

DESCRIPTION

POLISHING HEAD AND POLISHING APPARATUS

TECHNICAL FIELD

[0001]

The present invention relates to a polishing head configured to hold a workpiece at the time of polishing a front surface of a workpiece and a polishing apparatus including the polishing head, and more particularly to a polishing head configured to hold a workpiece on a rubber film, and a polishing apparatus including this polishing head.

BACKGROUND ART

[0002]

In recent years, higher integration of semiconductor devices place demand for higher flatness of semiconductor wafers used in such devices. The higher flatness up to near the edge of wafers is also needed to raise the yield of semiconductor chips.

The shape of finished semiconductor wafers depends on a final mirror polishing process. For a 300-mm-diameter silicon wafer, in particular, primary polishing by double-side polishing is performed to meet strict specifications of the flatness, and then secondary polishing and finish polishing by single-side polishing is performed to remove scratches on the surface or to improve surface roughness.

[0003]

The secondary and finish polishing by single-side polishing is needed to maintain or improve flatness obtained by the primary polishing by double-side polishing and to finish the front surface of a wafer into a perfect mirror-surface with no defects, such as scratches.

As shown in FIG. 10, a common single-side polishing

apparatus includes a turn table 103 on which a polishing pad 102 is attached, a polishing-agent-supply mechanism 104, a polishing head 101, for example. Such a polishing apparatus 110 holds a workpiece W with the polishing head 101, supplies a polishing agent 105 from the polishing-agent-supply mechanism 104 onto the polishing pad 102, rotates both the turn table 103 and the polishing head 101, and polishes the workpiece W by bringing a front surface of the workpiece into sliding contact with the polishing pad 102.

[0004]

Examples of a method of holding a workpiece with a polishing head include attaching the workpiece to a flat workpiece-holding board through an adhesive such as wax, and using a polishing head 121 of a waxless type, shown in FIG. 11, that holds a workpiece W with a workpiece-holding board 112 through a commercially available template assembly 113 having a template 113b, for preventing the workpiece from coming off, attached to an elastic film 113a called a backing film.

[0005]

Examples of the polishing head of a waxless type also include a polishing head 131, shown in FIG. 12, that includes a backing film 113a attached on a workpiece-holding board 112, instead of the commercially available template, and an annular guide ring 113b, for preventing a workpiece from coming off, provided around the side surface of the workpiece-holding board.

Although, the workpiece holding board 112 is commonly composed of a highly-flat ceramic plate, this polishing head unfortunately has a problem in that variation in thickness of the backing film 113a produces a small pressure distribution, resulting in waviness of the polished front surface of the workpiece and hence lower flatness of the workpiece.

[0006]

Accordingly, there is also disclosed a polishing head by

a rubber chuck method having a rubber film for holding a workpiece in place of the workpiece-holding board, in which the workpiece is pressed against a polishing pad by supplying pressurized fluid, such as air, to the back surface of a rubber film to inflate the rubber film with an uniform pressure (see Patent Document 1, for example).

[0007]

FIG. 13 schematically illustrates an example of a configuration of the polishing head by the rubber chuck method. The polishing head 141 is mainly constituted of an annular rigid ring 144, made of e.g., SUS, a rubber film 143 attached to the rigid ring 144, and a back plate 145 connected to the rigid ring 144. The rigid ring 144, the rubber film 143, and the back plate 145 define a sealed space 146. On a lower surface portion of the rubber film 143, a backing film 148 is attached, and an annular template 147 is provided concentrically with the rigid ring 144. The pressure in the space 146 is adjusted by supplying a pressurized fluid to the center of the back plate 145 with a pressure-adjusting mechanism 150. The back plate 145 is connected to a polishing head upper portion 149 having a pressing means (not illustrated) for pressing the back plate 145 toward the polishing pad.

CITATION LIST

PATENT LITERATURE

[0008]

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SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0009]

Such a polishing head by the rubber chuck method prevents

the small pressure distribution due to the variation in thickness of the backing film, and hence the waviness of the polished front surface of the workpiece. Since the template has an inner diameter larger than an outer diameter of the workpiece, there is disadvantageously a small gap between the template and the workpiece. At this gap between the template and the workpiece, the rubber film inflates largely, when a pressurized fluid is supplied into the space with the pressure-adjusting mechanism to adjust the pressure. This inflation increases the pressure at an outer peripheral portion of the workpiece. As a result, this outer peripheral portion tends to be polished excessively and thereby to produce an outer peripheral sag.

[0010]

Adjusting the thickness of the template allows the pressure at the outer peripheral portion of the workpiece to be adjusted to some extent, but variation in thickness of the template varies a polishing stock removal of the outer peripheral portion; consequently, the flatness cannot be kept stable.

In final polishing of the workpiece, the template is preferably kept from contacting the polishing pad, because an extraneous substance, separated from the template when the template contacts a polishing pad for final polishing, creates a defect on the front surface of a workpiece.

[0011]

A polishing head, configured to have a thickness thinner than that of a workpiece to avoid contact with a polishing pad, on the other hand, increases the pressure at the outer peripheral portion of the workpiece, thereby polishing the outer peripheral portion excessively to produce the outer peripheral sag and hence to lower the flatness of the workpiece. Thus, this polishing head cannot be used for final polishing.

[0012]

In view of the above-described problems, it is an object

of the present invention to provide a polishing head and a polishing apparatus that can be used for final polishing of the workpiece and polish the entire front surface of the workpiece uniformly regardless of the thickness of the template: more specifically a polishing head and a polishing apparatus, configured to hold a back surface of a workpiece on a rubber film and to hold an edge portion of the workpiece by a template, that can polish the workpiece uniformly up to the outer peripheral portion of the workpiece without creating surface defects, such as scratches, on the front surface of the workpiece, with the template configured to have a thickness thinner than that of the workpiece to avoid contact with a polishing pad.

SOLUTION TO PROBLEM

[0013]

To achieve the problem, the present invention provides a polishing head comprising an annular rigid ring; a rubber film attached to the rigid ring with a uniform tensile force; a back plate connected to the rigid ring, the back plate defining a space together with the rubber film, and the rigid ring; and an annular template configured to hold an edge portion of a workpiece, the template being provided concentrically with the rigid ring in a peripheral portion on a lower surface of the rubber film and, the polishing head configured to hold a back surface of the workpiece on the lower surface of the rubber film and to polish the workpiece by bringing a front surface of the workpiece into sliding contact with a polishing pad attached to a turn table, wherein an incompressible fluid is enclosed in the space.

[0014]

Such a polishing head can appropriately adjust a surface shape of the rubber film for holding the workpiece by the enclosed incompressible fluid, and suppress local deformation of the surface shape during polishing of the workpiece, thereby

polishing the entire front surface of the workpiece uniformly regardless of the thickness of the template. The polishing head can also be used for final polishing of a workpiece, because the polishing head can polish the entire front surface of the workpiece uniformly with the template configured to have a thickness thinner than that of the workpiece to avoid contact with a polishing pad.

[0015]

The incompressible fluid may be water or an incompressible fluid whose main component is water.

Such a polishing head can be configured at a low cost, and avoid a risk of contamination of the workpiece and the interior of a polishing apparatus, even when the incompressible fluid leaks from the space.

[0016]

Alternatively, the incompressible fluid may be a polishing agent used for the polishing of the workpiece or an aqueous solution containing at least one of components contained in the polishing agent.

Such a polishing head does not affect the polishing of the workpiece, even when the incompressible fluid leaks from the space.

[0017]

The lower surface portion of the rubber film is preferably adjustably inflated in accordance with a difference in thickness between the template and the workpiece.

Such a polishing head can adjust a polishing stock removal of the outer peripheral portion of the workpiece, thereby surely polishing the entire front surface of the workpiece uniformly.

[0018]

The incompressible fluid is preferably enclosed under a pressure higher than a polishing pressure applied during the polishing of the workpiece.

Such a polishing head can prevent the pressure to the outer

peripheral portion of the workpiece from increasing, and polish the workpiece with a more uniform polishing load for the workpiece.

[0019]

The rubber film is preferably attached to the rigid ring with the rubber film stretched by a tensile force of 30 N or more.

Such a polishing head can surely maintain the surface shape of the rubber film after the incompressible fluid is enclosed during polishing, thereby surely polishing the entire front surface of the workpiece uniformly.

[0020]

The rubber film is preferably composed of any one of isoprene rubber, styrene-butadiene rubber, chloroprene rubber, nitrile-butadiene rubber, urethane rubber, fluororubber, silicon rubber, ethylene-propylene rubber, polyester elastomer, polysulphone resin, and grilamid resin.

Such a polishing head, which uses a sturdy material hard to tear with high tensile force, can maintain the surface shape of the rubber film after the incompressible fluid for a long time, thereby surely polishing the entire front surface of the workpiece uniformly at a low cost.

[0021]

The preset invention also provides a polishing apparatus used for polishing a front surface of a workpiece, the apparatus comprising a polishing pad attached to an upper side of a turn table; a polishing-agent-supply mechanism configured to supply a polishing agent to an upper side of the polishing pad; and a polishing head configured to hold the workpiece according to the present invention.

Such a polishing apparatus can appropriately adjust a surface shape of the rubber film for holding the workpiece by the enclosed incompressible fluid, and suppress local deformation of the surface shape during polishing of the workpiece, thereby polishing the entire front surface of the workpiece uniformly

regardless of the thickness of the template. The polishing apparatus can also be used for final polishing of a workpiece, because the polishing head can polish the entire front surface of the workpiece uniformly with the template configured to have a thickness thinner than that of the workpiece to avoid contact with a polishing pad.

ADVANTAGEOUS EFFECTS OF INVENTION

[0022]

The polishing head of the present invention includes an incompressible fluid enclosed in the space. Such a polishing head can appropriately adjust a surface shape of the rubber film for holding the workpiece by the enclosed incompressible fluid, and suppress local deformation of the surface shape during polishing of the workpiece, thereby polishing the entire front surface of the workpiece uniformly regardless of the thickness of the template. The polishing head can also be used for final polishing of a workpiece, because the polishing head can polish the entire front surface of the workpiece uniformly with the template configured to have a thickness thinner than that of the workpiece to avoid contact with a polishing pad.

BRIEF DESCRIPTION OF DRAWINGS

[0023]

FIG. 1 is a schematic view showing an example of a polishing head of the present invention;

FIG. 2A is explanatory views of a method for enclosing an incompressible fluid in the case of using a template having a thickness thinner than that of a workpiece;

FIG. 2B is explanatory views of a method for enclosing an incompressible fluid in the case of using a template having a thickness larger than that of a workpiece;

FIG. 3 is a schematic view showing another example of a

polishing head of the present invention;

FIG. 4 is a schematic view showing an example of a polishing apparatus of the present invention;

FIG. 5 shows results of Examples 1 to 3;

FIG. 6 shows results of Comparative Examples 1 to 3;

FIG. 7A shows polishing stock removal distribution of a workpiece in Examples 4 to 7;

FIG. 7B shows polishing stock removal distribution in the range from 120 mm to 148 mm away from the center of the workpiece in Examples 4 to 7;

FIG. 8 is a view showing the relationship between tensile force applied at the time of attaching a rubber film and variation in polishing stock removal at the outer peripheral portion in Examples 4 to 7;

FIG. 9 is shows results of Examples 8 to 9;

FIG. 10 is a schematic view showing an example of a conventional polishing apparatus;

FIG. 11 is a schematic view showing an example of a conventional polishing head using a backing film;

FIG. 12 is a schematic view showing another example of the conventional polishing head using a backing film; and

FIG. 13 is a schematic view showing an example of a conventional polishing head by the rubber chuck method.

DESCRIPTION OF EMBODIMENTS

[0024]

Although an embodiment according to the present invention will be described below, the present invention is not restricted thereto.

There has been a problem in that the polishing stock removal at the outer peripheral portion of a workpiece varies depending on the thickness of a template and the flatness cannot be kept stable. The thickness of the template needs to be equal to or

larger than that of the workpiece to suppress outer peripheral sag. The template having such a thickness, however, contacts a polishing pad to produce an extraneous substance, which may cause defects, such as scratches, on the front surface of the workpiece.

[0025]

The present inventor repeatedly conducted keen examination to solve such a problem, and conceived that a rubber chuck portion, for holding a workpiece, which is configured in a manner that a rubber film is attached to an annular rigid ring with a uniform tensile force, a back plate is provided at an upper part to define a sealed space, and an incompressible fluid is enclosed into the sealed space. This configuration enables the workpiece to be polished into a flat workpiece regardless of the thickness of a template. The present inventor thereby brought the present invention to completion.

[0026]

FIG. 1 illustrates an example of a polishing head of the present invention.

As illustrated in FIG. 1, the polishing head 1 includes an annular rigid ring 4 composed of a rigid material such as SUS (stainless), a rubber film 3 attached to the lower surface of the rigid ring 4 with a uniform tensile force, and a back plate 5 provided on the upper surface of the rigid ring 4.

The rigid ring 4, the rubber film 3, and the back plate 5 define a sealed space 6.

[0027]

Here, the material and the shape of the back plate 5 are not restricted in particular, as long as the back plate 5 can define the space 6 together with the rigid ring 4 and the rubber film 3.

An annular template 7 having an inner diameter slightly larger than an outer diameter of a workpiece W is provided concentrically with the rigid ring 4 at the peripheral portion

on the lower surface of the rubber film 3. This template 7 is configured to hold an edge portion of the workpiece W, and provided so as to protrude downward along the outer peripheral portion of the lower surface portion of the rubber film 3.

[0028]

The template 7 may be configured to have an outer diameter larger than at least an inner diameter of the rigid ring 4 and an inner diameter smaller than the inner diameter of the rigid ring 4. Such a configuration enables the entire front surface of the workpiece to be pressed uniformly.

The template 7 is preferably composed of a material softer than the workpiece W and resistant to wear, which is hard to wear by being brought into sliding contact with a polishing pad of a polishing apparatus during polishing, to avoid contamination, scratches, and impressions of the workpiece W.

The polishing head, illustrated in FIG. 1 by way of example, includes the template 7 having a thickness thinner than that of the workpiece W, but is not limited thereto. As illustrated in FIG. 3, the polishing head may include a template 7 having a thickness equal to or larger than that of the workpiece W.

[0029]

A backing film 8 may be attached to at least a portion of the lower surface of the rubber film 3 at which the workpiece W is held. The backing film 8 contains water to stick the workpiece W so that the workpiece W is held on a workpiece-holding surface of the rubber film 3. The backing film 8 may be composed of polyurethane, for example. The backing film 8 containing water enables the workpiece W to be surely held by surface tension of the water.

[0030]

A commercially available template assembly having a template attached onto the backing film can be used.

In such a rubber chuck portion, constituted of the rubber

film 3, the rigid ring 4, the back plate 5, and others, an incompressible fluid 2 is preliminarily enclosed in the space 6 before polishing the workpiece W. When the incompressible fluid 2 is enclosed, the surface shape of the workpiece-holding portion of the rubber film 3 for holding the workpiece W is adjusted into an appropriate shape. A polishing head upper portion 9 including a non-illustrated pressurizing means is mounted on the upper surface of the back plate 5. The term "incompressible fluid" used in the invention means a fluid of which the volume does not greatly reduce by compression under pressure, unlike a gas.

[0031]

As illustrated in FIG. 3, through holes 11a and 11b and couplers 10a and 10b may be provided in the back plate 5 to enclose the fluid 2 in the space 6. The couplers 10a and 10b are capable of being connected with a later-described fluid enclosure apparatus.

[0032]

The volume of the incompressible fluid 2 enclosed in the space 6 of the polishing head of the invention hardly varies during polishing. The polishing head can therefore suppress deformation of the appropriately shaped surface of the rubber film 3, in particular, the local inflation of the rubber film 3 at the gap portion between the workpiece W and the template 7 so that a uniform polishing load can be applied over the workpiece W to polish the workpiece. As a result, the entire front surface of the workpiece can be uniformly polished, regardless of the thickness of the template 7. In addition, the polishing head enables the workpiece W to be uniformly polished up to the outer peripheral portion without surface defects, such as scratches, on the front surface of the workpiece W, and can thus be used for final polishing, even when the template 7 having a thickness thinner than that of the workpiece W is used to avoid contact of the template 7 with a polishing pad of a polishing apparatus.

[0033]

The incompressible fluid may be water or an incompressible fluid whose main component is water.

Such an incompressible fluid enables the polishing head to be configured at a low cost, and the polishing head does not contaminate a workpiece or the inside of a polishing apparatus, even when the incompressible fluid leaks from the space, for example, due to tear of the rubber film.

For a workpiece of semiconductor material, pure water, which does not contain metal ions, is preferably used as the incompressible fluid to prevent metal contamination, for example.

[0034]

Alternatively, the incompressible fluid may be a polishing agent used for the polishing of the workpiece or an aqueous solution containing at least one of components contained in the polishing agent.

Such a polishing head does not affect the polishing of the workpiece, even when the incompressible fluid leaks from the space.

[0035]

A method for enclosing an incompressible fluid in the space will now be described.

FIG. 2A illustrates an example of a method for enclosing the fluid when a template having a thickness thinner than that of a workpiece is used.

As illustrated in FIG. 2A, the polishing head 21 is provided with two through holes 11a and 11b in the upper surface of the back plate 5 to introduce the incompressible fluid 2 into the space 6 and to discharge the fluid from the space 6. Couplers 10a and 10b are provided at the respective through holes 11a and 11b to enclose the incompressible fluid 2 in the space 6 while maintaining a pressure of the incompressible fluid 2 (also referred to as an enclosure pressure, hereinafter). When the incompressible fluid

2 is enclosed in the space 6 before polishing the workpiece, a fluid enclosure apparatus is connected to the polishing head as follows.

[0036]

As illustrated in FIG. 2A, the fluid enclosure apparatus 30 has a circuit connecting with a pressure gauge 33 and a valve 32a to introduce the incompressible fluid 2. The circuit is connected with a nipple 31a at its terminal. This nipple 31a is connected with the coupler 10a provided on the back plate 5. The fluid enclosure apparatus 30 has a circuit having one terminal connected with a drain and a valve 32b connected at the middle of the circuit to discharge the incompressible fluid 2. The other terminal of this circuit is connected with a nipple 31b. This nipple 31b is connected with the coupler 10b provided on the back plate 5.

[0037]

Then, a workpiece W or an adjustment plate 36 having the same thickness as that of the workpiece W is placed on a flat base 35, and an adjustment spacer 34 having a thickness equal to a difference in thickness between the workpiece W and the template 7 is placed on the lower surface of the template 7. The polishing head components including the backing film 8, the template 7, the rubber film 3, the rigid ring 4, and the back plate 5 are placed on the base 35 such that the workpiece W or the adjustment plate 36 is accommodated in a hole of the template 7. The base 35 and the back plate 5 are then fixed by a clamp jig 37 to prevent the height of the back plate 5 from changing when the incompressible fluid 2 is enclosed.

[0038]

The valves 32a and 32b are then opened to introduce the incompressible fluid 2 into the space 6, and a degassing process is performed on the space 6. The degassing process can be performed in such a manner that the terminal on the drain side

is connected with a pressure reducing circuit, then the valve 32a is closed, and the valve 32b is opened, for example.

The valves 32a and 32b are then closed, a non-illustrated pressure-adjusting mechanism for the incompressible fluid 2 adjusts such that the pressure gauge 33 exhibits a predetermined pressure. The valve 32a is then opened to introduce the incompressible fluid 2 into the space 6. After confirming the pressure gauge 33 exhibits a predetermined pressure, the valve 32a is closed to enclose the incompressible fluid 2 in the space 6. After enclosure, the nipples 31a and 31b are removed from the couplers 10a and 10b provided on the upper portion of the back plate 5.

[0039]

In the enclosure of the fluid 2, the surface of the rubber film 3 is shaped by using the adjustment spacer 34 having a thickness thinner than a difference in thickness between the workpiece and the template, such that the inflation of the surface becomes small at the central part of the rubber film 3. Such an adjusted polishing head increases the polishing pressure applied to the outer peripheral portion of the workpiece, and thereby increases the polishing stock removal of the outer peripheral portion. On the contrary, the surface of the rubber film 3 is shaped by using the adjustment spacer 34 having a thickness thicker than a difference in thickness between the workpiece and the template, such that the inflation of the surface becomes large at the central part of the rubber film 3. Such an adjusted polishing head decreases the polishing pressure applied to the outer peripheral portion of the workpiece, and thereby decreases the polishing stock removal of the outer peripheral portion. The polishing stock removal of the outer peripheral portion of the workpiece can be adjusted by adjusting the thickness of the adjustment spacer 34 used for enclosing the fluid as described above.

[0040]

FIG. 2B illustrates an example of a method for enclosing the fluid when a template having a thickness thicker than that of a workpiece is used. In this case, as illustrated in FIG. 2B, the adjustment spacer 34 is inserted below the lower surface of a workpiece W, and the incompressible fluid 2 can be enclosed in the same manner as above. In this case, the polishing stock removal of the outer peripheral portion of the workpiece can be also adjusted by adjusting the thickness of the adjustment spacer 34.

[0041]

When the thickness of the workpiece is equal to that of the template, the incompressible fluid 2 may be enclosed without using the adjustment spacer.

As described above, the lower surface portion of the rubber film is preferably adjustably inflated in accordance with a difference in thickness between the template and the workpiece. Such a polishing head can adjust a polishing stock removal of the outer peripheral portion of the workpiece, thereby surely polishing the entire front surface of the workpiece uniformly.

[0042]

The incompressible fluid is preferably enclosed under a pressure higher than a polishing pressure applied during the polishing of the workpiece. The enclosure pressure can be adjusted by the above pressure-adjusting mechanism of the fluid enclosure apparatus, for example.

Such a polishing head can prevent the pressure to the outer peripheral portion of the workpiece from increasing, and polish the workpiece with a more uniform polishing load for the workpiece.

[0043]

The rubber film is preferably attached to the rigid ring with the rubber film stretched by a high tensile force, particularly a tensile force of 30 N or more, to maintain the

surface shape formed as above by enclosing the incompressible fluid.

Such a polishing head can surely maintain the surface shape of the rubber film after the incompressible fluid is enclosed during polishing, thereby surely polishing the entire front surface of the workpiece uniformly.

[0044]

The rubber film is preferably composed of a sturdy material that is hard to tear with high tensile force and resistant to creep deformation to maintain its surface shape formed as above by enclosing the incompressible fluid for a long time.

Accordingly, the rubber film is preferably composed of any one of isoprene rubber, styrene-butadiene rubber, chloroprene rubber, nitrile-butadiene rubber, urethane rubber, fluororubber, silicon rubber, ethylene-propylene rubber, polyester elastomer, polysulphone resin, and grilamid resin.

Such a polishing head can surely polish the entire front surface of the workpiece uniformly, and reduce cost due to longer lifetime of the rubber film.

[0045]

A polishing apparatus of the present invention will now be described.

FIG. 4 schematically illustrates an example of a polishing apparatus of the present invention.

As illustrated in FIG. 4, the polishing apparatus 20 of the invention includes a polishing pad 22 attached to an upper side of a turn table 23, a polishing-agent-supply mechanism 24 configured to supply a polishing agent 25 to an upper side of the polishing pad 22, and the polishing head 21 of the invention configured to hold a workpiece W. This polishing head 21 can press the workpiece W against the polishing pad 22 attached to the turn table 23 by using a non-illustrated pressurization mechanism.

[0046]

The front surface of workpiece W is polished by sliding the workpiece through rotation movement of the polishing head 21 coupled to a rotary shaft and revolution movement of the turn table 23 while supplying the polishing agent 25 onto the polishing pad 22 by the polishing-agent-supply mechanism 24.

Such a polishing apparatus can suppress deformation of the surface shape of the rubber film, particularly local inflation of the rubber film at the gap between the workpiece and the template during polishing of the workpiece, so that an uniform polishing load can be applied over the workpiece W to polish the workpiece. As a result, the entire front surface of the workpiece can be uniformly polished, regardless of the thickness of the template. In addition, the polishing apparatus can polish the entire front surface of the workpiece uniformly, even when the template having a thickness thinner than that of the workpiece is used. The polishing apparatus can thus be used for final polishing.

EXAMPLES

[0047]

Although the present invention will now be more specifically explained based on examples and comparative examples hereinafter, the present invention is not restricted thereto.

[0048]

(Examples 1 to 3)

A workpiece was polished with a polishing apparatus of the present invention including the polishing head as illustrated in FIG. 3, and variation in polishing stock removal in a plane of the polished workpiece was evaluated. A silicon single crystal wafer having a diameter of 300 mm and a thickness of 775 μm was used as the workpiece W. The polishing stock removal was calculated by measuring both the thicknesses of the wafer before and after polishing with a flatness measuring instrument in a region excluding a width 2 mm of the outermost peripheral portion

as a flatness-guaranteed region and by obtaining differences between the thicknesses before and after polishing in a cross section of the wafer along a diametric direction. A flatness measuring instrument (WaferSight) manufactured by KLA-Tencor was used for measuring the flatness.

[0049]

The following polishing heads were prepared: A rigid ring composed of SUS with an outer diameter of 360 mm and an inner diameter of 320 mm was used. A rubber film composed of silicon rubber with a thickness of 1 mm and a rubber hardness of 90 degrees was attached to the lower surface of the rigid ring under a tensile force of 7.5 N. A commercially available template assembly was attached to the front surface of the rubber film. The template assembly has a template with an outer diameter of 355 mm, an inner diameter of 302 mm, and a thickness of 700 μm (Example 1), or a thickness of 780 μm (Example 2), or a thickness of 800 μm (Example 3) attached to a surface of the backing film.

[0050]

As illustrated in FIG. 2A, an incompressible fluid was then enclosed with a fluid enclosure apparatus. At this time, an adjustment spacer of 75 μm was inserted below the lower surface of the template when the thickness of the template was 700 μm , no adjustment spacer was used when the thickness was 780 μm , and an adjustment spacer of 25 μm was inserted below the lower surface of the wafer when the thickness was 800 μm . Pure water was used as the incompressible fluid, and the fluid was enclosed in the space under a pressure of 20 kPa.

The prepared polishing head was mounted on a polishing apparatus of the invention as illustrated in FIG. 4, and the wafer was polished. It is to be noted that both surfaces of the wafer were subjected to primary polishing in advance, and the edge portion of the wafer was also polished in advance. A 800-mm diameter turn table and a regularly used polishing pad were used.

[0051]

In the polishing, an alkali solution containing colloidal silica was used as a polishing agent, and the polishing head and the turn table were each rotated at 30 rpm. A polishing load (pressing force) for the wafer was set to 20 kPa in terms of a contact pressure of the wafer surface by non-illustrated pressurizing means to polish the wafer. It is to be noted that a polishing time was adjusted such that an average polishing amount of the wafer was 1 μm .

FIG. 5 shows the polishing stock removal distribution of the wafer polished in each of Examples 1 to 3. As shown in FIG. 5, it can be understood that the polishing stock removal distribution of the wafer was substantially uniform and hardly dependent on the thickness of the template unlike the later-described Comparative Examples 1 to 3. A range of the polishing stock removal in a cross section was 0.042 μm in Example 1, 0.027 μm in Example 2, and 0.048 μm in Example 3, which were better than those of the later-described Comparative Examples 1 to 3.

[0052]

It was confirmed that the polishing head and the polishing apparatus of the invention enable the entire front surface of a wafer to be uniformly polished, regardless of the thickness of a template.

[0053]

(Comparative Examples 1 to 3)

A silicon single crystal wafer was polished under the same conditions as those for Examples 1 to 3, with a polishing apparatus, as illustrated in FIG. 10, having a conventional polishing head, as illustrated in FIG. 13, with no incompressible fluid of the invention. The rigid ring and the template of the polishing head used had the same configuration as Examples 1 to 3. The used rubber film was composed of silicon rubber with rubber hardness of 70

degrees, and attached to the lower surface of the rigid ring under a tensile force of 5 N.

[0054]

In each of cases where the template having a thickness of 700 μm (Comparative Example 1) was used, the template having a thickness of 780 μm (Comparative Example 2) was used, and the template having a thickness of 800 μm (Comparative Example 3) was used, variation in polishing stock removal in a plane of the polished wafer was evaluated.

FIG. 6 shows the polishing stock removal distribution of the wafer polished in each of Comparative Examples 1 to 3. As shown in FIG. 6, it can be understood that the polishing stock removal distribution of the wafer is strongly dependent on the thickness of the template, the outer peripheral portion of the wafer is excessively polished in the case of using the template having a thickness smaller than the thickness of the wafer (Comparative Example 1), and the polishing stock removal of the outer peripheral portion of the wafer was low in the case of using template having a thickness larger than the thickness of the wafer (Comparative Example 3). The range of the polishing stock removal in a cross section was 0.181 μm in Comparative Example 1, 0.061 μm in Comparative Example 2, or 0.104 μm in Comparative Example 3, which were worse than those of the Examples 1 to 3.

[0055]

(Examples 4 to 7)

A silicon single crystal wafer was polished under the same conditions as those of Example 1 except that silicon rubber was attached under conditions of a tensile force of 5 N (Example 4), 20 N (Example 5), 35 N (Example 6), and 48 N (Example 7), and the variation in polishing stock removal in a plane of the polished wafer was evaluated as with Example 1.

FIG. 7A shows the polishing stock removal distribution of the wafer polished in each of Examples 4 to 7. FIG. 7B shows the

polishing stock removal distribution in the range from 120 mm to 148 mm away from the wafer center as a polishing stock removal distribution of an outer peripheral portion of the wafer. As shown in FIGS. 7A and 7B, it can be understood that the wafer was polished uniformly up to the outer peripheral portion in each of Examples 4 to 7.

[0056]

Additionally, as an index representing the polishing stock removal distribution at the outer peripheral portion of the wafer, a difference between a maximum value and a minimum value of the polishing stock removal in the range from 135 mm to 148 mm away from the wafer center was calculated, which is regarded as the variation in polishing stock removal at the outer peripheral portion of the wafer. The variation in polishing stock removal at the outer peripheral portion of the wafer was 0.043 μm in Example 4, 0.027 μm in Example 5, 0.016 μm in Example 6, or 0.011 μm in Example 7.

FIG. 8 shows a relationship between the tensile force of the silicon rubber and the variation in polishing stock removal at the outer peripheral portion of the wafer. As shown in FIG. 8, it can be understood that the variation in polishing stock removal at the outer peripheral portion of the wafer decreases as the tensile force of the rubber increases. It can be also understood that, when the tensile force is 30 N or more, the variation in polishing stock removal at the outer peripheral portion of the wafer becomes 0.020 μm or less, which means the outer peripheral portion of the wafer can be more uniformly polished.

[0057]

(Examples 8 and 9)

To examine an influence of a charging pressure of an incompressible fluid, a silicon single crystal wafer was polished under the same conditions as those of Example 7 except that a

pressure at the time of enclosure was set to 10 kPa (Example 8) or 40 kPa (Example 9) and a polishing head having pure water enclosed therein was used, and a variation in polishing stock removal in a wafer radial direction after polishing was evaluated as with Example 7.

FIG. 9 shows the polishing stock removal distribution at an outer peripheral portion of the wafer polished in each of Examples 8 and 9. As described above, the variation in polishing stock removal at the outer peripheral portion of the wafer in Example 7 was 0.011 μm , whereas the variation in polishing stock removal at the outer peripheral portion of the wafer in Example 8 where the enclosure pressure is 10 kPa lower than an enclosure pressure of 20 kPa for pure water in Example 7 was as high as 0.033 μm , and the variation in polishing stock removal at the outer peripheral portion of the wafer in Example 9 where the enclosure pressure for pure water is 40 kPa higher than that in Example 7 was as low as 0.005 μm .

[0058]

It was understood from this result that the variation in polishing stock removal at the outer peripheral portion of the wafer can be reduced when the enclosure pressure of the incompressible fluid is set to a high pressure. When the enclosure pressure of the incompressible fluid is set to be higher than at least a polishing load of the wafer, the outer peripheral portion of the wafer can be further uniformly polished.

[0059]

It is to be noted that the present invention is not limited to the foregoing embodiment. The embodiment is just an exemplification, and any examples that have substantially the same feature and demonstrate the same functions and effects as those in the technical concept described in claims of the present invention are included in the technical scope of the present invention.

For example, the polishing head of the present invention is not restricted to the conformations shown in FIGS. 1 and 3. For example, the shape of a main body of the polishing head can be appropriately designed except requirements described in claims. Additionally, the configuration of the polishing apparatus is not restricted to that shown in FIG. 4. For example, a polishing apparatus may be provided with a plurality of polishing heads of the present invention.

CLAIMS

1. A polishing head comprising an annular rigid ring; a rubber film attached to the rigid ring with an uniform tensile force; a back plate connected to the rigid ring, the back plate defining a space together with the rubber film, and the rigid ring; and an annular template configured to hold an edge portion of a workpiece, the template being provided concentrically with the rigid ring in a peripheral portion on a lower surface of the rubber film and, the polishing head configured to hold a back surface of the workpiece on the lower surface of the rubber film and to polish the workpiece by bringing a front surface of the workpiece into sliding contact with a polishing pad attached to a turn table, wherein an incompressible fluid is enclosed in the space.

2. The polishing head according to claim 1, wherein the incompressible fluid is water or an incompressible fluid whose main component is water.

3. The polishing head according to claim 1, wherein the incompressible fluid is a polishing agent used for the polishing of the workpiece or an aqueous solution containing at least one of components contained in the polishing agent.

4. The polishing head according to any one of claims 1 to 3, wherein the lower surface portion of the rubber film is adjustably inflated in accordance with a difference in thickness between the template and the workpiece.

5. The polishing head according to any one of claims 1 to 4, wherein the incompressible fluid is enclosed under a pressure higher than a polishing pressure applied during the polishing of the workpiece.

6. The polishing head according to any one of claims 1 to 5, wherein the rubber film is attached to the rigid ring with the rubber film stretched by a tensile force of 30 N or more.

7. The polishing head according to any one of claims 1 to 6, wherein the rubber film is composed of any one of isoprene rubber, styrene-butadiene rubber, chloroprene rubber, nitrile-butadiene rubber, urethane rubber, fluororubber, silicon rubber, ethylene-propylene rubber, polyester elastomer, polysulphone resin, and grilamid resin.

8. A polishing apparatus used for polishing a front surface of a workpiece, the apparatus comprising a polishing pad attached to an upper side of a turn table; a polishing-agent-supply mechanism configured to supply a polishing agent to an upper side of the polishing pad; and a polishing head configured to hold the workpiece according to any one of claims 1 to 7.