treatment may be properly adjusted so that the desired anodized film is obtained. For instance, current density decreases and the film formation rate slows down when the electrolysis voltage is low. When the electrolysis voltage is too high, by contrast, dissolution of the anodized film progresses on account of the accompanying larger current, and the desired thickness may fail to be obtained. The electrolysis voltage at the time of the anodization treatment is preferably 5 V or higher, more preferably 15 V or higher, and preferably 100 V or lower, more preferably 80 V or lower. Alternatively, the current density at the time of the anodization treatment is preferably 100 A/dm² or lower, more preferably 30 A/dm² or lower, and yet more preferably 5 A/dm² or lower.

[0041] The step of forming a SiO₂ film on the anodized film is not particularly limited, and involves forming a SiO₂ film after formation of an anodized film of predetermined thickness on the surface of the aluminum sheet. When observed under the microscope, the surface of the anodized film, which has a porous structure, reveals numerous pit-like defects having a pore size of about 10 to 100 nm. The surface of such an anodized film is coated with an inorganic polysilazane-containing solution, and then, upon subsequent heating, a strong composite structure becomes formed by the SiO₂ to which there is converted the inorganic polysilazane having permeated into the interior of the anodized film, in accordance with a wet film formation method. In this matter the hardness of the coating film is further

enhanced as a result, and scratch resistance is likewise increased. In contrast to conventional anodized films, sufficient scratch resistance can accordingly be secured through formation of the SiO_2 film on the anodized film even if the latter is thin. Since the anodized film can be made thin, it becomes possible to suppress deterioration of surface roughness that accompanies development of a porous structure, as described above. Further, smoothness can be enhanced in that the inorganic polysilazane-containing solution penetrates into the pit-like defects of the anodized film, whereupon surface roughness caused by these defects is improved on account of the resulting leveling effect.

[0042] The inorganic polysilazane is a material having “ $-(\text{SiH}_2\text{NH})-$ ” as a basic structural unit and which contains no organic component such as a methyl group or the like in the basic structural unit; the inorganic polysilazane is made up of linear, cyclic or composite structures of the foregoing, and is converted to hard SiO_2 as a result of reactions with oxygen and water at high temperature. For instance, inorganic polysilazanes of various known compositions disclosed in, for example, Japanese Unexamined Patent Publication No. S60-145903 can be used herein.

[0043] Specifically, perhydropolysilazane can be suitably used as the above inorganic polysilazane. Preferably, a polysilazane having for instance a number-average molecular weight of about 500 to 2500 is used herein as the inorganic polysilazane.

[0044] As the above inorganic polysilazane-containing solution it suffices to use herein a solution in which an inorganic polysilazane is dissolved, while an organic solvent such as dibutyl ether, xylene, toluene or the like can be used for instance as the solvent. The concentration of the inorganic polysilazane in the inorganic polysilazane-containing solution is not particularly limited, but for instance is preferably 10 mass% or higher, more preferably 20 mass% or higher, with respect to the mass of the solution as a whole.

[0045] A catalyst such as a palladium catalyst may be further incorporated into the inorganic

polysilazane-containing solution in order to promote conversion of the inorganic polysilazane to SiO₂.

[0046] The above inorganic polysilazane-containing solution may be a commercially available product, for instance available from AZ Electronic Materials plc or the like. The procured solution may be used after having been concentrated.

[0047] Known polysilazanes include, besides inorganic polysilazanes, also organic polysilazanes that contain organic components, such as methyl groups, in the basic structural units. In inorganic polysilazanes, the formation of three-dimensional Si-O bonds at low temperature progresses readily and silica conversion proceeds suitably. Herein SiO₂ films formed using an inorganic polysilazane are harder than SiO₂ films formed using an organic polysilazane. In consequence, an inorganic polysilazane is used in the production method according to the present embodiment.

[0048] The method for coating the aluminum substrate surface with the above inorganic polysilazane-containing solution is not particularly limited, and a known method can be resorted to. For instance a method such as spin coating, dip coating, spray coating or the like can be utilized herein.

[0049] The coating amount of the inorganic polysilazane-containing solution is not particularly limited. Therefore, the coating amount may be adjusted as appropriate in accordance with the thickness of the SiO₂ film to be formed.

[0050] After application of the inorganic polysilazane-containing solution, the solvent is preferably removed through drying, as needed. The drying method is not particularly limited, and for instance the solvent may be removed through drying at a desired temperature, in air or in a dry atmosphere, specifically in an atmosphere containing no water vapor, for instance dry air, dry nitrogen or the like.

[0051] [Firing]

After coating of the anodized film surface with the inorganic polysilazane-containing solution, or after further drying, the aluminum sheet is placed in a heating furnace such as an electric furnace, and is heated to elicit conversion of the inorganic polysilazane to silica, and thereby form a hard SiO_2 film having mainly SiO_2 .

[0052] The aluminum sheet having been placed inside the firing furnace is heated up to the final firing temperature. The firing temperature (final firing temperature) is not particularly limited. If the final firing temperature is excessively high, however, the aluminum sheet deforms, and hence the final firing temperature must be set to a lower temperature than the temperature at which deformation of the aluminum sheet starts. The heatproof temperature of the aluminum sheet varies somewhat depending for instance on alloy components. Because the yield strength of the aluminum sheet is prone to change by dropping down to about 1/4 than that at room temperature beyond about 370°C , the firing temperature is preferably 370°C or lower. Preferably, the firing temperature of the aluminum sheet is 200°C or higher, more preferably 250°C or higher, since silica conversion of the inorganic polysilazane is promoted at temperatures of 200°C or higher, while a higher temperature translates into higher hardness. Silica conversion reactions are promoted by making the interior of the firing furnace into a steam atmosphere, but the interior of the furnace may be an air atmosphere until addition of steam.

[0053] The method for supplying steam is not particularly limited herein, and for instance air or the like may be caused to flow, at a predetermined flow rate, in a high-temperature vaporizer that is provided outside the firing furnace, while under dripping of a predetermined amount of water, to supply as a result, into the firing furnace, an atmosphere gas with controlled partial pressure of steam.

[0054] The amount of steam that is supplied into the firing furnace varies depending for instance on the size of the firing furnace, and the number, size and so forth of the aluminum

sheets to be fired, and is accordingly not particularly limited. The supply amount of steam may be adjusted as appropriate at least so as to allow forming a SiO_2 film having the below-described intensity and heat resistance, by causing the inorganic polysilazane to undergo a silica conversion reaction with the water that is supplied. The partial pressure of steam is not particularly limited. For instance the partial pressure of steam may be about 20% to 70%.

[0055] The presence of a SiO_2 film can be checked in a measurement of an FT-IR spectrum (Fourier transform infrared spectrophotometer) of the coating film before and after heating, on the basis of a decrease in peak intensity derived from Si-H bonds and N-H bonds or the disappearance of such peaks, and on the basis of the appearance of peaks derived from Si-O bonds or an increase in the intensity of such peaks.

[0056] Thereafter as well silica conversion is elicited through heating up to a predetermined final firing temperature while maintaining, in the interior of the firing furnace, a steam atmosphere through supply of steam. As a result there can be obtained an aluminum sheet covered with a hard SiO_2 film.

[0057] The holding time of the final firing temperature is not particularly limited, so long as silica conversion is completed, but for instance is preferably set to 30 minutes or longer, more preferably 1 hour or longer.

[0058] The rate of temperature rise within the firing furnace is not particularly limited, and the temperature may be raised under ordinary production conditions. For instance, the temperature may be raised at an average rate of temperature rise of about $3^\circ\text{C}/\text{minute}$ to $10^\circ\text{C}/\text{minute}$.

[0059] Firing is followed by cooling down to room temperature, but the cooling rate involved is not particularly limited, and for instance natural cooling by standing suffices herein.

[0060] The aluminum substrate according to the present embodiment thus obtained has excellent smoothness and scratch resistance.

[0061] The SiO₂ film surface may be polished, ground or cut under known conditions with a view to further enhancing smoothness. In the aluminum substrate according to the present embodiment a hard SiO₂ film is formed on the surface of the aluminum substrate, and accordingly methods, equipment and so forth that are used for polishing glass substrates conventionally used may be utilized herein without modification.

[0062] The aluminum substrate according to the present embodiment can be suitably used as a material for various types of electronic devices, for instance as a substrate for magnetic recording medium.

[0063] To produce a magnetic recording medium using the aluminum substrate according to the present embodiment it suffices to form a magnetic recording film, under known conditions, on the surface of the aluminum substrate, and to further form a protective film or lubricating film, as needed.

[0064] The present specification discloses the various technologies above, but the main features thereof can be summarized as follows.

[0065] One aspect of the present invention that allows attaining the above object is an aluminum substrate for magnetic recording medium comprising an aluminum sheet and a coating film formed on the surface of the aluminum sheet, wherein the coating film is a multilayer film including an anodized film and a SiO₂ film in this order from the side of the aluminum sheet, the anodized film has a thickness of 7 μm to 45 μm, and the SiO₂ film has a thickness of 1 μm to 5 μm.

[0066] Such a feature allows providing an aluminum substrate for magnetic recording medium that combines excellent smoothness and scratch resistance. Specifically, it becomes possible to provide an aluminum substrate for magnetic recording medium in which there is formed a coating film that combines excellent smoothness and scratch resistance.

[0067] Another aspect of the present invention is a method for producing the above

aluminum substrate for magnetic recording medium, the method including: a step of forming the anodized film on the aluminum sheet; and a step of forming the SiO₂ film on the anodized film by coating the surface of the anodized film with an inorganic polysilazane-containing solution, followed by heating to thereby convert the inorganic polysilazane to SiO₂.

[0068] Such a feature allows providing a method for producing an aluminum substrate for magnetic recording medium that makes it possible to produce suitably an aluminum substrate for magnetic recording medium which combines excellent smoothness and scratch resistance.

[0069] In the method for producing an aluminum substrate for magnetic recording medium, preferably, the step of forming the anodized film is an anodization treatment in which a solution of oxalic acid is used.

[0070] Such a feature allows producing suitably an aluminum substrate for magnetic recording medium having yet better smoothness and scratch resistance.

Examples

[0071] The present invention will be explained next more specifically by way of working examples, but the invention is not limited by these examples, and needless to say can be carried out while including additional modifications within the scope conforming to the gist disclosed heretofore and hereinafter, all such modifications being encompassed within the technical scope of the invention.

[0072] (Experiment 1)

In Experiment 1 scratch resistance was evaluated. Sheets of 5D86 alloy were used as the aluminum sheet. The composition of the 5D86 alloy is that of an aluminum alloy having Si: 0.015 mass%, Fe: 0.02 mass%, Cu: 0.04 mass%, Mg: 4.00 mass%, Zn: 0.15 mass%, and the balance made up of Al and unavoidable impurities. Each sheet of this aluminum alloy was cold-rolled and was thereafter punched to produce a disk-shaped disk having an outer

diameter of 65 mm, an inner diameter of 20 mm and a thickness of about 0.65 mm. The disk was ground using a PVA grindstone, to remove the altered layer derived from rolling. A double-sided processing machine 16B by SpeedFam Company Limited was used for grinding, under grinding pressure: 80 gf/cm² and sliding speed: 80 cm/second, with the removal amount per surface set to about 20 μm and the thickness of the aluminum sheet after grinding set to 0.61 to 0.62 mm, to thereby produce an aluminum sheet for testing.

[0073] An anodized film was formed on the aluminum sheet by performing an anodization treatment under the conditions given below. The thickness of the obtained anodized film was measured on the basis of below-described measurement method.

[0074] Anodization treatment conditions

Anodizing solution: 30 g/L oxalic acid solution

Treatment solution temperature: 30°C

Electrolysis voltage: 40 V

[0075] An inorganic polysilazane-containing solution (NL120A-20 by AZ Electronic Materials plc) was applied, by spin coating, on the anodized film of the aluminum sheet, and the solvent was removed through heating at 80°C for 10 minutes in an air atmosphere. This was repeated several times to obtain a desired thickness such that the film thickness of the formed SiO₂ film was as given in Table 1. Thereafter, each aluminum sheet was placed in an electric furnace and was warmed up to a final firing temperature of 300°C at an average rate of temperature rise of about 10°C/minute, after which the interior of the furnace was made into a steam atmosphere, and firing was performed through holding of the above temperature for 60 minutes. After firing, the sheet was allowed to cool down to room temperature, and thereafter the aluminum sheet having the SiO₂ film formed thereon was removed from the electric furnace, to yield a respective test specimen. The thickness of the SiO₂ film in each obtained test specimen was measured in accordance with the below-described measurement

method.

[0076] Herein No. 8 is an example where the aluminum sheet (aluminum sheet before formation of the anodized film and the SiO₂ film; i.e. the above disk-shaped disk) was subjected to NiP plating. The treatment conditions involved firstly degreasing of the aluminum sheet at 70°C for 5 minutes using AD-68F, followed by acid etching at 68°C for 2 minutes using AD-101F, and desmutting using 30% nitric acid. Thereafter, the sheet was subjected to a zincate treatment at 20°C for 30 seconds using AD-301F-3X, followed by dissolution of Zn using 30% nitric acid, after which the zincate treatment was performed again for 15 seconds at 20°C. Thereafter the sheet was subjected to an electroless NiP plating treatment at 90°C for 2 hours using an HDX-7G solution, to form a NiP plating film about 10 μm thick. Thereafter both faces, i.e. the NiP plating film surfaces, were polished to produce a test specimen. The above AD-68F, AD-101F and AD-301F-3X are NiP plating pretreatment solutions. The HDX-7G solution is a NiP plating solution. Solutions produced by C.Uyemura & Co., Ltd. were used in all the above instances.

[0077] Further, No. 9 is an aluminum sheet on the surface of which the above coating film (the anodized film and the SiO₂ film) was not formed. Specimens Nos. 10 to 13 are aluminum sheets in which no SiO₂ film was formed after formation of the anodized film.

[0078] (Measurement of the thickness of the anodized film)

The thickness of the anodized film was measured using an eddy-current film thickness meter. The measurement involved measuring a same site five times and taking the average value thereof as the thickness at that site; the measurements were performed at five sites of each sample, and the average thereof was taken as the thickness (μm) of the anodized film. The thickness of the obtained anodized films is set out in the tables in the column “Anodized film (μm)”.

[0079] (Measurement of the thickness of the SiO₂ film)

The thickness of the SiO₂ film was measured using nanospec/AFT model 5100 by Nanometrics Incorporated. The measurement involved measuring a same site five times and taking the average value thereof as the thickness at that site; the measurements were performed at five sites of each sample, and the average thereof was taken as the thickness (μm) of the SiO₂ film. The thickness of the obtained SiO₂ films is set out in the tables in the column "SiO₂ film (μm)".

[0080] (Evaluation of scratch resistance)

The evaluation of scratch resistance involved measurements using a continuous-loading scratching resistance tester Type 18 by Shinto Scientific Co., Ltd. The measurement involved that uses an conical indenter whose top was bonded to a diamond ball having a radius of 0.1mm, which results in a round top, and slides the indenter over 10mm across the surface of the test piece, the conical indenter being applied with a load of 50g. After the sliding, the depth of the indenter mark on the test piece surface was measured using a laser microscope model VP-9510 by Keyence Corporation. The measured depth is set out in the column "scratch depth (μm)" of the tables. The relative superiority or inferiority of scratch resistance was evaluated through comparison with the scratch depth in No. 8, which was a conventional Ni-P plated aluminum substrate.

[0081] [Table 1]

No.	Anodized film (μm)	SiO ₂ film (μm)	Scratch depth (μm)
1	7.1	2.17	0.279
2	8.2	1.8	0.280
3	10.9	1.2	0.262
4	10.2	2.89	0.247
5	15.2	3.37	0.145
6	19.9	2.47	0.078
7	30.9	3.21	0.125
8	NiP plating		0.280
9	None		1.111
10	5.3	None	1.040
11	9.9	None	0.571
12	20.2	None	0.281
13	31.7	None	0.371
14	5	1.2	0.583
15	10.5	0.8	0.484

[0082] Scratch resistance was superior in Nos. 1 to 7, in which multilayer films of an anodized film and a SiO₂ film having the thickness specified in the present invention were formed on an aluminum sheet; the scratch resistance in Nos. 1 to 7 was comparable or superior to that of No. 8, which was a Ni-P plated aluminum substrate.

[0083] In No. 9, being an example in which neither the anodized film nor the SiO₂ film was formed, there could be observed a deep indenter mark larger than 1 mm, indicative of virtual

absence of scratch resistance.

[0084] In Nos. 10 to 13, being examples in which only the anodized film was formed, a trend was observed whereby the scratch depth decreased with increasing thickness of the anodized film, but there was not obtained scratch resistance superior to that of No. 8.

[0085] Scratch depth remained large in No. 14, being an example in which a multilayer film of an anodized film and a SiO₂ film was formed but the thickness of the anodized film was small.

[0086] In No. 15 a multilayer film of an anodized film and a SiO₂ film was formed, but the thickness of the SiO₂ film was insufficient and scratch resistance was poor.

[0087] (Experiment 2)

Similarly to Experiment 1, in Experiment 2 there was evaluated the smoothness of samples in which an anodized film and a SiO₂ film were formed. As in Experiment 1, the thickness of the anodized films obtained through formation of an anodized film was measured and given in the column "Anodized film (μm)" of the tables. Similarly, the thickness of the SiO₂ films obtained through formation of a SiO₂ film on a respective anodized film was measured and given in the column "SiO₂ film (μm)" of the tables. The surface smoothness of the SiO₂ films was measured in accordance with the criteria below, and was notated as "surface roughness (nm)" in the tables. Further Nos. 2-11 to 2-16 are examples where no SiO₂ film was formed.

[0088] (Smoothness of the SiO₂ film)

The smoothness of the SiO₂ film was evaluated on the basis of surface roughness expressed as average surface roughness (Ra: nm) in an observation of a 10-micron field of view using an AFM (Atomic Force Microscope) model SPI-4000 by Seiko Instruments Inc. Smoothness was rated as excellent where Ra was 1.0 nm or less.

[0089] [Table 2]

No.	Anodized film (μm)	SiO ₂ film (μm)	Surface roughness (nm)
2-1	7.1	2.93	0.46
2-2	8.2	3.23	0.39
2-3	9.3	2.81	0.63
2-4	10.3	4.25	0.53
2-5	15.2	3.37	0.47
2-6	20.2	4.08	0.70
2-7	35.9	3.2	0.76
2-8	34.5	4.0	0.75
2-9	41.3	4.0	0.88
2-10	49.4	3.2	1.13
2-11	9.3	None	10.16
2-12	15.2	None	19.70
2-13	21	None	26.72
2-14	35.9	None	27.51
2-15	40.7	None	28.52
2-16	49.4	None	30.77
2-17	9.8	0.8	2.75
2-18	15.5	0.8	19.61
2-19	20.2	0.8	26.94
2-20	31.7	0.8	21.39

[0090] In Nos. 2-1 to 2-9, in which a multilayer film of an anodized film and a SiO₂ film having the thicknesses prescribed by the present invention was formed on an aluminum sheet,

surface roughness was 1.0 nm or less, indicative of excellent surface smoothness. In No. 2-10, by contrast, the anodized film was thick and surface roughness somewhat large.

[0091] In Nos. 2-11 to 2-16, being examples where only the anodized film was formed, the outermost surface had the porous structure characteristic of anodized films, and accordingly surface smoothness tended to worsen with increasing thickness of the anodized film, with surface roughness in excess of 10 nm in all instances.

[0092] Surface roughness remained large in Nos. 2-17 to 2-20, being examples in which a multilayer film of an anodized film and a SiO_2 film was formed but the thickness of the SiO_2 film was small.

[0093] (Experiment 3)

In Experiment 3 there was checked the leveling effect at the time of formation of the SiO_2 film. Similarly to Experiment 1, a sample was produced by forming a 10 μm anodized film and forming thereafter a SiO_2 film of predetermined thickness. In No. 3-1 there was formed no SiO_2 film. An Au film was vapor-deposited, to a thickness of 1000 Å, on the measurement-side surface of each sample, after which the presence or absence of pits was observed using an optical microscope at 150 magnifications. Fig. 2, Fig. 4 and Fig. 6 illustrate the obtained micrographs. Fig. 2 is a micrograph of No. 3-1, Fig. 4 is a micrograph of No. 3-2, and Fig. 6 is a micrograph of No. 3-3 in Experiment 3.

[0094] Evaluations of surface smoothness and presence or absence of pits were conducted on the basis of measurements using a laser microscope model VP-9510 by Keyence Corporation. The obtained shape charts are illustrated in Fig. 3, Fig. 5 and Fig. 7. Fig. 3 illustrates the shape chart of No. 3-1, Fig. 5 illustrates the shape chart of No. 3-2, and Fig. 7 illustrates the shape chart of No. 3-3.

[0095] [Table 3]

No.	Anodized film (μm)	SiO ₂ film (μm)	Number of coatings	Pits
3-1	10	None	None	Yes
3-2	10	0.8	1	No
3-3	10	2.4	3	No

[0096] Herein No. 3-1 is an example in which no SiO₂ film was provided. As depicted in Fig. 2, multiple pits could be observed in the surface, and surface smoothness was likewise poor, as illustrated in Fig. 3.

[0097] In Nos. 3-2 and 3-3, being examples in which a SiO₂ film of predetermined thickness was formed, pits did not form in the surface in either case, as illustrated in Fig. 4 and Fig. 6. The surface in No. 3-3, in which a thick SiO₂ film was formed, was smoother, as illustrated in Fig. 7. As illustrated in Fig. 5, surface roughness could not be reduced sufficiently in No. 3-2, where the SiO₂ film was thin.

[0098] These results reveal that pits that occur unavoidably in the anodized film can be covered, and defect portions eliminated, by providing a SiO₂ film of predetermined thickness on an anodized film.

[0099] The present application claims priority based on Japanese Patent Application No. 2014-184199, filed on September 10, 2014, the entire contents whereof are incorporated herein by reference.

[0100] The present invention has been appropriately and sufficiently explained above by way of embodiments, for the purpose of illustrating the invention. A person skilled in the art should recognize, however, that the embodiments described above can be easily modified and/or improved. Therefore, it is understood that any modified embodiments or improved

embodiments that a person skilled in the art can arrive at are encompassed within the scope as claimed in the appended claims, so long as these modifications and improvements do not depart from the scope of the claims.

Industrial Applicability

[0101] In the present invention a multilayer film of an anodized film and a SiO₂ film is formed, to a predetermined thickness, on the surface of an aluminum sheet. An aluminum substrate for magnetic recording medium is provided as a result that has superior characteristics in terms of smoothness and scratch resistance.

Reference Signs List

[0102]

- 1 Aluminum sheet
- 2 Anodized film
- 3 SiO₂ film

Claims

1. An aluminum substrate for magnetic recording medium comprising: an aluminum sheet and a coating film formed on the surface of the aluminum sheet,
wherein the coating film is a multilayer film including an anodized film and a SiO₂ film in this order from the side of the aluminum sheet,
the anodized film has a thickness of 7 μm to 45 μm , and
the SiO₂ film has a thickness of 1 μm to 5 μm .
2. A method for producing the aluminum substrate for magnetic recording medium of claim 1, the method comprising:
a step of forming the anodized film on the aluminum sheet; and
a step of forming the SiO₂ film on the anodized film by coating the surface of the anodized film with an inorganic polysilazane-containing solution, followed by heating to thereby convert the inorganic polysilazane to SiO₂.
3. The producing method according to claim 2, wherein the step of forming the anodized film is an anodization treatment in which a solution of oxalic acid is used.