

SPECIFICATIONS

A CHEMICAL MECHANICAL POLISHING SOLUTION FOR IMPROVING TEOS POLISHING RATE, AND USE THEREOF

TECHNICAL FIELD

The present invention relates to the field of chemical mechanical polishing, and in particular to a chemical mechanical polishing solution and use thereof.

BACKGROUND

With the iterative development of DRAM and 3D-NAND, it is necessary to remove a relatively thick layer of silicon oxide. Therefore, there is an urgent need in the art for a cerium oxide polishing slurry that can greatly increase the polishing rate of silicon oxide. Meanwhile, conventional chemical mechanical polishing solutions using negatively charged cerium oxide often face the technical problem of low TEOS polishing rate, so positively charged cerium oxide particles are used in most cases for polishing silicon oxide. However, chemical mechanical polishing solutions using positively charged cerium oxide have many problems, such as high defect rate, excessive particle residue, and difficulty in cleaning, etc.

Therefore, how to develop a chemical mechanical polishing solution with negatively charged cerium oxide particles that can achieve a TEOS polishing rate comparable to that of positively charged cerium oxide, while simplifying the cleaning process and improving yield, has become an urgent technical problem to be solved in the art.

DESCRIPTION

In order to overcome the above technical drawbacks, the purpose of the present invention is to provide a chemical mechanical polishing solution for increasing TEOS polishing rate and use thereof.

Specifically, the present invention discloses a chemical mechanical polishing solution for increasing TEOS polishing rate, comprising: a nitrogen-containing heterocyclic conjugated compound and cerium oxide particles with negative charges on the surface.

Preferably, the nitrogen-containing heterocyclic conjugated compound is selected from one or more of 2-picolinic acid, 1,2,4-triazole, 1-methyl-5-mercapto-1H-tetrazole, 5-methyltetrazole, 4-amino-1,2,4-triazole, 3-amino-1,2,4-triazole and cyanuric acid.

Preferably, the mass percentage concentration of the nitrogen-containing heterocyclic compound is 200ppm-2000ppm.

Preferably, the Zeta potential of the cerium oxide particles with negative charges on the surface is less than -30 mV.

Preferably, the cerium oxide particles with negative charges on the surface comprise sol-type cerium oxide particles.

Preferably, the concentration of the cerium oxide particles with negative charges on the surface is 0.1wt%-1.0wt%.

Preferably, the chemical mechanical polishing solution further comprises a pH regulator, wherein the pH regulator is selected from KOH or HNO₃.

Preferably, the pH value of the chemical mechanical polishing solution is 9~12.

The present invention also discloses a use of the chemical mechanical polishing solution, which is the use of the chemical mechanical polishing solution according to any of the above for increasing TEOS polishing rate.

After adopting the above technical solution, compared with the prior art, the present invention has the following beneficial effects: simplifying the post-polishing cleaning process, improving product yield and production efficiency, and reducing production cost.

EMBODIMENTS

Advantages of the invention are further elucidated below in connection with specific examples. The method for detecting the polishing rate of the chemical mechanical polishing solution in the comparative embodiments and embodiments of the present invention is:

Mirror polishing machine is used for polishing test on TEOS and Si blank wafers. The corresponding polishing conditions include: IC1010 polishing pad, the rotation speeds of the wafer and cerium oxide particles are 93 rpm and 87 rpm respectively, the pressure is 3 psi, and the flow rate of the polishing liquid is 150 mL/min. The TEOS film thickness is measured by a NanoSpec film thickness measurement system (NanoSpec 6100-300, Shanghai Nanotechnology Co., Ltd.). For the film thickness of the blank wafer, 49 points are measured at equal intervals on the diameter line starting from 3 mm from the edge of the wafer. The polishing rate is the average of the 49 points. The removal amount of Si is obtained by the weighing method. Si wafers are weighed with an analytical balance with an accuracy of 0.0002 g before and after polishing. The total weight loss is divided by the wafer area and Si density to calculate the average removed thickness, which is then divided by the polishing time to calculate the polishing rate.

The measurement method of Zeta potential on the surface of cerium oxide particles is as follows:

The surface charge of cerium oxide particles is characterized by Zeta potential. Dilute the chemical mechanical polishing solution until the content of cerium oxide reaches 0.2%, then place it in a quartz cuvette. Zeta potential is measured using a Malvern instrument.

Embodiment 1:

A series of nitrogen-containing heterocyclic compounds were tested in a polishing solution containing 0.5 wt% cerium oxide particles (designated as Type-1). Type-1 cerium oxide particles are negatively charged sol-type cerium oxide particles with a surface Zeta potential of less than -30mV. According to the component proportions in Table 1, each component is dissolved in deionized water, the pH is adjusted to 12 with KOH, and the mass percentage is adjusted to 100% with deionized water, so as to obtain the chemical mechanical polishing solutions of Comparative Embodiment 1 and Embodiments 1-7 of the present invention. The polishing data measured according to the above test method are shown in Table 1.

Table 1 Components, their contents and polishing test results in Embodiments 1-7 and Comparative Embodiment 1

	Cerium oxide concentration (Type-1)	Nitrogen-containing heterocyclic conjugated compound		pH	TEOS polishing rate (Å/min)
		Specific compounds	Concentration (ppm)		
Comparative Embodiment 1	0.5%	/	0	12	4756
Embodiment 1	0.5%	2-pyridinecarboxylic acid	1000	12	4960
Embodiment 2	0.5%	1,2,4-triazole (TAZ)	1000	12	6480
Embodiment 3	0.5%	1-methyl-5-mercapto-1H-tetrazole	1000	12	6145
Embodiment 4	0.5%	5-methyltetrazole	1000	12	6316
Embodiment 5	0.5%	4-amino-1,2,4-triazole	1000	12	6044
Embodiment 6	0.5%	3-amino-1,2,4-triazole	1000	12	6404
Embodiment 7	0.5%	Cyanuric acid	1000	12	6780

Based on the polishing data of the various nitrogen-containing heterocyclic compounds and the without a nitrogen-containing heterocycle compound in the Comparative Embodiment, listed in Table 1, the polishing solutions with the addition of the nitrogen-containing heterocyclic compound (Embodiments 1-7) both enhance the TEOS polishing rate as compared to Comparative Embodiment 1 without the addition of the nitrogen-containing heterocyclic compound. Among them, Embodiments 2 to 7 have a more obvious enhancement effect on the TEOS polishing rate.

Embodiment 2:

The effect of nitrogen-containing heterocyclic compounds on TEOS polishing rate was further investigated. Different concentrations of the nitrogen heterocyclic compound TAZ (1,2,4-triazole) were added on the basis of Comparative Embodiment 1 (0.5% Type-1 negatively charged sol-type cerium oxide particles, pH 12). According to the component proportions in Table 2, each component is dissolved in deionized water, the pH is adjusted to 12 with KOH, and the mass percentage is adjusted to 100% with deionized water, so as to obtain the chemical mechanical polishing liquids of Comparative Example 1 and Examples 8-12 of the present invention. The polishing data measured according to the above test method are shown in Table 2.

Table 2 Components, contents and polishing test results of Embodiments 8-12 and Comparative Embodiment 1

	Cerium oxide concentration (Type-1)	TAZ Concentration (ppm)	pH	TEOS polishing rate (Å/min)
Comparative Embodiment 1	0.5%	0	12	4756
Embodiment 8	0.5%	200	12	5364
Embodiment 9	0.5%	500	12	5772
Embodiment 10	0.5%	1000	12	6480
Embodiment 11	0.5%	1500	12	6618
Embodiment 12	0.5%	2000	12	6568

It can be seen from the data shown in Table 2 that when the content of TAZ is in the range of 200ppm to 1000ppm (Embodiments 8-10), the TEOS polishing rate of the polishing liquid increases with the increase of TAZ content, and there is an obvious linear relationship between the two. When the TAZ concentration reaches 1000ppm (Embodiment 10), and the content continues to increase to 1500ppm or 2000ppm (Embodiment 12), the enhancement of TEOS polishing rate by the chemical mechanical polishing solution reaches the maximum, and as the TAZ concentration further increases, the promoting effect on TEOS polishing rate is no longer obvious. It should also be noted that, referring to Embodiment 8, when only 200ppm of TAZ is added, the TEOS polishing rate of the polishing solution can still be increased by 12%, which proves that TAZ has a significant improvement effect on the TEOS polishing rate of the polishing solution.

Embodiment 3:

The pH range required for TAZ to increase TEOS polishing rate was further determined. 0.1% TAZ was added into the negatively charged cerium oxide dispersion, and potassium hydroxide or nitric acid was used to adjust the pH to 11, 10, 9 and 8 respectively. Then deionized water was added to make the total mass percentage reach 100%, so as to obtain the chemical mechanical polishing liquids of each comparative embodiment and embodiment. If the pH is further lowered to below 7, the stability of the polishing colloid will be destroyed, and the cerium oxide particles will aggregate and precipitate. The corresponding polishing

results are shown in Table 3.

Table 3 Components, contents and polishing test results of Embodiment 10, Embodiments 13-15, Comparative Embodiments 1-2

	Cerium oxide concentration (Type-1)	TAZ concentration (ppm)	pH	TEOS polishing rate ($\text{\AA}/\text{min}$)
Comparative Embodiment 1	0.5%	0	12	4756
Comparative Embodiment 2	0.5%	1000	8	3964
Embodiment 10	0.5%	1000	12	6480
Embodiment 13	0.5%	1000	11	5940
Embodiment 14	0.5%	1000	10	5908
Embodiment 15	0.5%	1000	9	5044

It can be seen from the data in Table 3 that when the pH value of the polishing liquid is 8, TAZ has no promoting effect on the TEOS polishing rate and is even worse than Comparative Embodiment 2 without adding TAZ. Therefore, when the pH value of the chemical mechanical polishing solution ranges from 9 to 12, TAZ has a significant promoting effect on the TEOS polishing rate.

Embodiment 4:

The effect of TAZ on TEOS polishing rate in cerium oxide dispersions with different concentrations was further verified. According to the component proportions in Table 4, each component is dissolved in deionized water, the pH is adjusted to 12 with KOH, and the mass percentage is adjusted to 100% with deionized water, so as to obtain the chemical mechanical polishing solutions of Comparative Embodiment 1, Comparative Embodiments 3-4, Embodiment 10 and Embodiments 16-17 of the present invention. The polishing data measured according to the above test method are shown in Table 4.

Table 4 Components, contents and polishing test results of Comparative Embodiment 1, Comparative Embodiments 3-4, Embodiment 10 and Embodiments 16-17

	Cerium oxide concentration (Type-1)	TAZ concentration (ppm)	pH	TEOS polishing rate (Å/min)
Comparative Embodiment 3	0.1%	0	12	2688
Embodiment 16	0.1%	1000	12	3120
Comparative Embodiment 1	0.5%	0	12	4756
Embodiment 10	0.5%	1000	12	6480
Comparative Embodiment 4	1.0%	0	12	6912
Embodiment 17	1.0%	1000	12	7746

It can be seen from the results in Table 4 that adding TAZ to polishing solutions with cerium oxide concentrations of 0.1%, 0.5% and 1% can effectively increase the TEOS polishing rate.

It should be noted that the embodiments of this invention are preferred implementations and do not constitute any form of limitation on the invention. Any skilled person in the field may modify or alter the disclosed technical content into equivalent effective embodiments. However, any modification, equivalent variation, or adaptation made to the above embodiments based on the technical essence of this invention, without departing from the scope of the invention's technical solution, still falls within the protection scope of this invention.

CLAIMS

1. A chemical mechanical polishing solution for increasing TEOS polishing rate, comprising: a nitrogen-containing heterocyclic conjugated compound and cerium oxide particles with negative charges on the surface.
2. The chemical mechanical polishing solution according to claim 1, characterized in that: the nitrogen-containing heterocyclic conjugated compound is selected from one or more of 2-picolinic acid, 1,2,4-triazole, 1-methyl-5-mercapto-1H-tetrazole, 5-methyltetrazole, 4-amino-1,2,4-triazole, 3-amino-1,2,4-triazole and cyanuric acid.
3. The chemical mechanical polishing solution according to claim 1, characterized in that the Zeta potential of the cerium oxide particles with negative charges on the surface is less than -30 mV.
4. The chemical mechanical polishing solution according to claim 1, characterized in that the cerium oxide particles with negative charges on the surface comprise sol-type cerium oxide particles.
5. The chemical mechanical polishing solution according to claim 1, characterized in that the concentration of the cerium oxide particles with negative charges on the surface is 0.1wt%-1.0wt%.
6. The chemical mechanical polishing solution according to claim 1, characterized in that the polishing solution comprises a pH regulator.
7. The chemical mechanical polishing solution according to claim 6, characterized in that the pH regulator is KOH or HNO₃.
8. The chemical mechanical polishing solution according to claim 1, characterized in that the pH value of the chemical mechanical polishing liquid is 9~12.
9. A use of a chemical mechanical polishing solution, which is the use of the chemical mechanical polishing liquid according to any one of claims 1 to 8 for increasing the TEOS polishing rate.