

(54) [Title of the Invention] DOUBLE-SIDE POLISHING  
APPARATUS

[Detailed Description of the Invention]

[Technical Field]

[0001]

The present invention relates to a double-side polishing apparatus, and specifically to a double-side polishing apparatus that can efficiently manufacture a wafer for a semiconductor having a high flatness.

[0002]

A conventional wafer manufacturing method will be explained by an example of a silicon wafer manufacturing method. First, a silicon single crystal ingot is grown, for example, by the Czochralski method (the CZ method). The obtained silicon single crystal ingot is sliced to produce silicon wafers, and thereafter the silicon wafers are subjected to each of the steps of chamfering, lapping, and etching one after the other. At least a polishing process is subsequently performed to make a main surface of each wafer a mirror surface.

[0003]

In this polishing process of the wafer, for example, a double-side polishing apparatus may be used to polish both surfaces of the silicon wafer.

As the double-side polishing apparatus, a so-called four-way double-side polishing apparatus is normally used which has a planetary gear construction in which a carrier for holding wafers are arranged between a sun gear provided at a center portion and an internal gear provided at an outer circumferential portion.

[0004]

The four-way double-side polishing apparatus can

simultaneously polish both surfaces of the silicon wafers by inserting the silicon wafers into a plurality of carriers, in which wafer-holding holes are formed, to hold the wafers, by rotating an upper turn table and a lower turn table, in which a polishing pad is attached on each of the surfaces facing to the wafers, in a direction relative to one another with pressing the upper turn table and the lower turn table against front and back surfaces of each of the wafers, while supplying a polishing slurry from above the held silicon wafers, and by concurrently rotating and revolving the carrier with the sun gear and the internal gear.

[0005]

However, when the above-described double-side polishing apparatus is used to polish, the polishing rate of the wafer varies every polishing due to deterioration of a polishing jig material such as the polishing pad and the carrier. When the polishing is performed for a predetermined polishing time, there arises a problem such that thicknesses of the polished wafers are different respectively due to a different polishing rate.

In view of this, there is disclosed a double-side polishing apparatus that polishes while measuring the thickness of the wafer during polishing.

[0006]

For example, with the polishing apparatus that polishes while measuring the thickness of a semiconductor wafer during polishing by using an optical reflection interferometry like inventions described in Patent Document 1 and Patent Document 2, the flatness of the polishing surface can be made high.

Moreover, according to the invention of Patent

Document 1 for example, with light having a light transmittable wavelength through the wafer, the thickness can be measured with forming focus by moving a measuring light flux along a thickness direction from a front surface of the semiconductor wafer to a back surface thereof.

[0007]

However, in this art described in Patent Document 1, since the focus is formed along the thickness, it is easy to be influenced by vibration of the wafer during the polishing, and a difference between a measured value and an actual thickness of the wafer therefore becomes large. It is also easy to be influenced by light attenuation depending on a distance from an object to be measured, and a distance between a point where the focus is formed and a point where the light is input and output needs to be approximated. There is therefore a problem of contamination and damage by mist due to the polishing slurry and the like in a passage of the light.

Moreover, a frequency of taking the measuring light from a designated area on a polishing surface in the measuring light needs to be increased during the polishing in order to improve the precision of the measurement. A confocal method such as Patent Document 1 is, however, inferior in responsivity, and it has a fault such that the frequency of taking in is low.

[0008]

[Patent Document 1] Japanese Unexamined Patent publication (Kokai) No.2002-59364

[Patent Document 2] Japanese Unexamined Patent publication (Kokai) No.H7-4921

[Disclosure of the Invention]

[The Problem to be solved by the Invention]

[0009]

The present invention was accomplished in view of the above-explained problems, and its object is to provide a double-side polishing apparatus that can polish the wafer while measuring the thickness of the wafer with high precision without being influenced by a measurement error as represented by vibration of the wafer during polishing, in the double-side polishing apparatus that can polish while measuring the thickness of the wafer.

[Means to solve the Problems]

[0010]

To achieve this object, the present invention provides a double-side polishing apparatus including at least: a lower turn table having a flat polishing-upper-surface rotationally driven; an upper turn table having a flat polishing-lower-surface rotationally driven, the upper turn table being arranged with facing to the lower turn table; and a carrier having a wafer-holding hole for holding a wafer, the apparatus comprising a plurality of openings provided between a rotation center and an edge of the upper turn table or the lower turn table, and a wafer-thickness-measuring mechanism for measuring a thickness of the wafer through the plurality of openings during polishing in real time, the apparatus wherein the wafer-thickness-measuring mechanism is fixed to a fixed end except the upper turn table and the lower turn table of the double-side polishing apparatus.

[0011]

In this manner, when the plurality of openings for measuring the thickness of the wafer are provided at the upper turn table or the lower turn table in the double-side polishing apparatus that can simultaneously polish

both surfaces of the wafer, a frequency of the measurement of the thickness can be increased, and the precision of the measurement can be thereby improved. In particular, in a batch-wise polishing apparatus that simultaneously polishes a plurality of wafers, the thicknesses of the wafers can be simultaneously measured through the plurality of openings, and it can particularly contribute to the improvement in the precision of the measurement.

In addition, when the wafer-thickness-measuring mechanism is fixed to a portion except the upper turn table and the lower turn table that are easily influenced by vibration during polishing, the thickness of the wafer can be measured without being influenced by the vibration and the like, and the precision of the measurement of the thickness can be improved.

Through the above-described effect, the thickness of the wafer can be accurately seen in real time during polishing, and the double-side polishing apparatus can therefore readily process the thickness of the polished wafer into a target thickness.

[0012]

Moreover, the wafer-thickness-measuring mechanism preferably has an apparatus of a wavelength-variable-infrared laser having a light transmittable wavelength through the wafer.

In this manner, when the apparatus of a wavelength-variable-infrared laser having a light transmittable wavelength through the wafer is used as the wafer-thickness-measuring mechanism, the reflection spectrum on the surface of the wafer (a situation of interference of light reflected from a front surface and a back surface of the wafer) can be evaluated, and the

thickness of the wafer can be thereby measured with high precision during polishing.

[0013]

Moreover, the wavelength of the laser is preferably 1575 to 1775 nm.

In this manner, when the infrared laser having a wavelength of 1575 to 1775 nm and a high speed, for example, for communication application is used as a laser for the measurement, temporal resolution can be increased, and the thickness of the wafer can be evaluated with higher precision during polishing.

[0014]

Moreover, the wafer-thickness-measuring mechanism preferably measures a bulk thickness of the wafer.

In this manner, when the bulk thickness of the wafer is measured, an actual thickness of the wafer can be judged during polishing, and the thickness of the polished wafer can be thereby made closer to a target thickness.

[0015]

Moreover, the plurality of openings are preferably provided with them equally spaced at a periphery of the upper turn table.

In this manner, when the plurality of openings are provided with them equally spaced, the thickness of the wafer can be readily measured, and the polishing can be thereby performed with high precision. In addition, when they are provided at the periphery, the thicknesses of all of the held wafers can be measured during polishing, for example, with the four-way double-side polishing apparatus without a bad influence on the polishing. When they are provided at the upper turn table, the leak of the polishing slurry through the

openings can be suppressed, and the maintenance of the turn tables thereby becomes easy. In addition, a risk of a measuring problem of the thickness of the wafer can be suppressed.

[0016]

Moreover, the fixed end to which the wafer-thickness-measuring mechanism is preferably fixed is a housing of the double-side polishing apparatus.

In this manner, when the wafer-thickness-measuring mechanism is fixed at the housing of the double-side polishing apparatus, the wafer-thickness-measuring mechanism can be protected from vibration and stain and also the thickness of the wafer can be measured with high precision through the plurality of openings. An influence of noise can be thereby reduced, and the thickness of the wafer can be measured with higher precision during polishing.

[Effects]

[0017]

As explained above, the present invention provides the double-side polishing apparatus polishing while measuring the thickness of the wafer, the apparatus which can perform polishing while measuring the thickness of the wafer with high precision without being influenced by a measurement error as represented by the vibration of the wafer during polishing.

[Best Mode for Carrying out the Invention]

[0018]

Hereinafter, the present invention will be explained in detail with reference to the drawings. However, the present invention is not restricted thereto.

As shown in FIG. 1, the double-side polishing apparatus 10 according to the present invention includes

the lower turn table 12 having the flat polishing-upper-surface 12a rotationally driven; the upper turn table 11 having the flat polishing-lower-surface 11a rotationally driven, the upper turn table being arranged with facing to the lower turn table 12; and the carrier 13 having the wafer-holding hole for holding the wafer W, in order to hold the wafer W, and also includes the wafer-thickness-measuring mechanism 16 for measuring the thickness of the wafer W during polishing.

The plurality of openings 14 for measuring the thickness of the wafer during polishing and a polishing-slurry-supply mechanism 15 are provided at a side of the upper turn table 11.

[0019]

The wafer-thickness-measuring mechanism 16 may have, for example, at least an optical unit 16a for radiating laser to the wafer W, a photo detector 16b for detecting the laser reflected from the wafer W, a laser source unit 16c, and a calculation/control unit 16d for calculating the thickness of the wafer from the detected laser.

[0020]

As described above, when the wafer-thickness-measuring mechanism is fixed to a portion (a fixed end) except the upper turn table and the lower turn table that are easily influenced by vibration during polishing, introducing unnecessary data, such as noise, into the measured raw data can be prevented. The precision of the measured data can be thereby remarkably improved in comparison with a conventional apparatus, and the thickness of the wafer can be thus accurately measured.

Moreover, when the plurality of openings for measuring the thickness of the wafer are provided at the

upper turn table or the lower turn table, the frequency of the measurement of the thickness can be increased. In particular, this is preferable for the case of simultaneously polishing a plurality of wafers in a batch-wise manner, and the precision of the measurement can be thereby improved.

Through these effects, the thickness of the wafer can be precisely seen during polishing in comparison with a conventional apparatus, and the double-side polishing apparatus can therefore readily make the thickness of the polished wafer close to a target thickness.

[0021]

Here, the fixed end to which the wafer-thickness-measuring mechanism 16 is fixed can be the housing 18 of the double-side polishing apparatus.

As described above, when the wafer-thickness-measuring mechanism is fixed to the housing of the double-side polishing apparatus, the wafer-thickness-measuring mechanism can be protected from vibration and stain. This allows the suppression of data deterioration and of introducing noise into the measured data of the thickness during polishing. The thickness of the wafer can be therefore measured with higher precision during polishing. It may be of course fixed to the fixed end of, for example, the ceiling of a house, but this has a disadvantage with regard to maintenance, vibration of the apparatus and the like.

[0022]

Moreover, the wafer-thickness-measuring mechanism 16 can measure a bulk thickness of the wafer.

When the thickness of the wafer measured with the wafer-thickness-measuring mechanism is the bulk

thickness, an actual thickness of the wafer during polishing is measured, and the thickness of the polished wafer can be therefore made closer to a target thickness. It can be of course the thickness of a SOI layer of a SOI wafer.

[0023]

Moreover, the wafer-thickness-measuring mechanism 16 can have the apparatus of the wavelength-variable-infrared laser having a light transmittable wavelength through the wafer.

As described above, when the apparatus of a wavelength-variable-infrared laser having a light transmittable wavelength through the wafer is used as the wafer-thickness-measuring mechanism, a situation can be analyzed, in which front-surface reflecting light reflected from the front surface of the wafer and back-surface reflecting light reflected from the back surface of the wafer, out of the input laser to the wafer, are interfered. The thickness of the wafer can be thereby evaluated during polishing with precision of an order of magnitude of a few nanometers to some dozen micrometers.

In addition to this, when the apparatus of the wavelength-variable-infrared laser is used, a great difference of the thickness of the wafer to be polished can be managed by changing the wavelength of the laser to be input, and a light source itself does not need to be changed. The cost can be thus reduced.

[0024]

The wavelength of the laser can be 1575 to 1775 nm.

As described above, when the laser having a wavelength of 1575 to 1775 nm is used, a decrease in the strength of the reflected laser, which is caused by the absorption of a part of the measuring laser into the

wafer and the polishing slurry, can be suppressed, and the thickness of the wafer can be measured with high precision.

[0025]

The plurality of openings 14 can be provided with them equally spaced at the periphery of the upper turn table 11.

As described above, when the plurality of openings are provided with them equally spaced at the upper turn table, the leak of the polishing slurry through each of the plurality of openings for the measurement can be suppressed, and the maintenance of the turn tables thereby readily carried out. In addition, a risk of a measuring problem of the thickness of the wafer can be suppressed. For example, in the four-way double-side polishing apparatus, it is advantageous to measure the thicknesses of all wafers.

[0026]

In the case of changing at least one of a polishing load, a rotation speed of the upper turn table 11, a rotation speed of the lower turn table 12 during polishing, the upper turn table 11 and the lower turn table 12 can be controlled by installing a polishing control unit 17 as illustrated in the double-side polishing apparatus 10. The at least one of a polishing load, a rotation speed of the upper turn table 11, a rotation speed of the lower turn table 12 can be thereby changed.

Accordingly, an appropriate response can be made against the changes in polishing conditions due to the deterioration of the polishing jig material such as the polishing pad and the carrier, the changes which are proved from the measured thickness of the wafer during

polishing of the wafer. The wafer having a very high flatness on the surface after polishing can be thereby stably obtained.

[0027]

Hereinafter, the wafer polishing method according to the present invention by using the above-described double-side polishing apparatus will be explained in detail. However, the present invention is not of course restricted thereto.

[0028]

First, the wafer W to be polished is set to the carrier 13. A plurality of the wafers W can be set this time.

The wafer W is held with the polishing-lower-surface 11a of the upper turn table 11, polishing-upper-surface 12a of the lower turn table 12, and the carrier 13, and the polishing is started while supplying the polishing slurry by a polishing-slurry-supply mechanism 15 and rotating the upper turn table 11 and the lower turn table 12 in a horizontal plane.

[0029]

In this case, the polishing is performed while measuring the thickness of the wafer W by a wafer-thickness-measuring mechanism, which is fixed to the fixed end at a different position from that of the upper turn table 11 or the lower turn table 12, through the plurality of openings 14 provided at the upper turn table 11 or the lower turn table 12.

[0030]

By the polishing method using the above-described double-side polishing apparatus, the state of a polishing surface of a wafer can be seen without stopping the polishing and, for example, the thickness

of the wafer during the polishing can be seen at any time. Whether the thickness reaches to a target thickness of the wafer can be thereby judged while performing the polishing. That is, whether the thickness reaches to a target thickness of the wafer can be judged without stopping the polishing, and the time required for the polishing can be consequently reduced.

In addition to these, since the wafer can be polished into a target thickness without predetermining the polishing time, the excess or deficiency of the polishing does not occur, and the deterioration of the flatness can be suppressed.

[Example]

[0031]

Hereinafter, the present invention will be explained in more detail based on Examples and Comparative Examples, but the present invention is not restricted thereto.

(Example)

The double-side polishing apparatus as shown in FIG. 1 was used to polish the wafers in a batch-wise manner (15 wafers in one batch). In this case, the target thickness of each of the polished wafers was 777  $\mu\text{m}$ .

As the wafer to be polished, there were prepared 600 silicon single wafers having a diameter of 300 mm and p<sup>-</sup>-type obtained by slicing, with a wire saw, an ingot grown by the CZ method. The wafers were subjected to chamfering, lapping, and etching. This p<sup>-</sup>-type wafer means a p-type wafer having a high resistivity.

There was prepared the wafer-thickness-measuring mechanism provided with the optical unit using the apparatus of a wavelength-variable-infrared laser, the

apparatus which can tune the wavelength of the laser to 1575 to 1775 nm. With this wafer-thickness-measuring mechanism, 300 wafers of 600 wafers were polished while measuring the thickness of the wafer, and the thickness of each of the polished wafers was evaluated by AFS (a capacitance flatness-measuring apparatus made of ADE co.,).

[0032]

(Comparative Example)

The same double-side polishing apparatus as Example was used to polish the other 300 wafers. In Comparative Example 3, however, the polishing was performed without operation of the wafer-thickness-measuring mechanism. The polishing time was determined in advance.

[0033]

FIG. 2 shows a relative frequency and a cumulative relative frequency of the thicknesses after the polishing of 300 wafers polished with the double-side polishing apparatus of Example and Comparative Example.

It was revealed that, in each of the wafers polished with the double-side polishing apparatus of Example, the variation of an average finishing thickness after the polishing was small in comparison with each of the wafers of Comparative Example and decreased by approximately 50%.

It was also revealed that the precision of standard deviation of 0.1  $\mu\text{m}$  or less was able to be achieved according to the double-side polishing apparatus of Example.

[0034]

As shown in FIG. 3, in each of the wafers polished with the double-side polishing apparatus of Example, the

thickness of each of the polished wafers was stable. On the other hand, each of the wafers of Comparative Example had a large variation and was unstable.

[0035]

It is to be noted that the present invention is not restricted 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.

[Brief Explanation of the Drawings]

[0036]

[FIG. 1] FIG. 1 is schematic view showing an example of the double-side polishing apparatus according to the present invention.

[FIG. 2] FIG. 2 is a graph showing a relative frequency and a cumulative relative frequency of the thicknesses after polishing of 300 wafers polished with the double-side polishing apparatus in Example and Comparative Example.

[FIG. 3] FIG. 3 is a graph showing the variation of the thicknesses after polishing of wafers polished with the double-side polishing apparatus in Example and Comparative Example.

[Explanations of Letters and Numerals]

[0037]

10 ... double-side polishing apparatus

11 ... upper turn table

11a ... flat polishing-lower-surface

12 ... lower turn table

12a ... flat polishing-upper-surface

13 ... carrier

14 ... plurality of openings

15 ... polishing-slurry-supply mechanism

16 ... wafer-thickness-measuring mechanism

16a ... optical unit

16b ... photo detector

16c ... laser source unit

16d ... calculation/control unit

17 ... polishing control unit

18 ... housing

W ... wafer

(57) [CLAIMS]

[Claim 1]

A double-side polishing apparatus including at least: a lower turn table having a flat polishing-upper-surface rotationally driven; an upper turn table having a flat polishing-lower-surface rotationally driven, the upper turn table being arranged with facing to the lower turn table; and a carrier having a wafer-holding hole for holding a silicon wafer, the apparatus comprising

a plurality of openings provided with them equally spaced at a periphery between a rotation center and an edge of the upper turn table, and

a wafer-thickness-measuring mechanism for measuring a thickness of the silicon wafer through the plurality of openings during polishing in real time, the apparatus wherein

the wafer-thickness-measuring mechanism is fixed to a fixed end except the upper turn table and the lower turn table of the double-side polishing apparatus, has an apparatus of a wavelength-variable-infrared laser having a light transmittable wavelength of 1575 to 1775 nm through the silicon wafer, and measures a bulk thickness of the silicon wafer by using an optical reflection interferometry.

[Claim 2]

The double-side polishing apparatus according to claim 1, wherein the fixed end to which the wafer-thickness-measuring mechanism is fixed is a housing of the double-side polishing apparatus.