

CHEMICAL MECHANICAL POLISHING LIQUID AND POLISHING METHOD

FIELD

[0001] The invention relates to a technical field of polishing in the manufacture process of semiconductor, and in particular to a chemical mechanical polishing liquid and a polishing method.

BACKGROUND

[0002] Silicon dioxide is an oxide semiconductor material, which has high dielectric constant, low leakage rate and excellent controllability, so it is widely used in silicon-based semiconductors. For example, silicon dioxide can be used as a gate oxide material in a metal oxide semiconductor field effect transistor (MOSFET) and as a dielectric layer in an integrated circuit (IC). Silicon dioxide is generally prepared by thermal oxidation, chemical vapor deposition (CVD), thermal decomposition, anodic oxidation or reactive sputtering during wafer processing.

[0003] Modern semiconductor circuits are highly integrated, and all have multi-layer interconnection structures. Thousands of complex structures on the wafer are interconnected by metals to form circuits and device units with corresponding functions. In these interconnection structures, materials such as silicon dioxide are usually filled between metal wires as dielectric layers. With the superposition and deposition of multi-layer materials, it is necessary to polish the wafer surface to keep its global flatness.

[0004] During the semiconductor processing, the removal rate and roughness of wafer surface materials are the key factors affecting its performance, so it is necessary to maintain both a higher removal rate and a very low post-polishing roughness.

[0005] Chemical mechanical polishing (CMP), as a common processing flow for planarization fine processing of semiconductor materials, is considered to be the most effective processing method to realize global planarization of materials. Chemical mechanical polishing combines chemical force and mechanical force, puts the wafer to be processed into CMP equipment, exerts

a certain pressure on the wafer, so that the wafer is mechanically rubbed on the polishing pad in a downward state, and at the same time, the polishing liquid is injected at a proper flow rate, so that the wafer can achieve the effects of removing surface defects, trimming scratches and damages under the superposition of mechanical friction and chemical force. However, the current polishing liquid still has the problems of surface roughness and instability under high concentration conditions in the process of treating silicon dioxide wafer.

SUMMARY

[0006] The technical problem solved by the invention is to provide a chemical polishing liquid. The chemical mechanical polishing liquid provided by the invention has a high removal rate for the surface material of a silicon dioxide wafer and remains stable under the condition of high concentration.

[0007] The present application provides a chemical mechanical polishing liquid, comprising abrasive particles, polyacrylic acid, potassium carbonate, alkyl quaternary ammonium salt, polymerization inhibitor, water and pH regulator;

[0008] The alkyl quaternary ammonium salt is $RR'(CH_3)_2N^+X^-$, wherein R is $-C_nH_{2n+1}$ and $n = 8$ to 18 ; R' is the same as R, or is $-CH_3$ or $-CH_2C_6H_5$; X^- is a halogen anion;

[0009] The polymerization inhibitor is selected from the group consisting of benzyl trimethyl ammonium chloride, benzyl trimethyl ammonium bromide, benzyl trimethyl ammonium hydroxide, benzyl triethyl ammonium chloride, benzyl triethyl ammonium bromide, benzyl triethyl ammonium hydroxide, phenyl trimethyl ammonium chloride, phenyl trimethyl ammonium bromide, phenyl trimethyl ammonium hydroxide, and a mixture thereof.

[0010] Preferably, the abrasive particles are selected from the group consisting of SiO_2 , fumed SiO_2 , Al_2O_3 , CeO_2 , TiO_2 , ZrO_2 , Fe_2O_3 , and a mixture thereof;

[0011] and/or, the abrasive particles have a particle diameter of 20 nm to 200 nm;

[0012] and/or, the polyacrylic acid has a number average molecular weight of 2,000 to 500,000;

[0013] and/or, the pH regulator is an acid regulator, the acid regulator is selected from organic

acid or inorganic acid, the inorganic acid is selected from the group consisting of hydrochloric acid, nitric acid, sulfuric acid, and a mixture thereof, and the organic acid is selected from the group consisting of succinic acid, malonic acid, tartaric acid, gluconic acid, and a mixture thereof;

5 **[0014]** and/or, the pH regulator is an alkali regulator, the alkali regulator is selected from inorganic alkali or organic alkali, the inorganic alkali is selected from the group consisting of potassium hydroxide, sodium hydroxide, and a mixture thereof, and the organic alkali is selected from the group consisting of ethanolamine, ethylenediamine, diethylamine, and a mixture thereof;

10 **[0015]** Preferably, the abrasive particles are SiO_2 ;

[0016] and/or, the abrasive particles have a particle diameter of 50 nm to 150 nm;

[0017] and/or, the polyacrylic acid has a number average molecular weight of 5,000 to 450,000;

15 **[0018]** and/or, the alkyl quaternary ammonium salt is selected from the group consisting of hexadecyl trimethyl ammonium salt, hexadecyl dimethyl benzyl ammonium salt, dodecyl trimethyl ammonium salt, dodecyl dimethyl benzyl ammonium salt, didodecyl dimethyl ammonium salt, octyltrimethyl ammonium salt, and a mixture thereof.

20 **[0019]** Preferably, the polishing liquid comprises SiO_2 abrasive particles, polyacrylic acid, potassium carbonate, cetyltrimethyl ammonium chloride, benzyl trimethyl ammonium chloride, water and a pH regulator; or the polishing liquid comprises SiO_2 abrasive particles, polyacrylic acid, potassium carbonate, didodecyl dimethylammonium chloride, benzyltriethyl ammonium hydroxide, water and a pH regulator.

[0020] Preferably, the polishing liquid further comprises a bactericide.

[0021] Preferably, in mass percent, the abrasive particles have a content of 5wt% to 50wt%;

25 **[0022]** and/or, the polyacrylic acid has a content of 0.01wt% to 1wt%;

[0023] and/or, the potassium carbonate has a content of 0.1wt% to 5wt%;

[0024] and/or, the alkyl quaternary ammonium salt has a content of 0.01wt% to 0.5wt%;

[0025] and/or, the polymerization inhibitor has a content of 0.1wt% to 5wt%;

[0026] and/or, the polishing liquid has a pH of 9 to 12.

[0027] Preferably, in mass percent, the abrasive particles have a content of 10wt% to 30wt%;

[0028] and/or, the polyacrylic acid has a content of 0.1wt% to 0.5wt%;

5 **[0029]** and/or, the potassium carbonate has a content of 0.5wt% to 1.5wt%;

[0030] and/or, the alkyl quaternary ammonium salt has a content of 0.01wt% to 0.1wt%;

[0031] and/or, the polymerization inhibitor has a content of 0.5wt% to 1.5wt%;

[0032] and/or, the polishing liquid has a pH of 10 to 11.

[0033] The present application further provides a method of chemical mechanical polishing,
10 comprising:

[0034] diluting a polishing liquid, and then polishing a sample to be polished;

[0035] wherein the polishing liquid is the chemical mechanical polishing liquid.

[0036] Preferably, the sample to be polished is a wafer containing silicon dioxide, the polishing
15 is performed for a time of 1 min to 3 min, and the diluted polishing liquid has a flow rate of 120
ml/min to 180 ml/min.

[0037] The present application provides a chemical mechanical polishing liquid, comprising
abrasive particles, polyacrylic acid, potassium carbonate, alkyl quaternary ammonium salt,
polymerization inhibitor, water and a pH regulator. The introduction of polyacrylic acid and
potassium carbonate has a synergistic effect on improving the surface material removal rate of
20 silicon dioxide wafer, and can significantly improve the surface material removal rate of silicon
dioxide wafer. The polished silicon dioxide wafer has good surface roughness. Furthermore,
using alkyl quaternary ammonium salt as charge balancer and polymerization inhibitor in
combination can still keep the concentrated polishing liquid stable under high concentration,
which has positive significance in production, transportation and use.

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DETAILED DESCRIPTION

[0038] In order to further understand the present invention, the preferred embodiments of the present invention will be described below in conjunction with examples. However, it should be understood that these descriptions are only for further illustrating the features and advantages of the present invention, rather than limiting the claims of the present invention.

[0039] In view of the performance requirements of silicon dioxide wafer polishing liquid for removal rate, surface roughness and stabilization in the prior art, the present application provides a chemical mechanical polishing liquid, which by combining polyacrylic acid and potassium carbonate and combining alkyl quaternary ammonium salt and polymerization inhibitor, improves the removal rate and roughness and enables the polishing liquid to have better stability under the condition of high concentration. Specifically, an embodiment of the present invention provides a chemical mechanical polishing liquid, comprising abrasive particles, polyacrylic acid, potassium carbonate, alkyl quaternary ammonium salt, polymerization inhibitor, water and a pH regulator.

[0040] The alkyl quaternary ammonium salt is $RR'(CH_3)_2N^+X^-$, wherein R is $-C_nH_{2n+1}$ and $n = 8$ to 18 ; R' is the same as R, or is $-CH_3$ or $-CH_2C_6H_5$; X^- is a halogen anion.

[0041] The polymerization inhibitor is selected from the group consisting of benzyl trimethyl ammonium chloride, benzyl trimethyl ammonium bromide, benzyl trimethyl ammonium hydroxide, benzyl triethyl ammonium chloride, benzyl triethyl ammonium bromide, benzyl triethyl ammonium hydroxide, phenyl trimethyl ammonium chloride, phenyl trimethyl ammonium bromide, phenyl trimethyl ammonium hydroxide, and a mixture thereof.

[0042] In the chemical mechanical polishing liquid, it further comprises a bactericide; specifically, the bactericide is selected from MTSB330 bactericide or KORDEK bactericide. In this application, the bactericide can be optionally added in the chemical mechanical polishing liquid, and it only has bactericidal effect.

[0043] In the chemical mechanical polishing liquid provided in this application, the abrasive particles are selected from the group consisting of SiO_2 , fumed SiO_2 , Al_2O_3 , CeO_2 , TiO_2 , ZrO_2 , Fe_2O_3 , and a mixture thereof. In a specific embodiment, the abrasive particles are selected from SiO_2 ; the abrasive particles have a particle diameter of 20 nm to 200 nm, specifically, the

abrasive particles have a particle diameter of 50 nm to 150 nm, and more specifically, the abrasive particles have a particle diameter of 80 nm to 120 nm. The abrasive particles have a content of 5wt% to 50wt%, more specifically, the abrasive particles have a content of 10wt% to 30wt%, and for example, the abrasive particles have a content of 5wt%, 7wt%, 8wt%, 9wt%, 10wt%, 12wt%, 15wt%, 17wt%, 18wt%, 19wt%, 20wt%, 21wt%, 22wt%, 24wt%, 26wt%, 28wt%, 29wt%, 31wt%, 32wt%, 35wt%, 38wt%, 40wt%, 41wt%, 43wt%, 47wt%, 48wt%, 50wt%.

[0044] The polyacrylic acid has a number average molecular weight of 2,000 to 500,000, specifically, the polyacrylic acid has a number average molecular weight of 5,000 to 450,000, and more specifically, the polyacrylic acid has a number average molecular weight of 7,000, 8,000, 9,000, 10,000, 30,000, 110,000, 130,000, 180,000, 210,000, 240,000, 280,000, 320,000, 330,000, 350,000, 380,000, 400,000, 420,000, 430,000. The polyacrylic acid has a content of 0.01 wt% to 1wt%, specifically, the polyacrylic acid has a content of 0.1 wt% to 0.5wt%, and for example, the polyacrylic acid has a content of 0.01wt%, 0.03wt%, 0.06wt%, 0.08wt%, 0.10wt%, 0.12wt%, 0.16wt%, 0.18wt%, 0.22wt%, 0.25wt%, 0.29wt%, 0.35wt%, 0.38wt%, 0.50wt%, 0.52wt%, 0.58wt%, 0.63wt%, 0.69wt%, 0.72wt%, 0.76wt%, 0.82wt%, 0.88wt%, 0.90wt%, 0.96wt%, 0.98wt%.

[0045] The potassium carbonate has a content of 0.1 wt% to 5wt%, specifically, the potassium carbonate has a content of 0.3 wt% to 3.5wt%, more specifically, the potassium carbonate has a content of 0.5 wt% to 1.5wt%, and for example, the potassium carbonate has a content of 0.8wt%, 1.0wt%, 1.2wt%, 1.5 wt%, 1.8wt%, 2.0wt%, 2.1wt%, 2.3wt%, 2.5wt%, 2.7wt%, 2.9wt%, 3.0wt%, 3.1wt%、3.3wt% or 3.5wt%.

[0046] The introduction of polyacrylic acid and potassium carbonate can improve the removal rate of polishing liquid on surface materials, and good surface roughness can be obtained after polishing, but the inventor found that the introduction of polyacrylic acid will affect the stability of polishing liquid during the research process.

[0047] The alkyl quaternary ammonium salt can promote the attraction between abrasive particles and silicon dioxide (TEOS) wafers and improve the abrasive rate, and also play a role in balancing charges and keeping the system stable. The alkyl quaternary ammonium salt is

$RR'(CH_3)_2N^+X^-$, wherein R is $-C_nH_{2n+1}$ and $n = 8$ to 18 ; R' is the same as R, or is $-CH_3$ or $-CH_2C_6H_5$; X^- is a halogen anion; specifically, n is $8, 9, 10, 11, 12, 13, 14, 15, 16, 17$ or 18 , and X^- is Cl^- , Br^- .

[0048] Specifically, the alkyl quaternary ammonium salt is selected from the group consisting of hexadecyl trimethyl ammonium salt, hexadecyl dimethyl benzyl ammonium salt, dodecyl trimethyl ammonium salt, dodecyl dimethyl benzyl ammonium salt, didodecyl dimethyl ammonium salt, octyltrimethyl ammonium salt, and a mixture thereof. The alkyl quaternary ammonium salt has a content of $0.01wt\%$ to $0.5wt\%$, specifically, the alkyl quaternary ammonium salt has a content of $0.01wt\%$ to $0.1wt\%$, and for example, the alkyl quaternary ammonium salt has a content of $0.01wt\%$, $0.03wt\%$, $0.06wt\%$, $0.08wt\%$, $0.10wt\%$, $0.12wt\%$, $0.15wt\%$, $0.18wt\%$, $0.20wt\%$, $0.23wt\%$, $0.25wt\%$, $0.28wt\%$, $0.30wt\%$, $0.35wt\%$, $0.40wt\%$, $0.43wt\%$, $0.45wt\%$, $0.48wt\%$, $0.50wt\%$.

[0049] In this application, the polymerization inhibitor is selected from the group consisting of benzyl trimethyl ammonium chloride, benzyl trimethyl ammonium bromide, benzyl trimethyl ammonium hydroxide, benzyl triethyl ammonium chloride, benzyl triethyl ammonium bromide, benzyl triethyl ammonium hydroxide, phenyl trimethyl ammonium chloride, phenyl trimethyl ammonium bromide, phenyl trimethyl ammonium hydroxide, and a mixture thereof. In specific embodiments, the polymerization inhibitor is benzyl trimethyl ammonium chloride and benzyl triethyl ammonium hydroxide. The polymerization inhibitor has a content of $0.1wt\%$ to $5wt\%$, specifically $0.5wt\%$ to $1.5wt\%$, for example, the polymerization inhibitor has a content of $0.8wt\%$, $1.0wt\%$, $1.2wt\%$, $1.5wt\%$, $1.8wt\%$, $2.0wt\%$, $2.1wt\%$, $2.3wt\%$, $2.5wt\%$, $2.7wt\%$, $2.9wt\%$, $3.0wt\%$, $3.1wt\%$, $3.3wt\%$ or $3.5wt\%$.

[0050] In the polishing liquid, a pH regulator is needed to adjust the polishing liquid to an appropriate pH. Specifically, the pH regulator is an acid regulator, the acid regulator is selected from organic acid or inorganic acid, the inorganic acid is selected from the group consisting of hydrochloric acid, nitric acid, sulfuric acid, and a mixture thereof, and the organic acid is selected from the group consisting of succinic acid, malonic acid, tartaric acid, gluconic acid, and a mixture thereof; and/or the pH regulator is an alkali regulator, the alkali regulator is selected from inorganic alkali or organic alkali, the inorganic alkali is selected from the group consisting of potassium hydroxide, sodium hydroxide, and a mixture thereof, and the organic alkali is selected

from the group consisting of ethanolamine, ethylenediamine, diethylamine, and a mixture thereof;

[0051] In the polishing liquid, the water has a content of 40wt% to 90wt%. In this application, the polyacrylic acid, the abrasive particles, the potassium carbonate, the alkyl quaternary ammonium salt, the polymerization inhibitor, the water, other additives and the pH regulator constitute the chemical mechanical polishing liquid, and the contents of the above-mentioned components are based on the total mass of all the above-mentioned components.

[0052] The polishing liquid has a pH of 9 to 12, more specifically, the polishing liquid has a pH of 10 to 11.

[0053] In a specific embodiment of the application, the polishing liquid comprises SiO₂ abrasive particles, polyacrylic acid, potassium carbonate, cetyltrimethyl ammonium chloride, benzyl trimethyl ammonium chloride, water and a pH regulator; or the polishing liquid comprises SiO₂ abrasive particles, polyacrylic acid, potassium carbonate, didodecyl dimethyl ammonium chloride, benzyl triethyl ammonium hydroxide, water and a pH regulator.

[0054] In the application, in mass percentage, the chemical mechanical polishing liquid specifically comprises:

[0055] 20% of SiO₂ with a particle diameter of 100 nm, 0.2% of polyacrylic acid with a number average molecular weight of 2000, 0.5% of potassium carbonate, 0.1% of cetyltrimethyl ammonium chloride and 0.5% of benzyl trimethyl ammonium chloride, wherein the polishing liquid has a pH value of 10.5; or

[0056] 20% of SiO₂ with a particle diameter of 100 nm, 0.2% of polyacrylic acid with a number average molecular weight of 5000, 0.5% of potassium carbonate, 0.1% of cetyltrimethyl ammonium chloride and 0.5% of benzyl trimethyl ammonium chloride, wherein the polishing liquid has a pH value of 10.5; or

[0057] 20% of SiO₂ with a particle diameter of 100 nm, 0.2% of polyacrylic acid with a number average molecular weight of 5000, 1% of potassium carbonate, 0.1% of cetyltrimethyl ammonium chloride and 0.5% of benzyl trimethyl ammonium chloride, wherein the polishing liquid has a pH value of 10.5; or

[0058] 20% of SiO₂ with a particle diameter of 100 nm, 0.2% of polyacrylic acid with a number average molecular weight of 100000, 0.5% of potassium carbonate, 0.1% of cetyltrimethyl ammonium chloride and 0.5% of benzyl trimethyl ammonium chloride, wherein the polishing liquid has a pH value of 10.5; or

5 **[0059]** 20% of SiO₂ with a particle diameter of 100 nm, 0.2% of polyacrylic acid with a number average molecular weight of 100000, 1% of potassium carbonate, 0.1% of cetyltrimethyl ammonium chloride and 0.5% of benzyl trimethyl ammonium chloride, wherein the polishing liquid has a pH value of 10.5; or

10 **[0060]** 20% of SiO₂ with a particle diameter of 100 nm, 0.2% of polyacrylic acid with a number average molecular weight of 340000, 0.5% of potassium carbonate, 0.1% of cetyltrimethyl ammonium chloride and 0.5% of benzyl trimethyl ammonium chloride, and the polishing liquid has a pH value of 10.5; or

15 **[0061]** 20% of SiO₂ with a particle diameter of 100 nm, 0.2% of polyacrylic acid with a number average molecular weight of 340000, 1% of potassium carbonate, 0.1% of cetyltrimethyl ammonium chloride and 0.5% of benzyl trimethyl ammonium chloride, wherein the polishing liquid has a pH value of 10.5; or

20 **[0062]** 20% of SiO₂ with a particle diameter of 100 nm, 0.4% of polyacrylic acid with a number average molecular weight of 340000, 1% of potassium carbonate, 0.5% of cetyltrimethyl ammonium chloride and 0.5% of benzyl trimethyl ammonium chloride, wherein the polishing liquid has a pH value of 10.5; or

[0063] 15% of SiO₂ with a particle diameter of 150 nm, 0.2% of polyacrylic acid with a number average molecular weight of 340000, 1% of potassium carbonate, 0.1% of didodecyl dimethyl ammonium chloride and 0.5% of benzyltriethyl ammonium hydroxide, wherein the polishing liquid has a pH value of 10.5; or

25 **[0064]** 30% of SiO₂ with a particle diameter of 70 nm, 0.2% of polyacrylic acid with a number average molecular weight of 340000, 1% of potassium carbonate, 0.1% of didodecyl dimethyl ammonium chloride and 0.5% of benzyl triethyl ammonium hydroxide, wherein the polishing liquid has a pH value of 10.5.

[0065] Further, the invention further provides a polishing method, which comprises:

[0066] diluting chemical mechanical polishing liquid, and then polishing the sample to be polished;

[0067] wherein the chemical mechanical polishing liquid is the polishing liquid described in the above-mentioned solution.

5 **[0068]** In this application, the polishing treatment is carried out in a specific operation mode well known to those skilled in the art, and there is no particular limitation in this application.

[0069] In the polishing method provided by the application, the sample to be polished is a wafer containing silicon dioxide, the polishing is performed for a time of 1 min to 3 min, and the diluted polishing liquid has a flow rate of 120 ml/min to 180 ml/min.

10 **[0070]** In the chemical mechanical polishing liquid provided in this application, the addition of polyacrylic acid and potassium carbonate has a synergistic effect on improving the removal rate of silicon dioxide (TEOS) wafer, and can significantly improve the removal rate of silicon dioxide dielectric material, and good surface roughness can be obtained after polishing. Furthermore, using alkyl quaternary ammonium salt as charge balancer and polymerization inhibitor in
15 combination can still keep the concentrated polishing liquid stable under high concentration. Accordingly, the invention prepares high-concentration polishing liquid, which has positive significance for subsequent production and transportation.

[0071] In order to further understand the invention, the chemical mechanical polishing liquid and preparation method and application thereof provided by the invention will be described
20 below in detail in conjunction with examples. The following examples are not intended to limit the scope of protection of the invention.

[0072] The components in the following examples are all commercially available products.

[0073] Table 1 provides the specific components of the chemical mechanical polishing liquids of the examples and comparative examples of the present application, in which each component
25 was calculated according to the content of pure substances and prepared according to the formula given in the table, and the balance was water (the content% in Table 1 represented the mass percentage). The polishing liquids were prepared by uniformly mixing all the components, and then adjusting the pH to the required value using nitric acid or potassium hydroxide and uniformly mixing. The prepared polishing liquid was diluted with water and then subjected to a

polishing test. The dilution ratio was 1:1 in weight ratio.

[0074] The sample to be polished was polished using the polishing liquid prepared in the examples and the comparative examples. The silicon dioxide sample to be polished was an 8-inch silicon dioxide (TEOS) wafer, the polishing pressure was 4 psi, and the polishing time was 1 min.

5 The polishing was performed using a polishing machine modeled SIZONE TENMS-200 Plus, a polishing pad modeled IC1010, in which the rotating speeds of the polishing head and the polishing disc were 100 rpm and 90 rpm respectively, and the flow rate of the polishing liquid was 150 ml/min.

[0075] The film thickness measuring machine was Filmetrics F54-xy-200, and the film
10 thickness changes before and after polishing were measured at 49 points, so as to calculate the polishing rate.

[0076] After the silicon dioxide wafer was polished, the surface roughness of polished silicon dioxide (TEOS) was tested by Nanosurf Alphacen 300 atomic force microscope, and the removal rate of silicon dioxide surface materials was detected. The results are shown in Table 2. Table 3 is
15 a data table showing the improvement of removal rate of Examples 1 to 8 and Comparative Examples 4 to 8 compared with Comparative Example 3;

[0077] Table 1 Data table showing the formula of the chemical mechanical polishing liquid provided in examples and comparative examples

Name	SiO ₂ content /%	Particle diameter /nm	Polyacrylic acid/%	Potassium carbonate/%	Hexadecyl trimethyl ammonium chloride/%	Didodecyl dimethyl ammonium chloride/%	Benzyl trimethyl ammonium chloride/%	Benzyl triethyl ammonium hydroxide/%	PH
Example 1	20	100	PAA2000 0.2	0.5	0.1	/	0.5	/	10.5
Example 2	20	100	PAA5000 0.2	0.5	0.1	/	0.5	/	10.5
Example 3	20	100	PAA5000 0.2	1	0.1	/	0.5	/	10.5
Example 4	20	100	PAA100000 0.2	0.5	0.1	/	0.5	/	10.5

Example 5	20	100	PAA100000 0.2	1	0.1	/	0.5	/	10.5
Example 6	20	100	PAA340000 0.2	0.5	0.1	/	0.5	/	10.5
Example 7	20	100	PAA340000 0.2	1	0.1	/	0.5	/	10.5
Example 8	20	100	PAA340000 0.4	1	0.5	/	0.5	/	10.5
Example 9	15	150	PAA340000 0.2	1	/	0.1	/	0.5	10.5
Example 10	30	70	PAA340000 0.2	1	/	0.1	/	0.5	10.5
Comparative Example 1	20	100	PAA340000 0.2	0.5	/	/	0.5	/	10.5
Comparative Example 2	20	100	PAA340000 0.2	0.5	0.1	/	/	/	10.5
Comparative Example 3	20	100	/	/	/	/	/	/	10.5
Comparative Example 4	20	100	PAA2000 0.2	/	0.1	/	0.5	/	10.5
Comparative Example 5	20	100	PAA5000 0.2	/	0.1	/	0.5	/	10.5
Comparative Example 6	20	100	PAA100000 0.2	/	0.1	/	0.5	/	10.5
Comparative Example 7	20	100	PAA340000 0.2	/	0.1	/	0.5	/	10.5
Comparative Example 8	20	100	/	0.5	0.1	/	0.5	/	10.5

[0078] Table 2 Data table showing the performance and stability of the polishing liquid provided in examples and comparative examples after polishing.

Name	Removal rate after dilution/Å/min	Aging of polishing liquid	Roughness/nm
Example 1	3038	Nomal	less than 0.25
Example 2	3060	Nomal	less than 0.25
Example 3	3174	Nomal	less than 0.25
Example 4	3118	Nomal	less than 0.25
Example 5	3215	Nomal	less than 0.25
Example 6	3126	Nomal	less than 0.25
Example 7	3259	Nomal	less than 0.25
Example 8	3222	Nomal	less than 0.25
Example 9	2780	Nomal	less than 0.25
Example 10	3552	Nomal	less than 0.25
Comparative Example 1	-	Settlement	-
Comparative Example 2	-	Settlement	-
Comparative Example 3	2753	Nomal	less than 0.25
Comparative Example 4	2760	Nomal	less than 0.25
Comparative Example 5	2803	Nomal	less than 0.25
Comparative Example 6	2852	Nomal	less than 0.25
Comparative Example 7	2977	Nomal	less than 0.25
Comparative Example 8	2904	Nomal	less than 0.25

[0079] Table 3 Data table showing the improvement of removal rate of Examples 1 to 8 and Comparative Examples 4 to 8 compared with Comparative Example 3

Name	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8
Improvement/%	10.35	11.15	15.29	13.26	16.78	13.55	18.38	17.04
Name	Comparative Example 4	Comparative Example 5	Comparative Example 6	Comparative Example 7	Comparative Example 8			

Improvment/%	0.25	1.82	3.6	8.14	5.48			
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[0080] By analyzing the data in Table 2 and Table 3, it can be seen from the comparison between Comparative Examples 1 to 3 and Example 6 that when polyacrylic acid and potassium carbonate are not introduced into the polishing liquid system (Comparative Example 3), the system is relatively stable, and the basic removal rate of silicon dioxide (TEOS) wafers and good surface roughness after removal can be provided under suitable processing conditions, but the removal rate of surface materials of silicon dioxide wafers is low. Compared with Example 6, when polyacrylic acid and potassium carbonate are introduced into the polishing liquid, both lacking alkyl quaternary ammonium salt in Comparative Example 1 and lacking polymerization inhibitor in Comparative Example 2 will cause delamination of high concentration polishing liquid. It indicates that when the polishing liquid contains polyacrylic acid and potassium carbonate, although the removal rate of the surface material of the silicon dioxide wafer is improved, it is not conducive to the stable storage of the concentrated stock solution. It is necessary to use alkyl quaternary ammonium salt as a charge balancer and polymerization inhibitor in combination to maintain the aging stability of the high concentration polishing liquid.

[0081] It can be seen from Comparative Examples 4 to 7 that when polyacrylic acid is added alone, the polishing liquid can improve the removal rate of silicon dioxide, and the higher the molecular weight, the more obvious the improvement. For example, after adding polyacrylic acid with molecular weight of 2,000, the removal rate is increased by about 0.25%, but after adding polyacrylic acid with molecular weight of 340,000, the removal rate is increased by 8.14%, and the surface roughness after polishing is all maintained well.

[0082] It can be seen from Comparative Example 8 that when potassium carbonate is added alone, the polishing liquid can improve the removal rate of silicon dioxide. Under the condition of adding 0.5% mass fraction, the removal rate is increased by 5.48%, and the surface roughness after polishing is maintained well.

[0083] By comparing Comparative Examples 4 to 8 with Examples 1 to 8, it can be seen that when both of polyacrylic acid and potassium carbonate are added, the polishing liquid can significantly improve the removal rate of silicon dioxide. In Example 7, the removal rate is as

high as 18.38%. It indicates that polyacrylic acid and potassium carbonate have a synergistic effect on improving the removal rate of silicon dioxide (TEOS) wafers.

[0084] It can be seen from Example 8 that when the content of polyacrylic acid in the system is 0.2%, it reaches the plateau value, and further increasing the concentration has no gain on the removal rate. For cost considerations, the content of polyacrylic acid is preferably below 1wt%, more preferably 0.1wt% to 0.5wt%.

[0085] From the analysis of the above experimental results, it can be seen that polyacrylic acid, potassium carbonate, alkyl quaternary ammonium salt and polymerization inhibitor are indispensable in the polishing liquid, which work together to significantly improve the removal rate and keep the polishing liquid stable at high concentration.

[0086] Based on the above test results, the chemical mechanical polishing liquid in the invention can significantly improve the removal rate of silicon dioxide dielectric materials, and good surface roughness can be obtained after polishing. In addition, the system can still maintain a stable state under the condition of preparing high concentration polishing liquid, which makes it have positive significance in production, transportation and use.

[0087] The above examples are only used to aid in understanding of the method and core concept of the present invention. It should be noted that, for those skilled in the art, many modifications and improvements may be made to the present invention without departing from the principle of the present invention, and these modifications and improvements also fall into the protection scope of the claims of the present application.

[0088] The above description of the disclosed embodiments enables those skilled in the art to implement or use the present invention. Various modifications to these embodiments are obvious to those skilled in the art. The general principles defined herein may be implemented in other embodiments without departing from the spirit and scope of the present invention. Therefore, the present invention will be not limited to these embodiments described herein, but should be in accordance with the broadest scope consistent with the principle and novel features disclosed herein.

CLAIMS

1. A chemical mechanical polishing liquid, comprising abrasive particles, polyacrylic acid, potassium carbonate, alkyl quaternary ammonium salt, polymerization inhibitor, water and pH regulator;

wherein, in mass percent, the abrasive particles have a content of 5wt% to 50wt%; the polyacrylic acid has a content of 0.01wt% to 1wt%; the potassium carbonate has a content of 0.1wt% to 5wt%; the alkyl quaternary ammonium salt has a content of 0.01wt% to 0.5wt%; and the polymerization inhibitor has a content of 0.1wt% to 5wt%;

the alkyl quaternary ammonium salt is $RR'(CH_3)_2N^+X^-$, wherein R is $-C_nH_{2n+1}$ and n = 8 to 18; R' is the same as R, or is $-CH_3$ or $-CH_2C_6H_5$; X^- is a halogen anion;

the polymerization inhibitor is selected from the group consisting of benzyl trimethyl ammonium chloride, benzyl trimethyl ammonium bromide, benzyl trimethyl ammonium hydroxide, benzyl triethyl ammonium chloride, benzyl triethyl ammonium bromide, benzyl triethyl ammonium hydroxide, phenyl trimethyl ammonium chloride, phenyl trimethyl ammonium bromide, phenyl trimethyl ammonium hydroxide, and a mixture thereof;

wherein the abrasive particles are SiO_2 and/or fumed SiO_2 ;

the polyacrylic acid has a number average molecular weight of 2,000 to 500,000; and

the polishing liquid has a pH of 9 to 12.

2. The chemical mechanical polishing liquid according to claim 1, wherein the abrasive particles have a particle diameter of 20 nm to 200 nm;

and/or, the pH regulator is an acid regulator, the acid regulator is selected from organic acid or inorganic acid, the inorganic acid is selected from the group consisting of hydrochloric acid, nitric acid, sulfuric acid, and a mixture thereof, and the organic acid is selected from the group consisting of succinic acid, malonic acid, tartaric acid, gluconic acid, and a mixture thereof;

and/or, the pH regulator is an alkali regulator, the alkali regulator is selected from inorganic alkali or organic alkali, the inorganic alkali is selected from the group consisting of potassium hydroxide, sodium hydroxide, and a mixture thereof, and the organic alkali is selected from the

group consisting of ethanolamine, ethylenediamine, diethylamine, and a mixture thereof.

3. The chemical mechanical polishing liquid according to claim 1, wherein the abrasive particles are SiO₂;

and/or, the abrasive particles have a particle diameter of 50 nm to 150 nm;

5 and/or, the polyacrylic acid has a number average molecular weight of 5,000 to 450,000;

and/or, the alkyl quaternary ammonium salt is selected from the group consisting of hexadecyl trimethyl ammonium salt, hexadecyl dimethyl benzyl ammonium salt, dodecyl trimethyl ammonium salt, dodecyl dimethyl benzyl ammonium salt, didodecyl dimethyl ammonium salt, octyltrimethyl ammonium salt, and a mixture thereof.

10 4. The chemical mechanical polishing liquid according to claim 1, wherein the polishing liquid comprises SiO₂ abrasive particles, polyacrylic acid, potassium carbonate, cetyltrimethyl ammonium chloride, benzyl trimethyl ammonium chloride, water and a pH regulator; or the polishing liquid comprises SiO₂ abrasive particles, polyacrylic acid, potassium carbonate, didodecyl dimethyl ammonium chloride, benzyl triethyl ammonium hydroxide, water and a pH
15 regulator.

5. The chemical mechanical polishing liquid according to claim 1, wherein the polishing liquid further comprises a bactericide.

6. The chemical mechanical polishing liquid according to claim 1, wherein, in mass percent, the abrasive particles have a content of 10wt% to 30wt%,

20 the polyacrylic acid has a content of 0.1wt% to 0.5wt%;

the potassium carbonate has a content of 0.5wt% to 1.5wt%;

the alkyl quaternary ammonium salt has a content of 0.01wt% to 0.1wt%;

the polymerization inhibitor has a content of 0.5wt% to 1.5wt%;

and the polishing liquid has a pH of 10 to 11.

25 7. A method of chemical mechanical polishing, comprising:

diluting a polishing liquid, and then polishing a sample to be polished;

wherein the polishing liquid is the chemical mechanical polishing liquid according to any one of claims 1 to 6.

8. The method according to claim 7, wherein the sample to be polished is a wafer containing silicon dioxide, the polishing is performed for a time of 1 min to 3 min, and the diluted polishing liquid has a flow rate of 120 ml/min to 180 ml/min.