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(54) POLISHING COMPOSITION

(75) Inventors: **Shigeo Fujii**, Wakayama-shi (JP); **Hiroaki Kitayama**, Wakayama-shi (JP)

Correspondence Address:
BIRCH STEWART KOLASCH & BIRCH
PO BOX 747
FALLS CHURCH, VA 22040-0747 (US)

(73) Assignee: **Kao Corporation**

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(57) ABSTRACT

A polishing composition containing an α-alumina, an intermediate alumina, an oxidizing agent and water; a method for reducing waviness of a substrate to be polished, including the step of applying the polishing composition to the substrate to be polished; and a method for manufacturing a substrate, including the step of polishing a substrate to be polished with the polishing composition. The polishing composition is suitable for polishing substrates for precision parts such as substrates for magnetic recording media for magnetic discs, optical discs, opto-magnetic discs, and the like; photomask substrates; glass for liquid crystals; optical lenses; optical mirrors; optical prisms; and semiconductor substrates.

POLISHING COMPOSITION

FIELD OF THE INVENTION

[0001] The present invention relates to a polishing composition having a high polishing rate and being capable of reducing waviness of a substrate to be polished. Further, the present invention relates to a method for reducing waviness of a substrate to be polished with the polishing composition, and a method for manufacturing a substrate with the polishing composition.

BACKGROUND OF THE INVENTION

[0002] In hard disks, in order to make the minimum recording area smaller and to increase storage capacity, the flying height of the magnetic head has been desired to be lowered. In order to lower the flying height of the magnetic head, it is necessary to reduce both the short-wavelength waviness (a waviness having a wavelength of from 50 to 500 μm) and the long-wavelength waviness (a waviness having a wavelength of from 0.5 mm or more). The term "waviness" as referred to herein means surface dents and projections having a wavelength longer than that of the surface roughness. In order to manufacture a substrate having reduced waviness as described above, mechanical conditions such as control of the pore size of the polishing pad, control of the hardness, and control of the polishing load or rotational speed during polishing have been studied. However, such mechanical conditions are effective but not to a satisfactory level. On the other hand, the reduction of waviness using the polishing compositions has been also studied. Japanese Patent Laid-Open No. Hei 3-115383 discloses a polishing composition containing α-alumina, a water-soluble peroxide and boehmite, and Japanese Patent Laid-Open No. 2001-260005 (U.S. Pat. No. 6,261,476B1) discloses a polishing composition containing primary polishing particles, dispersible colloidal particles and an oxidizing agent. Also, Japanese Patent Laid-Open No. 2002-327170 (U.S. 2002194789A1) discloses a polishing composition containing colloidal silica, an oxidizing agent and an organophosphonic acid, and Japanese Patent Laid-open No. 2003-41239 (U.S. 2003041526A1) discloses a polishing composition containing an intermediate alumina. However, these polishing compositions cannot be said to be satisfactory from the viewpoint of reduction of waviness while maintaining the necessary polishing rate.

SUMMARY OF THE INVENTION

[0003] The present invention relates to the following:

[0004] (1) a polishing composition containing an α-alumina, an intermediate alumina, an oxidizing agent and water;

[0005] (2) a method for reducing waviness of a substrate to be polished, including the step of applying the polishing composition of the above (1) to the substrate to be polished; and

[0006] (3) a method for manufacturing a substrate, including the step of polishing a substrate to be polished with the polishing composition of the above (1).

DETAILED DESCRIPTION OF THE INVENTION

[0007] The present invention relates to a polishing composition having a high polishing rate and being capable of reducing waviness of a substrate to be polished; a method for reducing waviness of a substrate to be polished with the polishing composition, and a method for manufacturing a high-quality substrate having reduced waviness with the polishing composition.

[0008] These and other advantages of the present invention will be apparent from the following description.

[0009] By polishing a substrate for precision parts or the like with the polishing composition of the present invention, an effect such as reduction of waviness of an object to be polished at a high polishing rate is exhibited. Especially, those composed of a short-wavelength waviness having a wavelength of from 50 to 500 μm and a long-wavelength waviness having a wavelength of from 0.5 to 5 mm are referred to microwaviness. The present invention has an excellent effect of reducing microwaviness.

[0010] In addition, since the obtained polished object has little deposition of stains such as polishing debris, the washing following the polishing can be conveniently carried out, so that a high-quality substrate having reduced waviness can be economically manufactured.

[0011] One of the significant features of the polishing composition of the present invention resides in the combined use of an α-alumina and an intermediate alumina as an abrasive and the use of an oxidizing agent as a polishing accelerator. By using the polishing composition having the above features, a remarkable effect is exhibited that a high polishing rate can be achieved, and that a waviness of a substrate to be polished can be significantly reduced.

[0012] Although not wanting to be limited by theory, the functional mechanism for exhibiting the effects of increasing polishing rates and reducing a waviness by using the α-alumina and the intermediate alumina together is presumably due to the fact that the packing property is increased because these aluminas are composed of particles having different particle sizes and different hardness, so that the physical polishing force effectively functions on the surface of the object to be polished.

[0013] The polishing composition of the present invention contains an α-alumina as an abrasive. As the α-alumina, an alumina that is prepared by baking gibbsite, bayerite, nordstrandite, diaspore, boehmite, pseudo-boehmite, alumino-gel, γ-alumina, θ-alumina or the like at a temperature of 1100° C. or more according to a conventional method is preferable. As the α-alumina, an aluminum oxide having a purity as alumina of 95% or more, more preferably 97% or more, even more preferably 99% or more is preferable, from the viewpoints of reducing the waviness, reducing the surface roughness, increasing the polishing rate, and preventing the surface defects.

[0014] The α-alumina has an average primary particle size of preferably from 0.005 to 0.8 μm, more preferably from 0.01 to 0.4 μm, and an average secondary particle size of preferably from 0.01 to 2 μm, more preferably from 0.05 to 1.0 μm, even more preferably from 0.1 to 0.5 μm, from the viewpoint of reducing the waviness. The average primary particle size of the abrasive is obtained by subjecting the abrasive to an image analysis by observing with a scanning electron microscope (preferably from 3000 to 30000 times) or a transmission electron microscope (preferably from 10000 to 300000 times), and is defined as a number-average particle size based on the arithmetic means of major axis length and minor axis length of the particle. In addition, the average secondary particle size can be determined as a volume-average particle size by using a laser diffraction method.

[0015] The specific surface area of the α-alumina determined by the BET method is preferably from 0.1 to 50 m^2/g, more preferably from 1 to 40 m^2/g, even more preferably from 2 to 20 m^2/g, from the viewpoints of increasing the polishing rate and reducing the waviness.

[0016] The content of the α-alumina is preferably 0.05% by weight or more, more preferably 0.1% by weight or more, even more preferably 0.5% by weight or more, even more preferably 1% by weight or more, of the polishing composition, from the viewpoints of increasing the polishing rate and reducing the waviness. Also, the content of the α-alumina is preferably 40% by weight or less, more preferably 30% by weight or less, even more preferably 25% by weight or less, even more preferably 20% by weight or less, from the viewpoints of surface quality and economic advantages. Specifically, the content of the α-alumina is preferably from 0.05 to 40% by weight, more preferably from 0.1 to 30% by weight, even more preferably from 0.5 to 25% by weight, even more preferably from 1 to 20% by weight, of the polishing composition.

[0017] The polishing composition of the present invention contains an intermediate alumina, from the viewpoints of increasing the polishing rate and reducing the waviness. The intermediate alumina in the present invention refers to alumina particles other than the α-alumina particles, and concrete examples thereof include γ-alumina particles, δ-alumina particles, θ-alumina particles, η-alumina particles, κ-alumina particles, and mixtures thereof. Among them, the following intermediate aluminas are preferable, from the viewpoints of increasing the polishing rate and reducing the waviness. The crystal forms thereof are preferably γ-alumina, δ-alumina and θ-alumina, and mixtures thereof, and more preferably γ-alumina and θ-alumina. Also, the specific surface area as determined by the BET method is preferably from 30 to 300 m^2/g, more preferably from 50 to 200 m^2/g. This average secondary particle size of the intermediate alumina is preferably from 0.01 to 5 μm, more preferably from 0.01 to 2 μm, even more preferably from 0.05 to 1 μm, even more preferably from 0.1 to 0.5 μm, from the viewpoint of reducing the waviness. The average particle size can be determined as a volume-average particle size by using a laser beam diffraction method with, for instance, one commercially available form Horiba, LTD. under the trade name of "LA-920."

[0018] The content of each of the alkali metal and the alkaline earth metal in the intermediate alumina is preferably 0.1% by weight or less, more preferably 0.05% by weight or less, even more preferably 0.01% by weight or less. For instance, in a case where aluminum hydroxide which has a relatively large specific surface area and a low content of the alkali metal and the alkaline earth metal is used as a raw material, there is little fusion of the intermediate alumina formed so that the particle strength is small, thereby making it effective for reducing the surface defects of the object to be polished.

[0019] The aluminum hydroxide which can be used as the raw material for the intermediate alumina has a specific surface area as determined by the BET method of preferably from 10 to 500 m^2/g, more preferably from 30 to 400 m^2/g, even more preferably from 50 to 300 m^2/g. In addition, the content of the alkali metal and the alkaline earth metal in the aluminum hydroxide is preferably 0.1% by weight or less, more preferably 0.05% by weight or less, even more preferably 0.01% by weight or less. Further, in a case where an intermediate alumina is prepared by thermally dehydrating aluminum hydroxide, an introduction of dry air or nitrogen gas during heating is effective in the prevention of surface defects of the object to be polished. Here, the above-mentioned thermal dehydration treatment can be carried out by a conventional method. These intermediate aluminas are adjusted to a given particle size, for instance, by wet pulverization or dry pulverization with a pulverizer such as a ball-mill, a beads-mill, a high-pressure homogenizer or a jet mill as occasion demands.

[0020] The aluminum hydroxide is represented by the formulas $Al(OH)_3$, AlOOH, $AlOOH.nH_2O$ or $Al_2O_3.nH_2O$, wherein n is a number of 1 to 3, and is not particularly limited, as long as the intermediate alumina can be prepared by thermal dehydration. Concrete examples thereof include gibbsite, bayerite, nordstrandite, diaspore, boehmite, pseudo-boehmite, alumino-gel, and the like.

[0021] Although the details of the functional mechanism during polishing with the intermediate alumina may not be certainly known, it is considered that the increase in the physical force to the surface of the object to be polished is exhibited because the polishing rate is increased by mixing both the α-alumina and the intermediate alumina as compared to a case of the α-alumina alone, or the intermediate alumina alone.

[0022] The content of the intermediate alumina is preferably 0.05% by weight or more, more preferably from 0.1% by weight or more, even more preferably 0.5% by weight or more, even more preferably 1% by weight or more, of the polishing composition, from the viewpoints of increasing the polishing rate and reducing the waviness. Also, the content of the intermediate alumina is preferably 40% by weight or less, more preferably 30% by weight or less, even more preferably 25% by weight or less, even more preferably 20% by weight or less, of the polishing composition, from the viewpoints of surface quality and economic advantages. Specifically, the content of the intermediate alumina is preferably from 0.05 to 40% by weight, more preferably from 0.1 to 30% by weight, even more preferably from 0.5 to 25% by weight, even more preferably from 1 to 20% by weight, of the polishing composition.

[0023] The weight ratio of the α-alumina to the intermediate alumina, i.e. α-alumina/intermediate alumina, is preferably from 99/1 to 30/70, more preferably from 97/3 to 40/60, even more preferably from 95/5 to 50/50, even more preferably from 93/7 to 55/45, from the viewpoints of satisfying both increase in the polishing rate and reduction in the waviness.

[0024] Also, the total amount of the α-alumina and the intermediate alumina is preferably from 0.1 to 45% by weight, more preferably from 0.2 to 35% by weight, even more preferably from 1 to 30% by weight, even more preferably from 2 to 25% by weight, in order to efficiently satisfy both the increase in the polishing rate and the reduction in the waviness.

[0025] The polishing composition of the present invention contains an oxidizing agent, from the viewpoints of increasing the polishing rate and reducing the waviness. Although the functional mechanism for polishing may not be certainly known, it is presumably as follows. By allowing the oxidizing agent to act on an object to be polished, the alumina is changed to a state in which the polishing effect can sufficiently be exhibited. The oxidizing agent usable in the present invention includes peroxide, peroxo acid of a metal or a salt thereof, an oxyacid or a salt thereof, a nitrate, a sulfate, a metal salt of an acid, and the like. The oxidizing agent is roughly classified into inorganic oxidizing agents and organic oxidizing agents according to their structures. Concrete examples of those oxidizing agents are as follows. As the inorganic oxidizing agents, there can be used peroxides of alkali metal or the alkaline earth metal, such as hydrogen peroxide, sodium peroxide, potassium peroxide, calcium peroxide, barium peroxide and magnesium peroxide; peroxocarbonates, such as sodium peroxocarbonate and potassium peroxocarbonate; peroxosulfuric acids or salts thereof, such as ammonium peroxodisulfate, sodium peroxodisulfate, potassium peroxodisulfate and peroxomonosulfuric acid; peroxonitric acids and salts thereof, such as peroxonitric acid, sodium peroxonitrate and potassium peroxonitrate; peroxophosphoric acids or salts thereof, such as sodium peroxophosphate, potassium peroxophosphate and ammonium peroxophosphate; peroxoborates, such as sodium peroxoborate and potassium peroxoborate; peroxochromates, such as potassium peroxochromate and sodium peroxochromate; permanganates, such as potassium permanganate and sodium permanganate; halogeno-acids or derivatives thereof, such as sodium perchlorate, potassium perchlorate, chloric acid, sodium hypochlorite, sodium periodate, potassium periodate, iodic acid and sodium iodate; and metal salts of inorganic acids, such as iron (III) chloride, iron (III) sulfate. As the organic oxidizing agents, there can be used percarboxylic acids, such as peracetic acid, performic acid and perbenzoic acid; peroxides, such as t-butyl peroxide and cumene peroxide; and iron (III) citrate. Among them, the inorganic oxidizing agent is preferable, when easy handling, such as the increase of the polishing rate, availability, water-solubility is compared. Moreover, in consideration of the environmental problems, an inorganic peroxide which does not contain a heavy metal is preferable. Furthermore, from the viewpoint of preventing the stains on the surface of the substrate to be polished, hydrogen peroxide, peroxosulfates, halogeno-acids or derivatives thereof are more preferable, and hydrogen peroxide is even more preferable. These peroxides can be used alone or in admixture of two or more kinds.

[0026] The content of the oxidizing agent is preferably 0.002% by weight or more, more preferably from 0.005% by weight or more, even more preferably 0.007% by weight or more, even more preferably 0.01% by weight or more, of the polishing composition, from the viewpoints of increasing the polishing rate and reducing the waviness. Also, the content of the oxidizing agent is preferably 20% by weight or less, more preferably 15% by weight or less, even more preferably 10% by weight or less, even more preferably 5% by weight or less, of the polishing composition, from the viewpoints of surface quality and economic advantages. Specifically, the content of the oxidizing agent is preferably from 0.002 to 20% by weight, more preferably from 0.005 to 15% by weight, even more preferably from 0.007 to 10% by weight, even more preferably from 0.01 to 5% by weight, of the polishing composition.

[0027] It is preferable that the polishing composition of the present invention further contains an acid, from the viewpoints of increasing the polishing rate and reducing the waviness.

[0028] The acid usable in the present invention has a pK1 of preferably 7 or less, more preferably 5 or less, even more preferably 3 or less, even more preferably 2 or less, from the viewpoints of increasing the polishing rate and reducing the waviness. Here, the pK1 refers to a logarithmic value of an inverse of a first acid dissociation constant, when a logarithmic value of an inverse of an acid dissociation constant at 25° C. is expressed as pKa. The pK1 of each compound is listed in, for instance, in Kagaku Binran (Kiso-hen) II, Fourth Revision, pp. 316-325 (Edit. by Nippon Kagakukai), and the like.

[0029] Concrete examples of acids usable in the present invention are as follows. Inorganic compounds include monovalent mineral acids, such as nitric acid, hydrochloric acid, perchloric acid, and amide sulfuric acid; and polyvalent mineral acids, such as sulfuric acid, sulfurous acid, phosphoric acid, pyrophosphoric acid, polyphosphoric acid, phosphonic acid, and phosphinic acid. Also, organic compounds include monocarboxylic acids, such as formic acid, acetic acid, glycolic acid, lactic acid, propanoic acid, hydroxypropanoic acid, butyric acid, benzoic acid, and glycine; and polycarboxylic acids, such as oxalic acid, succinic acid, glutaric acid, adipic acid, maleic acid, fumaric acid, itaconic acid, malic acid, tartaric acid, citric acid, isocitric acid, phthalic acid, nitrilotriacetic acid and ethylenediaminetetraacetic acid; alkylsulfonic acids, such as methanesulfonic acid and paratoluenesulfonic acid; alkylphosphoric acids, such as ethylphosphoric acid and butylphosphoric acid; organic phosphonic acids, such as phosphonohydroxyacetic acid, hydroxyethylidene diphosphonic acid, phosphonobutane tricarboxylic acid and ethylenediaminetetramethylene phosphonic acid; and the like. Among them, the polyvalent acids are preferable, more preferably polyvalent mineral acids, organic polycarboxylic acids and organic polyphosphonic acids, even more preferably polyvalent mineral acids and organic polycarboxylic acids, from the viewpoints of increasing the polishing rate and reducing the waviness. Here, the polyvalent acid refers to an acid having two or more hydrogen atoms in its molecule, which is capable of generating hydrogen ions. In addition, nitric acid, sulfuric acid, the sulfonic acids and the carboxylic acids are preferable, from the viewpoint of preventing the surface stains of the object to be polished.

[0030] Although the above-mentioned acids can be used alone, it is preferable to use the acids in admixture of two or more kinds. Especially in the case of polishing a metal surface such as a Ni—P-plated substrate, a metal ion of the object to be polished is eluted during polishing, thereby increasing the pH of the polishing composition, so that a high polishing rate cannot be achieved. In such case, it is preferable to use a combination of an acid having a pK1 of less than 2.5 and an acid having a pK1 of 2.5 or more, more preferably to use a combination of an acid having a pK1 of 1.5 or less and an acid having a pK1 of 2.5 or more, in order to make the pH change smaller. When the polishing composition contains the two or more kinds of the acids as mentioned above, among the acids having a pK1 of less than 2.5, it is preferable to use mineral acids, such as nitric acid, sulfuric acid, phosphoric acid and polyphosphoric acid, or organic phosphonic acid in considerations of increase in the polishing rate, reduction in the waviness and availability of the acid. On the other hand, among the acids having a pK1 of 2.5 or more, organic carboxylic acids, such as acetic acid, succinic acid, malic acid, tartaric acid and citric acid are preferable from the same viewpoints.

[0031] The total content of the above-mentioned acids is preferably 0.002% by weight or more, more preferably 0.005% by weight or more, even more preferably 0.007% or more, even more preferably 0.01% by weight or more, of the polishing composition, from the viewpoints of increasing the polishing rate and reducing the waviness. Also, the total content of the acids is preferably 20% by weight or less, more preferably 15% by weight or less, even more preferably 10% by weight or less, even more preferably 5% by weight or less, from the viewpoints of surface quality and economic advantages. Specifically, the total content of the acids is preferably from 0.002 to 20% by weight, more preferably from 0.005 to 15% by weight, even more preferably from 0.007 to 10% by weight, even more preferably from 0.01 to 5% by weight, of the polishing composition. The weight ratio of the acid having a pK1 of less than 2.5 to the acid having a pK1 of 2.5 or more, i.e. the acid having a pK1 of less than 2.5/the acid having a pK1 of 2.5 or more, is preferably from 9/1 to 1/9, more preferably from 7/1 to 1/7, even more preferably from 5/1 to 1/5, from the viewpoint of increasing the polishing rate.

[0032] Water in the polishing composition of the present invention is used as a medium. The content of water is preferably from 50 to 99% by weight, more preferably from 60 to 97% by weight, even more preferably from 70 to 95% by weight, from the viewpoint of effectively polishing the object to be polished.

[0033] In addition, there can be added other components to the polishing composition of the present invention, in accordance with the purpose of increasing the polishing rate, reducing the waviness and other purposes. For instance, other components include inorganic salts, thickeners, anticorrosive agents, basic substances, and the like. Examples of the inorganic salt include ammonium nitrate, ammonium sulfate, potassium sulfate, nickel sulfate, aluminum nitrate, aluminum sulfate, ammonium sulfaminate, and the like. These other components can be used alone or in admixture of two or more kinds. Also, the content of the other components is preferably from 0.05 to 20% by weight, more preferably from 0.05 to 10% by weight, even more preferably from 0.05 to 5% by weight, of the polishing composition, from the viewpoint of economic advantages.

[0034] In addition, there can be added other components, such as disinfectants and antibacterial agents, as occasion demands. The content of the disinfectant and the antibacterial agent is preferably from 0.0001 to 0.1% by weight, more preferably from 0.001 to 0.05% by weight, even more preferably from 0.002 to 0.02% by weight, of the polishing composition, from the viewpoint of exhibiting the function of the agents and from the viewpoints of the influence on polishing performance, and economic advantages.

[0035] The concentration of each component of the polishing composition in the present invention is the concentration which is preferable for polishing, and may be the concentration during the preparation of the composition. In many cases, the composition is usually prepared as a concentrate, which is diluted before use or upon use.

[0036] The polishing composition can be prepared by adding or mixing the intended components by an optional method.

[0037] It is preferable that the pH of the polishing composition is appropriately determined depending upon the kinds of the object to be polished and the required properties. For instance, the pH of the polishing composition is preferably less than 7, more preferably from 0.1 to 6, even more preferably from 0.5 to 5, even more preferably from 1 to 4, even more preferably from 1 to 3, from the viewpoints of increase in the polishing rate and reduction in the waviness, and from the viewpoints of prevention of the corrosion of the processing machine and operator safety. The pH can be adjusted by properly adding an inorganic acid, such as nitric acid or sulfuric acid; an organic acid, such as a hydroxycarboxylic acid, a polycarboxylic acid, an aminopolycarboxylic acid, an amino acid, or a metal salt or an ammonium salt thereof; or a basic substance, such as an aqueous ammonia, potassium hydroxide, sodium hydroxide or an amine, in a desired amount.

[0038] The method for manufacturing a substrate of the present invention includes the step of polishing a substrate to be polished with the above-mentioned polishing composition.

[0039] The material for the object to be polished represented by the substrate for the present invention includes, for instance, metals or metalloids such as silicon, aluminum, nickel, tungsten, copper, tantalum and titanium and alloys which contains these metals as the main components; glassy substances such as glass, glassy carbon and amorphous carbons; ceramic materials such as alumina, silicon dioxide, silicon nitride, tantalum nitride, and titanium nitride; resins such as polyimide resins; and the like. Among them, it is preferable that an object to be polished is made of a metal such as aluminum, nickel, tungsten or copper, or made of an alloy containing these metals as the main components; or an object to be polished is a semiconductor substrate made of semiconductor elements containing these metals. Especially, when the polishing composition of the present invention is applied to a substrate made of an aluminum alloy plated with Ni—P, it is preferable because the waviness can remarkably be reduced. The shape for the object to be polished is not particularly limited. For instance, those having shapes containing planar portions such as discs, plates, slabs and prisms, or shapes containing curved portions such as lenses can be subjects for polishing with the polishing composition of the present invention. Among them, those having the disc-shaped objects to be polished are especially preferable in polishing.

[0040] The present invention also relates to a method for reducing waviness of the above-mentioned substrate to be polished. In the method for reducing waviness of the substrate to be polished with the polishing composition of the present invention, the waviness can be remarkably reduced by polishing the above-mentioned substrate with the polishing composition of the present invention. For instance, a high-quality substrate having reduced waviness can be manufactured by the method including the steps of clamping a substrate with polishing platens to which a polishing cloth made of a porous organic polymer and the like is pasted; feeding the polishing composition of the present invention to a surface to be polished; and moving the polishing platens or the substrate, while applying pressure.

[0041] The polishing composition of the present invention can be preferably used in polishing a substrate for precision parts. For instance, the polishing composition is suitable for polishing substrates for magnetic recording media, such as magnetic disks, optical disks, opto-magnetic disks, and photomask substrates, optical lenses, optical mirrors, optical prisms and semiconductor substrates, and the like. The polishing of a semiconductor substrate includes, for instance, the steps of polishing a silicon wafer (bare wafer), forming a film for shallow trench isolation, subjecting an interlayer dielectric to planarization, forming an embedded metal line, and forming an embedded capacitor, and the like. The polishing composition is especially effective in the polishing step, and the polishing composition can be similarly applied to polishing steps other than these, for instance, lapping step, and the like. The polishing composition of the present invention is especially suitable for polishing a magnetic disk substrate.

EXAMPLES

[0042] The following examples further describe and demonstrate embodiments of the present invention. The examples are given solely for the purposes of illustration and are not to be construed as limitations of the present invention.

Examples 1 to 17, Comparative Examples 1 to 5

[0043] Method for Formulating Polishing Composition

[0044] There were mixed together given amounts of α-alumina (average primary particle size: 0.07 μm, average secondary particle size: 0.3 μm, specific surface area: 15 m^2/g, purity: 99.9%), O-alumina (average secondary particle size: 0.2 μm, specific surface area: 120 m^2/g, purity: 99.9%), an oxidizing agent, an acid and other additives as listed in Tables 1 to 3, and balance ion-exchanged water, while stirring, and pH-adjusted with an aqueous ammonia, to give a polishing composition.

[0045] Polishing Method

[0046] A substrate surface made of a Ni—P plated aluminum alloy, the substrate surface having an average deviation, of all points from plane fit to test part surface Ra of 0.2 μm, as determined by Talystep commercially available from Rank Taylor-Hobson Limited (size of tip end of profilometer: 25 μm×25 μm, by-pass filter: 80 μm, measurement length: 0.64 mm), a thickness of 1.27 mm and a diameter of 3.5 inches (diameter of 95.0 mm) was polished with a double-sided processing machine under Set Conditions for Double-Sided Processing Machine given below, to give a polished Ni—P plated, aluminum alloy substrate usable for a substrate for magnetic recording media.

[0047] Set Conditions for Double-Sided Processing Machine are as follows.

[0048] Set Conditions for Double-Sided Processing Machine

[0049] Double-sided processing machine: double-sided processing machine, Model 9B, manufactured by SPEEDFAM CO., LTD.

[0050] Processing pressure: 9.8 kPa

[0051] Polishing Pad: "H9900S" (manufactured by FUJIBO Co., Ltd.).

[0052] Rotational speed of platen: 50 r/min

[0053] Feeding flow rate for a polishing composition: 100 ml/min

[0054] Polishing time period: 5 minutes

[0055] Number of substrates introduced: 10

[0056] Polishing Rate

[0057] Weights of each substrate before and after polishing were measured using a device commercially available from Sartorius under the trade name of "BP-210S." Change in weight of each substrate was obtained, and an average of 10 substrates is defined as an amount reduced, and a value obtained by dividing the amount reduced by the polishing time is referred to as a rate of weight reduced. The rate of weight reduced is introduced into the following equation and converted to a polishing rate (μm/min). A relative value (relative polishing rate) of each Example or Comparative Example was calculated based on the polishing rate of the polishing composition in Comparative Example 1 as a standard value of 1.

Rate of Weight Reduction (*g*/min.)=[Weight Before Polishing (*g*)−Weight After Polishing (*g*)]/Polishing Time (min.)

Polishing Rate (*μm*/min.)=Rate of Weight Reduction (*g*/min.)/Area of One Side of Substrate (mm^2)/Ni—P Plating Density (g/cm^3)×10^6

[0058] Waviness

[0059] Each of the polished substrates was determined for short-wavelength waviness and long-wavelength waviness at two points of 180° intervals (total of 4 points) under the conditions given below.

Equipment:	"Zygo New View 200"
Object Lens:	Magnification, 2.5 times, Michelson
Zooming Ratio:	0.5
Remove:	Cylinder
Filter:	FFT Fixed Band Pass
Wavelength Determined:	
Short-Wavelength Waviness:	Filter High Wavelength 50 μm
	Filter Low Wavelength 500 μm
Long-Wavelength Waviness:	Filter High Wavelength 0.5 mm
	Filter Low Wavelength 5 mm
Area:	4.33 mm × 5.77 mm

[0060] Stains on Substrate Surface

[0061] Each of the polished substrate was subjected to washing with a liquid detergent using a PVA (polyvinyl acetate) pad in a sheet-fed cleaning machine, and then subjected to washing with ion-exchanged water. Thereafter, the washed substrate was observed with a polarization microscope at a magnification of 300, and the stains on the substrate surface was evaluated based on the 4 criteria as follows.

[0062] ◎: Alumina residue and polishing debris are not observed on the surface at all.

[0063] ○: Hardly any alumina residue and polishing debris are observed on the surface.

[0064] Δ: Some alumina residue and polishing debris are observed on certain locations on the surface.

[0065] x: Much alumina residue and polishing debris are observed on the surface.

[0066] The results are shown in Tables 1 and 2. The values for the polishing rates and waviness for each Example and each Comparative Example is expressed as a relative value based on the value of Comparative Example 1 as a standard value of 1. It is seen that the polishing compositions obtained in Examples 1 to 12 containing α-alumina, intermediate alumina and an oxidizing agent are remarkably excellent in both the increase in polishing rates and reduction in waviness, as compared to those of the comparative examples. Especially when an acid is added, such an effect is outstandingly excellent. In addition, it is seen that the polishing compositions obtained in Examples 1 to 12 have excellent stain-preventing effects for a substrate to be polished.

TABLE 1

	α- Alumina (%)	θ- Alumina (%)	Oxidizing Agent	(%)	Acid	(%)	pH	Polishing Rate (Relative Value)	Waviness (Relative Value) Short-wavelength	Long-wavelength	Stain on Substrate
Ex. 1	3	1	Hydrogen Peroxide	0.6	—	—	4.1	2.5	0.59	0.77	○
Ex. 2	3.5	0.5	Hydrogen Peroxide	0.6	Citric Acid	3.0	2.0	29	0.24	0.43	◎
Ex. 3	2	2	Hydrogen Peroxide	0.6	Citric Acid	3.0	2.0	28	0.23	0.38	◎
Ex. 4	1	3	Hydrogen Peroxide	0.6	Citric Acid	3.0	2.0	20	0.21	0.34	◎
Ex. 5	3	1	Hydrogen Peroxide	0.6	Citric Acid	3.0	2.0	42	0.26	0.25	◎
Ex. 6	3	1	Hydrogen Peroxide	0.6	Nitric Acid	1.1	0.8	36	0.27	0.42	◎
Ex. 7	3	1	Hydrogen Peroxide	0.6	Sulfuric Acid	1.7	0.8	53	0.26	0.21	◎
Ex. 8	3	1	Hydrogen Peroxide	1.8	Sulfuric Acid	5.1	0.5	63	0.25	0.19	◎
Ex. 9	3	1	Hydrogen Peroxide	0.6	Methanesulfonic Acid	1.7	0.8	41	0.26	0.30	◎
Ex. 10	3	1	Hydrogen Peroxide	0.6	Phosphoric Acid	1.7	1.4	34	0.27	0.35	○
Ex. 11	3	1	Hydrogen Peroxide	0.6	Hydroxyethylidene Diphosphonic Acid	1.8	1.2	44	0.26	0.22	○
Ex. 12	3	1	Hydrogen Peroxide	0.6	Polyphosphoric Acid	1.4	1.4	37	0.25	0.27	○
Comp. Ex. 1	3	1	—	—	—	—	4.1	1	1	1	X

In the table, "%" means % by weight.

[0067]

TABLE 2

	α- Alumina (%)	θ- Alumina (%)	Oxidizing Agent	(%)	Acid and Other Additives	(%)	pH	Polishing Rate (Relative Value)	Waviness (Relative Value) Short-wavelength	Long-wavelength	Stain on Substrate
Comp. Ex. 1	3	1	—	—	—	—	4.1	1	1	1	X
Comp. Ex. 2	3	0	Hydrogen Peroxide	0.6	Boehmite	1.0	4.1	1.1	0.91	0.92	○
Comp. Ex. 3	3	0	Aluminum Nitrate	0.6	Colloidal Silica*)	1.0	4.1	2.0	0.59	0.77	Δ
Comp. Ex. 4	3	1	—	—	Citric Acid	0.5	3.0	2.3	0.72	0.85	Δ
Comp. Ex. 5	0	0	Hydrogen Peroxide	0.6	Colloidal Silica*) Hydroxyethylidene Diphosphonic Acid	4.0 1.8	1.2	1.5	0.27	0.92	○

In the table, "%" means % by weight.

*)Average particle size: 0.05 μm, purity: 99.9%

[0068] Table 3 shows the results of cases where the pH is higher than those of Table 1, in consideration of safety to human bodies and corrosiveness to machines. It is seen that the polishing compositions obtained in Examples 13 to 17 are both excellent in the increase in polishing rate and reduction in waviness as compared to those of Comparative Example 1. In addition, it is seen that as in the cases of Examples 15 to 17 where two kinds of acids, such as a carboxylic acid and sulfuric acid, which is a mineral acid, are used together, the effects of an increase in polishing rate and reduction in waviness are further enhanced, as compared to the cases where an acid is used alone (Examples 13 and 14). Also, it is seen that all of the polishing compositions obtained in Examples 13 to 17 have excellent stain-preventing effects for a substrate to be polished.

[0069] In addition, since the waviness evaluated in Examples 1 to 17 is microwaviness, it is seen that all of the polishing compositions obtained in Examples 1 to 17 are excellent for reducing microwaviness.

TABLE 3

	α-Alumina	θ-Alumina	Oxidizing Agent		Acid*)					Polishing Rate (Relative Value)	Waviness (Relative Value)		Stain on Substrate
	(%)	(%)		(%)		(%)		(%)	pH		Short-wavelength	Long-wavelength	
Ex. 13	3	1	Hydrogen Peroxide	0.6	Citric Acid	1.0	—	—	2.2	35	0.29	0.37	◎
Ex. 14	3	1	Hydrogen Peroxide	0.6	—	—	Sulfuric Acid	1.1	2.1	20	0.29	0.40	○
Ex. 15	3	1	Hydrogen Peroxide	0.6	Citric Acid	1.0	Sulfuric Acid	1.1	2.1	49	0.25	0.19	◎
Ex. 16	3	1	Hydrogen Peroxide	0.6	Tartaric Acid	1.0	Sulfuric Acid	1.1	2.1	40	0.27	0.22	◎
Ex. 17	3	1	Hydrogen Peroxide	0.6	Citric Acid	1.0	Sulfuric Acid	1.1	2.1	41	0.26	0.20	◎
Comp. Ex. 1	3	1	—	—	—	—	—	—	4.1	1	1	1	X

In the table, "%" means % by weight.

*)Citric acid: pK1 = 2.9, tartaric acid: pK1 = 2.8, acetic acid: pK1 = 4.6, sulfuric acid: pK1 < 0

[0070] The polishing composition of the present invention is suitable for polishing substrates for precision parts such as substrates for magnetic recording media for magnetic discs, optical discs, opto-magnetic discs, and the like; photomask substrates; glass for liquid crystals; optical lenses; optical mirrors; optical prisms; and semiconductor substrates.

[0071] The present invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

1. A method for reducing waviness of a substrate to be polished, comprising the step of applying a polishing composition to the substrate to be polished, wherein the polishing composition comprising an α-alumina, an intermediate alumina, an oxidizing agent and water.

2. The method according to claim 1, wherein the polishing composition further comprises an acid.

3. A method for manufacturing a substrate, comprising the step of polishing a substrate to be polished with a polishing composition, wherein the polishing composition comprising an α-alumina, an intermediate alumina, an oxidizing agent and water.

4. The method of claim 3, wherein the polishing composition further comprises an acid.

5. The method according to claim 1 or **3**, wherein the polishing composition has a pH that is less than 7.

6. The method according to claim 1 or **3**, wherein the weight ratio of the α-alumina to the intermediate alumina (α-alumina/intermediate alumina) in the polishing composition is from 99/1 to 30/70.

7. The method according to claim 5, wherein the weight ratio of the α-alumina to the intermediate alumina (α-alumina/intermediate alumina) in the polishing composition is from 99/1 to 30/70.

8. The method according to claim 1 or **3**, wherein the α-alumina in the polishing composition has a secondary average particle size of from 0.01 to 2 μm and a specific surface area of from 0.1 to 50 m^2/g, and the intermediate alumina in the polishing composition has a secondary average particle size of from 0.01 to 5 μm and a specific surface area of from 30 to 300 m^2/g.

9. The method according to claim 5, wherein the α-alumina in the polishing composition has a secondary average particle size of from 0.01 to 2 am and a specific surface area of from 0.1 to 50 m^2/g, and the intermediate alumina in the polishing composition has a secondary average particle size of from 0.01 to 5 μm and a specific surface area of from 30 to 300 m^2/g.

10. The method according to claim 6, wherein the α-alumina in the polishing composition has a secondary average particle size of from 0.01 to 2 μm and a specific surface area of from 0.1 to 50 m^2/g, and the intermediate alumina in the polishing composition has a secondary average particle size of from 0.01 to 5 μm and a specific surface area of from 30 to 300 m^2/g.

11. The method according to claim 2 or **4**, wherein the acid in the polishing composition is a polyvalent acid.

12. The method according to claim 5, wherein the acid in the polishing composition is a polyvalent acid.

13. The method according to claim 6, wherein the acid in the polishing composition is a polyvalent acid.

14. The method according to claim 8, wherein the acid in the polishing composition is a polyvalent acid.

15. The method according to claim 2 or **4**, wherein the acid in the polishing composition comprises an acid having a pK1 of less than 2.5 and an acid having a pK1 of 2.5 or more.

16. The method according to claim 5, wherein the acid in the polishing composition comprises an acid having a pK1 of less than 2.5 and an acid having a pK1 of 2.5 or more.

17. The method according to claim 6, wherein the acid in the polishing composition comprises an acid having a pK1 of less than 2.5 and an acid having a pK1 of 2.5 or more.

18. The method according to claim 8, wherein the acid in the polishing composition comprises an acid having a pK1 of less than 2.5 and an acid having a pK1 of 2.5 or more.

19. The method according to claim 11, wherein the acid in the polishing composition comprises an acid having a pK1 of less than 2.5 and an acid having a pK1 of 2.5 or more.

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