

DESCRIPTION

POLISHING PAD

5 FIELD

[0001]

The present invention relates to a polishing pad, more specifically, relates to a polishing pad used for polishing a notch of a wafer.

10 BACKGROUND

[0002]

A wafer such as a silicon wafer has been used as a material of a semiconductor device such as an LSI. Such a wafer has a notch for showing its crystal orientation.

In general, the notch is formed by cutting a peripheral edge of the wafer and has a shape
15 such as a V-shape or a U-shape.

[0003]

In the production of a wafer having a notch, the notch is polished.

Commonly, a polishing slurry containing abrasive and a polishing pad having a disc shape are used in the polishing of notch. The notch is polished by allowing the
20 polishing pad which is rotated at a high speed to come into contact with the notch, while supplying the polishing slurry to the notch.

[0004]

As the polishing pad used for such an application, a polishing pad including, as a substrate, a nonwoven fabric excellent in flexibility has been known. Nevertheless,
25 the polishing pad formed by the nonwoven fabric has a problem of being easily worn by the contact with the notch. Thus, proposals for extending the lifetime of such a polishing pad have been conventionally made. For example, Patent Literature 1 provides a proposal to impregnate a urethane-based thermosetting resin in a nonwoven fabric that is formed into a circular shape. In such a polishing pad, the cured resin and
30 the fibers of the nonwoven fabric are integrated with each other to improve the strength, thereby allowing the polishing pad to exhibit superior wear resistance.

CITATION LIST

Patent Literature

[0005]

Patent Literature 1: JP 2011-009584 A

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SUMMARY

Technical Problem

[0006]

Due to the increased demands for semiconductor devices in recent years,
10 semiconductor devices may be required to be provided at a lower cost in the future. In
association with this, there is a likelihood that, as the requirements for polishing pads,
they may be required to be usable for a longer period of time and to have an excellent
polishing performance.

[0007]

15 Here, a polishing pad having a nonwoven fabric impregnated with a resin has
empty spaces that can absorb and keep a polishing slurry. In polishing a notch of a
wafer using the polishing pad, the polishing slurry is supplied to a contact area between
the polishing pad and the notch. At this time, part of the polishing slurry is absorbed
by the polishing pad, and then allowed to move from the peripheral edge of the
20 polishing pad to the notch by a centrifugal force due to high-speed rotation of the
polishing pad. It is considered that this indirect supply of the polishing slurry
contributes to the improvement of the polishing speed. From this point of view, a
polishing pad capable of easily absorbing the polishing slurry may be preferable.

[0008]

25 However, the present inventors have found that the polishing pad when being
allowed to excessively absorb the polishing slurry swells and then softens, as a result of
which the polishing pad becomes easily worn. In other words, it is considered that the
conventional polishing pad of this type excessively absorbs the polishing slurry and thus
is difficult to be used for a long-term period. In addition, the polishing pad that has
30 swollen and softened may not be able to produce a desired polishing performance.

[0009]

In view of the above circumstances, it is an object of the present invention to

provide a polishing pad that is suppressed from softening by a polishing slurry.

Solution to Problem

[0010]

5 The polishing pad according to an embodiment of the present invention is a disc-shaped polishing pad used for polishing a notch of a wafer, the polishing pad including a nonwoven fabric, the nonwoven fabric forming: a peripheral edge for polishing the notch; and a pair of side face parts, and the polishing pad configured to prevent a polishing slurry from penetrating through the side face parts.

10 [0011]

 According to such a configuration, the polishing pad is suppressed from softening by the polishing slurry since the polishing pad is configured to prevent the polishing slurry from penetrating through the side face parts which occupy most of the surface of the polishing pad.

15 [0012]

 In the polishing pad according to one form of the present invention, the polishing pad has empty spaces, and the empty spaces at the side face parts are closed by a resin. The resin is not particularly limited as long as it has a performance to close the empty spaces, but a thermoplastic resin is particularly preferable.

20

Effect

[0013]

 According to the present invention, a polishing pad that is suppressed from softening by a polishing slurry can be provided as described above.

25

BRIEF DESCRIPTION OF DRAWINGS

[0014]

 Fig. 1 is a schematic view of a polishing machine including a polishing pad of an embodiment as viewed from above, which allows visual observation of a peripheral
30 edge of the polishing pad.

 Fig. 2 is a schematic view of the polishing machine of Fig. 1 as viewed from one side in a horizontal direction, which allows visual observation of one side face part

of the polishing pad.

Fig. 3 is a schematic view showing the shape of a test piece for capturing a CT image in Examples.

Fig. 4 shows CT images of a polishing pad of Comparative Example 2, which allows visual observation of a polishing slurry penetrated inward in a thickness direction from a side face part.

Fig. 5 shows SEM images respectively showing surfaces of the side face parts of the polishing pads according to Comparative Example 2 and Example 1.

DESCRIPTION OF EMBODIMENTS

[0015]

Hereinafter, a description will be given for one embodiment of the present invention with reference to the drawings.

[0016]

As shown in Fig. 1 and Fig. 2, a polishing pad 1 of this embodiment is used by being incorporated into a polishing machine 100 for polishing a notch 21 of a silicon wafer 2. More specifically, the polishing pad 1 of this embodiment has a disc shape and is used by being incorporated into the polishing machine 100 while being held in an upright state. On the other hand, the silicon wafer 2 is supported so as to extend along a horizontal plane in the polishing machine 100. When in use, a peripheral edge 11 of the polishing pad 1 of this embodiment is held in contact with the notch 21 of the silicon wafer 2, while being rotated in a circumferential direction. That is, the polishing pad 1 incorporated into the polishing machine 100 has the peripheral edge 11 configured to move in a perpendicular direction in its contact area with the notch 21, and a pair of side face parts 12 each extending along a vertical plane.

[0017]

More specifically for the polishing machine 100, the polishing machine 100 includes a jig 3 for rotating the polishing pad 1 at a high-speed (e.g., 500 rpm or more), while supporting the polishing pad 1 in the upright state. The jig 3 is referred to as a drum and has a disc-shaped first support part 31 in abutting contact with a central area of a side face part 12 on one side of the polish pad 1, and a disc-shaped second support part 32 in abutting contact with a central area of a side face part 12 on another side of

the polishing pad 1. The jig 3 is configured to rotate each of the support parts at a high-speed in the circumferential direction, while holding the polishing pad 1 between the first support part 31 and the second support part 32.

[0018]

5 The polishing machine 100 further includes a slurry feeder (not shown) for supplying the polishing slurry from above to the notch 21, and a support table (not shown) for supporting the silicon wafer 2. The support table has a circular-shaped support surface for mounting the silicon wafer 2 thereon. The support table is configured to rotate the support surface to allow the silicon wafer 2 to shift from the position at which it is held in an upward-inclined state to the position at which it is held in a downward-inclined state with the notch at the center. Thereby, the polishing machine 100 can polish the notch 21 entirely.

[0019]

15 The polishing slurry used together with the polishing pad 1 of this embodiment includes abrasive composed of silica particles and a solvent for dispersing the abrasive.

[0020]

20 The polishing pad 1 of this embodiment includes one sheet of nonwoven fabric as a substrate. The one sheet of nonwoven fabric forms the peripheral edge 11 and the pair of side face parts 12. The nonwoven fabric of this embodiment is impregnated with a thermoplastic resin. That is, the polishing pad 1 of this embodiment is formed by the nonwoven fabric impregnated with a resin. In the polishing pad 1, the thermoplastic resin is adhered to fibers that form the nonwoven fabric. Gaps are formed between the fibers to which the thermoplastic resin is adhered. That is, the polishing pad 1 of this embodiment has empty spaces as the aforementioned gaps. In the polishing pad 1 of this embodiment, the empty spaces at the side face parts 12 are closed by the thermoplastic resin. Thereby, the polishing pad 1 of this embodiment is configured to prevent the polishing slurry from penetrating thereinto from the side face parts 12. The empty spaces can be formed in the thermoplastic resin coagulated on the fibers or can be formed between the fibers to which no thermoplastic resin is adhered, or can be composed of the mixture of them.

[0021]

The expression “to prevent the polishing slurry from penetrating from the side

face parts 12'' in this embodiment means that a penetration depth when a given polishing slurry is brought into contact with the side face parts 12 is 0.80 mm or less. The penetration depth can be measured according to the measurement method using an X-ray CT to be described below.

5 [0022]

[Method for measuring a penetration depth]

(Preparation of a test piece)

10 10 test pieces each having dimensions (length: 8 mm, width: 8 mm, thickness: 4.5 mm) shown in Fig. 3 are cut out from a polishing pad in a dry state (which means normal storage state and no pre-treatment by drying is required). An upper surface in each of the test pieces of Fig. 3 is a part corresponding to any of the side face parts of the polishing pad.

(Polishing slurry for measurement)

15 A polishing slurry (EG1103 manufactured by NITTA DuPont Incorporated, abrasive: colloidal silica, abrasive size: 80 to 140 nm, specific gravity of abrasive: 1.25, solvent: water) is diluted with ion-exchange water (surface tension: 71 mN/m) by 21 times to be served as a polishing slurry for measurement having a surface tension of 70 mN/m. The surface tension can be measured for a sample adjusted to 24 °C, using a measurement device (Drop Master 500 manufactured by Kyowa Interface Science Co.,
20 Ltd.), according to a pendant drop method. The abrasive size means a median size and can be measured in the following manner. That is, using the zeta-potential & particle size measurement system ELSZ-2 (manufactured by Otsuka Electronics Co., Ltd.), a volume particle size distribution is determined by a dynamic light scattering method. Then, the particle size, at which the cumulative volume frequency in the obtained
25 volume particle size distribution is 50%, is taken as the median size of the abrasive. The measurement is performed by filling a measurement cell with the polishing slurry diluted by 50 times by ultrapure water.

(X-ray CT scanning)

30 The test piece is set on the X-ray CT device (3D X-ray microscopic CT scanner TDM1000H-1 manufactured by Yamato Scientific Co., Ltd.), and first, subjected to an X-ray CT measurement in the dry state. Thereafter, 1 drop of the polishing slurry for measurement is placed on the upper surface of the test piece by a dropper (E-22

manufactured by AS ONE Corporation, material: polyethylene, capacity: 1 mL, total length: 150 mm), followed by leaving as it is until the lapse of 1 minute, and starting to capture images of the test piece as a polishing pad after dropping. The test piece is allowed to stand still from the start of dropping to the end of measurement. Thereafter,

5 CT images in a thickness direction of the test piece in the dry state and the test piece after the lapse of 1 minute from the dropping are captured under the following conditions. The amount of dropping by the dropper falls within a range of 20 to 50 mg. According to the actual measurement in Examples, however, it has been found that such a degree of change in the amount of dropping has no influence on the value of

10 the penetration depth.

(Measurement conditions for X-ray CT)

Number of views per revolution: 600

Number of frames / views: 9

15 X-ray tube voltage [KV]: 32.000

X-ray tube voltage [mA]: 0.080

Spreading axis position [mm]: 7.416

Reconstructed pixel size X [mm]: 0.003880

Reconstructed pixel size Y [mm]: 0.003880

20 Reconstructed pixel size Z [mm]: 0.003880

(Capture of X-ray CT image)

An image processing software VGStudio Max 2.1 manufactured by Volume Graphics can be used as a CT image processing software. ImageJ (Rasband, W.S.,

25 U.S. National Institutes of Health, Bethesda, Maryland, USA) can be used as an image analyzing software for calculating the penetration depth. Binarization processing to classify each of the measurement areas into empty spaces and parts other than the empty spaces (parts with the forming materials and the polishing liquid present therein) is performed in the manner mentioned below. In binarization processing, the contrast

30 adjustment is performed in the image of each measurement area in order to classify the area into empty spaces and parts other than the empty spaces (parts with the forming

materials present therein) using the image processing software VGStudio Max. The contrast adjustment is performed in Ramp mode. In VGStudio Max, the contrast adjustment is displayed as “Opacity Adjustment”. In this contrast histogram, a peak of empty spaces, a peak of the polishing pad, and a peak of the abrasive appeared at the same time. In the adjustment of the contrast, a gray value is adjusted to make these three peaks clear in the CT image. Specifically, the lower limit of gray value is set to be immediately beneath (= zero) the peak of empty spaces, and the upper limit of gray value is set to be over the peak of parts where materials are present by about +100 to +400. The contrast adjustment is not necessarily performed under these conditions because the transmittance varies depending on the presence or absence of the materials and the slurry and the degree of penetration of the slurry. Slice images of the measurements areas are captured based on 2D images, for which the contrast adjustments have been performed. The visual field size (vertical $\times$ horizontal $\times$ height) in this case is 1.986650 mm $\times$ 1.986650 mm $\times$ 1.994410 mm, and the polishing pad is adjusted to have the side face part placed at a position equal to or higher than half the height of the view angle.

(Calculation of penetration depth)

As shown in Fig. 4, two CT images are obtained and aligned in a horizontal row. Hereinafter, the direction orthogonal to the thickness direction in each image (i.e., vertical direction in Fig. 4) is referred to as a width direction (i.e., right-left direction in Fig. 4). A reference line L0 for defining the surface of the side face part 12 is drawn to include fibers appearing on the uppermost part of the test piece in the dry state. The reference line L0 is a line segment in a linear shape and has a length corresponding to the width of the image. Next, in the image after the lapse of 1 minute after the dropping, a bottom line L1 is set by extracting, from any line segments parallel to the reference line L0, a line segment of which length at the position intersecting with the polishing slurry is 10% based on the length of the reference line L0. The distance in the thickness direction between the reference line L0 and the bottom line L1 is designated as the penetration depth of the test piece. The calculation of each of the reference line L0, the bottom line L1, and the penetration depth was performed by measuring the number of pixels using the aforementioned ImageJ. The mean value of

the penetration depths of 10 test pieces is designated as the penetration depth in the side face part 12.

[0023]

The penetration depth from the side face part 12 is preferably 0.5 mm or less.

5 The thickness of the polishing pad 1 of this embodiment is 4 to 6 mm, which is a general thickness of the polishing pad of this type. Since the polishing pad 1 of this embodiment is configured to prevent a polishing slurry from penetrating through the side face part 12, the thermoplastic resin adhered to the nonwoven fabric as a substrate and the fibers of the nonwoven fabric can be suppressed from softening and thereby are
10 less likely to be worn.

[0024]

The side face part 12 can be formed by hot-pressing the nonwoven fabric impregnated with the thermoplastic resin at a temperature at which the thermoplastic resin can soften. The thermoplastic resin is flowable across the side face part 12 by the
15 hot pressing and thus is preferable. Thereby, the empty spaces can be closed at the side face part 12.

[0025]

The fibers that form the nonwoven fabric of this embodiment are one or more selected from the group consisting of polyester fibers, nylon fibers, polypropylene
20 fibers, polyvinyl alcohol fibers, and polyamide fibers. The weight of the nonwoven fabric is preferably 500 to 1000 g/m². The fineness of the fibers that form the nonwoven fabric is preferably 1 to 10 dtex. Thereby, the empty spaces become easily closed by the thermoplastic resin, while appropriate flexibility can be imparted to the polishing pad 1. The aforementioned weight can be measured by the method regulated
25 in JIS L 1913:2010 (Test methods for nonwoven fabrics), “6.2 Mass per unit area”. The aforementioned fineness can be measured by “8.3 Fineness a) Method A” according to JIS L 1013:2010 (Testing methods for man-made filament yarns).

[0026]

It is preferable that the thermoplastic resin have a softening temperature lower
30 than a melting point of the resin that forms the fibers of the nonwoven fabric. By using such a thermoplastic resin, it can become possible to close the empty spaces, while maintaining the performance such as strength or flexibility due to the nonwoven

fabric structure at the time of hot pressing.

[0027]

As the thermoplastic resin, a synthetic resin such as a urethane resin, a polycarbonate resin, an acrylic resin, a melamine resin, a phenol resin, or an acetal resin can be suitably used. As described above, these thermoplastic resins can be selected in terms of the softening point and the melting point of (the resin of) the fiber that forms the nonwoven fabric.

[0028]

The polishing pad 1 of this embodiment has the pair of side face parts 12 and an inner layer part located between the side face parts 12. The inner layer part has the empty spaces. More specifically, the empty spaces are left in the inner layer part while being not closed by the thermoplastic resin so that a porous structure is formed. A peripheral edge of the inner layer part is exposed and form, together with the pair of side face parts 12, the peripheral edge 11 of the polishing pad 1. In other words, the peripheral edge 11 of the polishing pad 1 is formed by the peripheral edges of the pair of side face parts 12 and the inner layer part. The polishing slurry supplied to the polishing pad 1 from the slurry feeder in the polishing machine 100 is absorbed mainly through the peripheral edge of the inner layer part in the polishing pad 1.

Subsequently, the absorbed polishing slurry scatters from the peripheral edge 11 toward the notch 21 by the centrifugal force of the polishing pad 1 rotating at a high speed. At this time, the pair of side face parts 12 function to direct scattering of the polishing slurry to the notch 21, while serving as inner walls to prevent the scattering of the polishing slurry from the side face parts 12, thereby increasing the thickness of a slurry film formed between the peripheral edge 11 and the notch 21. Thereby, the polishing slurry is intensively supplied to the notch 21, and thus the polishing performance can be improved. Further, the intensive supply of the polishing slurry can suppress the generation of heat at the peripheral edge 11. That is, the abrasion of the peripheral edge 11 can be suppressed.

[0029]

The polishing pad 1 of this embodiment can be produced by the following method. That is, the method for producing the polishing pad 1 includes an impregnation step of impregnating an impregnation solution containing the

thermoplastic resin in the nonwoven fabric, a coagulation step of causing the thermoplastic resin to be coagulated, a wash and dry step of removing the solvent from the nonwoven fabric and then drying it, and a surface treatment step of hot-pressing the nonwoven fabric impregnated with the thermoplastic resin.

5 [0030]

In the impregnation step, as a preparation step, the impregnation solution is prepared. The impregnation solution contains the thermoplastic resin and a solvent to dissolve it. As such a solvent, an aprotic polar solvent such as dimethylformamide, dimethylacetamide, dimethylsulfoxide, or tetrahydrofuran is preferable. Then, the
10 nonwoven fabric is impregnated in a container filled with the impregnation solution and taken out after a certain period. At this time, excess resin is squeezed and thereby removed by, for example, a mangle. Next, in the coagulation step, the nonwoven fabric filled with the impregnation solution is soaked in a coagulation liquid to subject it to wet-coagulation. Thereafter, in the wash and dry step, the solvent of the
15 impregnation solution is removed with water and the nonwoven fabric is dried.

[0031]

In the surface treatment step, the nonwoven fabric is hot-pressed at a temperature equal to or more than the glass transition temperature of the thermoplastic resin to allow the thermoplastic resin to flow into pores of the nonwoven fabric, to close
20 the pores with the thermoplastic resin. The temperature at the time of hot-pressing is preferably equal to or less than the melting point of the resin that forms the nonwoven fabric. In this case, the performance of the nonwoven fabric as a substrate becomes easily maintained.

[0032]

25 As described above, the embodiments have been shown as examples, but the polishing pad according to the present invention is not limited to the configurations of the aforementioned embodiments. The polishing pad according to the present invention is not limited by the aforementioned operational effects, either. Various modifications can be made to the polishing pad according to the present invention
30 without departing from the gist of the present invention.

[0033]

As a closing agent of the pores of the nonwoven fabric, for example, a thermosetting resin or a photocurable resin can be used. Further, two or more out of the thermoplastic resin, the thermosetting resin, and a photocurable resin can be used as the closing agent. Among them, the polishing pad impregnated with the thermoplastic resin is preferable since it can easily fit the shape of the notch, thereby reducing unpolished parts (uneven polishing).

[0034]

The polishing pad having the disc shape can have an annular shape with no central area.

[0035]

The polishing pad can be used in combination with other abrasive such as alumina abrasive.

[0036]

In the side face part, the pores in the area (i.e., the central area) in contact with the support part of the jig 3 can be not necessarily closed. In other words, the side face part can be configured to have pores closed in the area outside of the central area.

[0037]

In the method for producing the polishing pad, the pores can be closed by placing a resin sheet made of, for example, a thermoplastic resin on each of both sides of the nonwoven fabric, followed by hot-pressing.

EXAMPLES

[0038]

Hereinafter, the present invention will be further described by way of Examples, but is not limited thereto.

[0039]

(Production Example of Comparative Examples)

A polishing pad as a Comparative Example was produced by impregnating an impregnation solution containing a urethane resin as a thermoplastic resin into polyester fibers, and allowing it to be coagulated, washed, and dried, followed by a surface

treatment by buff finish.

[0040]

(Production Example of Examples)

Using an impregnation solution containing a thermoplastic resin of the same type as that in Comparative Examples, a polishing pad as an Example was produced by impregnating the impregnation solution into a nonwoven fabric, and allowing it to be coagulated, washed, and dried, followed by a surface treatment by hot-pressing at a temperature equal to or less than the melting point of the polyester fibers.

[0041]

10 (Evaluation method of lifetime)

Evaluation of lifetime of each polishing pad was performed by polishing a notch of a silicon wafer for 3 hours under the polishing conditions provided in Table 1, and observing the abrasion amount per hour. The results are as shown in Table 2 and Table 3. Table 2 shows the penetration depth of each polishing pad measured by the above measurement method. Table 3 shows the evaluation result of each polishing pad.

[0042]

[Table 1]

Item	Set value
Processing time	1200 sec/sheet × 9 times (Total time: 3 hours)
Number of revolution	± 1000 rpm
Pressing load	1 kgf
Turning angle	± 48°
Turning speed	10 °/sec
Traverse width	1.0 mm
Traverse speed	1.0 mm/sec

[0043]

[Table 2]

	Penetration depth in side face part of each test piece (mm)				
	C. Ex. 1	C. Ex. 2	C. Ex. 3	Ex. 1	Ex. 2
n1	> 1.2	0.98	1.09	0.49	0.50
n2	> 1.2	1.16	1.05	0.48	0.41
n3	> 1.2	0.98	1.16	0.49	0.53
n4	> 1.2	0.97	1.17	0.54	0.53
n5	> 1.2	> 1.2	1.16	0.50	0.49
n6	> 1.2	> 1.2	0.93	0.41	0.46
n7	> 1.2	> 1.2	0.91	0.41	0.45
n8	> 1.2	> 1.2	0.86	0.49	0.46
n9	> 1.2	> 1.2	0.97	0.48	0.43
n10	> 1.2	> 1.2	1.02	0.48	0.49

* Measurement of the penetration depth at 1.2 mm or more is impossible in terms of the view angle.

5 [0044]

[Table 3]

	C. Ex. 1	C. Ex. 2	C. Ex. 3	Ex. 1	Ex. 2
Thickness of polishing pad (mm)	4.5	4.0	4.5	4.5	4.1
Penetration depth (mm)	> 1.2	> 1.2	1.03	0.48	0.48
Lifetime (mm/hour)	3.25	3.15	1.73	1.24	1.15

[0045]

10 From the SEM images of Fig. 5 showing the surface on the side face part of each polishing pad, it can be found in Comparative Example 2 that relatively large numbers of openings derived from empty spaces which are not closed by the thermoplastic resin are seen at the side face part. On the other hand, it can be found in Example 1 that most parts of the empty spaces are closed by the thermoplastic resin,

15 and less openings derived from empty spaces are seen. It is considered that a difference was caused by this in the penetration depth between these polishing pads as shown in Table 2. Further, as shown in Table 3, there can be found a tendency that the polishing pad is further suppressed from swelling and softening, as a result of which the

polishing pad has a longer life time, as it has less penetration depth.

[0046]

No significant difference was found in the polishing performance between Comparative Examples and Examples. As a result, it is considered that, regardless of the amount of absorption of the polishing slurry is relatively low, the polishing pads according to Examples have a polishing performance not inferior to those according to Comparative Examples, and enable efficient polishing to enable reduction in the amount of supply of the polishing slurry.

10 REFERENCE SIGNS LIST

[0047]

- 1: Polishing pad
- 11: Peripheral edge
- 12: Side face part
- 15 2: Silicon wafer
- 21: Notch
- 3: Jig
- 31: First support part
- 32: Second support part
- 20 100: Polishing machine

CLAIMS

1. A disc-shaped polishing pad used for polishing a notch of a wafer, the polishing pad comprising a nonwoven fabric,
5 the nonwoven fabric forming: a peripheral edge for polishing the notch; and a pair of side face parts, and
the polishing pad configured to prevent a polishing slurry from penetrating through the side face parts.
- 10 2. The polishing pad according to claim 1, wherein
the polishing pad has empty spaces, and
the empty spaces at the side face parts are closed by a resin.
3. The polishing pad according to claim 2, wherein
15 the resin is a thermoplastic resin.