

[Name of Document] SPECIFICATION

[Title of the Invention] HIGH CONCENTRATION SILICA SLURRY

[Field of the invention]

The present invention relates to a silica slurry having low viscosity even if a high silica concentration by using a silica powder having a uniform particle size and low agglomeration, and also relates to a polishing composite having excellent performance by using said silica slurry. As for the silica dispersion slurry of the present invention, the silica powder is dispersed in the wide concentration range from low to high without precipitating, and the viscosity is low. So this slurry is excellent in handling, stable with the passage of time, and suitable to high-speed polishing or rough polishing. Moreover, since the impurity concentration is low, it is suitable to a chemical mechanical polishing of semiconductor materials. Furthermore, since said silica dispersion slurry can be handled with the high concentration, the supplying cost of the slurry is low.

[Description of the Prior Art]

In a chemical mechanical polishing (CMP), a dispersion slurry of fumed silica or colloidal silica has been used (Japanese Patent Laid Open No. 30333-1987, 154760-1993, 342455-2001). Generally, a polishing process of a silicon wafer is classified with 3 processes, i.e., a primary polishing, a secondary polishing and a finishing polishing, and it is required in the finishing polishing that the final condition of the surface has no scratch and haze. Furthermore, the high purity polishing slurry is strongly required in

order to prevent metal ionic contaminations aroused by taking metal ions, especially sodium, into a surface layer of the substrate at the time of polishing.

As for the dispersion liquid of the silica powder, in order to obtain a polishing liquid having few metal contaminations and excellent polishing accuracy and speed, it is necessary that the slurry has the excellent dispersibility, the low viscosity, and the excellent stability with the passage of time even if high silica concentration, in addition using the high purity silica powder. However, the silica concentration of the conventional silica dispersion slurry is limited about 40 %. If the silica concentration is more than 40 %, the suitable flowability is lost easily. Moreover, the conventional dispersion liquid has a problem that the viscosity stability with the passage of time is low. Especially, in the case of the silica powder having the fine particle size, this problem is large. More concretely, for example, in the case of the conventional slurry using the fumed silica having the average primary particle size of from 7 to 50 nm, since the silica powder is existed as agglomerates in the slurry in many cases, the particle size at the time of polishing is not uniform, and the viscosity change with the passage of time is large.

The present invention solves these problems in the conventional silica slurry, and provides the high concentration silica slurry having low viscosity and little viscosity change with the passage of time even if having high concentration.

[Summary of the Invention]

The present invention relates to the high concentration silica slurry and the polishing composite comprising the following constitutions.

[1] A high concentration silica slurry having a silica concentration of more than 50 weight % and viscosity of less than 1000 mPa's, wherein the silica powder is dispersed in an solvent, has the ratio DL/DT of less than 1.3, where DL is an average particle size of the silica powder measured by a laser diffraction particle size distribution method and DT is that by a TEM photography observation, and has the average primary particle size of from $0.08\ \mu\text{m}$ to $0.8\ \mu\text{m}$.

[2] The high concentration silica slurry according to [1], wherein the silica concentration is from more than 70 % by weight to less than 80 % by weight and the viscosity of less than 800 mPa's at the time of preparing.

[3] The high concentration silica slurry according to [1] or [2], wherein the ratio B/A is less than 1.5, where A is the viscosity of the slurry measured at the time of preparing and B is that after one month.

[4] The high concentration silica slurry according to any one of [1] to [3], wherein the impurity concentrations of silica powder are less than 1.0 ppm each of sodium and potassium, less than 1.0 ppm aluminum, and less than 5 ppm each of sulfur, nickel, chromium, and iron.

[5] A polishing composite, comprising the high concentration silica slurry according to any one of from [1] to [4].

[Detailed description of the preferred embodiment]

Hereinafter, the present invention is explained more concretely according to the preferred embodiment. In addition, % is by weight unless it is shown especially.

The silica slurry of the present invention is a high concentration silica slurry having a silica concentration of more than 50 weight % and viscosity of less than 1000 mPa·s, wherein the silica powder is dispersed in an solvent, has the ratio DL/DT of less than 1.3, where DL is an average particle size of the silica powder measured by a laser diffraction particle size distribution method and DT is that by a TEM photography observation, and has the average primary particle size of from $0.08\ \mu\text{m}$ to $0.8\ \mu\text{m}$.

The silica powder used in the slurry of the present invention is the powder having the average primary particle size of from $0.08\ \mu\text{m}$ to $0.8\ \mu\text{m}$. When the silica powder having the average primary particle size of smaller than $0.08\ \mu\text{m}$ is used, the slurry becomes unstable easily, so that the viscosity change with the passage of time and the precipitation in the slurry occurs easily. On the other hand, when the silica powder having the average primary particle size of larger than $0.80\ \mu\text{m}$ is used, said powder precipitates easily in the slurry, and causes the scratch or the like at the time of polishing.

Moreover, the silica powder used in the slurry of the present invention is the powder, in which the ratio DL/DT is less than 1.3, where DL is the average particle size of the silica powder measured by the laser diffraction particle size distribution method and DT is that by the TEM photography observation. Since the TEM observation is suitable to measure

the primary particle size, the average particle size of the silica powder by the TEM photography observation (DT) shows the primary particle size. On the other hand, the laser diffraction particle size distribution method is suitable to measure the particle size including the secondary agglomerates, so that the average particle size of the silica powder measured by the laser diffraction particle size distribution method (DL) shows the particle size including the secondary agglomerates. Therefore, the ratio of these particle sizes (DL/DT) shows the ratio of the agglomeration of particles. More concretely, the silica powder having the ratio of the average particle sizes (DL/DT) of more than 1.3, has many secondary agglomerates, so that it is difficult to make the silica slurry having high concentration and low viscosity.

As mentioned above, the silica powder of the present invention has few secondary agglomerates, and as for the secondary agglomerates, it is preferable that the average particle size of them is mostly smaller than $1.0\ \mu\text{m}$. Moreover, as for the agglomerated particles, it is preferable that the agglomerated particles of more than 95 % are in one peak of a size distribution curve in the range of the particle size of less than $1.0\ \mu\text{m}$. When the agglomerated particles of less than 95 % are in one peak of the size distribution curve or the average particle size of the secondary agglomerates in this peak is more than $1.0\ \mu\text{m}$, the slurry becomes unstable, so that the viscosity change with the passage of time becomes large.

Moreover, as for the silica powder used in the slurry of the present invention, it is preferable that the each impurity concentration of sodium and potassium in the silica powder is less than 1.0 ppm. When the slurry

dispersed with the silica powder having each impurity concentration of sodium and potassium of more than 1.0 ppm is used in the polishing of the wafer or the like, ionic impurities of sodium and potassium contained in the silica powder are taken into to contaminate the surface layer of the wafer at the time of polishing, so that the scratch or the haze occurs easily on the polished surface.

In order to prevent metal contaminations, it is preferable that the concentrations of impurities other than sodium and potassium are kept as low as possible. More concretely, for example, it is preferable that aluminum is less than 1.0 ppm, and each of sulfur, nickel, chromium and iron is less than 0.5 ppm. More preferably, each of sulfur, nickel and chromium is less than 0.1 ppm.

The silica powder having the low impurities concentration and the particle size of said range is, for example, the fumed silica or the like produced by a dry process, such as a flame hydrolysis method or the like. In the case of the silica powder produced by a wet process, it is difficult to obtain the slurry having the impurities concentration of less than the above-mentioned level. As the silica powder produced by the dry process, for example, it is preferable to use the silica powder produced by the method described in Japanese Patent Laid Open No. 3213-2002. This production method is to produce an amorphous fine silica powder by introducing a gaseous silicon compound into a flame and hydrolyzing it. In this production method, the amorphous silica powder having the average particle size (median size) of from 0.08 to $0.8\mu\text{m}$ and the specific surface area of from 5 to $30\text{ m}^2/\text{g}$ by the BET method, is produced by making the flame temperature

to be more than a melting point of silica, growing the silica particle while keeping the silica concentration in the flame of more than 0.25 kg / Nm^3 , and staying the grown silica particle at the high temperature of more than the melting point of silica in short time.

In said production method, as a raw material, the silicon compounds, such as, silicon tetrachloride, trichlorosilane, dichlorosilane, methyltrichlorosilane or the like are used and can be carried out a hydrolysis reaction at high temperature by introducing into an oxy-hydrogen flame in gaseous state. These gaseous silicone compounds, such as silicon tetrachloride or the like, are suitable to produce the high purity silica particle since the impurities in the raw material can be removed easily by a distillation refining.

By using the silica particle, in which the ratio of average particle size (DL/DT) and the average primary particle size are above-mentioned range, it is possible to obtain the low viscosity silica slurry having the viscosity of less than $1000 \text{ mPa}\cdot\text{s}$ and the little viscosity change with the passage of time, even if having the high silica concentration of more than 50 %. More concretely, for example, it is possible to obtain the low viscosity silica slurry, in which the silica concentration is more than 70 %, the initial viscosity is less than $800 \text{ mPa}\cdot\text{s}$., and the ratio B/A is less than 1.5, where B is the viscosity of the slurry measured after one month and A is that at the time of preparing (hereinafter, it is said to as the viscosity ratio with the passage of time). When the viscosity ratio with the passage of time (B/A) is more than 1.5, the viscosity change with the passage of time is large and the slurry is unstable.

It is preferable that the silica concentration of the slurry is less than 80 %. When the silica concentration is more than 80 %, the viscosity becomes too high to generate gelation or precipitation easily. Moreover, the stability with the passage of time of the slurry is reduced, by which the gelation or the precipitation generates easily by the general temperature change or the difference of the transportation or preservation conditions. Furthermore, when the viscosity of the slurry is more than 1000 mPa·s, the handling becomes difficult. In addition, as a solvent dispersing the silica powder, a polar solvent, such as the distilled water or the like, is preferable. It is suitable that the viscosity of the solvent is less than 10 mPa·s.

In the silica slurry of the present invention, if the characteristics of the silica powder, such as the concentration of impurities, the ratio of average particle size (DL/DT) and the average primary particle size, are in above-mentioned range, more than two kinds of the silica powder having the different particle size can be used. Furthermore, other metal oxide powders, such as an alumina powder, composite oxide powders, doped materials or the like, can be contained with the silica powder. It is necessary that the amount of these oxide powders is in the range which does not disturb the characteristics of the slurry of the present invention. By containing these metal oxide powders, the polishing according to the purpose can be carried out.

[Effectiveness of the Invention]

The silica slurry of the present invention is the slurry having the high concentration and low viscosity, i.e., the silica concentration is more

than 50 % and the viscosity is less than 1000 mPa · s, by using the silica powder in which the ratio of the average particle size (DL/DT) and the average primary particle size are prepared in the fixed range. It is preferable that the silica concentration is from 70 % by weight to 80 % by weight, the viscosity at the time of preparing is less than 800 Pa·s, and the viscosity ratio with the passage of time (B/A) is less than 1.5. The silica slurry of the present invention is the slurry having low viscosity and little viscosity change with the passage of time, even if having high silica concentration. More preferably, the silica slurry of the present invention uses the silica having low impurities, in which the each impurity concentration of sodium and potassium is less than 1.0 ppm, the amount of aluminum is less than 1.0 ppm, and each of the content of sulfur, nickel, chromium and iron is less than 0.5 ppm. Therefore, the silica slurry having high silica concentration of the present invention is suitable to use for polishing and, in the chemical mechanical polishing (CMP) or the like, the polishing speed is comparatively high and the polishing accuracy is excellent.

[Example]

Hereinafter, the present invention will be explained more concretely with examples and comparison examples. In addition, in each example, the viscosity is measured using Rheo Stress meter produced by HAAKE Co., and the particle size is measured using a laser dispersion type particle size distribution meter produced by HORIBA Co. The viscosity is the value at the shearing speed of 100 / s, and the viscosity change with the passage of time is measured after one month from the time of the slurry preparation.

[Example 1]

Fumed silica produced by Nippon Aerosil Co. Ltd, having the impurities concentration shown in Table 1 (a trade name was VP-OX30 and the specific surface area was $30\text{m}^2/\text{g}$ by the BET method) was added to a distilled water. The added fumed silica was dispersed to become slurry by stirring, and pH was adjusted to 8.9. Then, the slurry having the silica concentration of 75 % was prepared. The viscosity and the viscosity ratio with the passage of time of this slurry were measured. These results were shown in Table 1 with the making slurry conditions.

[Example 2]

Fumed silica produced by Nippon Aerosil Co. Ltd, having the impurities concentration shown in Table 1 (the trade name was VP-OX10 and the specific surface area was $10\text{m}^2/\text{g}$ by the BET method) was added to a distilled water. The added fumed silica was dispersed to become slurry by stirring, and pH was adjusted to 9.2. Then, the slurry having the silica concentration of 80 % was prepared. The viscosity and the viscosity ratio with the passage of time of this slurry were measured. These results were shown in Table 1 with the making slurry conditions.

[Test Example]

Fumed silica produced by Nippon Aerosil Co. Ltd, having the impurities concentration shown in Table 1 (the trade name was VP-OX30 and the specific surface area was $30\text{m}^2/\text{g}$ by the BET method) was added to a distilled water. The added fumed silica was dispersed to become slurry by stirring, and pH was adjusted to 8.9. Then, the slurry having the silica

concentration of 85 % was prepared. The viscosity and the viscosity ratio with the passage of time of this slurry were measured. These results were shown in Table 1 with the making slurry conditions.

[Comparison example]

A commercial colloidal silica was added to a distilled water. The added colloidal silica was dispersed to become slurry by stirring, and pH was adjusted to 9.2. Then, the slurry having the silica concentration of 70 % was prepared. The viscosity and the viscosity ratio with the passage of time of this slurry were measured. These results were shown in Table 1 with the making slurry conditions. (Comparison example 1)

The slurry having the silica concentration of 70 % was prepared by the same process as the comparison example 1 excepting using the silica powder produced by the wet process instead of the colloidal silica. The viscosity and the viscosity ratio with the passage of time of this slurry were measured. These results were shown in Table 1 with the making slurry conditions. (Comparison Example 2)

The slurry was prepared by the same process as Example 1 excepting using fumed silica having the ratio of the average particle size (DL/DT) of 5.5 and the average primary particle size of $0.012\mu\text{m}$. The concentration of silica, the viscosity and the viscosity ratio with the passage of time of this slurry were measured. These results were shown in Table 1 with the making slurry conditions.

[Results]

As shown in Table 1, in the case of each silica slurry of Example 1 and 2 of the present invention, each initial viscosity of the slurry at the time of preparing was 700 mPa·s and 800 mPa·s respectively, even when each silica concentration was more than 75 %. That is, the each viscosity of the silica slurries was low. Moreover, each viscosity of the silica slurries after one month was 730 mPa·s and 850 mPa·s respectively, so that each slurry had little viscosity change with the passage of time and was stable. On the other hand, in the case of Comparison example 1, the average primary particle size was too small and had a high impurity concentration. In the case of Comparison example 2, the ratio of the average particle size (DL/DT) was a little high and had an extremely high impurity concentration. Thus these slurries of Comparison example 1 and 2 were not suitable for the polishing agent. Moreover, in the case of Comparison example 3, since the ratio of the average particle size (DL/DT) is rather high and the average primary particle size is lower than the range of present invention, the viscosity of the slurry is remarkably high as more than 3000mPa·s even when the silica concentration was low as 10 %.

[Table 1]

			Example 1	Example 2	Test Example	Comparison example 1	Comparison example 2	Comparison example 3
Silica Particle	Impurities Amount [ppm]	Na	< 1.0	< 1.0	< 1.0	277	2226	< 1.0
		K	< 1.0	< 1.0	< 1.0	< 10	< 1.0	< 1.0
		S	< 0.1	< 0.1	< 0.1	< 1.0	1200	< 0.1
		Fe	< 0.5	< 0.5	< 0.5	< 1.0	210	< 0.5
		Al	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
		Ni	< 0.1	< 0.1	< 0.1	< 1.0	< 1.0	< 0.1
		Cr	< 0.1	< 0.1	< 0.1	< 1.0	< 1.0	< 0.1
	DL/DT		1.2	1.1	1.2	1.1	1.6(*)	1.5(*)
	Average Primary Particle Size (μm)		0.1	0.15	0.065(*)	0.03(*)	0.25	0.012(*)
Slurry	Silica Concentration (%)		75	80	85	70	70	10
	Viscosity (at the time of preparing) [A]		700	800	880	630	820	>3000(*)
	Viscosity (after one month) [B]		730	850	1620	660	750	>3000(*)
	Viscosity Ratio with Passage of Time [B/A]		1.04	1.06	1.84(*)	0.95	0.91	—

(Note)DL is an average particle size by a laser dispersion type particle size distribution meter, and DT is an average particle size by the TEM photography observation.

DL/DT is the ratio of the average particle size. The unit of Viscosity is [mPa·s]

(*) is out of the value of the preferable range of the present invention

[Name of Document] INDUSTRIAL APPLICABILITY

The silica dispersion slurry of the present invention uses the silica powder having few impurities, has the low viscosity, and the little viscosity change with the passage of time even if having high concentration. Therefore, the silica dispersion slurry of the present invention is suitable as the polishing composite of a silicon wafer or the like. In addition, when said silica dispersion slurry is used in CMP, it is possible to obtain the excellent effect in both performances of the polishing speed and accuracy.

[Name of Document] CLAIMS

[What is claimed is]

[Claim 1] A high concentration silica slurry having a silica concentration of more than 50 % by weight and viscosity of less than 1000 mPa·s,

wherein a silica powder is dispersed in an solvent, has the ratio DL/DT of the silica powder is less than 1.3, where DL is an average particle size of the silica powder measured by a laser diffraction particle size distribution method and DT is that by a TEM photography observation, and has the average primary particle size of silica powder of from $0.08\ \mu\text{m}$ to $0.8\ \mu\text{m}$.

[Claim 2] The high concentration silica slurry according to Claim 1, wherein the silica concentration is from more than 70 % by weight to less than 80 % by weight and the viscosity is less than 800 mPa·s at the time of preparing.

[Claim 3] The high concentration silica slurry according to Claim 1 or Claim 2,

wherein the ratio B/A is less than 1.5, where A is the viscosity of the slurry measured at the time of preparing and B is that after one month.

[Claim 4] The high concentration silica slurry according to any one of Claim 1 to Claim 3,

wherein the impurity concentrations of silica powder are less than 1.0 ppm each of sodium and potassium, less than 1.0 ppm aluminum, and less than 5 ppm each of sulfur, nickel, chromium, and iron.

[Claim 5] A polishing composite,

comprising the high concentration silica slurry according to any one of from Claim 1 to Claim 4.