

Method for double side polishing of wafers of semiconductor material

Technical field

The present invention provides a method for double side polishing of at least one wafer of semiconductor material.

5

Prior art

Wafers of semiconductor material are produced in a multiplicity of process steps, comprising the pulling of a single-crystal ingot from a melt, the sawing of the crystal into wafers, and the surface processing of the wafers.

- 10 The target of the surface processing is a defect-free, highly flat (planar) wafer surface. Polishing is one of the methods of surface processing. A variety of methods are known in the prior art for the polishing of wafers of semiconductor material. They include single side and double side polishing methods, with double side polishing in particular being very important.
- 15 Double side polishing (DSP) is a bilateral polishing method in which at the same time the front side and the back side of a wafer are polished. For this, the wafer is carried in a carrier plate which is located within a working gap formed by an upper and a lower polishing platen of a double side polishing machine. The polishing platens are each lined with a polishing pad. The wafer of semiconductor material is disposed in
- 20 the carrier plate between the polishing platens such that the front and back sides of the wafer are in sliding contact with the polishing pads. The polishing platens are set in rotation in opposite directions, while a polish is supplied, so that the front and back sides are polished simultaneously. In the case of double side polishing, multiple wafers are usually polished simultaneously.
- 25 In double side polishing methods, the planarity of the surface is influenced by the composition of the polish. For instance, EP 4 039 767 A1 describes how the flatness at the wafer edge can be improved by using a polish composition which comprises abrasive particles, a basic compound and a phosphorus compound. WO 2022/130800 A1 describes the influence of the composition of the polish, particularly the

concentration of the base and of the abrasive particles, on the removal rate during polishing and on the geometry of a semiconductor wafer.

DE 11 2015 005 277 T5 describes the recovery and reprocessing of a polishing slurry, with the polishing slurry recovered being circulated without addition of unused
5 abrasive particles for polishing.

Technical object of the invention and achievement of said object

It is an object of the present invention to provide a method for double side polishing of semiconductor wafers that allows the edge roll-off of a wafer of semiconductor material to be reduced and also reduces the consumption of polish.

10 This object is achieved by the method of the invention for double side polishing of at least one wafer of semiconductor material, comprising the following steps:

placing the at least one wafer of semiconductor material in at least one carrier plate between an upper and a lower polishing platen of a double side polishing machine, the lower side of the upper polishing platen and the upper side of the lower
15 polishing platen each being covered with a polishing pad;

setting the at least one carrier plate, the upper polishing platen and the lower polishing platen in rotation;

circulating a polish between a collecting vessel and the at least one wafer of semiconductor material disposed between the upper and lower polishing platens of
20 the double side polishing machine;

measuring the pH of the polish; and

regulating the pH of the polish;

characterized in that a target for the pH is not less than 11.4 and not more than 12.4 and the pH is regulated by temporary supply of a basic composition to the polish as a
25 function of the measured pH such that the deviation of the measured pH from the target pH during the circulation of the polish between the collecting vessel and the at least one wafer of semiconductor material disposed between the upper and lower polishing platens of the double side polishing machine is at no instant more than ± 0.2 .

It has surprisingly been found that the method of the invention permits the production of a wafer of semiconductor material that exhibits improved edge roll-off. Moreover, it has been found that by the method of the invention, it is possible to increase the removal rate during polishing and to prevent pad glazing for a longer period, and so as to achieve an overall increase in the efficiency and economics of the polishing operation.

Preferred embodiments of the method of the invention are subjects of the dependent claims. Furthermore, the method of the invention makes it possible to reduce the consumption of polish.

Brief description of the figures

Fig. 1 shows schematically an apparatus suitable for implementing the method of the invention. The apparatus comprises a double side polishing machine (1), a collecting vessel (2) for the polish, a meter (3) for determining the pH, and a reservoir vessel for a basic solution with metering pump (4) for regulating the pH.

Fig. 2 shows the change in thickness in radial direction of a monocrystalline silicon wafer polished according to the method described in Comparative Example 1.

Fig. 3 shows the change in thickness in radial direction of a monocrystalline silicon wafer polished according to the method of the invention as described in Working Example 1.

Fig. 4 shows the profile of the pH over time, where the first polishing run was carried out in interval a and the second polishing run in interval b, each according to the method of the invention at a pH of 11.8, and the deviation of the measured pH from the target during polishing was not more than ± 0.05 . The metering pump was subsequently switched off in the third interval c during the polishing run under otherwise identical process conditions for 10 minutes in order to regulate the pH and a drop in the pH was observed. Spikes in the pH profile which occur between the intervals are attributable to the refreshing of the polish.

Detailed description of the invention

The method of the invention for double side polishing of at least one wafer of semiconductor material comprises the following steps:

placing the at least one wafer in at least one carrier plate between an upper and a lower polishing platen of a double side polishing machine, the lower side of the upper polishing platen and the upper side of the lower polishing platen each being covered with a polishing pad;

setting the at least one carrier plate, the upper polishing platen and the lower polishing platen in rotation;

circulating a polish between a collecting vessel and the at least one wafer disposed between the upper and lower polishing platens of the double side polishing machine;

measuring the pH of the polish; and

regulating the pH of the polish;

characterized in that a target for the pH is not less than 11.4 and not more than 12.4 and the pH is regulated by temporary supply of a basic composition to the polish as a function of the measured pH such that the deviation of the measured pH from the target pH during the circulation of the polish between the collecting vessel and the at least one wafer of semiconductor material disposed between the upper and lower polishing platens of the double side polishing machine is at no instant more than ± 0.2 .

In the method of the invention, a defined target pH of the polish is specified and the pH of the polish is tightly regulated within defined limits. In particular, a target pH of the polish in the range of not less than 11.4 and not more than 12.4 is specified, the deviation from the target being not more than ± 0.2 , preferably ± 0.1 , most preferably not more than ± 0.05 . The maximum deviation from the specified target is also referred to below as the control range. The tight regulation of the pH within this range makes it possible, surprisingly, to improve the edge roll-off of the polished wafers. Moreover, the tight regulation of the pH within this range stabilizes the polish. In particular, coagulation of colloidal constituents, especially the abrasive particles contained in the

polish, is prevented. Coagulation leads to a deterioration in flatness and in edge roll-off of the polished wafers, and therefore necessitates exchange of the polish.

The method of the invention therefore firstly improves the flatness and the edge roll-off of the polished wafers and secondly raises the useful life of the polish, so reducing
5 the consumption of polish over time.

The method of the invention is employed preferably for the double side polishing of at least one wafer of semiconductor material having a diameter of 150 to 450 mm, more preferably 200 to 300 mm, most preferably 300 mm. The semiconductor material is preferably monocrystalline silicon. The semiconductor material may optionally also be
10 p- or n-doped. The crystal orientation of the main face of the front side of a wafer of monocrystalline silicon is preferably a {100} orientation, a {110} orientation or a {111} orientation.

The method of the invention for double side polishing of the at least one wafer of semiconductor material may be carried out using a suitably sized commercial double
15 side polishing machine. Such a polishing machine is described for example in US 4,974,370, EP 787 562 B1 or DE 100 60 697 B4. The polishing pressure exerted on the wafer of semiconductor material during polishing (applied pressure) is preferably in the range from 0.05 to 0.5 bar. The polishing time is preferably 5 to 90 minutes, more preferably 10 to 60 minutes, and most preferably 15 to 45 minutes. The
20 polishing time generally depends on the pretreatment of the wafers. Thus the polishing time may be reduced, for example, by implementing a step of fine grinding before the method of the invention.

A double side polishing machine comprises a lower polishing platen which is freely horizontally rotatable and an upper polishing platen which is freely horizontally
25 rotatable, the lower side of the upper polishing platen and the upper side of the lower polishing platen each being covered with a polishing pad. The wafers of semiconductor material may be disposed horizontally in the polishing gap between the polishing platens, and during polishing may make contact with the polishing pad-covered polishing platens or be in sliding contact with said platens. A double side
30 polishing machine contains a polishing platen drive for setting the platens in rotation.

The drive may be aligned such that the two polishing platens can be set in co-directional or counter-directional rotation, preferably counter-directional rotation. A double side polishing machine further comprises an apparatus for continuous supply and withdrawal of polish to and from the wafers of semiconductor material disposed
5 between the polishing platens, with supply taking place preferably into the polishing gap.

The at least one wafer of semiconductor material may lie in at least one carrier plate disposed horizontally between the polishing platens. One carrier plate may usually accommodate 1 to 5 wafers. 3 to 5 carrier plates preferably are disposed between the
10 polishing platens. The at least one carrier plate possesses cutouts dimensioned sufficiently to accommodate the at least one wafer of semiconductor material, and possesses a lower thickness than the wafer. During polishing, the wafers of semiconductor material can be guided accordingly by the carrier plates, i.e. held on a geometric path determined by machine parameters and operating parameters. The at
15 least one carrier plate may be in contact with the polishing machine, with a rack-and-pinion gearing or an involute gearing, via a rotating inner drive pin or gear ring and a generally counter-rotating outer drive pin or gear ring, which sets the carrier plate into a rotating movement between the two polishing platens.

In the method of the invention, in a first step, the at least one wafer of semiconductor
20 material is placed in the at least one carrier plate between an upper and a lower polishing platen of a double side polishing machine, with the lower side of the upper polishing platen and the upper side of the lower polishing platen each being covered with a polishing pad.

25 A polishing pressure (applied pressure) is subsequently exerted on the at least one wafer of semiconductor material by the polishing platens with the polishing pad. The polishing pressure (applied pressure) is preferably in the range from 0.05 to 0.5 bar, and the magnitude of the polishing pressure may be changed during the polishing method, preferably in steps or steplessly and continuously.

In the next step, the carrier plates, the upper polishing platen and the lower polishing platen are then set in rotation. Here, the upper and lower polishing platens may rotate co-directionally or counter-directionally, preferably counter-directionally. The carrier plates preferably possess a circumferential gearing and are set in rotation by a
5 complementary outer and inner gearing of the polishing machine.

In a further step, which takes place preferably during the rotation of the carrier plate, the upper polishing platen and the lower polishing platen about a common vertical axis, the polish is circulated between a collecting vessel and the at least one wafer of
10 semiconductor material that is disposed between the upper and lower polishing platens of the double side polishing machine. Here, the polish may be guided via a polishing gap to the at least one wafer of semiconductor material. The polishing gap in the sense of the present invention is the space between the lower side of the upper polishing platen and the upper side of the lower polishing platen, each of which are
15 covered with a polishing pad. The polishing gap is therefore bounded on one side by the surface on the lower side of the polishing pad on the upper polishing platen, and on the other side by the surface on the upper side of the polishing pad on the lower polishing platen.

20 During circulation, the polish is guided from a collecting vessel (2) to the at least one wafer of semiconductor material that is disposed between an upper and a lower polishing platen of a double side polishing machine (1), and is returned from the wafer to the collecting vessel (2). This circulation of the polish between the collecting vessel (2) and the double side polishing machine (1) is represented in Fig. 1. The polish may
25 gain access to the wafers of semiconductor material for example through a combination of gravitational force and rotation-induced centrifugal force or else through application of pressure in a multiplicity of supply lines. The polish may be supplied, for example, via multiple bores with or without nozzles in the upper polishing platen. The upper polishing platen preferably comprises multiple bores, so that
30 uniform distribution of polish between the polishing pads is achieved, with the number of bores being guided essentially by the size of the polishing machine. The return of the polish to the collecting vessel may be accomplished by an intercept apparatus with drain duct, disposed under the lower polishing platen. The configuration of this

intercept apparatus with drain duct may be such that the polish running over the edge of the lower polishing platen is intercepted by the intercept apparatus and conveyed from there back into the collecting vessel via the drain duct. The collecting vessel may communicate with the bores in the upper polishing platen and with the drain duct via hoses. The circulation may be driven by a pump. The circulation rate, being the flow rate of the polish in the polish circuit, is preferably in the range from 0.5 to 50 litres per minute, more preferably 2 to 20 litres per minute, very preferably 3 to 10 litres per minute. The polish may also be conveyed past the double side polishing machine temporarily via a bypass, so that there is no need to interrupt the circulation of the polish during wafer exchange or during an additional step of final polishing with a different polish.

The steps already described above, of (i) placing the at least one wafer of semiconductor material in at least one carrier plate between an upper and a lower polishing platen, covered with polishing pad; (ii) setting the at least one carrier plate, the upper polishing platen and the lower polishing platen in rotation; and (iii) circulating a polish between a collecting vessel and the at least one wafer disposed between the upper and the lower polishing platens of the double side polishing machine, are preferably carried out in that order. In this case, the rotational movement produces a uniform distribution of the polish on the polishing pads and on the front and back sides of the wafers of semiconductor material. The more uniform distribution of polish achieves more uniform application of material and hence improved flatness and reduced edge roll-off of the wafers of semiconductor material. A polishing pressure is exerted on the at least one wafer of semiconductor material by the polishing platens covered with a polishing pad.

The polish used in the method of the invention may contain abrasive particles, preferably colloidal silicon dioxide particles. The polish preferably comprises abrasive particles and one or more compounds selected from the group of surface-active additives, preservatives, biocides, alcohols and complexing agents. The polish used in the method of the invention is preferably a dispersion or a slurry having a solids content of 0.1% to 10.0% by weight, preferably 0.3% to 5.0% by weight, more preferably 0.5% to 2.0% by weight. In one particularly preferred embodiment, the

polish is a dispersion comprising silicon dioxide particles as colloidal solid. The specific density of the polish is preferably 1.0 to 1.2, more preferably 1.02 to 1.10. The average particle size of the colloidal silicon dioxide particles is preferably 10 to 200 nm, more preferably 20 to 100 nm, very preferably 40 to 80 nm.

- 5 The method of the invention preferably uses a polishing pad having a hardness (Shore A hardness) of 40 to 100, more preferably of 70 to 95, and most preferably of 80 to 95. Where a polishing pad having a hardness of 80 to 95 is used, a further improvement in the edge roll-off can be achieved. The Shore hardness may be determined according to the standard DIN ISO 7619-1. The polishing pad used in the
- 10 method of the invention is preferably what is called a 'foamed pad'. The invention, however, is not restricted to such pads, and other polishing pads can also be used to achieve the object on which the invention is based.

- If the target pH of the polish is not less than 11.4 and not more than 12.4 and if a control range of ± 0.2 is not exceeded, it is possible to improve the edge roll-off of a
- 15 wafer of semiconductor material, more particularly of a single-crystal silicon wafer. In this way, moreover, pad glazing over multiple polishing procedures can be prevented. A particularly pronounced improvement in edge roll-off may be achieved if the pH of the polish is not less than 11.5 and not more than 12.3, preferably not less than 11.5 and not more than 12.0, more preferably not less than 11.7 and not more than 11.9,
- 20 and if the deviation of the measured pH from the target pH during the circulation of the polish between the collecting vessel and the at least one wafer of semiconductor material disposed between the upper and lower polishing platens of the double side polishing machine is at no instant more than ± 0.2 . In one particularly preferred embodiment, the target pH is not less than 11.7 and not more than 11.9 and the
- 25 control range, i.e. the deviation from the target, is in the range of ± 0.1 . If the target is within this range and if only a deviation of ± 0.1 from the target is allowed, then a particularly pronounced improvement in edge roll-off is observed. Edge roll-off may be further reduced if the method of the invention allows only a deviation from the target pH of ± 0.05 .

- 30 The target pH of the polish and the maximum deviation from the target (control range) are based on the pH at a defined point in the polish circuit. The target pH of the polish

and the maximum deviation from the target are based preferably on the pH in a collecting vessel. In the method of the invention, therefore, the pH of the polish is measured preferably in the collecting vessel. A collecting vessel in the sense of the present invention is a vessel in the polish circuit from which the polish is guided during the polishing operation to the at least one wafer of semiconductor material, preferably via the polishing gap, and to which the polish is returned from the at least one wafer of semiconductor material. The collecting vessel is preferably equipped with or connected to a measuring instrument for pH measurement, more preferably a pH electrode.

If the pH is not regulated during double side polishing, a continuous drop is observed in the pH during a polishing procedure (a polishing run). Interrupting the regulation of the pH during polishing for only 10 minutes produces a drop in pH by 0.3. Fig. 4 shows accordingly that an interruption in the regulation of the pH during a polishing run for 10 minutes in interval c leads to a drop in pH from 11.8 to around 11.5.

The pH is regulated by temporary supply of a basic composition to the polish. Here, the basic composition is supplied such that the deviation of the measured pH from the target pH during the circulation of the polish between the collecting vessel and the at least one wafer of semiconductor material disposed between the upper and lower polishing platens of the double side polishing machine is at no instant more than ± 0.2 , preferably at no instant more than ± 0.1 , most preferably at no instant more than ± 0.05 . More frequent measurement of the pH makes it possible to reduce the deviation from the target, since a shift in pH, particularly a continuous fall in pH, can be counteracted more quickly and efficiently by supply of the basic composition. Furthermore, it is possible to increase the accuracy of pH measurement and hence also to reduce the control range (deviation from the target pH) by regularly calibrating the pH measuring instrument, preferably a pH electrode.

The basic composition is preferably a basic solution. The basic composition is more preferably a basic solution which comprises at least one compound selected from sodium carbonate, potassium carbonate, ammonium carbonate, sodium

hydrogencarbonate, potassium hydrogencarbonate, sodium hydroxide, potassium

hydroxide, ammonium hydroxide, tetramethylammonium hydroxide and tetraethylammonium hydroxide.

The pH may be regulated by temporary supply of the basic composition, preferably the basic solution, to the collecting vessel. In one embodiment of the method of the invention, the collecting vessel communicates with a reservoir vessel which contains the basic composition. In this embodiment, the pH is regulated by temporary supply of the basic composition, preferably the basic solution, from the reservoir vessel to the collecting vessel by means of a pump or a valve. The pH electrode may be connected to a control unit which drives the valve or the metering pump to supply the basic composition. Hence the collecting vessel may be supplied temporarily with basic composition to regulate the pH, as a function of the pH. The more frequent the pH measurement and the pH regulation linked to the measurement, the narrower the control range and hence the smaller the deviations from the target.

The pH is preferably measured continuously or at uniform intervals of 0.01 to 60 seconds, more preferably at uniform intervals of 0.1 to 10 seconds. The pH is preferably also regulated at uniform timegaps, preferably at the same intervals as the pH is measured. The measurement may be made using a Knick SE554X/2-NMSN pH electrode. The electrode is preferably calibrated regularly, more preferably at least monthly, using a plurality of calibrating solutions having a defined pH in the range from 7 to 12.

The pH is regulated in each case as a function of the measured pH. In one particularly preferred embodiment of the method of the invention, regulation of the pH in the collecting vessel comprises the following steps: (i) supplying the basic solution as soon as the pH in the collecting vessel falls below a specified lower limit, and (ii) pausing or ending the supply of the basic solution as soon as the pH in the collecting vessel exceeds a specified upper limit, the lower limit and the upper limit deviating by not more than ± 0.2 from the target. The specified lower limit and the specified upper limit preferably deviate by not more than ± 0.1 , more preferably by not more than ± 0.05 , from the target. The supplying and the pausing or ending of the supply of the basic solution may be accomplished, for example, by switching a pump on and off, by driving a metering pump correspondingly, or by opening and closing a valve, driven

preferably by a control unit which is connected in turn to a pH electrode. The basic solution is preferably supplied from a reservoir vessel with a metering pump, the reservoir vessel being connected via conduits to the collecting vessel.

In another embodiment of the method of the invention, the pH may be regulated by adding a specified amount of the basic solution at variable intervals of time from the reservoir vessel to the collecting vessel. The lower the measured pH, the shorter the intervals between the addition of the specified amount of basic solution.

After the end of the polishing of the at least one wafer of semiconductor material, one or more further polishing procedures may be carried out on at least one exchanged unpolished wafer. The wafers are exchanged by withdrawal of the wafers already polished and insertion correspondingly of unpolished wafers into the at least one carrier plate, which are disposed between the upper and lower polishing platens of the double side polishing machine. The insertion of the at least one new, unpolished wafer is followed by the start of a new polishing procedure. Between the polishing procedures, which are also referred to as polishing runs, the wafers are therefore exchanged. After the conclusion of polishing (the polishing procedure) of the at least one wafer and before the start of a new polishing procedure on at least one exchanged, unpolished wafer, the polish may be circulated via a bypass, so that temporarily the polish is no longer circulated via the double side polishing machine. During the exchange of the at least one wafer, therefore, the polish is not circulated via the double side polishing machine. During the exchange of the at least one wafer, the polish may be refreshed, by exchange of 1% to 30% by volume of the polish for fresh polish and subsequent adjustment of the pH to the target by addition of the basic composition. Between the various polishing runs, preferably 2% to 20% by volume, more preferably 4% to 10% by volume, very preferably 4% to 5% by volume of the polish is exchanged for new polish and the pH is subsequently adjusted to the target by addition of the basic solution.

It has surprisingly been observed that the improved edge geometry obtained in the method of the invention is achieved in a plurality of successive polishing procedures (polishing runs), for example more than 10 polishing runs, even when between the polishing runs only 1% to 30% by volume of the polish in the collecting vessel is

exchanged for fresh polish and the pH is subsequently adjusted to the target by addition of the basic composition.

The method of the invention therefore makes it possible on the one hand to improve the edge geometry, i.e. the edge roll-off, of a wafer of semiconductor material, more particularly a wafer of single-crystal silicon, and on the other hand to increase the economics and efficiency of the polishing operation through reduced consumption of polish.

Optionally, in the method of the invention, a step of final polishing may be carried out in the double side polishing machine, by (i) switching the circulation of the polish (first polish) to the bypass and so interrupting the supply of the circulated polish to the polishing machine, and (ii) subsequently passing a polish for final polishing (second polish) to the at least one wafer of semiconductor material that is disposed between the upper and lower polishing platens of the double side polishing machine, with the second polish not being circulated during the final polishing step. In the final polishing step, rotation of the polishing platens and of the carrier plates is continued. The final polishing step is shorter than the preceding polishing step which takes place with circulation of the first polish.

Withdrawal of the at least one wafer of semiconductor material from the double side polishing machine may optionally also be followed by final polishing, for example chemical-mechanical polishing (CMP), and/or by final cleaning. Final cleaning is typically a wet-chemical cleaning operation in multiple baths at temperatures of 30 to 90°C. In that case, in one bath, ammonium hydroxide, hydrogen peroxide and deionised water are used, in a ratio of 1:1:5 to 1:2:7, for example. In a further bath, hydrochloric acid, hydrogen peroxide and deionised water are used, in a ratio of 1:1:6 to 1:2:8, for example. Additionally, after the final cleaning, the at least one wafer of semiconductor material may also undergo epitaxial coating.

In the sense of the present invention, the edge roll-off is the edge roll-off measured as ROA, ESFQR or ZDD. The edge roll-off preferably refers to ESFQR_{max} or ZDD. ZDD and ESFQR are parameters which characterize the edge geometry of a semiconductor wafer, and are also the concern of SEMI standards. For instance, the

standard SEMI M68-1015 is concerned with ZDD and the standard SEMI M67-1015 with ESFQR.

The front side-based ZDD describes the mean near-edge curvature of the surface on the front side of a wafer of semiconductor material. More particularly, the ZDD
5 expresses the double derivative of the height perpendicularly from the median plane to the surface on the front side of the wafer. The ZDD is preferably determined with division of the wafer surface into 16 sectors and with an edge exclusion of 1 mm.

ESFQRmax designates the ESFQR of the sector in which the ESFQR is at its greatest. ESFQRmax is preferably ascertained with division of the surface of the
10 wafer edge into 72 sectors each with a length of 35 mm and with an edge exclusion of 1 mm.

Detailed description of working examples of the invention and of comparative examples

15 In Working Example 1, multiple wafers of single-crystal silicon having a diameter of 300 mm and a {100} orientation were polished according to the method of the invention in a commercial double side polishing machine, model AC2000 from the manufacturer Lapmaster Wolters, using a foamed polishing pad of type Exterior SM-11D from the manufacturer Nitta DuPont.

20 A Glanzox 7100 polish from the manufacturer Fujimi was used, and during the polishing operation was circulated between the collecting vessel and the wafers disposed between the upper and lower polishing platens of the double side polishing machine (the polishing gap). The polish contains colloidal silicon dioxide. A target pH for the polish in the collecting vessel of 11.8 was specified here. The pH in the
25 collecting vessel was regulated, by addition of potassium hydroxide solution from a reservoir vessel into the collecting vessel by means of a metering pump, such that the deviation from the target pH was not more than ± 0.05 . The pH here was measured continuously by a pH electrode in the collecting vessel. The pH electrode was connected to a control unit which was used to drive the pump, so that potassium
30 hydroxide solution was supplied temporarily through the operation of the pump as a

function of the pH. This was followed by a step for final polishing. For this step, the supply of the Glanzox 7100 polish to the polishing machine was first paused, with this polish being circulated via a bypass, the polish therefore being guided past the polishing machine. A second polish, for the final polishing, was then passed to the wafers disposed between the upper and lower polishing platens of the double side polishing machine, and polishing was carried out for a period of less than 5 minutes.

After the end of the polishing method, the polished wafers were withdrawn. Subsequently, on a random basis, one of the polished wafers was examined and found to have a front-side ZDD of -5 nm/mm^2 and an ESFQRmax of 25 nm. Moreover, no pad glazing was observed.

In Comparative Example 1, wafers of single-crystal silicon having a diameter of 300 mm, a {100} orientation and the same specification as in Working Example 1 were polished in a commercial double side polishing machine, the operating conditions employed being the same as in Working Example 1 except for the target pH specified being a pH of 11.0. For a polished wafer selected at random, a front-side ZDD of -12 nm/mm^2 and an ESFQRmax of 45 nm were found.

In Working Example 1 and in Comparative Example 1, the ZDD was determined with division of the wafer surface into 16 sectors and with an edge exclusion of 1 mm. In Working Example 1 and in Comparative Example 1, the ESFQRmax was determined with division of the wafer edge surface into 72 sectors each with a length of 35 mm and with an edge exclusion of 1 mm. Figs 2 and 3 show the change in thickness of the polished wafer in radial direction. Fig. 2 shows the change in thickness of the wafer polished according to Comparative Example 1. Fig. 3 shows the change in thickness of the wafer polished according to Working Example 1. A comparison of Figs 2 and 3

reveals the relatively low edge roll-off of the wafer polished according to the method of the invention (see circled regions on the right-hand edge in Figs 2 and 3).

Comparison of Working Example 1 and Comparative Example 1 shows that a target pH in the range from 11.4 to 12.4, with a low fluctuation span, i.e. a small deviation
5 from target, leads to a reduction in edge roll-off.

Furthermore, a number of methods for double side polishing in accordance with Working Example 1 were carried out one after another, with the polished wafers being exchanged for new, unpolished wafers between the individual polishing methods.

During the exchange of the polished wafers for unpolished wafers, the polish was
10 circulated via the bypass and the polish was refreshed. Refreshment took place by the draining of 5% by volume of the polish in the circulation circuit, the addition of 5% by volume of fresh polish, and the subsequent adjustment of the desired pH by supply of potassium hydroxide solution. It was possible to show that exchange of just 5% by
15 volume of the polish is sufficient to achieve the improved edge geometry, measured as ZDD and ESFQRmax, in the subsequent polishing operations (polishing runs) as well and to refresh the polish generally sufficiently.

Furthermore, in another comparative example, regulation of the pH was paused during polishing, by switching off the metering pump for 10 minutes during a polishing run, meaning that no potassium hydroxide solution was supplied. The pausing of pH
20 regulation during the polishing run for 10 minutes resulted in a drop in polish pH from originally 11.8 to 11.5 (see interval c in Fig. 4).

Claims

1. Method for double side polishing of at least one wafer of semiconductor material, comprising the following steps:

placing the at least one wafer of semiconductor material in at least one carrier plate between an upper and a lower polishing platen of a double side polishing machine (1), the lower side of the upper polishing platen and the upper side of the lower polishing platen each being covered with a polishing pad;

setting the at least one carrier plate, the upper polishing platen and the lower polishing platen in rotation;

circulating a polish between a collecting vessel (2) and the at least one wafer of semiconductor material disposed between the upper and lower polishing platens of the double side polishing machine (1);

measuring the pH of the polish, the pH being measured continuously or at regular intervals having a duration of 0.01 to 10 seconds; and

regulating the pH of the polish;

characterized in that a target for the pH is not less than 11.4 and not more than 12.4 and the pH is regulated by temporary supply of a basic composition to the polish as a function of the measured pH such that the deviation of the measured pH from the target pH during the circulation of the polish between the collecting vessel and the at least one wafer of semiconductor material disposed between the upper and lower polishing platens of the double side polishing machine is at no instant more than ± 0.2 .

2. Method for double side polishing of at least one wafer of semiconductor material according to Claim 1, characterized in that the target pH is not less than 11.5 and not more than 12.3.

3. Method for double side polishing of at least one wafer of semiconductor material according to Claim 1 or 2, characterized in that the target pH is not less than 11.7 and not more than 11.9.

4. Method for double side polishing of at least one wafer of semiconductor material according to any of Claims 1 to 3, characterized in that

the pH of the polish is measured in the collecting vessel (2), and
the pH is regulated by temporary supply of a basic composition into the
collecting vessel (2).

5 5. Method for double side polishing of at least one wafer of semiconductor material
according to any of Claims 1 to 4, characterized in that the basic composition is a
basic solution which comprises at least one compound selected from sodium
carbonate, potassium carbonate, ammonium carbonate, sodium hydrogencarbonate,
potassium hydrogencarbonate, sodium hydroxide, potassium hydroxide, ammonium
10 hydroxide, tetramethylammonium hydroxide and tetraethylammonium hydroxide.

6. Method for double side polishing of at least one wafer of semiconductor material
according to any of Claims 1 to 5, characterized in that
the collecting vessel (2) is connected to a reservoir vessel (4) which contains
15 the basic composition, and

the pH is regulated by temporary supply of the basic composition from the
reservoir vessel (4) to the collecting vessel (2) by means of a pump or a valve.

7. Method for double side polishing of at least one wafer of semiconductor material
20 according to any of Claims 1 to 6, characterized in that the deviation of the measured
pH from the target pH during the circulation of the polish between the collecting vessel
and the at least one wafer of semiconductor material disposed between the upper and
lower polishing platens of the double side polishing machine is at no instant more than
 ± 0.1 , preferably not more than ± 0.05 .

25

8. Method for double side polishing of at least one wafer of semiconductor material
according to any of Claims 1 to 7, characterized in that the regulation of the pH in the
collecting vessel (2) comprises the following steps:

supplying the basic composition as soon as the measured pH in the collecting
30 vessel (2) falls below a specified lower limit, and

interrupting the supply of the basic composition as soon as the measured pH in
the collecting vessel (2) exceeds a specified upper limit,

where the specified lower limit and the specified upper limit deviate by not more than ± 0.2 from the target pH and the basic composition is a solution.

9. Method for double side polishing of at least one wafer of semiconductor material according to Claim 8, characterized in that the specified lower limit and the specified upper limit deviate by not more than ± 0.1 , preferably not more than ± 0.05 , from the target pH.

10. Method for double side polishing of at least one wafer of semiconductor material according to any of Claims 1 to 9, characterized in that the pH is regulated by adding a specified amount of a basic solution at variable intervals from the reservoir vessel (4) to the collecting vessel (2), the length of the intervals each depending on the measured pH.

11. Method for double side polishing of at least one wafer of semiconductor material according to any of Claims 1 to 10, characterized in that the polish is a dispersion which comprises abrasive particles and one or more compounds selected from the group of surface-active additives, preservatives, biocides, alcohols and complexing agents, and the dispersion has a solids content of 0.1% to 10.0% by weight, preferably 0.3% to 5.0% by weight, more preferably 0.5% to 2.0% by weight.

12. Method for double side polishing of at least one wafer of semiconductor material according to any of Claims 1 to 11, characterized in that after the end of polishing the at least one wafer of semiconductor material and before the start of polishing at least one exchanged, unpolished wafer of semiconductor material, the polish is no longer circulated via the double side polishing machine, and the polish, while being no longer circulated via the double side polishing machine, is refreshed, by the exchange of 1% to 30% by volume of the polish in the collecting vessel (2) for fresh polish and the subsequent adjustment of the pH to the target pH by addition of the basic composition.

13. Method for double side polishing of at least one wafer of semiconductor material according to Claim 12, characterized in that the polish is refreshed by the exchange of

2% to 8% by volume of the polish in the collecting vessel (2) for fresh polish and the subsequent adjustment of the pH to the target pH by addition of the basic solution.

14. Method for double side polishing of at least one wafer of semiconductor material
5 according to any of Claims 1 to 13, characterized in that the method additionally comprises a step of final polishing and/or a step of final cleaning of the at least one wafer of semiconductor material.