

DESCRIPTION

Title of Invention: POLISHING CLOTH

5 CROSS-REFERENCE TO RELATED APPLICATION

[0001]

This application claims priority to Japanese Patent Application No. 2020-215154, the disclosure of which is incorporated herein by reference in its entirety.

10

FIELD

[0002]

The present invention relates to a polishing cloth.

15 BACKGROUND

[0003]

A polishing cloth is used for polishing a polishing object such as a silicon wafer (for example, Patent Literature 1). The polishing cloth includes, as forming materials of the polishing cloth, an unwoven fabric and a resin that is impregnated in the unwoven fabric.

20

[0004]

As to such a polishing cloth, it is known that an edge sagging occurs in the outer peripheral edge portion of a polishing object when the polishing cloth has an excessively high flexibility. Conventionally, the edge sagging has been reduced by increasing the amount of resin to be impregnated to harden the polishing cloth, to thereby prevent an excessive contact with the outer peripheral edge portion of the polishing object.

25

CITATION LIST

30 Patent Literature

[0005]

Patent Literature 1: JP 2006-43811 A

SUMMARY

5 **Technical Problem**

[0006]

However, when the content of resin is increased, irregularities are likely to locally occur at intervals of about 100 to 200 μm in the entire polishing cloth. In particular, irregularities due to vertical interlacing of an
10 unwoven fabric causes minute fluctuations in the hardness of the polishing cloth. As a result, there was a problem in that the polishing cloth has excessive local contacts with the polishing object and thereby the flatness of the polishing object is deteriorated.

[0007]

15 In view of the aforementioned problem, it is an object of the present invention to provide a polishing cloth that can suppress minute fluctuations in the hardness of the polishing cloth.

Solution to Problem

20 [0008]

The polishing cloth according to the present invention includes, as forming materials of the polishing cloth, an unwoven fabric and a resin that is impregnated in the unwoven fabric, wherein an Asker-C hardness is 80 or more, and an interquartile range of mean values of vertical abundance
25 ratios of the forming materials in a width of 100 μm is 10.5 or less.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 is a graph showing an interquartile range of mean values of
30 vertical abundance ratios of forming materials in a width of 100 μm

according to each of polishing cloths of Comparative Example 1 and Examples 1 to 3, and a flatness of polishing objects respectively subjected to the polishing cloths.

Fig. 2 is a graph showing an interquartile range of mean values of vertical abundance ratios of forming materials in a width of 100 μm according to each of polishing cloths of Comparative Example 2 and Examples 4 to 5, and a flatness of each of polishing objects respectively subjected to the polishing cloths.

DESCRIPTION OF EMBODIMENTS

[0010]

Hereinafter, a description will be given for one embodiment of the present invention.

[0011]

A polishing cloth according to this embodiment includes, as forming materials for forming the polishing cloth, an unwoven fabric and a resin that is impregnated in the unwoven fabric. That is, the polishing cloth according to this embodiment includes the forming materials, and the forming materials include the unwoven fabric and the resin that is impregnated in the unwoven fabric.

[0012]

An Asker-C hardness of the polishing cloth according to this embodiment is 80 or more, preferably 85 or more. On the other hand, the Asker-C hardness is preferably 95 or less in terms of making defects (for example, scratches) hardly occur on the polishing object. Note that the case where the Asker-C hardness falls in the aforementioned range herein means the case where, when one polishing cloth is measured in two areas ($N = 2$) not overlapping each other (i.e., two non-overlapping areas), both areas satisfy the aforementioned range.

[0013]

The Asker-C hardness is a hardness measured using a rubber durometer adopted according to JIS K 7312 and generally used as a hardness index of the polishing cloth. The Asker-C hardness is measured for one surface of the polishing cloth, that is, a polishing surface. A press
5 needle for the measurement has a shape with a diameter of 5.08 mm and a height of 2.54 mm. In the case where the Asker-C hardness is 90, an area in a circle having a diameter of 2.2 mm is set as a measurement area. Because of this, minute fluctuations in the hardness of the polishing cloth occurring at intervals of about 100 to 200 μm cannot be reflected only by the Asker-C
10 hardness.

[0014]

As a result of diligent studies, the present inventors obtained a finding that a mean value of vertical abundance ratios obtained by an image processing in a thickness direction of the polishing cloth is proportional to
15 the hardness. From this finding, the present inventors found that minute fluctuations in the hardness of the polishing cloth can be suppressed by limiting the measurement area to a width of 100 μm and defining the vertical abundance ratio within a certain range.

[0015]

20 That is, in the polishing cloth according to this embodiment, the interquartile range of mean values of vertical abundance ratios of the forming materials in a width of 100 μm is 10.5 or less. The interquartile range of the mean values of the vertical abundance ratios is preferably 10.0 or less, more preferably 9.0 or less. Further, in the polishing cloth, the
25 interquartile range of the mean values of the vertical abundance ratios of the forming materials in a width of 100 μm can be 7.2 or more. Note that the case where the interquartile range of the mean values of the vertical abundance ratios of the forming materials falls in the aforementioned range herein means the case where, when one polishing cloth is measured in two
30 non-overlapping areas ($N = 2$), the aforementioned range is satisfied in both areas.

[0016]

The interquartile range of the mean values of the vertical abundance ratios of the forming materials in a width of 100 μm can be obtained in the following manner.

5 [0017]

First, a polishing cloth is sliced to obtain a slice surface (i.e., a cross sectional surface) vertical to the front surface, followed by capturing an image of a measurement area with a field of view of 2,000 $\mu\text{m} \times 2,000 \mu\text{m}$ of a slice surface, and extracting a plurality of small sections each having a size of 100 $\mu\text{m} \times 100 \mu\text{m}$. In the case where, for example, the polishing cloth has a thickness of 1.3 mm, 144 small sections each having a size of 100 $\mu\text{m} \times 100 \mu\text{m}$ are extracted in the measurement area of 1,200 μm (in a direction parallel to a surface of the polishing cloth) $\times$ 1,200 μm (in a direction orthogonal to the surface of the polishing cloth, that is, the thickness direction of the polishing surface). At this time, the measurement area in the thickness direction depends on the thickness of the polishing cloth.

[0018]

The arithmetic mean value of abundance ratios of the forming materials in a vertical column aligning from the front surface to the back surface of the polishing cloth is referred to as “the mean value of the vertical abundance ratios in a width of 100 μm ” (i.e., a mean value of the vertical abundance ratios of one vertical column having a width of 100 μm). According to the measurement herein, 17 cross sections of the polishing cloth at intervals of 100 μm were captured in one measurement for each of two areas (N=2) that do not overlap each other, followed by calculating mean values of vertical abundance ratios of the captured columns (12 columns $\times$ 17 images = 204 columns) each having a width of 100 μm ”, and then determining an interquartile range of the calculated mean values.

30 [0019]

The abundance ratio of the forming materials in each small section

of $100\ \mu\text{m} \times 100\ \mu\text{m}$ herein means a proportion of the area of a part with the forming materials present therein, when the entire area of the small section of $100\ \mu\text{m} \times 100\ \mu\text{m}$ is 100%.

[0020]

In the aforementioned measurement, CT-scan is employed for capturing the image of the polishing cloth. Specifically, a polishing cloth is sliced to obtain a slice surface (i.e., a cross section) orthogonal to the front surface of the polishing cloth, followed by capturing images of two measurement areas with a field of view of $2,000\ \mu\text{m} \times 2,000\ \mu\text{m}$ (the two measurement areas do not overlapped with each other), extracting a plurality of small sections each having a size of $100\ \mu\text{m} \times 100\ \mu\text{m}$ in each of the measurement areas, subjecting an image of each of the extracted small sections each having a size of $100\ \mu\text{m} \times 100\ \mu\text{m}$ to banalization processing to classify them into voids and parts other than the voids (parts with the forming materials present therein) to measure the abundance ratio (i.e., the area ratio).

[0021]

A 3D X-ray microscopic CT scanner (TDM1000H-1) manufactured by Yamato Scientific Co., Ltd can be used as a CT scanner. 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., U.S. National Institutes of Health, Bethesda, Maryland, USA) can be used as an image analysis software for calculating the abundance ratio (area ratio) of the forming materials.

[0022]

The aforementioned abundance ratio (area ratio) of the forming materials is measured under, for example, the following conditions.

[0023]

In the aforementioned measurement, the measurement areas of the polishing cloth are continuously measured based on the visual field size as follows:

Size of field of view (vertical $\times$ horizontal $\times$ height): 2,000 $\mu\text{m} \times$ 2,000 $\mu\text{m} \times$ the entire area in the thickness direction.

[0024]

Further, the conditions for the aforementioned measurement are as follows:

Number of views per revolution: 1,500

Number of frames / views: 10

X-ray tube voltage [KV]: 28.000

Spreading axis position [mm]: 7.416

Reconstructed pixel size X [mm]: 0.003880

Reconstructed pixel size Y [mm]: 0.003880

Reconstructed pixel size Z [mm]: 0.003880

[0025]

Binarization processing to classify each of the measurement areas into voids and parts other than the voids (parts with the forming materials present therein) is performed in the manner mentioned below.

[0026]

In binarization processing, the contrast adjustment is performed in the image of each measurement area in order to classify the area into voids and parts other than the voids (parts with the forming materials present therein) using the image processing software VGStudio Max. The contrast adjustment is performed in Ramp mode.

[0027]

The contrast adjustment is performed to make the difference between voids and parts other than the voids significant.

[0028]

In VGStudio Max, the contrast adjustment is displayed as “Opacity Adjustment”. Specifically, on a display of the opacity adjustment in VGStudio Max, the lower limit of a gray value is set to be a peak value, and the upper limit of a gray value is subsequently set to be in a range of “the peak value + 100 $\pm$ 5”. The range of the contrast adjustment is not

necessarily limited thereto because the light transmittance varies depending on the material.

[0029]

An image of the cross-section of the slice surface that is the measurement area is captured based on 2D images, for which the contrast adjustments have been performed. In the case where the image of the cross section is stored, the polishing cloth is set with a surface layer of the polishing cloth located on the upper part of the image since it is necessary to set to have a large visual field angle with respect to the measurement area.

[0030]

Next, on the basis of the captured images of the measurement areas, the abundance ratios of the forming materials are measured by the image processing software ImageJ.

[0031]

Herein, the measurement range of ImageJ is $1,200\ \mu\text{m} \times$ a thickness of the polishing cloth. In the case where, for example, the polishing cloth has a thickness of 1.0 mm, the measurement range is extracted in the manner in which, with designating a position on the upper left of an image data as a position: $(x, y) = (0\ \text{pix}, 0\ \text{pix})$, a range is determined by a position $(120, 10)$, a position horizontally extending by 312 pix ($= 1201.2\ \mu\text{m}$) from the position $(120, 10)$, and a position vertically extending by 234 pix ($= 900.9\ \mu\text{m}$) from the position $(120, 10)$. Subsequently, each image is binarized by converting the image type from RGB color to 8 bit. In the binarization conditions herein, an area having a tonal range of “129” to “255” corresponds to the part with the forming materials present therein. The image size of the aforementioned image data is reduced to a size with 12 pix in horizontal direction $\times$ 9 pix in vertical direction. In the reduced-size image, an area of 1 pix $\times$ 1 pix corresponds to a surface of $100\ \mu\text{m} \times 100\ \mu\text{m}$. This operation is repeated every $100\ \mu\text{m}$ of each of 17 images in the direction orthogonal to the polishing surface. In the binarization processing by ImageJ, a tonal range of “129” to “255” corresponds to the part other than the voids (part

with the forming materials present therein).

[0032]

A compression ratio of the polishing cloth according to this embodiment is preferably 5% or less, more preferably 3.5% or less. Note
 5 that the case where the compression ratio falls in the aforementioned range herein means the case where, when one polishing cloth is measured in two areas ($N = 2$) which do not overlap each other, the aforementioned range is satisfied in both areas.

[0033]

10 The compression ratio can be obtained by the following method. That is, using a compressive elasticity testing machine described in JIS L1096:2010 (area of a pressure element: 50 mm²), a thickness T1 of the polishing cloth that has been pressed with a load of 300 gf/cm² in the thickness direction of the polishing cloth by a pressure element and kept
 15 pressed for 60 seconds is measured. Next, a thickness T2 of the polishing cloth that has been pressed with a load of 1,800 gf/cm² in the thickness direction of the polishing cloth by a pressure element and kept pressed for 60 seconds is measured. On the basis of the measurement results, a compression ratio can be obtained by the following expression.

20 The compression ratio = $(T1 - T2) \times 100 / T1$

[0034]

A thickness of the polishing cloth according to this embodiment is preferably 0.8 mm or more and 3.0 mm or less, more preferably 1.0 mm or more and 2.0 mm or less. The aforementioned polishing cloth having a
 25 thickness of 0.8 mm or more is advantageous in that it can easily reduce an adverse effect on polishing performance due to the conditions of a surface plate of the polishing machine. Because of this, the polishing cloth according to this embodiment is also advantageous, for example, in that it can stably planarize a polishing object. On the other hand, the polishing
 30 cloth according to this embodiment having a thickness of 3.0 mm or less is advantageous in that it can reduce the amount of deformation of the

polishing cloth during the polishing, and, as a result, prevent an edge sagging of the polishing object from being easily caused. Note that the case where the thickness falls in the aforementioned range herein means the case where, when one polishing cloth is measured in two areas ($N = 2$) which do not overlap each other, the aforementioned range is satisfied in both areas.

[0035]

It is preferable that the polishing cloth according to this embodiment have a compression ratio of 5% or less and have a thickness of 0.8 mm or more and 3.0 mm or less. This configuration enables minute fluctuations in the hardness of the polishing cloth to be further suppressed.

[0036]

In the polishing cloth according to this embodiment, an apparent density of the forming materials is 0.30 g/cm³ or more and 0.50 g/cm³ or less, more preferably 0.40 g/cm³ or more and 0.50 g/cm³ or less. The apparent density of the forming materials of 0.30 g/cm³ or more and 0.50 g/cm³ or less enables minute fluctuations in the hardness of the polishing cloth to be further suppressed. The apparent density can be measured based on JIS K7222:2005. Note that the case where the apparent density falls in the aforementioned range herein means the case where, when one polishing cloth is measured in two areas ($N = 2$) which do not overlap each other, the aforementioned range is satisfied in both areas.

[0037]

Examples of fibers for forming the aforementioned unwoven fabric include polyester fibers and nylon fibers.

[0038]

A basis weight of the aforementioned unwoven fabric is preferably 200 g/m² or more and 600 g/m² or less. The polishing cloth according to this embodiment having a basis weight of 200 g/m² or more is likely to have a high hardness, and therefore is advantageous in that it is less likely to cause an edge sagging of a polishing object. Further, the polishing cloth

according to this embodiment, the unwoven fabric of which has a basis weight of 200 g/m² or more and 600 g/m² or less, easily has voids in the polishing surface at an appropriate ratio. As a result, the polishing cloth according to this embodiment having such a configuration is advantageous in that it easily suppresses the dispersion of the polishing performance due to clogging of voids with grind debris or the like.

[0039]

Examples of the aforementioned resin include a urethane resin.

[0040]

Example of the polishing object to be polished with the polishing cloth according to this embodiment include a silicon wafer.

[0041]

The polishing cloth according to this embodiment is configured as described above. Next, the description will be given for a method for producing the polishing cloth according to this embodiment.

[0042]

Hereinafter, the method for producing the polishing cloth according to this embodiment is described by taking, for example, the case where a method including a two-step impregnation treatment is performed, which includes allowing the unwoven fabric to be wet impregnated with a urethane resin, and to be additionally dry impregnated with a urethane resin.

[0043]

In the wet impregnation, a urethane resin is dissolved in an aqueous organic solvent to obtain a first impregnation liquid. Examples of the aqueous organic solvent include dimethylformamide, dimethylsulfoxide, tetrahydrofuran, and dimethylacetamide. The first impregnation liquid may include a filler. Examples of the filler include carbon black. Also, the first impregnation liquid may include a dispersion stabilizer. Examples of the dispersion stabilizer include a surfactant.

[0044]

Next, the unwoven fabric is dipped in the first impregnation liquid, and then the unwoven fabric dipped in the first impregnation liquid is dipped in water. Thereby, an aqueous organic solvent of the first impregnation liquid adhered to the unwoven fabric is replaced by water to
5 allow the urethane resin to coagulate and hence adhere to the surface of the unwoven fabric.

[0045]

In the dry impregnation, a prepolymer having terminal isocyanate groups, a curing agent that is an organic compound having active hydrogen,
10 and an organic solvent are mixed together to obtain a second impregnation liquid. Examples of the organic solvent include methyl ethyl ketone, acetone, alcohol, and ethyl acetate.

[0046]

Subsequently, the wet-impregnated unwoven fabric is dipped in the
15 second impregnation liquid, and the unwoven fabric dipped in the second impregnation liquid is heated in a drying furnace. Thereby, the organic solvent is vaporized to cause curing reaction of the prepolymer with the curing agent to proceed and form a urethane resin, and, as a result, a urethane resin further adheres to the surface of the unwoven fabric.

20 [0047]

The polishing cloth according to this embodiment configured as above has the following advantages.

[0048]

That is, the polishing cloth according to this embodiment includes,
25 as forming materials of the polishing cloth, an unwoven fabric and a resin that is impregnated in the unwoven fabric, wherein an Asker-C hardness is 80 or more, and an interquartile range of mean values of vertical abundance ratios of the forming materials in a width of 100 μm is 10.5 or less.

[0049]

30 The aforementioned polishing cloth in which the Asker-C hardness of 80 or more and the interquartile range of the mean values of the vertical

abundance ratios of the forming materials in a width of 100 μm is 10.5 or less can thereby reduce the unevenness due to the vertical interlacing of a unwoven fabric. As a result, minute fluctuations in the hardness of the polishing cloth which cannot be reflected by only the Asker-C hardness can be suppressed.

[0050]

The polishing cloth according to the present invention is not limited to the aforementioned embodiment. Also, the polishing cloth according to the present invention is not limited by the aforementioned function or effect.

Various modifications of the polishing cloth according to the present invention can be made without departing from the gist of the present invention.

EXAMPLES

[0051]

Next, the present invention will be more specifically described by way of Examples and Comparative Examples.

[0052]

Polishing cloths of Examples respectively having different physical properties shown in Table 1 and Table 2 were produced. Further, polishing cloths (commercially available products) of Comparative Examples respectively having different physical properties shown in Table 1 and Table 2 were prepared. An Asker-C hardness, a compression rate, an apparent density of the forming materials, mean values of vertical abundance ratios of the forming materials in a width of 100 μm , and an interquartile range of the mean values were respectively measured by the aforementioned methods.

[0053]

The flatness was evaluated with the different conditions for the polishing cloths having a thickness of 1.2 mm to 1.3 mm and the polishing cloths having a thickness of 0.9 mm to 1.1 mm as described below.

[0054]

Polishing cloths having a thickness of 1.2 mm to 1.3 mm:

Comparative Example 1, Examples 1 to 3

The GBIR was measured for a polished shape of a wafer using each
 5 of the polishing cloths. The polishing was carried out after each of the
 polishing cloths was set on the double-face polishing machine and subjected
 to dress treatment before polishing. As the GBIR and ESFQR of the wafer,
 the best values of GBIR / ESFQR while setting the gap between 0 to 3 μm
 were adopted. The results are shown in Table 1 and Fig. 1.

10 [0055]

The polishing conditions are as follows:

Polishing machine: Speed FAM 20B

Dresser: Speed FAM genuine dresser #100/#120

Gap setting: 0 to 3 μm

15 Polishing load: 1,500 kg

Revolutions: 10 rpm

Wafer: 12 inch P- Wafer

Polishing liquid: Solution having a solid content (115 °C) of 36.6%, a
 mean particle size of 108 nm, and a pH of 11.3.

20 [0056]

Polishing cloths having a thickness of 0.9 mm to 1.1 mm:

Comparative Example 2, Examples 4 to 5

The polishing was carried out after each of the polishing cloths was
 set in a single-face machine and subjected to dressing treatment before
 25 polishing. In the single-face machine, however, the flatness is greatly
 influenced by the shape before polishing, and thus the flatness was
 evaluated as difference GBIR obtained by difference analysis between a pre-
 polishing shape and a post-polishing shape. Further, comparison of shape
 was carried out with difference GBIR / polishing rate because the difference
 30 GBIR is a parameter well correlated with the polishing rate. The results
 are shown in Table 2 and Fig. 2.

[0057]

The polishing conditions are as follows:

Polishing machine: Poli762

Dresser: Dresser #150 manufactured by Kinik

5 Polishing pressure: 300 gf/cm²

Revolutions: Head/Platen: 40/43 rpm

Wafer: 8" (P-)

Polishing liquid: NP6610 (manufactured by NITTA DuPont Incorporated), 7.14% of which was used by being added to DIW (pure water)

10 Flow rate of polishing liquid: 600 mL/min

[0058]

Table 1

		C. Ex. 1		Ex. 1		Ex. 2		Ex. 3	
		N=1	N=2	N=1	N=2	N=1	N=2	N=1	N=2
Physical properties	Thickness (mm)	1.27	1.27	1.26	1.26	1.26	1.26	1.27	1.27
	Asker-C hardness	88	88	85	85	86	86	88	88
	Compression ratio (%)	2.0	2.0	2.0	2.3	2.3	2.0	2.1	1.9
	Apparent density (g/cm ³)	0.45	0.46	0.44	0.44	0.45	0.45	0.45	0.45
	Vertical abundance ratio in a width of 100μm	Mean value (%)		36.1	38.0	35.5	36.9	36.7	36.5
		Interquartile range of mean value (%)		11.1	11.4	8.3	8.9	8.5	9.3
Evaluation	GBIR: Rate of improvement from C. Ex. 1 (%)		100	69		74		68	
	ESFQR: Rate of improvement from C. Ex. 1 (%)		100	59		59		63	

[0059]

15 **Table 2**

		C. Ex. 2		Ex. 4		Ex. 5	
		N=1	N=2	N=1	N=2	N=1	N=2
Physical properties	Thickness (mm)	1.02	1.01	1.02	1.02	0.99	1.00
	Asker-C hardness	84	83	81	82	83	84
	Compression ratio (%)	3.1	3.4	3.5	3.3	3.3	3.0
	Apparent density (g/cm ³)	0.46	0.46	0.44	0.46	0.45	0.45
	Vertical abundance ratio in a width of 100μm	Mean value (%)		35.2	36.3	37.7	34.7
		Interquartile range of mean value (%)		13.6	16.8	10.2	10.4
Evaluation	Difference GBIR / Polishing rate: Rate of improvement from C. Ex. 2 (%)		100	85		80	

[0060]

As shown in Tables 1 and 2, and Figs. 1 and 2, it can be found that the polishing cloth of each of Examples satisfying all the essential features of the present invention can suppress minute fluctuations in the hardness of the polishing cloth, as a result of which the wafer has a good flatness.

CLAIMS

1. A polishing cloth comprising, as forming materials of the polishing cloth, an unwoven fabric and a resin that is impregnated in the unwoven
5 fabric, wherein
an Asker-C hardness is 80 or more, and
an interquartile range of mean values of vertical abundance ratios of the forming materials in a width of 100 μm is 10.5 or less.
- 10 2. The polishing cloth according to claim 1, having a compression ratio of 5% or less and having a thickness of 0.8 mm or more and 3.0 mm or less.
3. The polishing cloth according to claim 1 or 2, wherein
an apparent density of the forming materials is 0.30 g/cm^3 or more
15 and 0.50 g/cm^3 or less.