

DESCRIPTION

Title of the invention: POLISHING CLOTH AND METHOD FOR PRODUCING SAME
TECHNICAL FIELD

[0001] The present invention relates to a polishing cloth suitably used for the ultrahigh precision polishing and/or cleaning of substrates such as aluminum alloy substrates and glass substrates used in magnetic recording discs and the like, and also relates to a method for producing the same.

BACKGROUND ART

[0002] Magnetic recording discs are required to be extremely smooth on the disc surfaces as the storage densities become higher in recent years. In the systems for recording onto magnetic recording discs in recent years, perpendicular recording media in which the axes of easy magnetization within magnetic films are oriented in the perpendicular direction are mainly employed. Consequently if the substrate not yet having a magnetic layer formed thereon has unevenness or flaws, the axes of easy magnetization may incline to form abnormal portions after the magnetic film is formed. In order to address the problem, the disc surface not yet having the magnetic film formed thereon is required to have a substrate surface roughness of 0.2 nm or smaller and to be minimized in substrate surface flaws called scratch defects. Further, even in the recording systems developed after the perpendicular recording media, the substrate not yet having a magnetic film formed thereon is required to be extremely smooth as described above.

[0003] Hitherto, the slurry grinding and/or cleaning using a tape-like polishing cloth has been employed to perform the surface treatment for allowing the magnetic head to float at a low level. In this case, in order to respond to the higher recording density required recently for the sharply increasing recording capacity, it is required to achieve a substrate surface roughness of 0.2 nm or smaller and to minimize the substrate surface flaws called scratch defects, and a polishing cloth capable of responding to these requirements is earnestly desired.

[0004] Hitherto, it has been proposed to use ultrafine fibers as the fibers constituting the nonwoven fabric of the polishing cloth in order to reduce the substrate surface roughness, and also to impregnate the nonwoven fabric constituting the polishing cloth with a polymeric elastic material for providing cushioning properties in order to minimize the flaws on the substrate surface. For example, a polishing cloth in which a nonwoven fabric comprising ultrafine fibers with a single fiber diameter of 0.05 to 2.0 μm is made to contain a polymeric elastic material with polyurethane as a main component is proposed (see patent documents 1 and 2). These proposals achieve a surface roughness of approx. 0.2 nm.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0005] Patent document 1: JP 2009-83093 A

SUMMARY

PROBLEM TO BE SOLVED BY

[0006] However, the magnetic recording discs of recent perpendicular recording systems are increasingly required to be smoother, that is, to minimize scratches. Further, these conventional proposals merely describe general needle punching conditions common to general artificial leathers comprising nonwoven fabrics. That is, it is desired to set the optimum conditions for forming the surface fiber-napped portion structures on the surface of the polishing cloth and the universal needle punching conditions for obtaining a surface capable of maintaining sufficient dispersibility.

[0007] In view of the abovementioned conventional problems, an object of the embodiments disclosed herein is to provide a polishing cloth giving less scratch defects than those of the conventional polishing cloth comprising ultrafine fibers at the time of polishing and having high performance of allowing highly precise polishing.

[0008] Another object of the embodiments disclosed herein is to provide a method for efficiently producing the abovementioned polishing cloth.

MEANS FOR SOLVING THE PROBLEM

[0009] This disclosure is intended to solve the abovementioned problem. The polishing cloth of this disclosure mainly comprises a nonwoven fabric formed by entangling the ultrafine fiber bundles formed by bundling ultrafine fibers with an average single fiber diameter of 0.05 to 2.0 μm and a polymeric elastic material, wherein the average size of the surface fiber-napped portions constituted by the aforementioned ultrafine fiber bundles of the aforementioned nonwoven fabric in the width direction of the ultrafine fiber bundles is 50 to 180 μm .

[0010] In a preferred mode of the polishing cloth of this disclosure, the average size of the aforementioned surface fiber-napped portions in the width direction of the ultrafine fiber bundles is 50 to 120 μm .

[0011] In a preferred mode of the polishing cloth of this disclosure, the surface roughness of the polishing cloth is 5 to 18 μm .

[0012] In a preferred mode of the polishing cloth of this disclosure, the CV value of the aforementioned ultrafine fibers is 1 to 30%.

[0013] Further, the method for producing the polishing cloth of this disclosure comprises at least the following steps (1) through (5) in combination, wherein the number of islands-in-sea type composite fibers convertible into ultrafine fibers, which are brought in by the needle punching of the following step (2), is 3 to 6 fibers/1 barb:

(1) a step of producing islands-in-sea type composite fibers convertible into ultrafine fibers with an average single fiber fineness of 0.05 to 2.0 μm ;

(2) a step of forming and laminating fiber webs by a card and a crosslapper using said

- islands-in-sea type composite fibers, and obtaining a nonwoven fabric by needle punching;
- (3) a step of giving a polymeric elastic material to said nonwoven fabric by 10 to 200 mass% based on the mass of the ultrafine fibers obtained by converting the composite fibers;
 - (4) a step of buffing at least one surface; and
 - (5) a step of converting said islands-in-sea type composite fibers into ultrafine fibers.

[0013a] In an aspect, there is provided a method for producing a polishing cloth mainly comprising a nonwoven fabric formed by entangling the ultrafine fiber bundles including ultrafine fibers with an average single fiber diameter of 0.05 to 2.0 μm and a polymeric elastic material, wherein the average size of the surface fiber-napped portions constituted by the aforementioned ultrafine fiber bundles is 20 to 180 μm , comprising at least the following steps (1) through (6) in combination, wherein the number of islands-in-sea type composite fibers convertible into ultrafine fibers, which can be brought in by the needle punching of the following step (2), is 3 to 6 fibers/1 barb:

- (1) a step of producing islands-in-sea type composite fibers convertible into ultrafine fibers with an average single fiber diameter of 0.05 to 2.0 μm ;
- (2) a step of laminating fiber webs by a card and a crosslapper using said islands-in-sea type composite fibers, and obtaining a nonwoven fabric by needle punching;
- (3) a step of shrinking said nonwoven fabric by hot water, to have a higher fiber density from the view point of denser surface fibers;
- (4) a step of giving a polymeric elastic material to said nonwoven fabric by 10 to 200 mass% based on the mass of the ultrafine fibers obtained by converting the composite fibers;
- (5) a step of buffing at least one surface; and
- (6) a step of converting said islands-in-sea type composite fibers into ultrafine fibers.

[0014] In a preferred mode of the method for producing the polishing cloth of this disclosure, the number of the islands-in-sea type composite fibers convertible into ultrafine fibers, which are brought in by the needle punching of the step (2), is 3 to 4 fibers/1 barb.

EFFECT

[0015] According to this disclosure, a polishing cloth smaller in the size of the surface fiber-napped portions comprising ultrafine fiber bundles in the width direction of the ultrafine fiber bundles and more excellent in smoothness than the conventional polishing cloth can be obtained. Therefore, a high-performance polishing cloth that can make the scratches and the surface roughness of the polished material small when used as a tape-like polishing cloth in the slurry grinding and/or slurry cleaning of the substrate surface of a recording disc, can be obtained.

[0016] The polishing cloth as defined above can be suitably used for polishing and/or cleaning the aluminum alloy substrate or glass substrate of a magnetic disc in ultrahigh precision finishing.

[0017] The production method as defined above allows the abovementioned polishing cloth to be produced efficiently.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] [Fig. 1] Fig. 1 is an enlarged SEM photo (40x) as a substitute for a drawing showing an example of the polishing cloth surface of this invention.

[Fig. 2] Fig. 2 is a typical view showing the relation between a needle and composite fibers at the time of needle punching for explaining the method for estimating the number of composite fibers brought in at the time of needle punching.

MODES FOR CARRYING OUT THE INVENTION

[0019] With regard to the polishing cloth of this invention and the production method thereof, modes for carrying out the invention are explained below.

[0020] With regard to the aforementioned problem, i.e., the problem of making small the scratch defects on the substrate surface and the surface roughness of the polished material, the inventors made an intensive study on the surface fiber-napped portion structures comprising ultrafine fiber bundles on the surface of the polishing cloth by paying attention to the size in the width direction, of the portions where the ultrafine fibers constituting the ultrafine fiber bundles are disposed substantially uniformly in the length direction and aligned in one direction, and also to the surface smoothness. Thus, the inventors found that the denseness

and dispersibility on the surface of the polishing cloth greatly contribute to the highly precise slurry grinding and/or cleaning.

[0021] As a result, the inventors found that if the nonwoven fabric constituting the polishing cloth mainly comprises a nonwoven fabric formed by entangling the ultrafine fiber bundles formed by bundling ultrafine fibers with an average single fiber diameter of 0.05 to 2.0 μm , and is also a nonwoven fabric in which the size of the surface fiber-napped portion structures comprising the ultrafine fiber bundles on the surface of the polishing cloth in the width direction of the ultrafine fiber bundles is 50 to 180 μm , the abovementioned problem can be solved at once.

[0022] In view of the denseness, fiber strength and abrasive grain holdability of the surface fibers of the polishing cloth, it is important that the average single fiber diameter of the ultrafine fibers used in this invention is 0.05 to 2.0 μm . If the average single fiber diameter is 2.0 μm or smaller, the surface roughness of the polished material can be kept small. On the other hand, if the average single fiber diameter is 0.05 μm or larger, fiber strength and stiffness can be maintained, and consequently polishing can be performed efficiently.

[0023] As examples of the polymer forming the ultrafine fibers used in this invention, enumerated are polyesters, polyamides, polyolefins and polyphenylene sulfide (PPS), etc. Many of polycondensation polymers typified by polyesters and polyamides are high in melting point and excellent in heat resistance to the heat generated at the time of polishing, and consequently they can be preferably used. Examples of the polyesters include polyethylene terephthalate, polybutylene terephthalate, polytrimethylene terephthalate, etc. Further, examples of the polyamides include nylon 6, nylon 66, nylon 12, etc.

[0024] Further, the polymer constituting the ultrafine fibers may also be copolymerized with another comonomer, and any of those polymers can also be made to contain additives such as particles, flame retarder and antistatic agent. Examples of the comonomer include sodium 5-sulfoisophthalate, 3-hydroxybutanoic acid, nylon 6, nylon 66, nylon 12, etc. Further, as the particles, for example, titanium oxide can be used. Furthermore, as the flame retarder, for example, an organic flame retarder or inorganic flame retarder can be used. As the antistatic agent, for example, an alcohol-based antistatic agent can be used.

[0025] As the nonwoven fabric as a fiber-entangled sheet used in the polishing cloth of this invention, a staple-fiber nonwoven fabric obtained by forming a laminated fiber web from staple fibers using a card and a crosslapper and subsequently needle-punching or water-jet-punching the web can be suitably used. Further, a long-fiber nonwoven fabric obtained by a spun-bond method, melt-blow method or the like or a nonwoven fabric obtained by an aqueous fiber suspension screening method or the like can also be employed as appropriate. Among them, the staple-fiber nonwoven fabric and the spun-bond nonwoven fabric can be suitably used, since the mode of the ultrafine fiber bundles as described later can

be obtained by needle punching.

[0026] In the polishing cloth of this invention, it is necessary that the nonwoven fabric as the aforementioned fiber-entangled sheet contains a polymeric elastic material. If the fiber-entangled sheet is made to contain a polymeric elastic sheet, the binding effect of the polymeric elastic material prevents that the ultrafine fibers come off from the polishing cloth and allows uniformly napped fibers to be formed by fiber raising. Further, if the nonwoven fabric as a fiber-entangled sheet is made to contain a polymeric elastic material, the polishing cloth can be provided with cushioning properties, and the scratch defects by polishing on the surface of the polished substrate can be decreased.

[0027] As the polymeric elastic material used in this invention, for example, polyurethane, polyurea, polyurethane-polyurea elastomer, polyacrylic acid, acrylonitrile-butadiene elastomer, styrene-butadiene elastomer and the like can be used. Among them, polyurethane-based elastomers such as polyurethane and polyurethane-polyurea elastomer can be preferably used.

[0028] It is preferred that the weight average molecular weight of the polymer diol component of the polyurethane used as a main component of the abovementioned polymeric elastic material is 500 to 5000. A more preferred range is 1000 to 3000. If the weight average molecular weight is 500 or higher, more preferably 1000 or higher, the strength of the polishing cloth can be held, and it can be prevented that the ultrafine fibers come off. Further, if the weight average molecular weight is 5000 or lower, more preferably 3000 or lower, the increase in the viscosity of the polyurethane solution can be inhibited, and the ultrafine fiber layer can be more easily impregnated with polyurethane.

[0029] As the diol component used as a raw material of the polyurethane, polyether diol, polyester diol, polycarbonate diol, polylactone diol and copolymers thereof can be preferably used.

[0030] Further, as the diisocyanate component used as a raw material of the polyurethane, an aromatic diisocyanate, alicyclic isocyanate and aliphatic isocyanate and the like can be used. Further, in order to enhance the fitness to the polished surface and the cushioning properties contributing to the inhibition of flaws, in view of flexibility, it is preferred that the rate of the polyether diol component in the polymer diol is 60 mass% or larger. More preferred is 70 mass% or larger.

[0031] It is preferred that the weight average molecular weight of the polyurethane used in this invention is 100,000 to 300,000. A more preferred range is 150,000 to 250,000. If the weight average molecular weight of the polyurethane is 100,000 or higher, the strength of the obtained polishing cloth can be held, and further it can be prevented that the ultrafine fibers on the nap surface come off. Further, if the weight average molecular weight of the polyurethane is 300,000 or lower, the increase in the viscosity of the polyurethane solution can be inhibited, and the nonwoven fabric can be more easily impregnated.

[0032] Further, from the viewpoint of satisfying the denseness and distribution uniformity of the ultrafine fibers on the surface of the polishing cloth, it is preferred that the gelation point of the polyurethane is in a range from 2.5 to 6.0 ml. A more preferred gelation point range is 3.0 to 5.0 ml.

[0033] To obtain the gelation point of the polyurethane, while 100 g of an N,N'-dimethylformamide (hereinafter may be abbreviated as DMF) solution with a polyurethane concentration of 1 mass% is stirred, distilled water is added dropwise into the solution, and when the polyurethane begins to be solidified and becomes slightly cloudy at a temperature of $25\pm 1^{\circ}\text{C}$, the amount of the dropwise added water is defined as the gelation point. Consequently it is necessary that the DMF used for measuring the gelation point has a water content of 0.03% or less. The abovementioned method for measuring the gelation point presupposes that the polyurethane DMF solution is transparent. However, in the case where the polyurethane DMF solution is slightly cloudy in advance, the amount of the dropwise added water when the polyurethane begins to be solidified and changes in the degree of cloudiness can be considered to be the gelation point.

[0034] In the case where the gelation point is less than 2.5 ml, the foam of the polyurethane present in the inner spaces of the nonwoven fabric may have large and coarse bubbles since the solidification rate is too high when the polyurethane is wet-solidified. Further, in the case where the gelation point is less than 2.5 ml, the foam becomes partially defective, and as a result, in the case where the surface of a sheet is ground by the buffing described later, the lengths of the napped ultrafine fibers on the nap surface may become uneven, or the napped fibers may be partially distributed, or a state where the abrasive grains are uniformly dispersed on the nap surface may not be able to be obtained, not allowing ultrahigh precision finishing to be achieved as the case may be.

[0035] On the other hand, in the case where the gelation point is more than 6.0 ml, the polyurethane present in the inner spaces of the nonwoven fabric shows little foaming since the solidification rate is too low when the polyurethane is wet-solidified, and the polyurethane may exist as a very thick and hard film. Consequently in the case where the surface of a sheet is ground by buffing, the grinding of the polyurethane is hard to perform, and the lengths of the napped ultrafine fibers on the nap surface are very short. Further, the fiber bundles cannot be easily carded, and the density of the surface fibers becomes very uneven. Therefore, the abrasive grains may locally aggregate and scratch defects may be produced.

[0036] Further, in this invention, a polyurethane can be preferably used as a main component of the polymeric elastic material, and it may be made to contain another resin as a binder to such an extent that performance and the uniformly dispersed state of napped fibers may not be impaired. As the other resin, for example, enumerated are polyester-based, polyamide-based and polyolefin-based elastomer resins, acrylic resins, ethylene-vinyl acetate resin, etc.

[0037] Furthermore, the polymeric elastic material may contain slight amounts of various additives, for example, phosphorus-based, halogen-based, inorganic and other flame retarders, phenol-based, sulfur-based, phosphorus-based and other antioxidants, benzotriazole-based, benzophenone-based, salicylate-based, cyanoacrylate-based, oxalic acid anilide-based and other ultraviolet light absorbers, hindered amine-based, benzoate-based and other light stabilizers, polycarbodiimide and other hydrolysis-resistant stabilizers, plasticizers, antistatic agents, surfactants, solidification-adjusting materials, etc.

[0038] Moreover, from the viewpoints that the fibers little come off and that the napped fibers are uniformly aligned in direction, a preferred mode of the polymeric elastic material inside the nonwoven fabric is a state where at least some of the single fibers positioned in the outermost circumferences of the fiber bundles comprising ultrafine fibers are bonded.

[0039] This mode can be obtained by the method of (B) described later. That is, since polyvinyl alcohol protects most of the outer circumference of ultrafine fiber bundles, the entry of the polyurethane into the fiber bundles of ultrafine fibers is prevented, and the polyurethane partially adheres to the outer circumferential portions of the fiber bundles free from the protection by polyvinyl alcohol.

[0040] Since the polymeric elastic material partially bonds and arrests the fibers positioned at the outermost circumferences of the ultrafine fiber bundles, the degree of freedom of the napped ultrafine fibers on the nap surface can be moderately controlled. As a result, the directional freedom of the napped fibers after buffing is kept very small. That is, the napped fibers can be adjusted to be into a state where they are aligned in one direction. Thus, a state where the napped fibers are uniformly aligned in one direction can be obtained, and the ultrafine fibers present on the nap surface are kept very less uneven in denseness, providing a state where the ultrafine fibers are uniformly disposed. Thus, a structure in which the napped fibers are densely and uniformly aligned in one direction and in which the fibers are oriented in one direction, can be obtained. With this structure, the dispersibility of abrasive grains at the time of polishing can be enhanced, and the abrasive grain distribution on the surface of the polishing cloth can be uniformed. Therefore, the scratch defects can be remarkably decreased.

[0041] In the polishing cloth of this invention, cushioning properties and fitness are important for polishing precision. The cushioning properties and fitness can be controlled and adjusted by the rates of the ultrafine fibers and the polymeric elastic material and the void ratio (can be known from the apparent density).

[0042] In the polishing cloth of this invention, it is preferred that the total rate of the ultrafine fibers and the polymeric elastic material is 50 to 100 mass% based on the total mass of the polishing cloth. A more preferred range is 80 to 100 mass%. It is preferred that the rate of the ultrafine fibers is 40 to 90 mass% based on the total mass of the polishing cloth. A more preferred range is 50 to 80 mass%. It is preferred that the content of the polymeric elastic

body is 10 to 50 mass% based on the total mass of the polishing cloth. A more preferred range is 10 to 40 mass%. The surface state, void ratio, cushioning properties, hardness, strength and the like of the polishing cloth can be adjusted by the content of the polymeric elastic material as appropriate. If the content of the polymeric elastic material is more than 50 mass%, both processability and productivity become poor, and it is difficult to obtain nap surface where the ultrafine fibers are uniformly dispersed on the surface of the sheet-like material. For this reason, the production of scratch defects at the time of slurry grinding may not be able to be inhibited sufficiently. On the other hand, it is not preferred that the content of the polymeric elastic material is smaller than 10 mass%, for such reasons that the strength of the polishing cloth declines and that the polishing cloth is likely to be deformed at the time of slurry grinding. Further, the polishing cloth of this invention may also contain a reinforcing material such as a woven fabric as a component other than the ultrafine fibers and the polymeric elastic material.

[0043] In the polishing cloth of this invention, from the viewpoints of the denseness and dispersibility of the ultrafine fibers on the surface of the polishing cloth, it is important that at least one surface of the polishing cloth is a nap surface comprising ultrafine fibers.

[0044] Fig. 1 is an enlarged SEM photo (40x) as a substitute for a drawing showing an example of the surface fiber-napped portion structures constituting the ultrafine fiber bundles on the surface of the polishing cloth of this invention.

[0045] As shown in Fig. 1, the nap surface of the polishing cloth is formed by the structures containing the surface fiber-napped portions comprising ultrafine fiber bundles. The surface fiber-napped portions are indicated by rectangles of Fig. 1. In this invention, in the rectangles shown in Fig. 1, the ultrafine fiber bundle direction (the width direction of the fiber bundles) corresponds to the transverse direction of the surface fiber-napped portion structures, and the length direction in which the ultrafine fibers of the ultrafine fiber bundles are aligned corresponds to the length direction of the surface fiber-napped portion structures. In the mode of the surface fiber-napped portion structures, the ultrafine fibers may be uniformly aligned, or the ultrafine fibers may also be more or less apart from each other, or may also be partially bonded or cohere to each other.

[0046] In this case, the bonding refers to bonding by chemical reaction or physical fusion or the like, and cohesion refers to sticking by intermolecular force such as hydrogen bonding or the like.

[0047] In the polishing cloth of this invention, the average size of the surface fiber-napped portion structures in the width direction of the ultrafine fiber bundles is in a range from 50 to 180 μm , and a preferred range is 50 to 120 μm . In the case where the average size of the surface fiber-napped portion structures in the width direction of the ultrafine fiber bundles is 180 μm or less, the ultrafine fiber bundles of the surface fiber-napped portions do not overlap

each other, and the surface unevenness of the polishing cloth becomes small. Consequently, in the case where the polishing cloth is used for polishing, scratch defects are unlikely to be given to the polished material, and the surface roughness of the polished material can be kept small. Further, it is a preferred mode that the average size of the surface fiber-napped portion structures in the width direction of the ultrafine fiber bundles is 50 μ or more, since the amount of the ultrafine fibers present on the surface of the polishing cloth increases to enhance the surface cover rate.

[0048] In the polishing cloth of this invention, it is preferred that the average size of the surface fiber-napped portion structures in the length direction of the ultrafine fiber bundles is 100 μ m to 500 μ m. The length direction of the ultrafine fiber bundles is the length direction of the ultrafine fibers, and corresponds to the length direction of the rectangles in Fig 1. In the case where the average size of the surface fiber-napped portion structures in the length direction is 500 μ m or less, the ultrafine fiber bundles are unlikely to overlap each other, and the unevenness on the surface of the polishing cloth is small. Consequently in the case where the polishing cloth is used for polishing, scratch defects are unlikely to be given to the polished material, and the surface roughness of the polishing cloth can be kept small. Further, it is a preferred mode that the average size in the length direction is 100 μ m or more, since the amount of the ultrafine fibers present on the surface increases to enhance the surface cover rate.

[0049] It is preferred that the polishing cloth of this invention has a surface roughness of 5 to 18 μ m. A more preferred surface roughness range is 5 to 15 μ m, and a further more preferred range is 5 to 8 μ m. From the viewpoints of the holdability and dispersibility of abrasive grains at the time of slurry grinding, it is preferred that the surface roughness is larger than 5 μ m. Further, in the case where the surface roughness is smaller than 18 μ m, scratch defects are unlikely to be given to the polished material at the time of polishing, and the surface roughness of the polished material can be kept small.

[0050] In the case where the polishing cloth of this invention is used as a tape for slurry grinding or cleaning, if it is dimensionally changed, the substrate surface cannot be polished uniformly. Therefore, in view of the dimensional stability of the polishing cloth, it is preferred that the weight per unit area of the polishing cloth of this invention is 100 to 400 g/m². A more preferred range of the weight per unit area is 150 to 300 g/m².

[0051] Next, the method for producing the polishing cloth of this invention is explained below.

[0052] The polishing cloth of this invention can be suitably obtained by combining at least the following steps (1) through (5). In this case, in order to achieve the surface fiber-napped portion structures in the polishing cloth of this invention, it is essential that the number of the islands-in-sea type composite fibers convertible into ultrafine fibers, which are brought in by

the needle punching of the following step (2), is 3 to 6 fibers/1 barb:

- (1) a step of producing islands-in-sea type composite fibers convertible into ultrafine fibers with an average single fiber diameter of 0.05 to 2.0 μm ;
- (2) a step of forming and laminating fiber webs by a card and a crosslapper using said islands-in-sea type composite fibers, and obtaining a nonwoven fabric by needle punching;
- (3) a step of giving a polymeric elastic material to said nonwoven fabric by 10 to 200 mass% based on the mass of the ultrafine fibers obtained by converting the composite fibers;
- (4) a step of buffing at least one surface; and
- (5) a step of converting said islands-in-sea type composite fibers into ultrafine fibers.

[0053] As a means for obtaining a fiber-entangled sheet like a nonwoven fabric formed by entangling ultrafine fiber bundles, fibers convertible into ultrafine fibers such as islands-in-sea type composite fibers can be used. It is difficult to produce a fiber-entangled sheet directly from ultrafine fibers, but a fiber-entangled sheet having ultrafine fiber bundles entangled therein can be obtained by producing a fiber-entangled sheet from the islands-in-sea type composite fibers convertible into ultrafine fibers and converting the composite fibers in the fiber-entangled sheet into ultrafine fibers.

[0054] A composite fiber convertible into ultrafine fibers, which can be employed, can be (a) an islands-in-sea type composite fiber containing two thermoplastic resins different in solvent dissolvability as a sea component and an island component, in which the sea component is dissolved and removed by using a solvent or the like, to convert the island component into ultrafine fibers, (b) a splittable composite fiber having two thermoplastic resins disposed therein radially or in layers alternately in the cross section thereof, in which the respective components are separated for splitting into ultrafine fibers, or the like.

[0055] An islands-in-sea type composite fiber can be an islands-in-sea type composite fiber in which a sea component and an island component are disposed separately using an islands-in-sea type spinneret when spun, or a mixed spun fiber in which a sea component and an island component are mixed when spun, or the like. Among them, an islands-in-sea type composite fiber can be preferably used from the viewpoints that ultrafine fibers with a uniform fineness can be obtained and that sufficiently long ultrafine fibers can be obtained to contribute to the strength of a sheet-like material.

[0056] As the sea component of the islands-in-sea type composite fiber, polyethylene, polypropylene, polystyrene, sodiumsulfoisophthalic acid, polyester copolymers copolymerized with polyethylene glycol or the like, polylactic acid, etc. can be used.

[0057] The dissolution of the sea component for removal can be performed at any time before or after adding the elastic polymer or after raising the fibers.

[0058] As the method for obtaining a fiber-entangled sheet such as a nonwoven fabric, as described before, a method of entangling a fiber web by needle punching or water jet

punching, or a spun-bond method, melt-blow method, aqueous fiber suspension screening method or the like can be used. Among them, in order to obtain the abovementioned mode of ultrafine fiber bundles, a method of undergoing treatment such as needle punching or water jet punching can be preferably used.

[0059] From the viewpoint of forming a dense nap surface by highly entangling fibers, it is preferred that the number of punches by the needle punching treatment is 2000 to 8000 punches/cm², and a more preferred range is 3000 to 5000 punches/cm². If the number of punches is 2000 punches/cm² or more, the surface fibers are excellent in denseness and desired highly precise finishing can be obtained. Further, if the number of punches is 8000 punches/cm² or less, the processability is not lowered, and fiber damage and strength decline do not occur.

[0060] It is preferred that the fiber density of the nonwoven fabric after completion of needle punching is 0.15 to 0.4 g/cm³ from the viewpoint of denser surface fibers. A more preferred range is 0.2 to 0.3 g/cm³.

[0061] It is necessary that the average size of the surface fiber-napped portion structures in the width direction is 50 to 180 μm, and a preferred average size range is 50 to 120 μm. In order to achieve this size range, it is essential that the number of composite fibers such as composite fibers convertible into ultrafine fibers brought in by one time of needle punching is 3 to 6 fibers/1 barb. A preferred range is 3 to 4 fibers/1 barb.

[0062] The number of composite fibers such as composite fibers convertible into ultrafine fibers caught by each barb is decided by the shape of the barb and the diameter of each composite fiber. In this connection, the idea about the number of composite fibers convertible into ultrafine fibers, caught by the barb, is explained below in reference to Fig. 2.

[0063] Suppose an isosceles triangle in which the angle (α of Fig. 2) formed at the depth of a barb is a vertex of the triangle while the line from the depth (B of Fig. 2) of the barb to the tip (A of Fig. 2) of the barb is a side of the triangle. The isosceles triangle is packed with composite fibers in the closest manner, starting from the depth of the triangle (from the depth of the barb). With regard to each composite fiber convertible into ultrafine fibers disposed partially out of the isosceles triangle, if the area occupation rate of the composite fiber within the isosceles triangle is 50% or more, the composite fiber convertible into ultrafine fibers is defined as a composite fiber that can be brought in, and the number of composite fibers including the composite fibers defined like this is defined as the total number of composite fibers that can be brought in.

[0064] Therefore, in the present invention, it is important that among the abovementioned polishing cloth production steps (1) through (5), the needle punching step (2) precedes the step (5) of converting the composite fibers of the nonwoven fabric into ultrafine fibers.

[0065] Further, it is preferred that each of the needles used in the needle punching step has 1

to 3 barbs, and that each barb is shaped to have a kick-up dimension of 0 to 50 μm , an undercut angle of 0 to 40°, a throat depth of 40 to 80 μm and a throat length of 0.5 to 1.0 mm.

[0066] In a preferred mode, the nonwoven fabric containing the elastic polymer obtained as described above is shrunk by dry heat and/or wet heat, to have a higher fiber density from the viewpoint of denser surface fibers.

[0067] It is important that the polishing cloth of this invention mainly comprises a nonwoven fabric formed by entangling the aforementioned ultrafine fiber bundles.

[0068] In the polishing cloth of this invention, it is preferred to give a polymeric elastic material with polyurethane as the main component before and/or after converting the aforementioned nonwoven fabric into ultrafine fibers in view of the fitness to the polished material and an excellent effect of inhibiting the flaws on the surface of the polished material. The polymeric elastic material has such roles as cushioning properties for absorbing surface unevenness and vibration and fiber shape maintainability. That is, since the inner spaces of the nonwoven fabric are packed with the polymeric elastic material for integration, the fitness to the polished material and the effect of inhibiting the flaws on the surface of the polished material are excellent.

[0069] As the method for giving the polymeric elastic material such as polyurethane to the nonwoven fabric, a method of coating the nonwoven fabric with the polymeric elastic material or impregnating the nonwoven fabric with the polymeric elastic body followed by solidification or the like can be employed. Among the methods, in view of processability, a method of impregnating the nonwoven fabric with a polymeric elastic material solution followed by wet solidification can be preferably used.

[0070] For example, the polyurethane used as the polymeric elastic material is formed into a polyurethane solution using a solvent such as dimethylformamide. Then, a method (A) of impregnating a nonwoven fabric formed by entangling composite fibers convertible into ultrafine fibers, with the aforementioned polyurethane solution, solidifying in water or in an organic solvent aqueous solution, and dissolving and removing the polymer component to be dissolved and removed in the composite fibers convertible into ultrafine fibers, using a solvent incapable of dissolving the polyurethane, can be used. Otherwise, a method (B) of giving polyvinyl alcohol preferably with a saponification degree of 80% or more to a nonwoven fabric formed by entangling composite fibers convertible into ultrafine fibers, to protect most of the circumferences of the fibers, then dissolving and removing the polymer component to be dissolved and removed in the composite fibers convertible into ultrafine fibers, using a solvent incapable of dissolving polyvinyl alcohol, subsequently impregnating with the polyurethane solution, then solidifying in water or in an organic solvent aqueous solution, and removing polyvinyl alcohol, or the like can be preferably used.

[0071] The surface fibers of the nonwoven fabric obtained as described above can be suitably

raised by buffing using sand paper, roll sander or the like. In particular, if sand paper is used, uniform and dense nap can be formed on the surface of the nonwoven fabric.

[0072] In order to improve the uniformity and denseness of the fiber distribution on the surface and in order to extremely narrow the direction of napped fibers for the purposes of performing slurry grinding and cleaning on the substrate surface in ultrahigh precision finishing and inhibiting scratch defects, it is preferred that the grinding load is smaller. In a larger grinding load state, many napped fibers become curly, and napped fibers are likely to remain as bundled. In order to make the grinding load smaller, it is preferred to adjust the number of buffing steps, sand paper grain sizes and the like as appropriate. Above all, multi-step buffing of three or more buffing steps and keeping the sand paper grain sizes used in the respective steps in a range from JIS No. 150 to 600 are preferred.

[0073] As a method for suitably performing slurry grinding and cleaning using the polishing cloth of this invention, from the viewpoints of working efficiency and stability, it is preferred that the polishing cloth is cut like a tape with a width of 30 to 50 mm, to be used as a tape for slurry grinding and cleaning. In this invention, using such a polishing tape and a slurry containing loose grains for the slurry grinding and cleaning of aluminum alloy magnetic recording discs or glass magnetic recording discs is a suitable method.

[0074] With regard to the polishing conditions, a slurry in which highly hard abrasive grains such as fine diamond grains are dispersed in an aqueous dispersion medium can be preferably used. Above all, from the viewpoints of the holdability and dispersibility of abrasive grains, the inhibition of scratch defects and the decrease of surface roughness, a preferred mode of the abrasive grains fitting to the ultrafine fibers constituting the polishing cloth of this invention is monocrystalline diamond with a primary grain size of 1 to 20 nm. A more preferred range is 1 to 10 nm.

[0075] That is, the polishing cloth of this invention can be suitably used for polishing or cleaning the aluminum alloy substrate or the glass substrate used for magnetic discs in ultrahigh precision finishing.

EXAMPLES

[0076] The polishing cloth of this invention and a production method thereof are more specifically explained below based on examples, but this invention is not limited thereto or thereby. Further, the evaluation methods and evaluation conditions used in the examples are as follows.

[0077] (1) Melting point of polymer

The peak top temperature showing the melting of the polymer in the 2nd run using DSC-7 produced by Perkin Elmaer was employed as the melting point of the polymer. The heating rate in this case was 16°C/min, and the amount of the sample was 10 mg.

[0078] (2) Melt flow rate (MFR) of polymer

Four to five grams of sample pellets were placed in the cylinder of an electric furnace of an MFR meter, and the amount (g) of the resin extruded in 10 minutes at a load of 2160 gf and at a temperature of 285°C was measured using a melt indexer (S101) produced by Toyo Seiki Seisaku-Sho, Ltd. The same measurement was repeated 3 times, and the mean value was employed as the MFR.

[0079] (3) Number of composite fibers brought in at the time of needle punching

Fig. 2 is a typical drawing for explaining the method for estimating the number of composite fibers brought in at the time of needle punching in connection with the relation between a needle and composite fibers at the time of needle punching. The typical drawing of a needle and composite fibers shown in Fig. 2 is used to explain the method for estimating the composite fibers brought in at the time of needle punching. First of all, point D is obtained on the line BC of Fig. 2 so that the length BD may become equal to the length between the tip (A of Fig. 2) of a barb and the depth (B of Fig. 2) of the barb. Then, the tip A of the barb of Fig. 2 is connected with D by a line segment, to form an isosceles triangle BAD with $BA = BD$. The isosceles triangle is packed with composite fibers in the closest manner, starting from the depth of the triangle (from the depth of the barb). With regard to each composite fiber disposed partially out of the isosceles triangle, if the area occupation rate of the composite fiber within the isosceles triangle is 50% or more, the composite fiber is defined as a composite fiber that can be brought in, and the number of composite fibers including the composite fibers defined like this is defined as the total number of composite fibers that can be brought in.

[0080] (4) Average fiber diameter and CV of fiber diameter

The polishing cloth was cut in the thickness direction, and the cross section was observed at a magnification of 5000x by a scanning electron microscope (SEM), and 50 single fiber diameters sampled at random were measured. The measurement was performed at three places, and the diameters of 150 single fibers in total were measured. With these fibers as the population, the mean value and standard deviation value were calculated. The mean value was employed as the average fiber diameter, and the value obtained by dividing the standard deviation value by the mean value and expressed as a percentage (%) was employed as the CV of fiber diameter.

[0081] (5) Size measurement of surface fiber-napped portion structures

As shown in Fig. 1, the surface of the polishing cloth was observed at a magnification of 40x by an SEM, and an ultrafine fiber bundle in which the ultrafine fibers present on the surface are disposed to contact each other is defined as a surface fiber-napped portion structure. Fifty such surface fiber-napped portion structures were sampled at random, and the sizes of the sampled fifty surface fiber-napped portion structures in the width direction and in the length direction were measured. The respective mean values were

calculated.

[0082] (6) Surface roughness measurement of polishing cloth

The surface roughness of the polishing cloth was measured using a surface roughness measuring instrument, SE-40C at a cut-off of 2.5 mm, at an evaluation length of 12.5 mm and at an evaluation rate of 0.5 m/s. Measurement was performed three times in the grain direction along the nap, and the mean value was calculated.

[0083] (7) Polishing by the polishing cloth

The polishing cloth was cut to a tape with a width of 30 mm. Polished was a glass substrate made of amorphous glass with the surface roughness controlled at 0.3 nm or less, produced by KMG. A slurry with a loose grain concentration of 0.01% having monocrystalline diamond grains with a primary grain size of 5 nm clustered to an average diameter of 80 nm was added dropwise to the surface of the polishing cloth at 50 ml/min. Further, at a tape running rate of 70 mm/min, at a disc rotational speed of 600 rpm, at an oscillation of 100 times/min and at a pressing pressure of 1.5 kgf, polishing was performed for 15 seconds. The polishing was performed on both the surfaces of each disc.

[0084] (8) Surface roughness of the polished substrate

“AFM NanoScope” (registered trademark) 111a produced by Veeco was used for measurement in the tapping mode. An observation area on the substrate was $10\text{ }\mu\text{m} \times 10\text{ }\mu\text{m}$, and measurement was made at a given one point on the substrate. The mean value of given 3 points was employed as the surface roughness (Ra). A substrate surface roughness of 2.0 nm or less was determined to be good in polishing performance.

[0085] (9) Number of scratches on the polished substrate

The number of grooves with a depth of 2 nm or more was counted as scratches on both the entire surfaces of five polished substrates, i.e., ten surfaces in total by using an optical surface analyzer (Candela 6100), and the counted scratches of the ten surfaces were averaged. A smaller value shows higher performance. Twenty scratches or less were determined to be good in polishing performance.

[0086] [Example 1]

(Raw fibers)

(Sea component and island component)

Nylon 6 with a melting point of 220°C and an MFR of 10.5 was employed as the island component, and polystyrene copolymer (co-PSt) having 22 mol% of 2-ethylhexyl acrylate copolymerized, with a melting point of 53°C and an MFR of 12, was employed as the sea component.

[0087] (Spinning/stretching)

The abovementioned sea component and island component were melt-spun using an islands-in-sea type spinneret with 376 islands/holes at a spinning temperature of 285°C, at an

islands/sea mass ratio of 40/60, at a discharge rate of 1.7 g/min-hole and at a spinning rate of 1200 m/min, to obtain an islands-in-sea type composite fiber. Subsequently the composite fiber was stretched to 3.0 times in a spinning oil bath with a temperature of 85°C, and the fiber was crimped using a force crimper and cut to obtain islands-in-sea type composite fibers with a fineness of 6.5 dtex and a fiber length of 51 mm as raw fibers.

[0088] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

The abovementioned islands-in-sea type composite fibers as raw fibers were used to form a laminated fiber web via card and crosslapper steps. Then, the obtained laminated fiber web was needle-punched using a needle punch with needles having a throat depth of 60 μm , a kick-up dimension of 0 μm , an undercut angle of 4°, and a throat length of 0.9 mm, at a needle depth of 8 mm and at 3200 punches/ cm^2 , to produce a nonwoven fabric comprising islands-in-sea type composite fibers with a weight per unit area of 800 g/m^2 and an apparent density of 0.190 g/cm^3 . The number of islands-in-sea type composite fibers brought in by the needle punch was 3 fibers/1 barb.

[0089] (Polishing cloth)

The abovementioned nonwoven fabric comprising islands-in-sea type composite fibers was shrunk with hot water and subsequently impregnated with 12% polyvinyl alcohol aqueous solution, then being dried. Then, the co-PST as the sea component was dissolved and removed in trichloroethylene, and the residue was dried to obtain an ultrafine fiber nonwoven fabric having ultrafine fiber bundles entangled therein.

[0090] To the nonwoven fabric obtained as described above, a polyurethane (gelation point 4.2 ml) comprising 75 mass% of polyether polymer diol and 25 mass% of polyester polymer diol was given by 20 mass% as solid based on the mass of the fibers, and the polyurethane was solidified by 30% DMF aqueous solution with a temperature of 35°C, hot water with a temperature of approx. 85°C being used to remove DMF and polyvinyl alcohol. Subsequently a half splitter having an endless band knife was used to split into halves in the thickness direction, and the non-split surfaces were ground in three steps using JIS #240 sand paper, for napping, to produce polishing cloths.

[0091] The obtained polishing cloths were 0.72 μm in the average single fiber diameter of the ultrafine fibers, 7.0% in the CV of fiber diameter, 0.5 mm in thickness, 180 g/m^2 in weight per unit area and 0.36 g/cm^3 in apparent density. The obtained polishing cloths were used to evaluate the polishing performance. Both the substrate surface roughness and the number of scratches were satisfactory, and the surface after polishing was highly uniform. The results are shown in Table 1.

[0092] [Example 2]

(Raw fibers)

(Sea component and island component)

The sea component and the island component were identical to those used in Example 1.

[0093] (Spinning/stretching)

The abovementioned sea component and island component were melt-spun using an islands-in-sea type spinneret with 200 islands/holes at a spinning temperature of 285°C, at an islands/sea mass ratio of 40/60, at a discharge rate of 0.9 g/min-hole and at a spinning rate of 1200 m/min, to obtain an islands-in-sea type composite fiber. Subsequently the composite fiber was stretched to 3.0 times in a spinning oil bath with a temperature of 85°C, and the fiber was crimped using a force crimper and cut to obtain islands-in-sea type composite fibers with a fineness of 5.2 dtex and a fiber length of 51 mm as raw fibers.

[0094] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

As described in Example 1, a nonwoven fabric comprising islands-in-sea type composite fibers with a weight per unit area of 680 g/m² and an apparent density of 0.224 g/cm³ was produced.

[0095] (Polishing cloth)

As described in Example 1, a polishing cloth was obtained. The obtained polishing cloth was 1.53 μm in the average single fiber diameter of the ultrafine fibers, 5.8% in the CV of fiber diameter, 0.51 mm in thickness, 186 g/m² in weight per unit area and 0.365 g/cm³ in apparent density. The results are shown in Table 1.

[0096] [Example 3]

[Raw fibers]

(Sea component and island component)

The sea component and the island component were identical to those used in Example 1.

[0097] (Spinning/stretching)

The spinning and stretching were identical to those of Example 1.

[0098] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising composite fibers convertible into ultrafine fibers, with a weight per unit area of 800 g/m² and an apparent density of 0.190 g/cm³ was produced as described in Example 1, except that needles with a throat depth of 60 μm, a kick-up dimension of 10 μm, an undercut angle of 27°, and a throat length of 0.8 mm were used.

[0099] (Polishing cloth)

A polishing cloth was obtained as described in Example 1.

[0100] The obtained polishing cloth was 0.72 μm in the average fiber diameter of the ultrafine fibers, 7.0% in the CV of fiber diameter, 0.49 mm in thickness, 175 g/m² in weight per unit area and 0.357 g/cm³ in apparent density. The results are shown in Table 1.

[0101] [Example 4]

(Raw fibers)

The sea component and the island component were identical to those used in Example 2.

[0102] (Spinning/stretching)

The spinning and the stretching were identical to those of Example 2.

[0103] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers with a weight per unit area of 680 g/m^2 and an apparent density of 0.224 g/cm^3 was produced as described in Example 3.

[0104] (Polishing cloth)

A polishing cloth was obtained as described in Example 1.

[0105] The obtained polishing cloth was $1.53 \mu\text{m}$ in the average fiber diameter of the ultrafine fibers, 5.8% in the CV of fiber diameter, 0.5 mm in thickness, 180 g/m^2 in weight per unit area and 0.360 g/cm^3 in apparent density. The results are shown in Table 1.

[0106] [Example 5]

(Raw fibers)

(Sea component and island component)

The sea component and the island component were identical to those used in Example 1.

[0107] (Spinning/stretching)

The abovementioned sea component and island component were melt-spun using an islands-in-sea type spinneret with 800 islands/holes at a spinning temperature of 285°C , at an islands/sea mass ratio of 30/70, at a discharge rate of $2.1 \text{ g/min}\cdot\text{hole}$ and at a spinning rate of 1200 m/min , to obtain an islands-in-sea type composite fiber. Subsequently the composite fiber was stretched to 3.0 times in a liquid bath with a temperature of 85°C , and the fiber was crimped using a force crimper and cut to obtain islands-in-sea type composite fibers with a fineness of 12.1 dtex and a fiber length of 51 mm as raw fibers.

[0108] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

As described in Example 3, a nonwoven fabric comprising islands-in-sea type composite fibers with a weight per unit area of 680 g/m^2 and an apparent density of 0.224 g/cm^3 was produced.

[0109] (Polishing cloth)

A polishing cloth was obtained as described in Example 3.

[0110] The obtained polishing cloth was $0.50 \mu\text{m}$ in the average fiber diameter of the ultrafine fibers, 7.7% in the CV of fiber diameter, 0.48 mm in thickness, 175 g/m^2 in weight per unit area and 0.365 g/cm^3 in apparent density. The results are shown in Table 1.

[0111] [Example 6]

(Raw fibers)

(Sea component and island component)

The sea component and the island component were identical to those used in Example 1.

[0112] (Spinning/stretching)

A so-called mixed spinning method of mixing 50 wt% each of the abovementioned sea and island components to melt-spin an islands-in-sea type composite fiber at a spinning temperature of 285°C was used to obtain an island-in-sea type composite fiber having approx. 1000 islands disposed in the sea component at a spinning rate of 1200 m/min. Then, the composite fiber was stretched to 3.0 times in a spinning oil bath with a temperature of 85°C, and crimped using a force crimper, being cut to obtain islands-in-sea type composite fibers with a fineness of 11.6 dtex and a fiber length of 51 mm as raw fibers.

[0113] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers was obtained as described in Example 1, except that JIS #320 sand paper was used.

[0114] (Polishing cloth)

The abovementioned nonwoven fabric comprising islands-in-sea type composite fibers was shrunk by hot water, and subsequently impregnated with 12% polyvinyl alcohol aqueous solution, then being dried. To the nonwoven fabric, a polyurethane comprising 75 mass% of polyether polymer diol and 25 mass% of polyester polymer diol was given by 20 mass% as solid based on the mass of the fibers, and the polyurethane was solidified by 30% DMF aqueous solution with a liquid temperature of 35°C, DMF being removed by hot water with a temperature of approx. 85°C. Then, the co-PST as the sea component was dissolved and removed in trichloroethylene, and the residue was dried to obtain an ultrafine fiber nonwoven fabric comprising ultrafine fiber bundles and polyurethane.

[0115] Subsequently a half splitter having an endless band knife was used to split the obtained ultrafine fiber nonwoven fabric into halves in the thickness direction, and the non-split surfaces were ground in three steps using JIS #320 sand paper, for napping, to produce polishing cloths.

[0116] The obtained polishing cloths were 0.72 μm in the average fiber diameter of the ultrafine fibers, 32.3% in the CV of fiber diameter, 0.55 mm in thickness, 180 g/m² in weight per unit area and 0.327 g/cm³ in apparent density. The results are shown in Table 1.

[0117] [Example 7]

(Raw fibers)

(Sea component and island component)

The sea component and the island component were identical to those used in Example 5.

[0118] (Spinning/stretching)

The spinning and the stretching were identical to those of Example 5.

[0119] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

As described in Example 3, a nonwoven fabric comprising islands-in-sea type composite fibers was obtained.

[0120] (Polishing cloth)

A polishing cloth was obtained as described in Example 5. The obtained polishing cloth was 0.72 μm in the average fiber diameter of the ultrafine fibers, 32.3% of the CV of fiber diameter, 0.5 mm in thickness, 190 g/m^2 in weight per unit area and 0.380 g/cm^3 in apparent density. The results are shown in Table 1.

[0121] [Example 8]

[Raw fibers]

(Sea component and island component)

The sea component and the island component were identical to those used in Example 1.

[0122] (Spinning/stretching)

Islands-in-sea type composite fibers with a single fiber fineness 2.2 dtex and a fiber length of 51 mm were obtained as raw fibers as described in Example 1, except that an islands-in-sea type spinneret with 600 islands/holes was used and that the discharge rate was 1.0 $\text{g}/\text{min-hole}$.

[0123] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers was obtained as described in Example 6.

[0124] (Polishing cloth)

A polishing cloth was obtained as described in Example 1. The obtained polishing cloth was 0.35 μm in the average fiber diameter of the ultrafine fibers, 6.2% in the CV of fiber diameter, 0.5 mm in thickness, 177 g/m^2 in weight per unit area, and 0.354 g/cm^3 in apparent density. The results are shown in Table 1.

[0125] [Example 9]

(Raw fibers)

(Sea component and island component)

The sea component and the island component were identical to those used in Example 1.

[0126] (Spinning/stretching)

Islands-in-sea type composite fibers with a fineness of 6.8 dtex and a fiber length of 51 mm were obtained as raw fibers as described in Example 1, except that an islands-in-sea type spinneret with 448 islands/holes was used, that the island/sea mass ratio was 50/50, and

that the discharge rate was 2.0 g/min-hole.

[0127] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers with a weight per unit area of 680 g/m² and an apparent density of 0.224 g/cm³ was produced as described in Example 1. The number of islands-in-sea type composite fibers brought in by needle punching was 3 fibers/1 barb.

[0128] (Polishing cloth)

A polishing cloth was obtained as described in Example 1. The obtained polishing cloth was 0.52 μm in the average fiber diameter of the ultrafine fibers, 5.5% in the CV of fiber diameter, 0.5 mm in thickness, 180 g/m² in weight per unit area, and 0.36 g/cm³ in apparent density. The obtained polishing cloth was used to evaluate the polishing performance, and both the substrate surface roughness and the number of scratches were satisfactory. Also after polishing, the surface was highly uniform. The results are shown in Table 1.

[Example 10]

(Raw fibers)

(Sea component and island component)

Polyethylene terephthalate with a melting point of 260°C and an MFR of 46.5 was used as the island component, and polystyrene with a melting point of 85°C and an MFR of 117 was used as the sea component.

[0129] (Spinning/stretching)

Islands-in-sea type composite fibers with a fineness of 2.5 dtex and a fiber length of 51 mm were obtained as raw fibers as described in Example 1, except that an islands-in-sea type spinneret with 200 islands/holes was used, that the islands/sea mass ratio was 50/50, and that the discharge rate was 1.0/min-hole.

[0130] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers with a weight per unit area of 650 g/m² and an apparent density of 0.224 g/cm³ was produced as described in Example 1. The number of islands-in-sea type composite fibers brought in by needle punching was 4 fibers/1 barb.

[0131] (Polishing cloth)

A polishing cloth was obtained as described in Example 1. The obtained polishing cloth was 0.75 μm in the average fiber diameter of the ultrafine fibers, 6.8% in the CV of fiber diameter, 0.5 mm in thickness, 190 g/m² in weight per unit area, and 0.38 g/cm³ in apparent density. The obtained polishing cloth was used to evaluate the polishing performance, and both the substrate surface roughness and the number of scratches were satisfactory. The surface after polishing was also highly uniform. The results are shown in Table 1.

[Example 11]

(Raw fibers)

(Sea component and island component)

The sea component and the island component were identical to those used in Example 11.

[0132] (Spinning/stretching)

Islands-in-sea type composite fibers with a fineness of 4.1 dtex and a fiber length of 51 mm were obtained as raw fibers as described in Example 1, except that an island-in-sea type spinneret with 200 islands/holes was used, that the islands/sea mass ratio was 50/50, and that the discharge rate was 1.6 g/min-hole.

[0133] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers with a weight per unit area of 650 g/m² and an apparent density of 0.224 g/cm³ was produced as described in Example 1. The number of islands-in-sea type composite fibers brought in by needle punching was 3 fibers/1 barb.

[0134] (Polishing cloth)

A polishing cloth was obtained as described in Example 1. The obtained polishing cloth was 0.94 μm in the average fiber diameter of the ultrafine fibers, 5.2% in the CV of fiber diameter, 0.5 mm in thickness, 190 g/m² in weight per unit area, and 0.38 g/cm³ in apparent density. The obtained polishing cloth was used to evaluate the polishing performance, and both the substrate surface roughness and the number of scratches were satisfactory. The surface after polishing was also highly uniform. The results are shown in Table 1.

[0135]

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Example 10	Example 11
Felt	Composite fiber fineness (dtex)	6.5	5.2	6.5	5.2	12.1	11.6	11.6	6.5	6.8	2.5	4.1
	Number of fibers brought in	3	4	5	6	3	3	6	6	3	4	3
Ultrafine fibers	Average fiber diameter (μm)	0.72	1.53	0.72	1.53	0.50	0.72	0.72	0.35	0.52	0.75	0.84
	CV of fiber diameter (%)	7.0	5.8	7.0	5.8	7.7	38.0	38.0	6.2	5.5	6.8	5.2
Polishing cloth	Size of surface fiber-napped portion structure in width direction (μm)	114.0	116.8	147.4	138.5	62.5	67.4	132.4	172.3	113.2	120.5	122.7
	Size of surface fiber-napped portion structure in length direction (μm)	393.2	394.1	304.4	520.5	451.3	89.6	304.9	92.7	388.4	322.5	352.4
	Surface roughness (μm)	14.3	14.3	13.5	17.5	5.8	6.2	12.7	15.9	12.1	9.7	12.7
Evaluation of performance	Substrate surface roughness ($\text{\AA}$)	0.6	0.9	0.8	0.9	0.5	0.7	0.8	1.1	0.6	0.7	0.8
	Number of scratches	6	9	12	13	9	11	15	15	5	8	10

[0136] [Comparative Example 1]

(Raw fibers)

(Sea component and island component)

The sea component and the island component were identical to those used in Example 1.

[0137] (Spinning/stretching)

The spinning and the stretching were identical to those of Example 1.

[0138] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers with a weight per unit area of 870 g/m^2 and an apparent density of 0.220 g/cm^3 was produced as described in Example 1, except that needles with a throat depth of $65 \text{ }\mu\text{m}$, a kick-up dimension of $10 \text{ }\mu\text{m}$, an undercut angle of 35° , and a throat length of $0.9 \text{ }\mu\text{m}$ were used.

[0139] (Polishing cloth)

A polishing cloth was obtained as described in Example 1. The obtained polishing cloth was $0.72 \text{ }\mu\text{m}$ in the average fiber diameter of the ultrafine fibers, 7.0% in the CV of fiber diameter, 0.51 mm in thickness, 180 g/m^2 in weight per unit area, and 0.360 g/cm^3 in apparent density. The obtained polishing cloth was used to evaluate polishing performance, and both the substrate surface roughness and the number of scratches were unsatisfactory. The results are shown in Table 2.

[0140] [Comparative Example 2]

(Raw fibers)

(Sea component and island component)

The sea component and the island component were identical to those used in Example 2.

[0141] (Spinning/stretching)

The spinning and the stretching were identical to those of Example 2.

[0142] (Nonwoven fabric comprising islands-in-sea type composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers was obtained as described in Comparative Example 1.

[0143] (Polishing cloth)

A polishing cloth was obtained as described in Example 1. The obtained polishing cloth was $1.53 \text{ }\mu\text{m}$ in the average fiber diameter of the ultrafine fibers, 5.8% in the CV of fiber diameter, 0.51 mm in thickness, 180 g/m^2 in weight per unit area, and 0.353 g/cm^3 in apparent density. The results are shown in Table 2.

[0144] [Comparative Example 3]

(Sea component and island component)

The sea component and the island component were identical to those used in Example 1.

[0145] (Spinning/stretching)

The abovementioned sea and island components were used for melt-spinning at a spinning temperature of 285°C, at an islands/sea mass ratio of 50/50, at a discharge rate of 1.5 g/min-hole and at a spinning rate of 1000 m/min using an islands-in-sea type spinneret with 36 islands/holes. Then, the fiber was stretched to 3.0 times in a spinning oil bath with a temperature of 85°C, and crimped using a force crimper, then being cut to obtain islands-in-sea type composite fibers with a fineness of 3.8 dtex and a fiber length of 51 mm as raw fibers.

[0146] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers was obtained as described in Comparative Example 1.

[0147] (Polishing cloth)

A polishing cloth was obtained as described in Example 6. The obtained polishing cloth was 3.73 μm in the average fiber diameter of the ultrafine fibers, 6.9% in the CV of fiber diameter, 0.53 mm in thickness, 184 g/m² in weight per unit area, and 0.347 g/cm³ in apparent density. The results are shown in Table 2.

[0148] [Comparative Example 4]

(Raw fibers)

(Sea component and island component)

The sea component and the island component were identical to those used in Example 5.

[0149] (Spinning/stretching)

The spinning and the stretching were identical to those of Example 5.

[0150] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers with a weight per unit area of 660 g/m² and an apparent density of 0.188 g/cm³ was produced as described in Example 1, except that needles with a throat depth of 40 μm , a kick-up dimension of 0 μm , an undercut angle of 2°, and a throat length of 0.8 mm were used.

[0151] (Polishing cloth)

A polishing cloth was obtained as described in Example 1. The obtained polishing cloth was 0.50 μm in the average fiber diameter of the ultrafine fibers, 7.7% in the CV of fiber diameter, 0.52 mm in thickness, 162 g/m² in weight per unit area, and 0.311 g/cm³ in apparent density. The results are shown in Table 2.

[0152] [Comparative Example 5]

(Sea component and island component)

The sea component and the island component were identical to those used in Comparative Example 3.

[0153] (Spinning/stretching)

The spinning and the stretching were identical to those of Example 3.

[0154] (Nonwoven fabric comprising composite fibers convertible into ultrafine fibers)

A nonwoven fabric comprising islands-in-sea type composite fibers with a weight per unit area of 640 g/m² and an apparent density of 0.196 g/cm³ was produced as described in Example 1.

[0155] (Polishing cloth)

A polishing cloth was obtained as described in Example 1.

[0156] The obtained polishing cloth was 3.73 μ m in the average fiber diameter of the ultrafine fibers, 6.8% of the CV of fiber diameter, 0.51 mm in thickness, 192 g/m² in weight per unit area, and 0.376 g/cm³ in apparent density. The results are shown in Table 2.

[0157]

[Table 2]

		Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5
Felt	Composite fiber fineness (dtex)	6.5	5.2	3.8	12.1	3.8
	Number of fibers brought in	8	9	11	2	5
Ultrafine fibers	Average fiber diameter (μ m)	0.72	1.53	3.73	0.50	3.73
	CV of fiber diameter (%)	7.0	5.8	6.9	7.7	6.8
Polishing cloth	Size of surface fiber-napped portion structure in width direction (μ m)	189.0	192.0	225.3	47.6	169.5
	Size of surface fiber-napped portion structure in length direction (μ m)	311.8	396.4	89.4	320.0	545.3
	Surface roughness (μ m)	16.2	17.7	20.4	15.4	17.2
Evaluation of performance	Substrate surface roughness ($\text{\AA}$)	2.3	2.1	3.3	3.1	2.4
	Number of scratches	24	33	76	29	32

15. Comparative Example 1

MEANINGS OF SYMBOLS

[0158] A: Tip of barb

B: Depth of barb

C: Given point in the direction from B to the tip of needle (point complying with $BC > BA$)

D: Point on line BC, which makes line BD equal to line BA

CLAIMS

[Claim 1] A method for producing a polishing cloth mainly comprising a nonwoven fabric formed by entangling the ultrafine fiber bundles including ultrafine fibers with an average single fiber diameter of 0.05 to 2.0 μm and a polymeric elastic material, wherein the average size of the surface fiber-napped portions constituted by the aforementioned ultrafine fiber bundles is 20 to 180 μm , comprising at least the following steps (1) through (6) in combination, wherein the number of islands-in-sea type composite fibers convertible into ultrafine fibers, which can be brought in by the needle punching of the following step (2), is 3 to 6 fibers/1 barb:

- (1) a step of producing islands-in-sea type composite fibers convertible into ultrafine fibers with an average single fiber diameter of 0.05 to 2.0 μm ;
- (2) a step of laminating fiber webs by a card and a crosslapper using said islands-in-sea type composite fibers, and obtaining a nonwoven fabric by needle punching;
- (3) a step of shrinking said nonwoven fabric by hot water, to have a higher fiber density from the view point of denser surface fibers;
- (4) a step of giving a polymeric elastic material to said nonwoven fabric by 10 to 200 mass% based on the mass of the ultrafine fibers obtained by converting the composite fibers;
- (5) a step of buffing at least one surface; and
- (6) a step of converting said islands-in-sea type composite fibers into ultrafine fibers.

[Claim 2] A method for producing a polishing cloth, according to claim 1, wherein the number of islands-in-sea type composite fibers brought in by needle punching is 3 to 4 fibers/1 barb.