

SPECIFICATION

POLISHING PAD

5 FIELD OF THE INVENTION

[1] The present invention relates to a polishing pad which is used for polishing an object to be polished, such as a silicon wafer, in a manufacturing process of a semiconductor device or the like.

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BACKGROUND OF THE INVENTION

[2] As a process for flattening a semiconductor wafer such as a silicon wafer is conventionally adopted a chemical mechanical polishing (CMP) process (for example, see the Patent Document 1).

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[3] According to the CMP process, a polishing pad is retained on a machine platen and an object to be polished, such as a silicon wafer, is retained on a polishing head, and the polishing pad and the object to be polished, which are being pressurized, are slid over each other while slurry is continuously supplied thereto so that the object is polished.

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PATENT DOCUMENT 1: 2000-334655 of the Japanese Patent Applications Laid-Open

25 DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[4] As a semiconductor device is increasingly highly integrated, demand for a higher level of flattening of an object to be polished increasingly grows. Therefore, various approaches have been so far made to satisfy such demand. For example, grooves are formed on the surface of a polishing pad so that slurry can be homogeneously supplied into between the polishing pad and the object to be polished or an average surface

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roughness Ra of the surface of a polishing pad is improved. These approaches, however, are not as effective as expected. When a large wafer is polished, in particular, it is not easy to achieve a higher level of flatness overall.

5 [5] Further, when a polishing pad is used, it is conventionally necessary, as a means of improving polishing performance, to roughen the surface of the polishing pad in a dressing process using a disk containing diamond abrasive grains, such process being called break-in (startup) in general,
10 in an initial stage in which the polishing pad is attached to a polishing device and the polishing device is then activated. In order to improve the productivity of semiconductor wafers, it is desirable to reduce an amount of time required for break-in.

[6] Therefore, a main object of the present invention is
15 to improve qualities of an object to be polished by improving the flatness of the object, and to reduce break-in time.

MEANS FOR SOLVING THE PROBLEM

[7] The inventors of the present invention tackled various
20 challenges in order to achieve the foregoing object, and found out that the improvement of corrugations on a surface of a polishing pad effectively led to the improvement of the flatness of an object to be polished and completed the present invention.

[8] The corrugations denote unevenness whose cycle is in
25 the range of 20 mm - 200 mm and whose amplitude is in the range of 10 μ m - 200 μ m.

[9] A polishing pad according to the present invention is a polishing pad used for polishing an object to be polished, comprising a polishing surface pressed onto the object to be
30 polished, wherein corrugations on the polishing surface have a cycle in the range of 5 mm - 200 mm and a largest amplitude of 40 μ m or less.

[10] According to the present invention, since the

corrugations on the polishing surface pressed onto the object to be polished are reduced, influences generated on the object to be polished by the corrugations on the polishing surface are lessened. As a result, the flatness of the object to be polished can be improved.

[11] A polishing pad according to the present invention is a polishing pad used for polishing an object to be polished, comprising a polishing surface pressed onto the object to be polished, wherein a zeta potential of the polishing surface measured with a use of a neutral solution is equal to or above -50 mV and less than 0 mV.

[12] According to the present invention, the minus zeta potential of the polishing surface of the polishing pad is equal to or above -50 mV and less than 0 mV, which is closer to zero than a zeta potential of a polishing surface of a conventional polishing pad. Therefore, repulsion against abrasive particles of slurry is controlled, and the slurry can be smoothly applied to the polishing surface of the polishing pad. As a result, the break-in time can be reduced, and the productivity can be improved.

[13] In a preferred embodiment of the present invention, an average surface roughness Ra of the polishing surface may be equal to or above 1 μm and equal to or below 5 μm .

[14] In another preferred embodiment of the present invention, an underground layer may be provided below a polishing layer comprising the polishing surface so that suitable cushioning characteristics can be provided by the underground layer.

EFFECT OF THE INVENTION

[15] According to the present invention, wherein the

corrugations on the polishing surface to be pressed onto the object to be polished are reduced, the flatness of the object to be polished can be improved.

[16] Further, the minus zeta potential of the polishing

surface of the polishing pad is closer to zero comparing to the zeta potential of the polishing surface of the conventional polishing pad. Accordingly, the repulsion against the minus abrasive particles of the slurry is controlled, and a fit between the slurry and the polishing surface of the polishing pad becomes better. As a result, the break-in time can be reduced, and the productivity can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

10 [17] Fig. 1 is a schematic sectional view of a polishing pad.

Fig. 2 is a drawing illustrating a measurement result of corrugations on a polishing surface of a polishing pad according to a conventional example 1 and a measurement result of corrugations on a polishing surface of a polishing pad according to a embodiment 1 of the present invention

15 Fig. 3 is a drawing illustrating a shape of a silicon wafer polished by the polishing pad according to the embodiment 1.

20 Fig. 4 is a drawing illustrating a shape of a silicon wafer polished by the polishing pad according to the conventional example 1.

Fig. 5 is an illustration of the variation of polishing rates versus the number of times a polishing process is repeated in the embodiment 1 and the conventional example 1.

25 Fig. 6 is an illustration of a relationship between a polishing time and frictional force in the polishing process in which the polishing pad according to the embodiment 1 is used.

30 Fig. 7 is an illustration of a relationship between a polishing time and frictional force in the polishing process in which the polishing pad according to the conventional example 1 is used.

Fig. 8 is an illustration of the variation of polishing

rates in the case where a polishing pad according to a embodiment 2-1 of the present invention, a polishing pad according to a conventional example 2, and a polishing pad according to the conventional example 2 after break-in are used.

5 Fig. 9 is a schematic sectional view of a polishing pad according to another preferred embodiment of the present invention.

DESCRIPTION OF REFERENCE SYMBOLS

10 [18] 1 polishing pad
2 polishing surface

PREFERRED EMBODIMENTS FOR CARRYING OUT THE INVENTION

[19] Hereinafter, preferred embodiments of the present
15 invention are described in detail referring to the drawings.

[20] Fig. 1 is a sectional view of a polishing pad according to a preferred embodiment of the present invention.

[21] A polishing pad 1 according to the present preferred
20 embodiment can be obtained when foamable resin, such as polyurethane, is foamed and then cured. The polishing pad may not necessarily have foamable structure and may have a non-foamable structure. Further, a non-woven fabric pad may also be used.

[22] In the present preferred embodiment, in order to improve
25 the flatness of an object to be polished such as a silicon wafer, the entire area of a polishing surface 1a to be pressed onto the object to be polished is buffed so that corrugations on the polishing surface 1a are lessened

[23] When the polishing surface 1a is thus buffed, a largest
30 amplitude of the corrugations in a cycle of 5 mm - 20 mm on the polishing surface 1a is reduced to be 40 μ m or less. The largest amplitude is preferably as small as possible.

[24] The method of reducing the corrugations on the polishing

surface is not limited to a buffing process and the polishing surface may be milled or pressed.

[25] Hereinafter, preferred embodiments of the present invention are described.

5 EMBODIMENT 1

In an embodiment 1 of the present invention and a conventional example, an MH-type polishing pad manufactured by Nitta Haas Incorporated, which is a foamable urethane pad having relatively large foaming diameters suitable for
10 polishing silicon, was used.

[26] Fig. 2 is a drawing illustrating a measurement result of corrugations on a polishing surface of a polishing pad according to the embodiment 1 which was buffed by sand paper of count #240, and a measurement result of corrugations on a
15 polishing surface of a polishing pad according to the conventional example 1 which was not buffed.

[27] In the drawing, a horizontal axis denotes positions on the polishing surface of the polishing pad, and Line L1 denotes the embodiment 1 and Line L2 denotes the conventional example
20 1. The corrugations on the polishing surface were measured by a measurement device HSS-1700 manufactured by Hitachi Zosen Corporation.

[28] In the case of the polishing pad according to the conventional example 1, the surface of which was not buffed,
25 a sharp rise is shown as illustrated in Line 2, the polishing surface has many corrugations, and the largest amplitude thereof exceeds 40 μm . In contrast, the polishing pad according to the embodiment 1 shows a modest rise as illustrated in Line 1, and it is learnt that the polishing surface has fewer
30 corrugations, and the largest amplitude is reduced to be 40 μm or less.

[29] Each of the polishing pads according to the embodiment 1 and the conventional example 1 was used to polish both surfaces

of a silicon wafer of 300 mm under the following conditions, and the flatness of the silicon wafer and a polishing rate were evaluated.

[30] The number of rotations of an upper machine platen was 20 rpm, the number of rotations of a lower machine platen was 15 rpm, an applied pressure was 100 / cm², silica slurry at 25°C was used, and a volumetric flow of the slurry was 2.5 L / min.

[31] Table 1 shows the GBIR (Global Back Ideal Range), SFQR (Site Front Least Squares Range), roll off and polishing rate of the polished silicon wafer. In the table, respective average values obtained in a polishing test for five silicon wafers are shown.

[32] Table 1

	embodiment 1	conventional example 1
GBIR	0.207	0.349
SFQR	0.100	0.152
Roll-off	0.100	0.23
Removal rate	0.46	0.39

[33] As shown in Table 1, the flatness represented by the GBIR and SFQR of the silicon wafers polished by the polishing pad according to the embodiment 1 was improved in comparison to that achieved by the polishing pad according to the conventional example 1, and the roll off and the polishing rate were also improved.

[33] Figs. 3 and 4 respectively illustrate a shape of the silicon wafer polished by the polishing pads according to the embodiment 1 and a shape of the silicon wafer polished by the polishing pads according to the conventional example 1.

[34] The silicon wafers were measured by a laser measuring device, which was NANOMETRO 200TT manufactured by KURODA Precision Industries Ltd.

[35] It can be confirmed that a central portion, rather than a peripheral portion, of the silicon wafer was polished by the polishing pad according to the conventional example 1 as illustrated in Fig. 4, while the entire surface of the silicon wafer was homogeneously polished by the polishing pad according to the embodiment 1 as illustrated in Fig. 3.

[36] As described, when the polishing pad according to the embodiment 1 capable of reducing the corrugations on the polishing surface is used, the flatness of the silicon wafer can be improved, and the roll off and the polishing rate can also be improved.

[37] Fig. 5 is an illustration of the variation of the polishing rates versus the number of times a polishing process is repeated in the embodiment 1 and the conventional example 1.

[38] The polishing rate of the polishing pad according to the embodiment 1 was kept high with stability from the first round of the polishing process, while the polishing rate of the polishing pad according to the conventional example 1 was stable from the second round of the polishing process.

[39] As is learnt from Fig. 5, an amount of time necessary for the polishing rate to be increased and then leveled off, which is generally called break-in time, can be reduced, and the polishing rate can be improved in the polishing pad according to the embodiment 1 in comparison to the polishing pad according to the conventional example 1.

[40] Figs. 6 and 7 respectively illustrate the variation of frictional force relative to a polishing time in the polishing pad according to the embodiment 1 and the variation of the frictional force relative to the polishing time in the polishing pad according to the conventional example 1.

[41] It is necessary for the frictional force to be constant in order to obtain a constant polishing rate. It takes 60 seconds

for the constant frictional force to be obtained in the polishing pad according to the embodiment 1, while 150 seconds are necessary in the polishing pad according to the conventional example 1. It can be learnt therefore that the startup time of the polishing process in the polishing pad according to the embodiment 1 is shorter than that in the polishing pad according to the conventional example 1.

[42] Table 2 is measurement results showing values of an average surface roughness Ra of the polishing surfaces of the polishing pads according to the embodiment 1 and the conventional example 1 measured by a real-time scan laser microscope 1LM21D manufactured by Lazertec Co., Ltd. Table 2 shows measurement results obtained from five points in the region of $45\text{ }\mu\text{m} \times 45\text{ }\mu\text{m}$, and respective average values thereof.

[43] Table 2

average surface roughness Ra (μm)	embodiment 1	conventional example 1
sample 1	2.87	1.79
sample 2	2.94	1.68
sample 3	1.86	1.49
sample 4	2.42	1.50
sample 5	2.44	1.92
Ave.	2.51	1.68

As illustrated in Table 2, the average surface roughness Ra of the polishing surface according to the embodiment 1 which was buffed is larger than that of the conventional example 1. Therefore, the break-in time necessary for the polishing rate to be increased and then leveled off can be reduced in comparison to the conventional example 1 as described earlier.

[44] EMBODIMENT 2

An MH-type polishing pad was used in the embodiment 1 and the conventional example 1. In a embodiment 2 (2-1 and

2-2) and a conventional example 2, an IC-type polishing pad, which is a foamable urethane pad having relatively small foaming diameters manufactured by Nitta Haas Incorporated, was used.

[45] For the embodiment 2, a embodiment 2-1 in which a
5 polishing surface of the IC-type polishing pad was buffed by sand paper of count #100 and a embodiment 2-2 in which the polishing surface was buffed by sand paper of count #240 finer than #100 were prepared, and they are compared to the conventional example 2 in which the polishing surface was not
10 buffed.

[46] In a manner similar to the foregoing embodiment, it was confirmed that the corrugations on the polishing surfaces of the polishing pads according to the embodiments 2-1 and 2-2 were fewer, and the largest amplitudes were also reduced to
15 be 40 μm or less in comparison to the polishing pad according to the conventional example 2, according to measurement results obtained by the measurement device HSS-1700 manufactured by Hitachi Zosen Corporation.

[47] Then, values of the average surface roughness R_a of the
20 polishing surfaces of the polishing pads according to the embodiments 2-1 and 2-2 and the conventional example 2 were measured by the real-time scan laser microscope 1LM21D manufactured by Lazertec Co., Ltd.

[48] Table 3 shows results of the measurement. In Table 3,
25 the measurement results obtained from five points in the region of $18\ \mu\text{m} \times 18\ \mu\text{m}$ and respective average values thereof are shown.

[49] Table 3

average surface roughness Ra(μm)	embodiment 2-1	embodiment 2-2	conventional example 2
sample1	1.75	1.25	0.45
sample2	2.62	1.64	0.53
sample3	2.70	0.99	0.63
sample4	1.77	1.81	0.67
sample5	1.75	1.10	0.63
Ave.	2.12	1.36	0.58

As illustrated in Table 3, the average surface roughness Ra is increased on the polishing surfaces which were buffed according to the embodiments 2-1 and 2-2 in comparison to the polishing surface according to the conventional example 2. Therefore, the reduction of the break-in time necessary for the polishing rate to be increased and then leveled off can be expected.

[50] In order to reduce the break-in time, the average surface roughness Ra of the polishing surface is preferably equal to or above 1 μm , and more preferably 1 μm - 5 μm . The average surface roughness more than 5 μm , which may result in the generation of scratches, is not suitable.

[51] Next, zeta potentials of the polishing surfaces of the polishing pads according to the embodiments 2-1 and 2-2 and the conventional example 2, and the zeta potential of the polishing surface of the polishing pad according to the conventional example 2 after the break-in were measured by a zeta potential / particle diameter measuring system ELS-Z2 manufactured by OTSUKA ELECTRONICS CO., LTD. according to the laser Doppler method (dynamic / cataphoretic light diffusion method) in which 10 mM of a neutral NaCl solvent was used.

[52] Table 4 shows a result of the measurement.

[53] Table 4

zeta potential (mV)	embodiment 2-1	embodiment 2-2	conventional example 2	conventional example 2 subjected to break-in
sample1	-9.16	-10.57	-130.75	-32.59
sample2	-10.32	-13.26	-127.37	-32.25
sample3	-8.05	-13.30	-141.36	-33.83
Ave.	-9.18	-12.38	-133.16	-32.89

As shown in Table 4, average values of the zeta potentials of the polishing surfaces of the polishing pads according to the embodiments 2-1 and 2-2 were -9.18 mV, and -12.38 mV, respectively, while an average value of the zeta potentials of the polishing surface of the polishing pad according to the conventional example 2 was -133.16 mV. Thus, the values obtained from the embodiments 2-1 and 2-2 were closer to 0 mV comparing to the conventional example 2.

[54] As described, the minus zeta potentials of the polishing surfaces of the polishing pads according to the embodiments 2-1 and 2-2 were closer to 0 mV in comparison to the zeta potential of the polishing surface in the conventional example 2. Therefore, the repulsion against the minus abrasive particles of the slurry is controlled, and a fit between the slurry and the polishing surface of the polishing pad becomes better. As a result, the reduction in the break-in time can be expected.

[55] The values obtained from the embodiments 2-1 and 2-2 were closer to zero than -32.89 mV which was the zeta potential average value of the polishing surface of the polishing pad according to the conventional example 2 subjected to break-in. This demonstrates that it is unnecessary in the embodiments 2-1 and 2-2 to perform such break-in as is required in the conventional technology.

[56] In order to reduce the break-in time, the zeta potential of the polishing surface of the polishing pad is preferably equal to or above -50 mV and less than 0 mV.

[57] Next, a silicon wafer with an 8-inch TEOS film attached thereto was polished by the polishing pads according to the embodiment 2-1 and the conventional example 2 and the polishing pad according to the conventional example 2 subjected to break-in under the following conditions, and the polishing rates thereby obtained were evaluated.

[58] The number of rotations of the upper machine platen was 60 rpm, the number of rotations of the lower machine platen was 41 rpm, the applied pressure was 48 kPa, slurry ILD3225 manufactured by Nitta Haas Incorporated was used, and the volumetric flow of the slurry was 100 mL / min. The silicon wafer was polished for 60 seconds, and the 60-second polishing was repeatedly implemented with a 30-second dressing process interposed therebetween.

[59] Fig. 8s shows a result of the polishing process.

[60] In the polishing pad according to the embodiment 2-1 shown by ▲, the polishing rate is higher and leveled off sooner in comparison to the polishing pad according to the conventional example 2 shown by ●. Further, the polishing pad according to the embodiment 2-1 was substantially the same as the polishing pad according to the conventional example 2 subjected to break-in shown by □ in terms of a polishing rate and stability.

[61] In other words, the embodiment 2-1 in which break-in was omitted demonstrates the characteristics similar to those of the conventional example 2 subjected to break-in. Therefore, it can be learnt that such break-in as is required in the conventional example 2 is unnecessary for the polishing pad according to the embodiment 2-1.

[62] The flatness of the silicon wafers which were polished by the polishing pads according to the embodiments 2-1 and 2-2 and the conventional example 2 was evaluated in a manner similar to the embodiment 1. As a result, the silicon wafers polished by the polishing pads according to the embodiments 2-1 and 2-2

with no break-in showed the GBIR and SFQR representing the flatness which were equal to or better than those of the silicon wafer polished by the polishing pad according to the conventional example 2 subjected to break-in.

- 5 [63] In the preferred embodiments described so far, the polishing pad has a single-layer structure; however, may have a multilayer structure comprising a ground layer 2, which is made up of a non-woven cloth impregnated with urethane or soft foam, as a lower layer as illustrated in Fig. 9.

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INDUSTRIAL APPLICABILITY

- [64] The present invention is useful when a semiconductor wafer, such as a silicon wafer, is polished.

WHAT IS CLAIMED IS:

1. A polishing pad for polishing an object to be polished, comprising a polishing surface pressed onto the object to be polished, wherein corrugations on the polishing surface have a cycle in the range of 5 mm - 200 mm and a largest amplitude of 40 μ m or less.

2. A polishing pad for polishing an object to be polished, comprising a polishing surface pressed onto the object to be polished, wherein a zeta potential of the polishing surface measured with a use a neutral solution is equal to or above -50 mV and less than 0 mV.

3. The polishing pad as claimed in Claim 1, wherein

a zeta potential of the polishing surface measured with a use a neutral solution is equal to or above -50 mV and less than 0 mV.

4. The polishing pad as claimed in any of Claims 1 through 3, wherein

an average surface roughness Ra of the polishing surface is equal to or above 1 μ m and equal to or below 5 μ m.

5. The polishing pad as claimed in any of Claims 1 through 4, wherein

an underground layer is provided below a polishing layer comprising the polishing surface.