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Watanabe et al.

(54) **METHOD OF PRODUCING POLISHING SHEET**

(75) Inventors: **Nobuyoshi Watanabe**, Tokyo (JP); **Kazunori Tani**, Tokyo (JP)

Correspondence Address:
Weaver Austin Villeneuve & Sampson LLP
P.O. BOX 70250
OAKLAND, CA 94612-0250 (US)

(73) Assignee: **NIHON MICRO COATING CO., LTD.**, Tokyo (JP)

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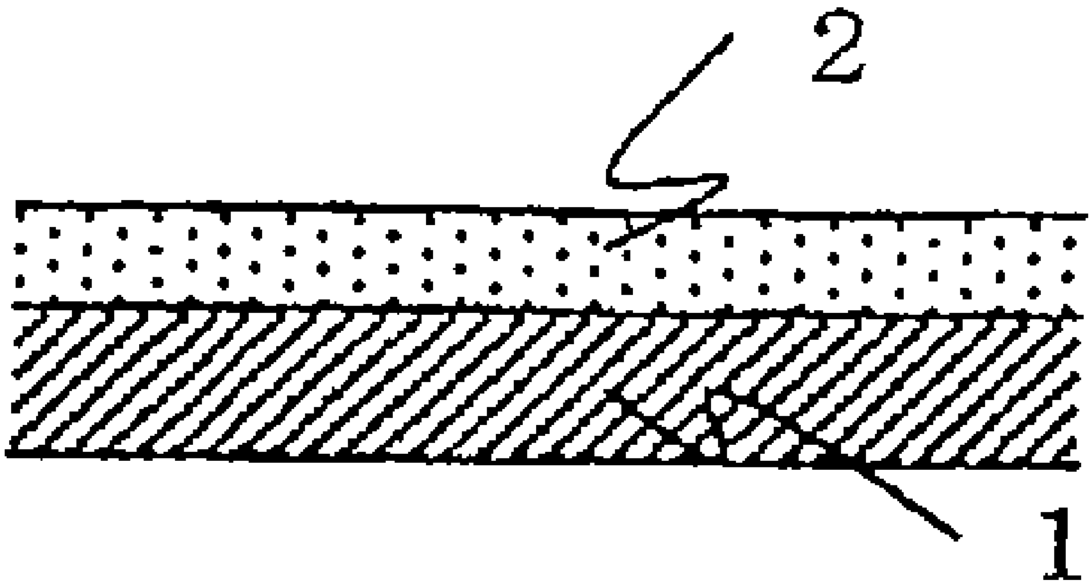
(57) **ABSTRACT**

A polishing sheet, having polishing particles fixed to a base sheet in a single-layer formation by an adhesive agent so as to be mutually separated in the direction of their plane and having cutting edges exposed and arranged to be coplanar, is produced by forming on a provisional base sheet a film of a provisional adhesive agent of a thickness smaller than the average diameter of the polishing particles, dispersing the polishing particles onto the film of the provisional adhesive agent so as to contact the provisional base sheet, pressing the base sheet covered with the adhesive agent onto the polishing particles with the adhesive agent facing towards the polishing particles, hardening the pressed adhesive agent, and removing the provisional base sheet and the film of the provisional adhesive agent. The polishing particles are charged in a same polarity when dispersed.



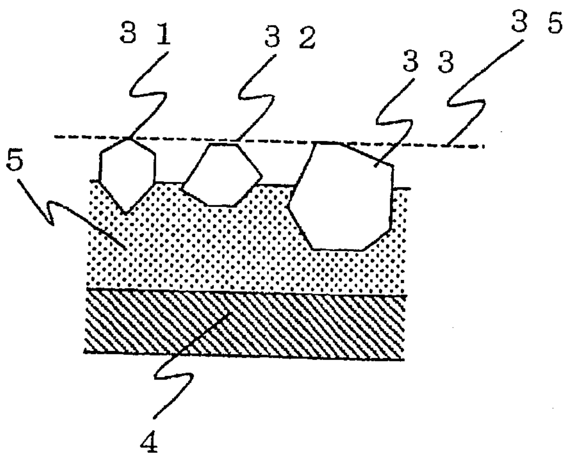


Fig. 1

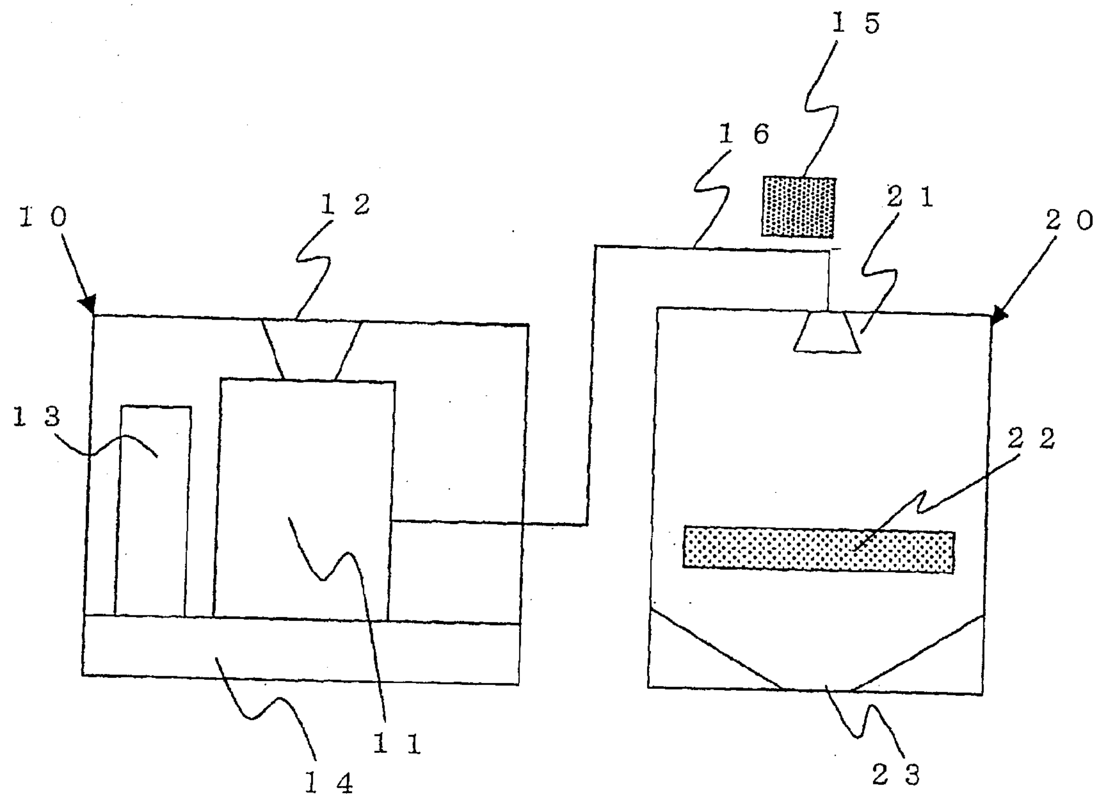


Fig. 3

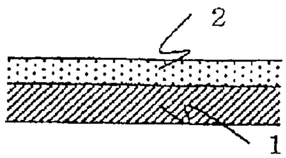


Fig. 2A

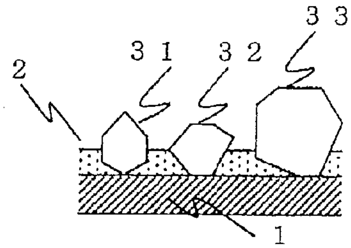


Fig. 2B

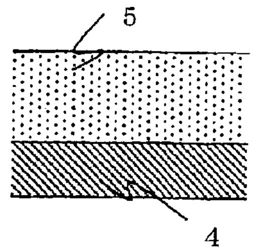


Fig. 2C

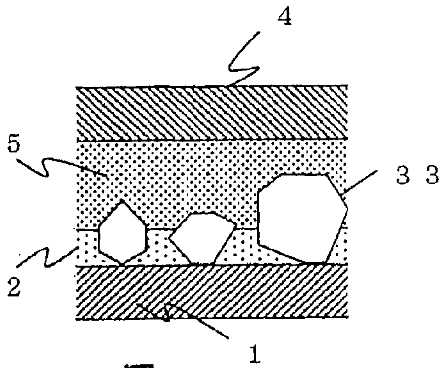


Fig. 2D

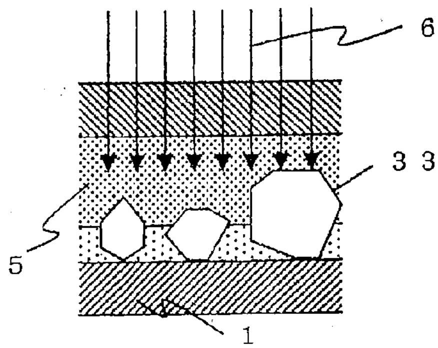


Fig. 2E

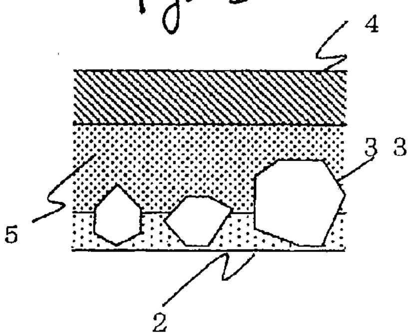


Fig. 2F

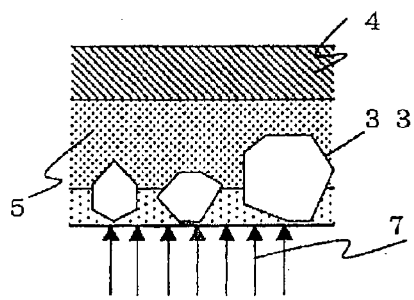


Fig. 2G

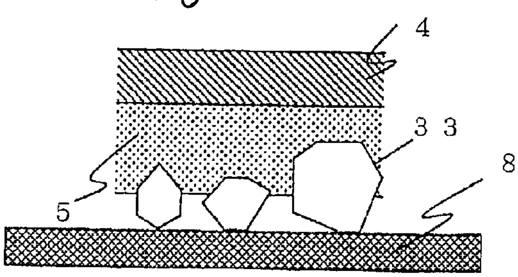


Fig. 2H

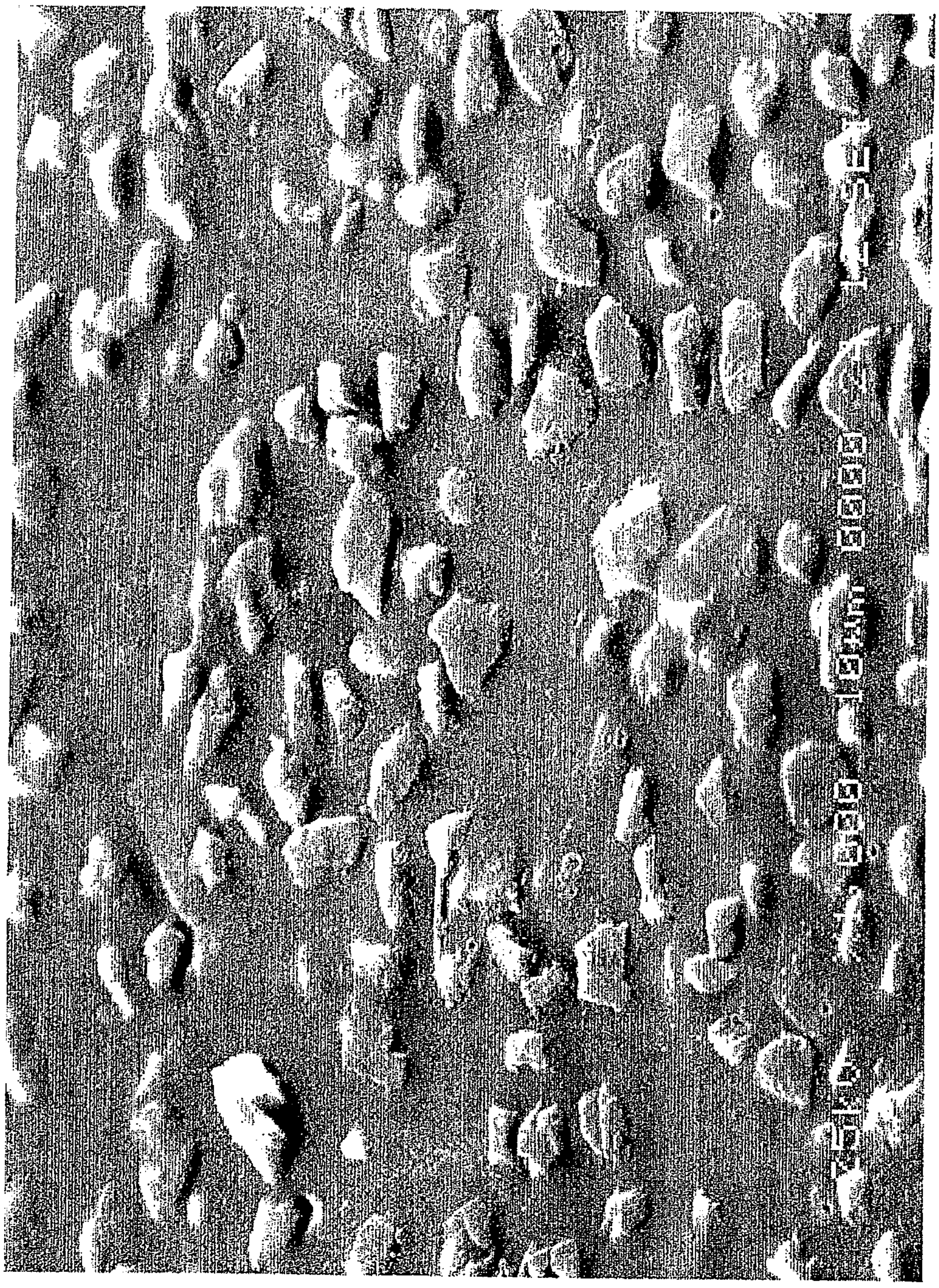


Fig. 4

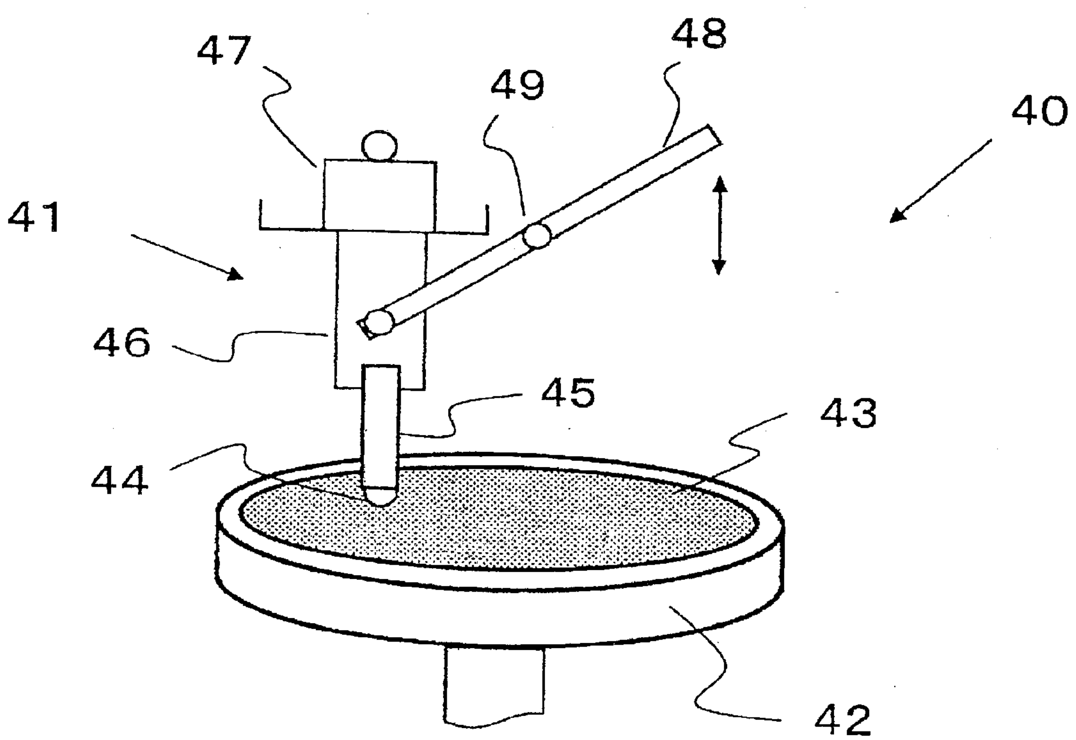


Fig. 5

METHOD OF PRODUCING POLISHING SHEET

TECHNICAL FIELD OF THE INVENTION

[0001] This invention relates to a polishing sheet for smoothly polishing a magnetic disk substrate, a silicon wafer, a glass substrate for a display device, the end surface of optical fibers and the surface of a variety of objects to be polished such as a lens, and more particularly a polishing sheet for polishing a target object to be polished extremely precisely, as well as a method of its production.

TECHNICAL BACKGROUND

[0002] While polishing particles as small as possible are used for polishing the surface of a target object smoothly and flatly, methods of polishing may be roughly classified into the free particle method which is carried out by supplying polishing particles to the target object from outside and the fixed particle method carried out by using a polishing sheet having polishing particles fixed to a substrate. The fixed particle method is widely used because it does not require a large amount of polishing material, unlike the free particle method, and also because polishing sheets of various shapes for having polishing materials affixed to can be realized.

[0003] The substrate for a polishing sheet for use in the fixed particle method is made of a material such as organic resins such as polyethylene terephthalate, woven and unwoven cloths, and fine particles of an inorganic polishing material such as alumina, silica and diamond are fixed on this substrate by means of a binder such as a resin.

[0004] The polishing performance of a polishing sheet varies significantly, depending on the polishing particles themselves, their mixing ratio with the resin, the thickness of fixing, etc. and particularly on the characteristics of the polishing particles. Important factors of the characteristics of polishing particles include their material, size and shape but the manner in which the individual particles are arranged in the layer where the polishing particles are affixed becomes another important factor for having their characteristics fully utilized even after the particles themselves are optimally selected.

[0005] Especially for the purpose of polishing a target object at an extremely high level of precision, arrangements of particles wherein the individual particles are fixed to the substrate in an aggregated form are not desirable. There are many situations in which the particles are not uniformly arranged if they are viewed microscopically. It is likely that aggregations of particles are formed, and the arrangement includes clumps that are scattered around.

[0006] When the polishing particles are thus arranged, the surface roughness of the polishing sheet becomes uneven, and only polishing operations of the kind resulting in scratches on the surface of the target object are possible.

[0007] In view of the above, polishing sheets having the particle diameters of the polishing particles made as uniform as possible for eliminating the generation of such flaws and also having polishing particles fixed in a single layer have been proposed (Patent References 1 and 2). There have been known, for example, polishing sheets with a single-particle layer such as shown in FIG. 2 of Patent Reference 1 and polishing sheets with a single diamond layer such as shown in FIG. 1 of Patent Reference 2.

[0008] It is disclosed in Patent Reference 1 that a single-particle layer can be obtained easily merely by mixing a binder with polishing particles and applying the mixture to a substrate, without explaining any application method requiring any particular inventive details. Patent Reference 2, on the other hand, describes a special method for obtaining a single-particle layer, disclosing a method of fixing polishing particles by electrodeposition inside an electrolyte solution having the polishing particles dispersed therein or by roll-coating a mixture of an organic binder and polishing particles.

[0009] Although polishing tapes having polishing particles in a single-particle layer formation have been disclosed, as explained above, the individual polishing particles in these prior art examples are found to be covered with the binder on the side of the surface contacting the object to be polished, if seen microscopically. By the method disclosed in Patent Reference 1, for example, it can be seen from its FIG. 2 that the surfaces of the polishing particles on the side contacting the object to be polished are covered with the binder indicated by dotted lines since a mixture of the binder and the polishing particles is simply applied. If polishing particles are thus covered with a binder that does not contribute to the polishing, their polishing performance is significantly affected negatively.

[0010] As for Patent Reference 2, although polishing particles are described as if not covered by the binder, the inventors herein discovered by an investigation that the binders remain on the surfaces of the polishing particles if the mixture of the binder and the polishing particles is simply applied.

[0011] Even if a classification process is carried out for making the sizes of the polishing particles uniform, there is a limit to the degree of classification and the polishing particles have a specified size distribution. If polishing particles having a finite size distribution are simply applied, the protruding edge parts of the polishing particles on the side contacting the object to be polished (or the contacting parts with the object to be polished) have different heights and not on a perfectly straight line, if observed microscopically. It is not desirable at the time of polishing to have coexisting together both polishing particles that contact the target object and contribute to the polishing and polishing particles that do not make any contact with the object and do not contribute to the polishing. The edge parts of polishing particles that will contact the object to be polished will be hereinafter referred to as the cutting edges, and if cutting edges are on a straight line, it will be said that the cutting edges are uniform, or even.

[0012] In view of the above, a method of removing the binder attached to the surfaces of the polishing particles after a single-particle layer has been formed has been devised in order to realize a condition of polishing particles fixed in a single-particle layer with the cutting edges of the individual polishing particles not covered with any binder or electrodeposited material that would adversely affect the polishing performance (Patent Reference 3). According to this method, after a mixture of the binder and the polishing particles is applied, this mixture is exposed to ultraviolet light for removing the binder on the particle surfaces such that the surfaces of the single-layer polishing particles become exposed and the adverse effect on the polishing performance will be prevented.

[0013] This method, however, takes a long time for removing the binder from the particle surfaces and hence is not suitable for mass production. Since the ultraviolet light will affect not only the particle surfaces but also the side surfaces of the polishing particles, furthermore, the portions of the binder serving to firmly hold the polishing particles are also lost, making it easier for the polishing particles to drop off.

[0014] There are other methods of forming a single layer with the surfaces of polishing particles exposed, besides those described above (Patent Reference 4). According to a method disclosed in Patent Reference 4, polishing particles are firstly mixed with a first binder with low viscosity into the form of slurry and this slurry is applied to a substrate such that the polishing particles will form a single layer. This is then dried such that the binder will shrink and the surface of each polishing particle will project out from the binder part. Next, these projecting parts are pushed into a second binder with high viscosity such that these projecting parts become covered. As the second binder is dried, each of the polishing particles comes to be held more strongly by the second binder with stronger viscosity than by the first binder with weaker viscosity. As the first binder is peeled off, the polishing particles are still held by the second binder, forming a single layer with their surfaces exposed.

[0015] By this method, however, the first binder is not necessarily peeled off easily from the polishing particles. It is likely that there results a polishing sheet with the first binder still remaining thereon to cover the particle surfaces.

[0016] The polishing means according to Patent Reference 5, on the other hand, has a plurality of polishing composites exposed on the surface of a polishing sheet, distributed at uniform intervals but is less than acceptable because the device itself becomes complicated and there is no guarantee that the front edges of the polishing composites would become arranged evenly.

[0017] Patent Reference 1: Japanese Patent Publication Tokkai 1-234169

[0018] Patent Reference 2: Japanese Patent Publication Tokkai 4-129660

[0019] Patent Reference 3: Japanese Patent Publication Tokkai 2-243271

[0020] Patent Reference 4: Japanese Patent Koho 3314154

[0021] Patent Reference 5: Japanese Patent Publication Tokkai5-253852

DETAILED DESCRIPTION OF THE INVENTION

Problem to be Solved by the Invention

[0022] For forming polishing particles in a single layer and to further obtain a polishing sheet with the surfaces of cutting edges not covered with the binder and completely exposed, as explained above, conventional methods can provide a single-particle layer but allow polishing debris to remain on the surfaces of the cutting edges. Conventional methods for removing remaining polishing debris are less than perfect in the debris-removing performance and are not suited for mass production.

[0023] If the cutting edges are not evenly arranged, the natural polishing capability of polishing particles cannot be fully realized. On polishing sheets produced by a conventional method, furthermore, neighboring polishing particles are frequently in mutual contact as seen in the direction of their plane. As a mechanism for generating polishing flaws which are problematical in a polishing operation, it is known that remaining polishing debris can be one of the causes. In order to eliminate polishing flaws due to such a mechanism, it is necessary to efficiently discharge such polishing debris. Since a polishing operation is usually carried out by applying a load on the target object to be polished or on the polishing sheet, the target object and the polishing sheet are in a tight contact with each other, making it difficult for the polishing debris to be discharged. In the case of conventional examples with neighboring polishing particles mutually contacting as seen in the direction of their plane, the discharge of polishing debris becomes even more difficult.

[0024] It is therefore an object of this invention to provide a polishing sheet (1) having exposed cutting edges of polishing particles, (2) having even cutting edges and (3) capable of efficiently discharging debris of polishing.

Means for Solving the Problem

[0025] In view of the object described above, the present invention provides a polishing sheet comprising polishing particles fixed to a base sheet in a single-layer formation by an adhesive agent, parts of the polishing particles contacting a target object to be polished and being exposed from the adhesive material and edge parts of the polishing particles being mutually separated and arranged to be coplanar.

[0026] The invention further provides a method of producing a polishing sheet comprising polishing particles fixed to a base sheet in a single-layer formation by an adhesive agent, parts of the polishing particles contacting an object to be polished and being exposed from the adhesive material and edge parts of the polishing particles being arranged to be coplanar, the method comprising a first step of forming on a provisional base sheet a film of a provisional adhesive agent of a thickness smaller than the average diameter of the polishing particles, a second step of dispersing the polishing particles onto the film of the provisional adhesive agent so as to contact the provisional base sheet, a third step of pressing the base sheet covered with the adhesive agent onto the polishing particles with the adhesive agent facing towards the polishing particles, a fourth step of hardening the pressed adhesive agent, and a fifth step of peeling off the provisional base sheet and further removing the film of the provisional adhesive agent after the adhesive agent hardens.

[0027] According to this invention, a water-soluble or organic acid water-soluble film is formed on the surface of the provisional base sheet to a thickness of 1/10 or more and 2/3 of less of the average diameter of the polishing particles, these polishing particles are charged negatively or positively in a same polarity, the container of the dispersion device for dispersing the polishing particles is also charged in the same polarity, the base sheet is maintained at the ground potential as the polishing particles are dispersed onto this water-soluble or organic acid water-soluble film such that the edges of these polishing particles will contact the provisional base sheet, a resin for fixing the polishing particles is pressed against the polishing particles from the side opposite from the provisional base sheet, and the provisional base sheet is peeled off and this film is removed after this resin is hardened. By this novel method, it is possible to obtain a polishing tape with a superior polishing performance.

[0028] According to the method of this invention, a provisional base sheet for fixing the polishing particles is firstly prepared and this is coated with a water-soluble or organic acid water-soluble thin film. Next, the polishing particles are dispersed onto this water-soluble or organic acid water-soluble film. The polishing particles are electrostatically charged negatively or positively in the same polarity, and the provisional base plate is electrically maintained at the ground potential as the polishing particles are dispersed.

[0029] Since the inner wall of the device for carrying out the electrostatic dispersion is also charged in the same polarity as the polishing particles at this time, the polishing particles can be dispersed efficiently over the base sheet without becoming adhered to the inner walls of the container. The polishing particles are buried into the water-soluble or organic acid water-soluble film so as to contact the provisional base plate as the thickness of the water-soluble or organic acid water-soluble film and the potential difference between the potential for the electrostatic charging and the ground potential are properly selected, portions of the polishing particles on the opposite side from the provisional base sheet projecting from the water-soluble or organic acid water-soluble film.

[0030] Next, an adhesive agent such as a resin is applied so as to cover the projected portions of the polishing particles. This adhesive agent is hardened so as to strongly secure the polishing particles. Next, the provisional base sheet is peeled off and the water-soluble or organic acid water-soluble film is finally dissolved in water or an acid such that an ideal sheet is obtained with the polishing particles mutually separated in the direction of their plane and the cutting edges arranged uniformly. In what follows, this novel technology and the product that can be produced thereby will be described in detail.

EFFECTS OF THE INVENTION

[0031] The present invention provides a polishing sheet capable of efficiently polishing a target object with a good surface roughness without generating polishing flaws.

[0032] The present invention makes it possible in particular to obtain polishing sheet having polishing particles mutually separated as seen in the direction of their plane by using a water-soluble or organic acid water-soluble material as the provisional adhesive agent, charging the polishing particles at the same time in a same polarity and maintaining the base sheet at the ground potential. Moreover, the cutting edges are completely exposed and arranged uniformly such that a superior polishing capability is exhibited as a polishing sheet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] FIG. **1** is a partially sectional view of a polishing sheet embodying this invention.

[0034] FIGS. **2**A, **2**B, **2**C, **2**D, **2**E, **2**F, **2**G and **2**H are schematic drawings for explaining the production process of a polishing sheet according to this invention.

[0035] FIG. **3** is a schematic drawing for showing the structure of a dispersing device for dispersing polishing particles electrostatically according to this invention.

[0036] FIG. **4** is a photographic image showing the distribution of polishing particles after they are dispersed according to this invention.

[0037] FIG. **5** is a schematic diagonal view of a test piece fabrication device using a polishing sheet of this invention.

BEST EMBODIMENT OF THE INVENTION

[0038] A preferred embodiment of this invention is described next with reference to the drawings.

[0039] FIG. **1** is a partially sectional view of a polishing sheet embodying this invention, FIGS. **2**A through **2**H are schematic drawings for explaining the production process of a polishing sheet according to this invention, FIG. **3** is a schematic drawing for showing the structure of a dispersing device for dispersing polishing particles electrostatically according to this invention, FIG. **4** is a photographic image showing the distribution of polishing particles after they are dispersed according to this invention, and FIG. **5** is a schematic diagonal view of a test piece fabrication device using a polishing sheet of this invention.

[0040] As shown in FIG. **1**, a polishing sheet of this invention has a layer of adhesive resin **5** tightly adhering to one of the surfaces of a base sheet **4**, which is a base material in the form of a film, and firmly fixing polishing particles **31**-**33**.

[0041] Examples of the material for the base sheet **4** include polyester resins such as polyethylene terephthalate and polyethylene naphthalate, polyolefin resins such as polyethylene and polypropylene, polystyrene, vinyl chloride, polyvinyl alcohol, acryl resins having methacryl alcohol as principal component, and polycarbonates.

[0042] The polishing particles **31**-**33** are formed in a single-particle layer without forming aggregations, each having on the opposite side from the base sheet **4** a cutting edge which contacts an imaginary line **35**. In other words, the cutting edges are in a completely uniform condition and not covered by anything that may adversely affect the polishing performance. Moreover, these polishing particles **31**-**33** are fixed such that mutually adjacent ones of them are not tightly in contact with each other but are separated from each other. Thus, the cutting edges of all polishing particles for contacting a target object to be polished are not only arranged to be coplanar but are separated one from another.

[0043] The adhesive resin **5** is selected for its adhesive characteristic to the base sheet **4** from a wide range of materials such that any commonly used kind may be used. Moreover, it is preferable to use a UV resin for the purpose of its hardening.

[0044] FIGS. **2**A-**2**H show schematically the production process of a polishing sheet according to this invention.

[0045] FIG. **2**H is a schematic view of a polishing sheet as finally produced as a product, comprising a base sheet **4**, polishing particles **31**-**33** and an adhesive resin **5** for securely fixing the polishing particles **31**-**33**. The cutting edges of the polishing particles **31**-**33** contact a target object **8** to be polished.

[0046] Such a polishing sheet is produced by going through steps shown in FIGS. **2**A through **2**G. Firstly, a provisional base sheet **1** is prepared. Materials of various kinds such as polymer, Si wafer and metals may be used for the provisional base sheet **1**. Although there is no strict limit on the material itself to be used, it is necessary to make its surface smooth. The degree of smoothness depends on the size of the polishing particles to be used but if the average diameter of the polishing particles is 20 microns, the average surface roughness may be about 1 micron or less and if the average diameter of the polishing particles is 5 microns, the smoothness may be 0.5 micron or less.

[0047] Next, a thin film **2** of a provisional adhesive agent (also hereinafter referred to simply as "the film") which is water-soluble or soluble in an organic acid, having the function of provisionally adhering onto the provisional base sheet **1**, is applied to the provisional base sheet **1**. Polysaccharides, pastes, starches, gelatins, etc. may be used as the water-soluble film material. More specifically, polysaccharides such as glycogen, cellulose, dextran and dextrine, water-soluble polymers (pastes) such as polyvinyl alcohol, acryl polymers and polyethylene oxides, starches generated from plants such as corns and potatoes, and gelatins comprising animal protein may be mentioned.

[0048] Those materials not easily soluble in water but soluble in solutions having an organic acid added to them are also useful. Use may be made, for example, of chitin and poly-β1,4-glucosamine(chitosan) obtained by removing acetyl group from chitin. Chitosan, in particular, is soluble in vinegar and it is suitable for the purpose of the present invention since it has no problem also from the point of view of safety.

[0049] Any known method may be used for applying such film **2** of a provisional adhesive agent soluble in water or organic acid water, but the spray coating and roll coating methods are generally known methods. The thickness of this film **2** is controlled by the concentration of the liquid, the application temperature and the application speed. It is preferable to adjust the thickness to 1/10-2/3 of the average diameter of the polishing particles.

[0050] Next, polishing particles **31-33** are buried into the water-soluble or organic acid water-soluble film **2**, as shown in FIG. **2**B. The material for the polishing particles may be selected according to the relationship between the target object to be polished and the polishing performance of the polishing particles. Inorganic particles of alumina, silica, diamond, boron nitride and silicon carbide and organic particles of cross-linked acryl resins, cross-linked polystyrene resins and melamine resins may be used.

[0051] For burying the polishing particles into the water-soluble or organic acid water-soluble film **2** as a single-particle layer, the electrostatic dispersion method of electrostatically charging the polishing particles and holding the base sheet **1** at the ground potential may be used. The electrostatic dispersion method is carried out by using a device shown in FIG. **3**.

[0052] FIG. **3** is a plan view of the dispersion device for the electrostatic dispersion of the polishing particles, comprising a supply unit **10** and a dispersing unit **20**. Polishing particles are supplied into an adjustment chamber **11** from a supply hopper **12** and then charged positively or negatively in a single polarity inside a pressure-transporting pipe **16**. The polarity into which the polishing particles are to be charged depends on the material of the polishing particles. If the polishing particles are diamond, for example, they are charged negatively. If they are alumina, a positive potential is selected.

[0053] The level of charging of the polishing particles is detected by a charge sensor **15** and the quantity of particle supply is controlled by the supply control box **13** such that the level of charging will take upon a suitable value. The polishing particles with the supply quantity thus controlled are dispersed towards a substrate stage **22** from the dispersion nozzle **21** through the pressure-transporting pipe **16**. Since the inner walls of the container of the dispersion device are charged in the same polarity as the polishing particles, the polishing particles are subjected to a repulsive force from the inner walls and hence efficiently reach the provisional base sheet **1** without becoming attached to the inner walls of the container.

[0054] Methods of preventing pressure loss inside the pressure-transporting pipe for accelerating friction with the inner walls of the pressure-transporting pipe include (a) providing the interior of the pressure-transporting pipe with the function of supplying a supplementary gas (dry air, nitrogen gas, etc.), (b) providing a negative pressure inside the pressure-transporting pipe, and (c) adding a plurality of branches to the pressure-transporting pipe for increasing the friction efficiency.

[0055] The charged particles led to the dispersion nozzle **21** of the dispersion chamber **20** are blown onto the substrate **23** together with a compressed gas discharged through gas nozzles provided around the dispersion nozzle **21**. Dry air and nitrogen gas from an ordinary high-pressure container may be used as the compressed gas.

[0056] The provisional base sheet **1** with the water-soluble or organic acid water-soluble film **2** applied thereto is set on the substrate stage **22** and is maintained at a ground potential. The polishing particles dispersed from the dispersion nozzle **21** are charged by a potential of the same polarity at 1-50 kV. For this reason, the individual polishing particles remain as individual particles as they fly onto the water-soluble or organic acid water-soluble film **2** on the provisional base sheet **1** under the influence of the repulsive electrostatic force so as to be released from their aggregated condition. Since the inner walls of the electrostatic dispersion chamber **20** are also maintained at a potential of the same polarity as the polishing particles, the polishing particles dispersed from the dispersion nozzle **21** fly onto the water-soluble or organic acid water-soluble film **2** without becoming attached to the inner walls of the dispersion chamber **20**, resulting in a high yield.

[0057] What is important here is that the provisional base sheet **1** and the water-soluble or organic acid water-soluble film **2** are maintained at the ground potential. The polishing particles, maintained at a same priority, are strongly attracted electrostatically by and fly towards the water-soluble or organic acid water-soluble film **2** maintained at the ground potential and collide with it with large kinetic energy.

[0058] Since the water-soluble or organic acid water-soluble film **2** is soft, the polishing particles having large kinetic energy become easily buried inside the water-soluble or organic acid water-soluble film **2**, their front edges contacting the provisional base sheet **1** and coming to be uniformly arranged, as shown in FIG. **2**B.

[0059] Potential of 1 kV or more will be sufficient for achieving this effect. The same effect may be had with a potential in excess of 50 kV but since it becomes difficult to design a device as a practical matter, the present invention limits this potential to be within the range of 1-50 kV.

[0060] As compared to this method of this invention for dispersing polishing particles, conventional methods cannot provide a strong attractive force on polishing particles towards the provisional base sheet onto which the polishing particles are to become provisionally attached. If the polishing particles are merely dropped by the gravitational force, they merely become attached to the provisional adhesive agent without passing through this provisional adhesive agent to reach the provisional base sheet.

[0061] Since the polishing particles are charged in the same polarity, furthermore, they repel one another when they reach the water-soluble or organic acid water-soluble film **2** and do not newly form aggregations. Thus, they become temporarily fixed as a single-particle layer inside the film **2** of the provisional adhesive agent.

[0062] Moreover, since the polishing particles which have reached the water-soluble or organic acid water-soluble film **2** become temporarily fixed while remaining charged in the same polarity, they become fixed while remaining separated as seen in the direction of their plane. Thus, a polishing sheet with the polishing particles separated at effective distances among themselves for efficient discharge can be obtained.

[0063] In summary, a polishing sheet as shown in FIG. **2**H can finally be obtained with cutting edges arranged uniformly and the polishing particles separated in the direction of their plane in a single-particle layer formation because the electrostatic dispersion is carried out onto the water-soluble or organic acid water-soluble film **2**.

[0064] The thickness of the water-soluble or organic acid water-soluble film **2** is determined according to the size of the polishing particles, preferably being 1/10-2/3 of the average diameter of the polishing particles. The reason for this preference is, as shown in FIG. **2**D, such that 9/10-1/3 of the polishing parties would be covered by the adhesive resin **5** in the following step.

[0065] In order to make the size distribution of polishing particles small for the convenience of producing a single-particle layer, polishing particles conventionally used to be classified by having both very large and very small particles eliminated. Thus, polishing particles of the selected class were relatively expensive. According to the present invention, large particles merely stick out more from the water-soluble or organic acid water-soluble film and the portions that stick out are eventually covered by the adhesive resin **5** and hence present no problem. Very small particles will become buried inside the water-soluble or organic acid water-soluble film **2** and will have no cutting edges appearing and hence may be eliminated but if it is only small particles that are to be eliminated in a classification process, it is cost-wise still advantageous compared to the conventional method of eliminating both large and small particles.

[0066] Aside from the electrostatic dispersion process for the polishing particles, a base sheet **4** coated with an adhesive resin **5** as shown in FIG. **2**C is prepared. This is the base sheet **4** that will remain in the final product and may comprise polyester resins such as polyethylene terephthalate and polyethylene naphthalate, polyolefin resins such as polyethylene and polypropylene, polystyrene, vinyl chloride, polyvinyl alcohol, acryl resins having methacryl alcohol as principal component, and polycarbonates.

[0067] There is no particular limitation on the thickness of the base sheet **4** but it is preferably within the range of 5 microns or more and 100 microns less, and more preferably within the range of 10 microns or more and 75 microns or less. The base sheet **4** is coated with an adhesive resin **5**, which serves to fix the polishing particles in the final product.

[0068] A resin of the common UV-setting type of the thermosetting type may be used as the adhesive resin **5**. UV-setting resins are particularly preferable because they are easy to process, as will be described below.

[0069] The base sheet **4** prepared as shown in FIG. **2**C is pressed by a process such as the calendar roll such that its adhesive resin **5** will contact the polishing particles **31-33**. By this operation, the projecting parts of the polishing particles **31-33** not contacting the water-soluble or organic acid water-soluble film **2** become buried inside the adhesive resin **5** and will become firmly fixed after a hardening operation.

[0070] Next, the hardening of the adhesive resin **5** will be explained. FIG. **2**E shows an example wherein the base sheet **4** comprises polyethylene terephthalate which is transmissive to UV light **6** being irradiated from the back surface to complete the hardening of the adhesive UV-setting resin **5**. In the case of an adhesive resin not transmissive to UV light, a specified process of heating and drying may be carried out to obtain the same result.

[0071] Since the water-soluble or organic acid water-soluble film **2** does not become hardened in this process for hardening the adhesive resin **5**, the peeling of the provisional base sheet **1** and the removal of the water-soluble or organic acid water-soluble film **2** in the next step can be carried out easily. If an epoxy-type thermosetting resin with a strong adhesive characteristic is used instead of the water-soluble or organic acid water-soluble film **2**, such thermosetting resin will also become hardened when the adhesive resin **5** is hardened such that the peeling of the adhesive resin **5** and the provisional base sheet **1** becomes difficult, the cutting edges of the polishing particles remaining covered by this thermosetting resin and failing to become exposed. It should now be understood that it is an important novel point of this invention to use water-soluble or organic acid water-soluble material for the film **2** of the provisional adhesive agent.

[0072] After the process of hardening the adhesive resin **5** is completed, the provisional base sheet **1** is peeled off and water or a liquid organic acid is sprayed on the water-soluble or organic acid water-soluble film **2**. In the case of a film **2** comprising chitin or chitosan, the film **2** can be easily removed by spraying vinegar. In the case of a film **2** comprising polysaccharide, paste or starch, the film **2** can be removed by a spray of water to expose the cutting edges. The polishing sheet thus obtained comprises a single-particle layer with cutting edges arranged uniformly, having no aggregates as shown in FIG. **2**H. Since the uniformly arranged cutting edges contact the target object **8** to be polished, the target object **8** can be polished efficiently without leaving flaws. The invention is explained next by way of test examples.

Test Examples

(1) Preparation of Polishing Particles

[0073] Diamond particles of average diameter 10 microns were used and small particles of less than about 2 microns were removed by a classifying device of the cyclone type. Many aggregations were observed after the classification by a microscopic inspection but they were directly used as polishing particles.

(2) Preparation of Provisional Base Sheet

[0074] A polyethylene terephthalate film with thickness of 50 microns and having good smoothness was used as the provisional base sheet. As measured preliminarily by a surface roughness meter with a probe, its average surface roughness Ra was 0.4 microns. In order to form films of provisional adhesive agents on this film, a chitosan solution, a 10% aqueous solution of polyvinyl alcohol with degree of polymerization about 200 and a solution obtained by dissolving in water corn starch which is a kind of starch were individually applied to obtain three kinds. Applications were effected by the spray method and their thickness was adjusted within the range of 3-5 micros by compiling the conditions of application and the thickness data measured by a load meter of the push-in type.

(3) Dispersion of Polishing Particles

[0075] The diamond polishing particles classified as described above were electrostatically dispersed. The diameter of the dispersion nozzle was adjusted to 5 mm and each emission was for 5 seconds with a carrier gas at 3 kg/cm^2, and such emission was repeated 10 times. The charging potential was 5 kV.

(4) Preparation and Compression of Base Sheet and Hardening

[0076] Epoxy-type UV resin was applied as adhesive resin to the polyethylene terephthalate base sheet with thickness of 75 microns. Although there was no strict limitation on the thickness of application, a range of about 10-15 microns was selected. This base sheet was positioned such that the UV adhesive resin would contact the polishing particles which had been electrostatically dispersed to the film of the provisional adhesive agent and pressed. UV light beams at intervals of 100 mm between them were thereafter projected from the side of the polyethylene terephthalate base sheet to completely harden the UV resin serving as the adhesive resin.

(5) Removal of Provisional Base Sheet and Provisional Adhesive Agent

[0077] The provisional base sheet was peeled off after the irradiation of the UV light. The peeling was possible by using a pair of pincers. Since remainders of the provisional adhesive agent were visible on its surface after the peeling, they were dissolved in water or an acid. When the provisional adhesive agent was chitosan, commercially available vinegar was sprayed for 20 minutes. In the case of a 10% aqueous solution of polyvinyl alcohol with degree of polarization **200**, water heated to about 60° C. was sprayed. In the case of a corn starch liquid, the removal of the provisional adhesive agent was completed to the extent that the remainder of the provisional adhesive agent was no longer visible after tap water at room temperature was sprayed for 5 minutes.

(6) Method of Evaluation

[0078] The condition of attachment of the polishing particles after the series of processes described above was observed microscopically. FIG. **4** is a microscopic photograph of the condition of the aforementioned diamond polishing particles having been dispersed by the electrostatic dispersion method described above into a film of 10% aqueous solution of polyvinyl alcohol. The portions appearing white in the photograph are the polishing particles. As can be seen, no aggregations of the individual polishing particles are visible and it can be understood that the polishing particles are formed in a single-particle layer formation. Moreover, these diamond polishing are separated as seen in the direction of their plane so as to be in a condition useful for the discharge of polishing debris.

[0079] A test for polishing performance was carried out as a bearing ball fabrication test by comparing the stock removal over a specified length of time, the central line surface roughness (Ra) and the maximum surface roughness (Rmax).

[0080] A performance test for the polishing tape was carried out by using steel balls serving as ball bearing (SUJ-2) with diameter 4 mm as test pieces and by polishing them with a ball bearing fabrication tester **40**, as shown in FIG. **5**.

[0081] This fabrication tester **40** is adapted to have a polishing sheet **43** of this invention attached to a rotatable lapping plate **42**, to fix a steel ball **44** as described above as a test piece to a jig **45** and to have a specified load **47** from above onto a polishing head **42** provided to a principal shaft **46**.

[0082] The fabrication test was carried out by rotating the lapping plate **42**, causing the polishing head **41** with the steel ball **44** fixed thereto to contact the surface of the polishing sheet **43** pasted onto the lapping plate **42** at a specified load and to move a specified distance from a central position to an outer peripheral position on the lapping plate **42** at a specified speed. The fabrication process is started and ended automatically by moving up and down an arm **48** supported around a supporting point **49**. After the fabrication process is completed, the steel ball **44** is removed from the jig **45**, the steel ball **44** is weighed and the change (or the reduction) in its weight serves as the polished quantity. Five different steel balls were used for the test and the average value from them was used for the evaluation.

[0083] The conditions of the test were as follows.

[0084] (6-1) Load: 500 g

[0085] (6-2) Diameter of the lapping plate: 8 inches

[0086] (6-3) Rotary speed of the lapping plate: 300 rpm

[0087] (6-4) Distance of motion from the central position to the peripheral position: 100 mm

[0088] (6-5) Polishing time: 12 seconds

[0089] The average surface roughness Ra and the maximum surface roughness Rmax of the polished steel balls were measured by a surface roughness meter (SURFCON 480A produced by Tokyo Seimitsu Kabushiki Kaisha).

Comparison Example

[0090] The same UV resin as used in Test Examples was applied as Comparison Example onto a polyethylene terephthalate film with thickness 50 microns and diamond polishing particles with average diameter of 10 microns were further dispersed onto it directly. The dispersion was carried out by causing these polishing particles to be emitted from a small opening at an air pressure of 1 kg/mm^2 to cause them to fall freely. The UV resin was thereafter hardened under the same conditions as used for Test Examples to obtain a polishing sheet.

(7) Results of Evaluation

[0091] Table 1 shows the results of evaluation of Test and Comparison Examples.

TABLE 1

	Average surface roughness (Ra) (μm)	Maximum surface roughness (Rmax) (μm)	Stock removal (mg/min)
Test Example Chitosan	0.019	0.119	9.84
Test Example Polyvinyl alcohol	0.021	0.135	9.60
Test Example Corn starch	0.023	0.128	9.32
Comparison Example	0.296	0.210	8.64

[0092] Although many generated defects were observed in the case of Comparison Example, only one or two shallow flaws were observable on Test Examples. It may therefore be concluded that the polishing sheets according to Test Examples do not generate polishing flaws and are useful, capable of efficiently carrying out polishing for obtaining good surface roughness. Especially if a water-soluble or organic acid water-soluble material is used as the provisional adhesive agent to charge polishing particles at the same time in a same polarity and the base sheet is maintained at the ground potential, a polishing sheet can be obtained with the polishing particles separated mutually as seen in the direction of their plane. Moreover, their cutting edges are completely exposed and arranged uniformly such that the polishing sheet can exhibit extremely superior performance characteristics.

EXPLANATION OF SYMBOLS

[0093] **1**: Provisional base sheet
[0094] **2**: Film of a provisional adhesive agent (Film)
[0095] **4**: Base sheet
[0096] **5**: Adhesive resin
[0097] **6**: UV light
[0098] **8**: Target object to be polished

1. A polishing sheet comprising a base sheet and polishing particles fixed to the base sheet in a single-layer formation by an adhesive agent, edge parts of said polishing particles being arranged to be coplanar and being distributed separatedly.

2. A method of producing a polishing sheet characterized as having polishing particles fixed to a base sheet in a single-layer formation by an adhesive agent, edge parts of said polishing particles being arranged to be coplanar and being distributed separatedly, said method comprising:

- a first step of forming on a provisional base sheet a film of a provisional adhesive agent with thickness less than the average particle diameter of the polishing particles;
- a second step of distributing the polishing particles on the film of provisional adhesive agent so as to contact the provisional base sheet;
- a third step of pressing a base sheet covered with an adhesive agent such that said adhesive agent faces the polishing particles;
- a fourth step of hardening the adhesive agent that has been compressed; and
- a fifth step of peeling off said provisional base sheet after said adhesive agent has been hardened and further removing said film of provisional adhesive agent.

3. The method of producing a polishing sheet described in claim **2** characterized wherein the thickness of said provisional adhesive agent is 1/10 or more and 2/3 of less of the average diameter of said polishing particles.

4. The method of producing a polishing sheet described in claim **2** or **3** characterized wherein the polishing particles are charged in a same polarity.

5. The method of producing a polishing sheet described in claim **4** characterized wherein the polishing particles charged in said same polarity are dispersed onto aid film of said provisional adhesive agent on said provisional base sheet while maintaining said provisional base sheet at a ground potential such that said polishing particles are mutually separated and come into contact with said provisional base sheet.

6. The method of producing a polishing sheet described in claim **5** characterized wherein the polishing particles are charged in the same polarity at a charging potential of 1-50 kV.

7. The method of producing a polishing sheet described in any of claims **2**-**6** characterized wherein the film of said provisional adhesive agent formed on the provisional base sheet comprises a water-soluble or organic acid water-soluble film.

8. The method of producing a polishing sheet described in any of claim **7** characterized wherein the water-soluble or organic acid water-soluble film comprises polysaccharides, pastes, starches, chitin or chitosan.

9. The method of producing a polishing sheet described in any of claim **8** characterized wherein the water-soluble film comprises glycogen, cellulose, dextran, dextrine, polyvinyl alcohol, or starches generated from plants.

10. The method of producing a polishing sheet described in any of claims **4**-**6** further comprising the step of maintaining an inner wall of a dispersion device for dispersing said polishing particles charged in said same polarity onto said film of said provisional adhesive agent on said provisional base sheet in the same polarity as the polarity of said polishing particles.

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