

DESCRIPTION

POLISHING CLOTH

5 CROSS-REFERENCE TO RELATED APPLICATION

[0001]

This application claims priority to Japanese Patent Application No. 2019-239184 and to Japanese Patent Application No. 2020-168649, the disclosure of which is incorporated herein by reference in its entirety.

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FIELD

[0002]

The present invention relates to a polishing cloth.

15 BACKGROUND

[0003]

Conventionally, polishing cloths including, as forming materials, an unwoven fabric and a resin that is impregnated in the unwoven fabric are used for polishing a polishing object such as a silicon wafer (for example, Patent Literature 1).

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[0004]

Here, it is known that an edge sagging occurs in the outer peripheral edge portion of a polishing object when a polishing cloth has an excessively high flexibility. Problems such as an edge sagging can be avoided by increasing an impregnation amount of a resin impregnated into the unwoven fabric and thus making the polishing cloth harder; however, an abundance ratio of the materials for forming the polishing cloth is increased. A portion with no forming materials existing (e.g., void) of the polishing cloth is served as a storage space for grind debris (swarf) during the polishing of the polishing object, and therefore excessive increase of the

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impregnation amount of the resin increases the likelihood of clogging, and hence the likelihood of decrease in removal rate or polishing rate.

CITATION LIST

5 Patent Literature [0005]

Patent Literature 1: JP 2006-43811 A

SUMMARY

10 Technical Problem [0006]

In view of the aforementioned problem, it is an object of the present invention to provide a polishing cloth that is less likely to cause decrease in polishing rate even in the case where the polishing cloth includes a certain
15 amount of resin.

Solution to Problem [0007]

The polishing cloth according to the present invention includes, as
20 forming materials of the polishing cloth, an unwoven fabric and a resin that is impregnated in the unwoven fabric, wherein an apparent density of the polishing cloth is in a range of 0.30 g/cm³ to 0.50 g/cm³, and a standard deviation of the abundance ratio of the forming materials in the polishing cloth is 21.7% or less.

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BRIEF DESCRIPTION OF DRAWINGS [0008]

Fig. 1 is a schematic view of a device used for measurement of an air pressure resistance (APR).

30 Fig. 2 is a chart showing arithmetic mean values of the abundance

ratios of forming materials in the respective cross sections of polishing cloths of Example 1-1, Example 2-1, and Comparative Example 1-1.

Fig. 3 is a chart showing arithmetic mean values of the abundance ratios of forming materials in the respective cross sections of polishing cloths of Example 5-1, Example 6-1, and Comparative Example 2-1.

Fig. 4 is a chart showing polishing rates when a wafer is polished using the polishing cloths of Example 1-1, Example 2-1, Example 3, Example 4, and Comparative Example 1-1.

Fig. 5 is a chart showing polishing rates when a wafer is polished using the polishing cloths of Example 5-1, Example 6-1, and Comparative Example 2-1.

Fig. 6 is a chart showing the rates of decrease in removal rates when a wafer is polished using the polishing cloths of Example 1-1, Example 2-1, Example 3, Example 4, and Comparative Example 1-1.

Fig. 7 is a chart showing the rates of decrease in removal rates when a wafer is polished using the polishing cloths of Example 5-1, Example 6-1, and Comparative Example 2-1.

Fig. 8 is a SEM image of a surface of the polishing cloth of Example 1-1 (with 50 magnification).

Fig. 9 is a SEM image of a cross section of the polishing cloth of Example 1-1 (with 50 magnification).

Fig. 10 is a SEM image of a surface of the polishing cloth of Comparative Example 1-1 (with 50 magnification).

Fig. 11 is a SEM image of a cross section of the polishing cloth of Comparative Example 1-1 (with 50 magnification).

Fig. 12 is a SEM image of a surface of the polishing cloth of Example 5-1 (with 50 magnification).

Fig. 13 is a SEM image of a cross section of the polishing cloth of Example 5-1 (with 50 magnification).

Fig. 14 is a SEM image of a surface of the polishing cloth of

Comparative Example 2-1 (with 50 magnification).

Fig. 15 is a SEM image of a cross section of the polishing cloth of Comparative Example 2-1 (with 50 magnification).

5 DESCRIPTION OF EMBODIMENTS
[0009]

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

[0010]

10 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. It is important that the polishing cloth according to this embodiment has an apparent density of 0.30 g/cm^3 to 0.50 g/cm^3 and a standard deviation of an abundance ratio of
15 the forming material is 21.7% or less. In the polishing cloth of this embodiment, a mean value of the abundance ratio of the forming materials is preferably in a range of 22% to 45%, more preferably in a range of 30% to 45%, still more preferably in a range of 35% to 45%.

[0011]

20 The aforementioned apparent density is in a range of 0.30 g/cm^3 to 0.50 g/cm^3 , preferably in a range of 0.35 g/cm^3 to 0.50 g/cm^3 , more preferably in a range of 0.35 g/cm^3 to 0.45 g/cm^3 . The apparent density can be measured based on JIS K7222:2005.

[0012]

25 The “mean value of the abundance ratio of the forming materials” and the “standard deviation of the abundance ratio of the forming materials” can be obtained in the following manner. That is, a polishing cloth is sliced every $100 \text{ }\mu\text{m}$ in a thickness direction from a front surface to a back surface to obtain slice surfaces in parallel to the front surface, followed
30 by capturing images of two sections of a measurement area of $2,000 \text{ }\mu\text{m} \times 2,000 \text{ }\mu\text{m}$ for each slice surface (the two sections of the measurement area

are not overlapped with each other), extracting 168 small sections each having a size of $100\ \mu\text{m} \times 100\ \mu\text{m}$, and measuring the abundance ratio of the forming materials in each of the extracted small sections of $100\ \mu\text{m} \times 100\ \mu\text{m}$. The arithmetic mean value of the abundance ratio of the forming materials obtained by the measurement is referred to as “mean value of the abundance ratio of the forming materials”, and a standard deviation of the abundance ratio of the forming materials obtained by the measurement is referred to as “standard deviation of the abundance ratio of the forming materials”. The abundance ratio of the forming materials in each small section of $100\ \mu\text{m} \times 100\ \mu\text{m}$ 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%. For example, in the case where 12 slice surfaces in a range of $100\ \mu\text{m}$ to $1,200\ \mu\text{m}$ in the thickness direction from the front surface to the back surface are observed, the abundance ratio of the forming materials is measured for the $168 \times 12 \times 2$ small sections each having a size of $100\ \mu\text{m} \times 100\ \mu\text{m}$.

[0013]

In the aforementioned measurement, CT-scan is employed for capturing the image of the polishing cloth. Specifically, a polishing cloth is sliced every $100\ \mu\text{m}$ in the thickness direction from the front surface to the back surface to obtain slice surfaces in parallel to the front surface, followed by capturing images of two sections of a measurement area of $2,000\ \mu\text{m} \times 2,000\ \mu\text{m}$ for each slice surface (the two sections of the measurement area are not overlapped with each other), extracting 168 small sections each having a size of $100\ \mu\text{m} \times 100\ \mu\text{m}$, subjecting each of the extracted small areas 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 of the forming materials in the measurement areas. 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.

5 [0014]

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

[0015]

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

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

15 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

20 Reconstructed pixel size X [mm]: 0.003880

Reconstructed pixel size Y [mm]: 0.003880

Reconstructed pixel size Z [mm]: 0.003880

[0016]

25 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. 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)

30 using the image processing software VGStudio Max. The contrast adjustment is performed in Ramp mode. The contrast adjustment is

performed to make the difference between voids and parts other than the voids significant. 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 ± 5 ”. The range of the contrast adjustment is not necessarily limited thereto because the light transmittance varies depending on the material.

[0017]

Images of the measurements areas are captured based on 2D images, for which the contrast adjustments have been performed.

[0018]

Next, on the basis of the captured images of the measurement areas, the abundance ratio of the forming materials is measured by the image processing software ImageJ. Herein, the measurement range of ImageJ is $1,200 \mu\text{m} \times 1,400 \mu\text{m}$. The measurement range is set 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 $(132, 22)$, a position horizontally extending by 312 pix ($= 1201.2 \mu\text{m}$) from the position $(132, 22)$, and a position vertically extending by 364 pix ($= 1401.4 \mu\text{m}$) from the position $(132, 22)$. 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 $\times$ 14 pix in vertical direction. In the reduced-size image, an area of 1 pix $\times$ 1 pix corresponds to the aforementioned small section of $100 \mu\text{m} \times 100 \mu\text{m}$. This operation is repeated every $100 \mu\text{m}$ in the thickness direction from the front surface to the back 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).

[0019]

A compression ratio of the polishing cloth according to this embodiment is preferably 5% or less, more preferably 3.5% or less. The compression ratio can be obtained by the following method. That is, using
 5 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 pressed for 60 seconds is measured. Next, a thickness T2 of the polishing cloth that has been
 10 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.

$$\text{The compression ratio} = (T1 - T2) \times 100 / T1$$

15 [0020]

A hardness (Asker-C) of the polishing cloth according to this embodiment is preferably 80 or more, more preferably 85 to 95. The polishing cloth according to this embodiment having a hardness of 80 or more is advantageous in that it is less likely to cause an edge sagging in the
 20 outer peripheral edge portion of a polishing object (for example, a wafer). Also, the polishing cloth according to this embodiment having a hardness of 95 or less is advantageous in that it is less likely to cause defects (for example, scratches). The hardness herein means a value measured according the stipulation of SRIS0101 (the standard stipulated by The
 25 Society of Rubber Science and Technology, Japan). The Asker-C hardness is measured on the aforementioned one surface. That is, the hardness is measured on a polishing surface.

[0021]

The polishing cloth according to this embodiment has a thickness of
 30 preferably 0.8 mm to 2.0 mm, more preferably 1.0 mm to 1.5 mm. The polishing cloth according to this embodiment having a 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
5 planarize a polishing object. Further, the polishing cloth according to this embodiment having a thickness of 2.0 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.

10 [0022]

Examples of fibers for forming the aforementioned unwoven fabric include polyester fibers and nylon fibers. 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
15 weight of 200 g/m² or more per unit area 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 per unit area, easily has voids in the polishing
20 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 variation of the polishing performance due to clogging of voids with grind debris (swarf) or the like.

[0023]

25 Examples of the aforementioned resin include a urethane resin.

[0024]

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

[0025]

30 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.

[0026]

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.

[0027]

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. 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 allow the urethane resin to coagulate and hence adhere to the surface of the unwoven fabric.

[0028]

In the dry impregnation, a prepolymer having terminal isocyanate groups, a curing agent that is an organic compound having active hydrogen, 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. Subsequently, the wet-impregnated unwoven fabric is dipped in the 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.

[0029]

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

[0030]

That is, the polishing cloth according to this embodiment includes, as forming materials of the polishing cloth, an unwoven fabric and a resin that is impregnated in the unwoven fabric. In the polishing cloth according
10 to this embodiment, the polishing cloth has an apparent density of 0.30 g/cm³ to 0.50 g/cm³, and a standard deviation of the abundance ratio of the forming materials in the polishing cloth is 21.7% or less.

[0031]

The polishing cloth having an apparent density of 0.50 g/cm³ or less
15 tends to have a large number of voids, and therefore makes it possible to suppress decrease in the removal rate or polishing rate even if the voids are somewhat clogged with grind debris. Further, the polishing cloth according to this embodiment, in which a standard deviation of the abundance ratio of the forming materials is 21.7% or less, has voids distributed from the
20 surface to the inside of the polishing cloth at a relatively constant ratio. In such a polishing cloth, voids are likely to connect each other between the surface and the inside of the polishing cloth, and, as a result, a polishing rate is less likely to be reduced even if the voids are somewhat clogged with grind debris. Further, the polishing cloth having an apparent density of
25 0.30 g/cm³ or more can have many portions with the forming materials present therein to thereby have a high hardness, and, as a result, an edge sagging is less likely to be caused.

[0032]

The polishing cloth according to the present invention is not limited
30 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.

[0033]

5 In this embodiment, the polishing cloth is obtained by, for example, a method including performing a two-step impregnation treatment. However, the polishing cloth may be obtained by a method including only a single step, that is, either the wet impregnation or the dry impregnation.

10 EXAMPLES

[0034]

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

[0035]

15 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. A hardness, a compression rate, an apparent density, a
20 mean value of the abundance ratio of the forming materials, and a standard deviation of the abundance ratio of the forming materials were respectively measured by the aforementioned methods. An air pressure resistance (hereinafter also referred to as “APR”) herein means a pressure loss caused
25 when air (air flow rate: 30 L/min, air pressure: 100 Pa) has been passed through the polishing cloth in the thickness direction using a device shown in Fig. 1.

[0036]

Fig. 2 shows arithmetic mean values of the abundance ratio of the forming materials in each cross section of the polishing cloths of Example 1-
30 1, Example 2-1, and Comparative Example 1-1. Fig. 3 shows arithmetic mean values of the abundance ratio of the forming materials in each cross

section of polishing cloths of Example 5-1, Example 6-1, and Comparative Example 2-1.

[0037]

Polishing cloths having a density of more than 0.4 g/cm^3 and
 5 polishing cloths having a density of 0.4 g/cm^3 or less were evaluated in the different conditions as follows:

1) Polishing cloths having a density of more than 0.4 g/cm^3 : Comparative Example 1-1, Comparative Example 1-2, Comparative Example 1-3,
 Example 1-1, Example 1-2, Example 1-3, Example 2-1, Example 2-2,
 10 Example 2-3, Example 3, and Example 4

The polishing rate when a wafer was polished using each of the polishing cloths was measured. The measurement was carried out after each of the polishing cloths was set on the device and subjected to dress treatment before polishing in the following conditions under running water
 15 for 5 minutes.

Dresser: Pellet-type dresser #150 manufactured by Kinik Company
 (12 pellets having a diameter of 20 mm were disposed below a plate)

Load: 18.7 kg

Revolutions: Head/Platen = 100 / 115 rpm

20 2) Polishing cloths having a density of 0.4 g/cm^3 or less: Comparative Example 2-1, Comparative Example 2-2, Comparative Example 2-3, Example 5-1, Example 5-2, Example 5-3, Example 6-1, Example 6-2, and Example 6-3

The polishing rate was measured for each of the polishing cloths in
 25 the same manner as the polishing cloths having a density of more than 0.4 g/cm^3 except that the polishing cloths were not subjected to dress treatment.

[0038]

The polishing conditions in the measurement of the polishing rate are provided below. The weight of the wafer was measured every polishing
 30 (every running) to obtain a polishing rate (i.e., removal rate (RR)) from the difference between the weights before and after the polishing. The results

are partly shown in Fig. 4 and Fig. 5. The “rate of decrease in removal rate” was obtained by the formula below. The results are shown in Table 1, Table 2, Fig. 6 and Fig. 7.

Rate of decrease in removal rate (%) = (maximum value of polishing rate – minimum value of polishing rate) / maximum value of polishing rate × 100%

Between the runs, no treatment for removing clogging (for example, treatment such as dress treatment, brush treatment, or HPMJ (high pressure micro jet) cleaning) was carried out.

Polishing time: 60 minutes for the 1st run, 40 minutes for the 2nd and subsequent runs

Number of runs: 7 times (6 times for the polishing cloths having an apparent density of 0.40g/cm³ or less)

Polishing machine: Strasbaugh 6CA

Wafer: 8” (P-)

Polishing liquid : Additive rate of 7.14% for any polishing liquids to DIW (deionized water)

· Polishing cloth having a density of more than 0.4 g/cm³: solution having a solid content (115 °C) of 36.6%, a mean particle size of 108 nm, and a pH of 11.3

· Polishing cloth having a density of 0.4 g/cm³ or less: NP 6503 (manufactured by Nitta Haas Incorporated)

Flow rate of polishing liquid: 300 mL / min

Polishing time: 40 min / run

Further, SEM images of a surface and a cross section of each of the polishing cloths according to Example 1-1, Comparative Example 1-1, Example 5-1, and Comparative Example 2-1 are respectively shown in Fig. 8 to Fig. 15.

[0039]

[Table 1]

Physical properties	Hardness (Asker-C)(-)												
	Compression ratio(%)												
	APR (mmH ₂ O)												
	Apparent density (g/cm ³)												
	Abundance ratio of forming materials	Mean value (%)											
		Relative standard deviation (%)											
Evaluation	Rate of decrease in removal rate (%)												
	C. Ex. 1-1	C. Ex. 1-2	C. Ex. 1-3	Ex. 1-1	Ex. 1-2	Ex. 1-3	Ex. 2-1	Ex. 2-2	Ex. 2-3	Ex. 3	Ex. 4		
	88	88	88	87	86	85	88	86	87	90	88		
	2.0	2.0	2.0	2.0	2.0	2.0	1.9	2.3	1.7	1.9	2.2		
	56	56	56	34	31	49	42	43	41	37	36		
	0.47	0.45	0.47	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45		
	38.1	35.7	36.5	36.6	38.3	37.2	35.3	37.7	34.4	36.2	36.6		
	22.7	21.8	22.8	19.6	21.0	19.9	16.8	17.2	17.1	18.0	20.3		
	54	54	54	36	36	36	45	45	45	43	45		

[0040]

[Table 2]

		C. Ex. 2-1	C. Ex. 2-2	C. Ex. 2-3	Ex. 5-1	Ex. 5-2	Ex. 5-3	Ex. 6-1	Ex. 6-2	Ex. 6-3
Physical properties	Hardness (Asker-C)(-)	82	82	82	80	80	79	82	82	82
	Compression ratio (%)	3.9	3.6	3.7	3.8	3.7	3.8	3.9	3.8	3.2
	APR (mmH ₂ O)	51	48	51	42	42	42	26	23	27
	Apparent density (g/cm ³)	0.40	0.40	0.40	0.36	0.36	0.35	0.39	0.39	0.39
	Abundance ratio of forming materials	Mean value (%)		34.6	33.5	31.9	30.6	27.3	30.2	32.5
		Relative standard deviation(%)		23.4	23.9	23.3	20.8	19.3	21.6	17.8
Evaluation	Rate of decrease in removal rate (%)	58	58	58	42	42	42	34	34	34

[0041]

As shown in Fig. 6, Fig. 7, Table 1, and Table 2, the rates of decrease in removal rates were small when the polishing cloths of Examples were used compared with the case where the polishing cloths of Comparative

5 Examples were used.

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 apparent density is in a range of 0.30 g/cm³ to 0.50 g/cm³, and
a standard deviation of an abundance ratio of the forming materials
is 21.7% or less.
- 10 2. The polishing cloth according to claim 1, having a compression ratio
of 5% or less.
3. The polishing cloth according to claim 1 or 2, wherein
a mean value of the abundance ratio of the forming materials is in a
15 range of 22% to 45%.