Description

Title of Invention: METHOD OF PRODUCING QUARTZ GLASS JIG AND QUARTZ GLASS JIG

Technical Field

[0001]

The present invention relates to a method of producing a quartz glass jig including forming irregularities without microcracks on a quartz glass surface through chemical liquid treatment (chemical treatment), and a quartz glass jig in which irregularities are formed on a surface.

Background Art

[0002]

Quartz glass has hitherto been used as a material for semiconductor treatment, for optical applications, for physical and chemical appliances, for decoration, and the like because quartz glass has high purity and is excellent in chemical resistance. Such quartz glass processed products may each be roughened by subjecting a surface thereof to various kinds of irregular processing depending on an intended use. In particular, irregularities are formed on an inner surface of a core tube to be used in a semiconductor process to prevent peeling of a film having been formed, such as a polysilicon film, during low pressure chemical vapor deposition (LPCVD) treatment, and to prevent the generation of particles during heat treatment of a wafer.

[0003]

As an irregular processing method for the surface of quartz glass described above, sandblast treatment and surface treatment with a mixed solution of $HF/CH_3COOH/NH_4F$ (surface treatment liquid) have been known. The sandblast treatment is a processing method accompanied by mechanical destruction of a surface. Accordingly, microcracks are present on the quartz glass surface, and the presence of the microcracks may be a factor in the generation of particles or the like, and hence the sandblast treatment has not been said to be always effective. In addition, surface irregular processing through the surface treatment with a surface treatment liquid has long been employed because the irregular processing does not involve the presence of such microcracks as described above, and is hence suitable for use in the semiconductor process. As an example of performing irregular processing with a surface treatment liquid on a quartz glass surface, there are given, for example, Patent Documents 1 to 3. In addition, it is generally known that, with regard to prevention of peeling of a polysilicon film or the like (hereinafter also referred to as "film peeling ") from the quartz glass surface in the semiconductor process, the film peeling is less liable to occur when a surface roughness is higher.

[0004]

However, a surface treatment method for quartz glass with a surface treatment liquid has a problem in that the control of variations in surface roughness is difficult as compared to a processing method accompanied by mechanical destruction, such as sandblast treatment. Further, the resulting cloudy state of the surface generated through the formation of irregularities may be uniform, may be locally non-uniform, or may not be constant

depending on the state of a surface to be treated at the time of immersion in the surface treatment liquid. When such non-uniform portion is present, there are such problems as described below: a film adhering to quartz becomes locally fragile and causes film peeling, and hence an intended function is not achieved. In addition, when non-uniform irregularities (unevenness) are formed, chemical liquid treatment has hitherto been repeatedly performed in order to eliminate the unevenness. However, it has been difficult to eliminate the unevenness, such as large unevenness, streaky unevenness, or an aggregate of small unevenness, and it has been required in some cases that the chemical liquid treatment be performed a plurality of times.

[0005]

In Patent Document 4, there is a mention about unevenness of a treatment surface in paragraph 0008, and as a countermeasure against this, there is a proposal focused on a Reynolds number Re. The unevenness discussed here is the light and shade of the treatment surface when the treatment surface is seen from a position at a distance of about 1 m. Accordingly, for example, specification of a Reynolds number for treating a large treatment surface under the same conditions functions as a solution.

[0006]

Meanwhile, in a film formation process in a semiconductor manufacturing process in recent years, more local unevenness of an "irregular finished surface" has been emphasized. Such local unevenness is a slightly transparent area (i.e., a portion having an extremely low surface roughness Ra or a portion having an extremely high surface roughness Ra) of about 1-

centimeter square, or directional local unevenness, such as a brush pattern or a fingerprint, having a size of about 1-centimeter square, the area or the unevenness being formed on a cloudy and opaque irregular finished surface generated through the formation of irregularities on the surface. The directional local unevenness is divided into a case of having a surface roughness at the same level as that of the surrounding irregular finished surface and a case of having a surface roughness at a different level therefrom. While films stacked on each other depending on the number of times of film formation adhere to a quartz glass jig to be used in the film formation process, when the thickness of the films on the quartz glass jig is increased owing to prolongation of a washing cycle for improving productivity, fine peeling occurs from the above-mentioned local unevenness in temperature increasing and temperature decreasing procedures before and after the film formation process. The fine peeling may be the cause of contamination with particles in the process. This is why the local unevenness of the irregular finished surface has been emphasized.

[0007]

The related-art surface treatment as described in each of Patent Documents 1 to 4 was targeted at a relatively small area. In the case where a surface area was small, even when the formation of irregularities involved unevenness, such unevenness was inconspicuous, and hence appeared not to be present (to be present in a small amount).

[0008]

However, in recent years, along with upsizing of a semiconductor wafer, also the quartz glass jig has been upsized. In conventional

applications of a Si wafer of from 6 inch size to 8 inch size in diameter, unevenness was inconspicuous on the irregular finished surface on the surface. However, the number of Si wafers to be treated per batch has been increased, and a Si wafer of 12 inch size has become the mainstream. Along with this, the upsizing of the quartz glass jig has been progressed, with the result that a core tube, a round seal, or a top plate of quartz glass has been upsized and elongated to be increased in surface area. Accordingly, there has been a problem in that unevenness becomes conspicuous on the irregular finished surface on the surface.

[0009]

Non-uniform surface cloudiness due to irregular finish unevenness, specifically the presence of a transparent portion and an opaque portion results from a non-uniform peak and valley structure of the surface. Accordingly, it is not preferred that the irregular finish unevenness be present in the quartz glass jig because the adhesive effect of a film adhering to a wafer in a film formation process is varied as a consequence. In addition, there is another problem in that, when the irregular finish unevenness is present in the quartz glass jig, the transmission of a heat ray from a heater is varied to cause a temperature distribution in the film formation process. This is also not preferred from the viewpoint of film uniformity in wafer treatment.

Prior Art Documents

Patent Documents

[0010]

Patent Document 1: JP Hei 10-273339 A

Patent Document 2: WO 2004/051724 A

Patent Document 3: JP 2001-335342 A

Patent Document 4: JP 2005-145721 A

Disclosure of the Invention

Problems to be solved by the Invention

[0011]

A treatment workpiece that had been left for a long period of time has hitherto been wiped with an alcohol or the like as pretreatment of chemical liquid treatment. However, for example, a workpiece that had been subjected to surface flame polishing in a general product production process has been cooled under a clean environment and then directly proceeded with a step of forming an irregular treatment surface with a chemical liquid because such workpiece has a clean surface.

[0012]

The inventors of the present invention have extensively addressed the resolution of local unevenness, and as a result, have found that fat and oil derived from a fingerprint or a glove, an adhering water content such as adhering water, dust or lint, or dirt on a plastic cover for protecting dust adheres to the surface of a workpiece even at the time of, for example, short transfer between steps to disturb a reaction in a chemical liquid step, and the disturbance causes the local unevenness described above.

Accordingly, a reaction caused by chemical liquid treatment becomes unstable in a portion of a surface to be treated in which an adhering substance

(adhering water content or oil content) is present, and irregularities to be formed are partially varied in size, or the irregularities fail to be formed, with the result that a non-uniform irregular surface is formed for the whole of a quartz glass jig. A portion in which a sufficient effect is not exhibited in use in a film formation step is partially formed. Such non-uniform irregular surface is also a non-uniformly cloudy surface in its appearance, and concern is raised that film peeling is liable to occur in the non-uniform portion.

[0013]

When the portion and content (e.g., oil) of dirt on the surface are specified, wiping with an organic solvent, such as an alcohol or acetone, can be applied. However, a thin oil dirt or the like is difficult to detect and specify, and hence it has been found that the removal of a substance on at least a top surface of a workpiece as a whole before chemical liquid treatment is the most useful and effective improvement measure.

[0014]

The present invention has been made in view of the above-mentioned problems of the related art, and an object of the present invention is to provide a method of producing a quartz glass jig including forming irregularities without microcracks through chemical liquid treatment, to thereby produce even a large quartz glass jig having an irregular finished surface on a surface thereof, the irregular finished surface having excellent uniformity without conspicuous unevenness, and the quartz glass jig.

Means for solving the Problems

[0015]

According to the present invention, there is provided a method of producing a quartz glass jig in which irregularities are formed on a surface through chemical liquid treatment, the method including: an adhering substance removal step of removing an adhering substance on a smooth quartz glass surface; and a finished surface-forming chemical liquid treatment step of subjecting the quartz glass surface from which the adhering substance has been removed to the chemical liquid treatment to form irregularities thereon, to thereby form an irregular finished surface. A standard deviation of surface roughnesses Ra of the irregular finished surface measured at 10 or more points is 1.00 μm or less.

[0016]

A glossiness of the irregular finished surface measured with a 60° glossmeter is suitably less than 2. In addition, an average value and a standard deviation of visible light transmittances of the irregular finished surface measured at 10 or more points with a tintometer are suitably 30% or less and 1% or less, respectively.

A coefficient of variation of the surface roughness Ra of the irregular finished surface measured at 10 or more points is suitably 0.60 or less.

[0017]

It is suitable that the adhering substance removal step includes: a HF washing step of removing the adhering substance on the smooth quartz glass surface with a washing liquid containing HF; a first removal step of diluting and removing a HF component remaining on the quartz glass surface with water after the HF washing step; and a second removal step of removing an adhering water content and/or an adhering solvent remaining on the quartz

glass surface after the first removal step.

[0018]

It is suitable that a glass surface layer of the quartz glass surface is etched and removed by 0.10 μm or more in the HF washing step.

[0019]

It is suitable that the second removal step be a drying step of drying the quartz glass surface under an atmosphere at a humidity of less than 60% and under a clean environment.

[0020]

It is preferred that the chemical liquid treatment be performed with a treatment liquid containing HF, NH_4F, and acetic acid.

[0021]

According to the present invention, there is provided a quartz glass jig, including a chemical liquid treatment portion in which irregularities are formed in an area of at least 20 cm^2 or more of a quartz glass surface. The chemical liquid treatment portion is an irregular finished surface on which irregularities are formed. A standard deviation of surface roughness Ra of the irregular finished surface measured at 10 or more points is 1.00 μm or less.

[0022]

A glossiness of the irregular finished surface measured with a 60° glossmeter is suitably less than 2. In addition, an average value and a standard deviation of visible light transmittances of the irregular finished surface measured at 10 or more points with a tintometer are suitably 30% or less and 1% or less, respectively.

A coefficient of variation of the surface roughnesses Ra of the irregular finished surface measured at 10 or more points is suitably 0.60 or less.

[0023]

The quartz glass jig according to the present invention can be produced by the method of producing a quartz glass jig according to the present invention.

Advantageous Effects of the Invention

[0024]

The present invention has a prominent effect of being capable of providing a method of producing a quartz glass jig including forming irregularities without microcracks through chemical liquid treatment, to thereby produce even a large quartz glass jig having an irregular finished surface, the irregular finished surface having excellent uniformity without conspicuous unevenness, and the quartz glass jig. That is, according to the present invention, the method of producing a quartz glass jig having a good appearance capable of producing even a large quartz glass jig in which non-uniformity of the formation of irregularities, which leads to unevenness generated through irregular finish based on chemical liquid treatment, is reduced, and the quartz glass jig can be provided.

In addition, the following effect is also obtained: when variations in surface roughness of the quartz glass jig are reduced, even a large quartz glass jig achieves a uniformized surface cloudiness state, and can be prevented from film peeling in a non-uniformly cloudy portion.

Further, when the quartz glass jig is used in a semiconductor manufacturing apparatus, the resolution of non-uniform cloudiness has a suppressing effect on a temperature distribution in association with alleviation of variations in transmission of a heat ray from a heater, and also has a contributing effect on uniformity of wafer treatment in a semiconductor manufacturing process.

Brief Description of the Drawings

[0025]

FIG. 1 is an electron micrograph of a surface of a quartz glass jig produced in Example 1.

FIG. 2 is an electron micrograph of a densely cloudy portion of a surface of a quartz glass jig produced in Comparative Example 1.

FIG. 3 is an electron micrograph of a lightly cloudy and transparent portion of the surface of the quartz glass jig produced in Comparative Example 1.

FIG. 4a is a schematic explanatory view of measurement points in a method of measuring the surface roughness Ra of the quartz glass jig of Example 1 when seen from a side surface of the quartz glass jig.

FIG. 4b is a schematic explanatory view of the measurement points in the method of measuring the surface roughness Ra of the quartz glass jig of Example 1 when seen from an upper end side of the quartz glass jig.

FIG. 5 is a photograph of the appearance of the quartz glass jig produced in Example 1.

FIGS. 6 are each a photograph of the appearance of a quartz glass jig

produced by performing chemical liquid treatment four times.

FIG. 7 is a photograph of the appearance of an upper surface of the quartz glass jig obtained in Comparative Example 1.

FIGS. 8 are each a photograph of the appearance of a side surface of the quartz glass jig obtained in Comparative Example 1. FIG. 8(a) is a photograph of the side surface as a whole, and FIG. 8(b) is a main portion enlarged photograph of FIG. 8(a).

FIG. 9 is a photograph of the appearance of a lower surface of the quartz glass jig obtained in Comparative Example 1.

FIGS. 10 are each a photograph of a quartz glass jig obtained in Comparative Example 2, and FIG. 10(a) and FIG. 10(b) are a main portion enlarged photograph of a side surface and a main portion enlarged photograph of a lower surface, respectively.

FIGS. 11 are each a photograph of a quartz glass jig obtained in Comparative Example 3, and FIG. 11(a) and FIG. 11(b) are a main portion enlarged photograph of an upper surface and a main portion enlarged photograph of a lower surface, respectively.

Mode for carrying out the Invention

[0026]

Embodiments of the present invention are described below, but those embodiments are described as examples, and hence needless to say, various modifications may be made thereto without departing from the technical spirit of the present invention.

[0027]

According to the present invention, there is provided a method of producing a quartz glass jig in which irregularities are formed on a surface through chemical liquid treatment, the method including: an adhering substance removal step of removing an adhering substance on a smooth quartz glass surface; and a finished surface-forming chemical liquid treatment step of subjecting the quartz glass surface from which the adhering substance has been removed to the chemical liquid treatment to form irregularities thereon, to thereby form an irregular finished surface. A standard deviation of surface roughnesses Ra of the irregular finished surface measured at 10 or more points is 1.00 μm or less.

[0028]

The "smooth quartz glass surface" refers to a quartz glass surface on which no irregularities are formed through physical or chemical surface treatment.

[0029]

A quartz glass jig obtained by the method of the present invention has an irregular finished surface having excellent uniformity, and in the present invention, the surface roughness Ra is calculated based on JIS B 0601:2001. Further, a coefficient of variation of the surface roughnesses Ra of the irregular finished surface measured at 10 or more points is suitably 0.60 or less. The surface roughness Ra of the irregular finished surface is suitably measured at 10 or more points and 50 or less points. It is required that the number of measurement points for the surface roughness Ra be at least 10, but it is suitable that the number of measurement points be adjusted to be increased or reduced depending on the size or surface area of the quartz glass

jig so that the surface of the quartz glass jig can be subjected to the measurement in an unbiased manner.

As described above, with regard to judgment on whether the quartz glass jig is uniformly or non-uniformly cloudy (i.e., whether the formation of irregularities is performed uniformly or non-uniformly), it is preferred that a standard deviation of the surface roughnesses Ra of the irregular finished surface on which irregularities are formed measured at 10 or more points be 1.00 μm or less, and a coefficient of variation of the surface roughnesses Ra of the surface measured at 10 or more points be 0.60 or less.

[0030]

When the uniformity of the irregular finished surface is increased, a quartz glass jig having a uniformly cloudy and uniformly transparent surface can be provided.

The degree of cloudiness or transparency of the irregular finished surface is not particularly limited, but a uniformly cloudy and semi-transparent surface is suitable, and it is particularly suitable that the glossiness of the irregular finished surface measured with a 60° glossmeter be less than 2. In the present invention, the measurement of the glossiness may be performed by measuring 60-degree specular gloss with a known glossmeter based on JIS Z 8741-1997 Specular glossiness–Methods of measurement. An average value of the glossinesses of the irregular finished surface measured at 10 or more points is suitably less than 2, more suitably 1 or less. Further, the maximum value of the glossiness of the irregular finished surface measured with a 60° glossmeter is preferably less than 2, more preferably 1 or less.

In addition, an average value of the visible light transmittances of the irregular finished surface measured at 10 or more points with a tintometer is suitably 30% or less. In addition, a standard deviation of the visible light transmittances is suitably 1% or less, more suitably 0.5% or less. In the present invention, the measurement of the visible light transmittance is performed by measuring each of samples cut out of the quartz glass jig at 10 or more points for a visible light transmittance with a known tintometer (visible light transmittance measuring instrument). Each of the measurement samples suitably has a thickness of from 1 mm to 18 mm.

The measurement points for the glossiness and the visible light transmittance are suitably selected in conformity with the measurement points for the surface roughness Ra.

[0031]

The formation of irregularities through chemical liquid treatment is said to be as follows: a chemical liquid component and quartz glass react with each other, and part of a reaction product precipitates as a $(NH_4)_2SiF_4$ microcrystal on the quartz glass surface; a portion in which the microcrystal precipitates and a portion in which no microcrystal precipitates differ from each other in etching progression; and thus the surface is eroded non-uniformly, to thereby form irregularities. That is, the irregularities are basically generated when a treatment surface is eroded with a chemical liquid.

[0032]

Examples of the adhering substance on the quartz glass surface include an adhering oil content such as oil and fat adhering through touch with a finger, an adhering water content such as adhering water, and dust or

lint.

[0033]

It is preferred that the adhering substance removal step include: a HF washing step of removing the adhering substance on the smooth quartz glass surface with a washing liquid containing HF; a first removal step of diluting and removing a HF component remaining on the quartz glass surface with water; and a second removal step of removing an adhering water content and/or an adhering solvent remaining on the quartz glass surface. As described above, the adhering substance (adhering water content or oil content) on the surface of the quartz glass jig is removed with the washing liquid containing HF, and after the removal through the HF washing, the surface is sufficiently washed with water and dried. For example, a clean dryer or a room in which an atmosphere cleanliness is controlled is used for the drying, and a drying step under a clean environment in which a cleanliness is controlled is suitable. After that, surface treatment is immediately performed. The phrase "surface treatment is immediately performed" means that the surface treatment is immediately performed without storage such as temporal placement in an atmosphere without cleanliness control. Thus, an irregular finished surface having excellent uniformity is formed on the surface of the quartz glass jig, and also the cloudiness of the surface of the quartz glass jig generated through surface roughening is uniformized.

[0034]

The water to be used in the first removal step also includes pure water. When the HF component remains owing to insufficient water washing, the

HF component becomes an adhering substance, which leads to non-uniformity of the formation of irregularities, at the time of immersion of quartz glass in a surface treatment liquid. Accordingly, it is preferred that washing through water washing be performed sufficiently. The water to be used for the water washing is preferably pure water, more preferably pure water having a specific resistance value of 15 MΩ or more, still more preferably ultrapure water (having a specific resistance value of from 17.5 MΩ to 18.2 MΩ).

[0035]

It is suitable that the HF washing step include etching and removing a glass surface layer of the quartz glass surface by 0.10 μm or more. In addition, it is more suitable that the glass surface layer of the quartz glass surface be etched and removed by 0.10 μm or more and 30.0 μm or less.

The washing liquid containing HF is suitably an aqueous solution having a concentration of HF of from 2 mass% to 25 mass%. A treatment time period of the HF washing is not particularly limited, but is suitably appropriately selected so that the glass surface layer of the quartz glass surface may be etched and removed by the above-mentioned suitable amount.

[0036]

It is suitable that the second removal step be a drying step of drying the quartz glass surface under an atmosphere at a humidity of less than 60% and under a clean environment. As described above, the drying step is preferably performed under an atmosphere at a humidity of less than 60%.

The clean environment is preferably an environment having a cleanliness based on ISO 14644-1 of Class 7 (Class 10,000 under the United

States Federal Standard) or less, more preferably an environment of ISO Class 6 (Class 1,000 under the United States Federal Standard) or less. The drying step under the clean environment may be performed in a cleanroom in which a cleanliness is controlled, or may be performed with a clean dryer. As used herein, the "clean drying" refers to drying under a clean environment in which a cleanliness is controlled, and the "normal drying" refers to drying under an atmosphere without cleanliness control.

[0037]

A suitable drying mode is a mode under an environment at a room temperature of 20°C or more and a humidity of less than 60%, which may be performed with a dryer or in a room in which an atmosphere cleanliness is controlled. A method involving directly drying quartz glass with an IR lamp or hot air may also be applied in order to shorten a drying time period.

[0038]

As described above, in the method of producing a quartz glass jig of the present invention, the following operations may be performed in order to completely remove a water content on the quartz glass surface: HF washing with a washing liquid containing HF is performed; water washing is performed; and then a solvent (acetone, an alcohol, or the like) is used, followed by drying, so that a residual water content on the surface may be removed and dried, and thereafter, immersion in a surface treatment liquid is performed. When the solvent (acetone, an alcohol, or the like) is used, a method involving wiping the surface with a cloth based on a lint free cloth or applying the solvent through spraying may be adopted.

[0039]

The oil content described above, which is the adhering substance, refers not only to an oil content adhering to the glass surface but also to an oil content adhering when the glass surface is touched with a finger. The oil content is preferably removed as follows: the washing liquid containing HF is used; the surface is then sufficiently washed with water; removal with a solvent (acetone, an alcohol, or the like) is performed; and drying or irradiation with light from a UV lamp is performed, and thereafter, immersion in a surface treatment liquid is performed.

[0040]

While the water content and the oil content each serving as the adhering substance have been described, another example of the adhering substance is an organic substance (e.g., a hydrocarbon compound). Even such organic substance is simultaneously removed through the above-mentioned steps.

[0041]

Any treatment liquid that has hitherto been used may be used as a treatment liquid to be used for the chemical liquid treatment. Specifically, a surface treatment liquid (chemical liquid) containing hydrogen fluoride (HF) and ammonium fluoride (NH_4F) may be suitably used. In particular, an aqueous solution containing 10 mass% to 50 mass% of hydrogen fluoride, 6 mass% to 30 mass% of ammonium fluoride, and 30 mass% to 60 mass% of an organic acid is suitably used. The organic acid is not particularly limited, but for example, is preferably acetic acid, formic acid, or propionic acid. In addition, a liquid temperature at the time of use of the surface treatment liquid is suitably from 15°C to 25°C. In particular, it is suitable that the

surface treatment be performed with a treatment liquid containing HF, NH_4F, and acetic acid.

After the chemical liquid treatment, a component of the treatment liquid remaining on the quartz glass surface is suitably washed with water or a solvent, followed by drying.

[0042]

The chemical liquid treatment may be performed once, but it is more suitable that the irregular finished surface be formed by performing an irregularity-forming step through the chemical liquid treatment a plurality of times. When the chemical liquid treatment is performed a plurality of times, the method of the present invention suitably includes a step of washing a component of the treatment liquid remaining on the quartz glass surface with water or a solvent, followed by drying, between the respective chemical liquid treatment steps. The drying before the chemical liquid treatment step is preferably clean drying under a clean environment. In addition, after the drying, the next chemical liquid treatment is suitably immediately performed.

According to the present invention, the method of producing a quartz glass jig capable of suppressing the generation of non-uniform irregularities (unevenness), capable of reducing the unevenness, capable of reducing the number of times of treatment for eliminating the unevenness, and capable of achieving a quartz glass jig having excellent uniformity and less unevenness even when the chemical liquid treatment is performed a few times, such as once or twice, can be provided, and the quartz glass jig can also be provided. In the case where the smooth quartz glass surface is subjected to the adhering substance removal step and the chemical liquid treatment step, even when

the chemical liquid treatment is performed once, a quartz glass jig in which non-uniformity of the formation of irregularities, which leads to unevenness generated through irregular finish based on chemical liquid treatment, is reduced, and which has a good appearance can be provided. Thus, even when the second chemical liquid treatment is performed, the second chemical liquid treatment becomes more effective.

[0043]

According to the present invention, there is provided a quartz glass jig, including a chemical liquid treatment portion in which irregularities are formed in an area of at least 20 cm^2 or more of a quartz glass surface. The chemical liquid treatment portion is an irregular finished surface on which irregularities are formed. A standard deviation of surface roughnesses Ra of the irregular finished surface measured at 10 or more points is 1.00 μm or less.

[0044]

Further, a coefficient of variation of the surface roughnesses Ra of the irregular finished surface measured at 10 or more points is suitably 0.60 or less. As described above, with regard to judgment on whether the quartz glass jig is uniformly or non-uniformly cloudy (i.e., whether the formation of irregularities is performed uniformly or non-uniformly), it is preferred that a standard deviation of the surface roughnesses Ra of the irregular finished surface on which irregularities are formed measured at 10 or more points be 1.00 μm or less, and a coefficient of variation of the surface roughnesses Ra of the surface measured at 10 or more points be 0.60 or less.

[0045]

In addition, the irregular finished surface is suitably a uniformly cloudy and semi-transparent surface.

The degree of cloudiness or transparency of the irregular finished surface is not particularly limited, but it is suitable that the glossiness of the irregular finished surface measured with a 60° glossmeter be suitably less than 2. In particular, an average value of the glossinesses of the irregular finished surface measured at 10 or more points is more suitably less than 2, still more suitably 1 or less. Further, the maximum value of the glossiness of the irregular finished surface measured with a 60° glossmeter is preferably less than 2, more preferably 1 or less.

In addition, an average value of the visible light transmittances of the irregular finished surface measured at 10 or more points with a tintometer is suitably 30% or less. In addition, a standard deviation of the visible light transmittances is suitably 1% or less, more suitably 0.5% or less.

[0046]

For producing the quartz glass jig of the present invention, the method of producing a quartz glass jig of the present invention described above is suitably used.

[0047]

In addition, it is suitable that irregular finish unevenness within the range of 200 mm^2 or more be absent in the chemical liquid treatment portion. Examples of the irregular finish unevenness include unevenness of various forms, such as a mottled one, a portion having high transparency (low cloudiness), a striped one based on many streaky patterns, and an aggregate of fine spots. In particular, an example thereof is directional local

unevenness, such as unevenness like a brush pattern or a fingerprint mark.

Examples

[0048]

Now, the present invention is more specifically described by way of Examples. It goes without saying that Examples are given for illustrative purposes and should not be interpreted as limiting the present invention.

[0049]

(Example 1)

A quartz glass jig (quartz glass core tube for Si wafer treatment for semiconductor industry, area: 6,000 cm^2) having a smooth and transparent quartz glass surface (fire finished surface with a burner or a mirror polished surface) not having been subjected to surface treatment was prepared. The quartz glass surface of the quartz glass jig was subjected to HF washing with a 5 mass% HF aqueous solution for 15 minutes so that a glass surface layer of the quartz glass surface was etched and removed (corresponding to an etching amount of 0.45 μm), followed by rinsing with pure water for 5 minutes. After that, the quartz glass jig was subjected to clean drying by being held in a clean dryer (Class 1,000) at 30°C and a humidity of from 40% to 50% for 3 hours or more.

[0050]

Subsequently, a first chemical liquid treatment step was started within 30 minutes after the clean drying, and a chemical liquid treatment step of immersing the quartz glass surface of the quartz glass jig in a surface treatment liquid for 90 minutes was performed. An aqueous solution

containing 15 mass% of HF, 15 mass% of NH_4F, and 35 mass% of acetic acid was used as the surface treatment liquid to be used for the chemical liquid treatment. After the chemical liquid treatment, the quartz glass jig was rinsed with pure water, and was then subjected to similar clean drying with the clean dryer.

Subsequently, a second chemical liquid treatment step was started within 30 minutes after the clean drying. Chemical liquid treatment with the surface treatment liquid, rinsing with pure water, and clean drying were performed by the same methods as those in the first chemical liquid treatment step. Thus, a quartz glass jig having an irregular surface having been subjected to chemical liquid treatment was obtained.

[0051]

The resultant quartz glass jig had a cloudy and semi-transparent surface, and a large distribution in the density of cloudiness was not visually observed. In addition, irregular finish unevenness within the range of 200 mm^2 or more was not present on the surface. FIG. 1 is an electron micrograph of the surface of the quartz glass jig obtained in Example 1. The scale shown in the lower right of the photograph of FIG. 1 represents 100 μm. FIG. 5 is a photograph of the quartz glass jig obtained in Example 1.

[0052]

In addition, the area of a non-uniformly cloudy portion of the surface of the resultant quartz glass jig was measured. A method of measuring the area of the non-uniformly cloudy portion was as follows: a portion having a different shade of cloudiness was visually extracted through use of a black board as a background; the area of the portion was determined from vertical

and horizontal dimensions thereof by a rough estimate; and the ratio thereof with respect to the total surface area was measured. When a plurality of portions each having a different shade of cloudiness were present, the areas of all the portions were measured in combined total. The results are shown in Table 1. In Table 1, the examination criteria for the area of the non-uniformly cloudy portion were as follows: a case in which the ratio of the area of the non-uniformly cloudy portion with respect to the total surface area of the quartz glass jig was 25% or less was judged as a good product, and a case in which the ratio was more than 25% was judged as a poor product. As shown in Table 1, the area of the non-uniformly cloudy portion of the quartz glass jig obtained in Example 1 was 10%.

[0053]

In addition, the surface roughness Ra of the resultant quartz glass jig was measured at 18 Ra measurement points with a surface roughness meter (portable surface roughness measurement instrument "Surftest SJ-310" manufactured by Mitutoyo Corporation). FIG. 4a and FIG. 4b are each a schematic explanatory view in which the Ra measurement points in a method of measuring the surface roughness Ra of the quartz glass jig of Example 1 are indicated by the arrows. FIG. 4a is a view when the measurement points are seen from a side surface of the quartz glass jig (quartz glass core tube for Si wafer treatment), and FIG. 4b is a view when the measurement points are seen from an upper end side of the quartz glass jig (quartz glass core tube for Si wafer treatment). In each of FIG. 4a and FIG. 4b, the quartz glass core tube serving as the quartz glass jig is denoted by reference numeral 10, a body portion of the quartz glass core tube is denoted by reference numeral 12, and

a flange portion of the quartz glass core tube is denoted by reference numeral 14.

[0054]

As illustrated in FIG. 4a, the surface roughness Ra was measured at upper, middle, and lower points (the arrows O, P, Q, R, S, and T) on the inner and outer surfaces of a body portion 12 of a quartz glass jig 10. As illustrated in FIG. 4b, the surface roughness Ra was measured (at 18 points) as follows: the body portion 12 of the quartz glass jig 10 was equally divided at three points in a circumferential direction (120°); and further, the surface roughness Ra was measured at each of upper, middle, and lower points (the arrows O, P, Q, R, S, and T) on the inner and outer surfaces of the body portion 12. In FIG. 4b, the body portion 12 of the quartz glass jig 10 is equally divided at three points in a circumferential direction (120°), and upper measurement points (the arrows O1, O2, and O3, and R1, R2, and R3) on the inner and outer surfaces thereof are illustrated.

[0055]

According to FIG. 4a and FIG. 4b in each of which the measurement points for the surface roughness are simply illustrated, when the flange portion 14 of the quartz glass core tube 10 serving as the quartz glass jig was excluded, and a length from an upper end to a lower end of a cylindrical portion thereof in a side plane was regarded as a total height, the upper, middle, and lower measurement points were set to an upper measurement point closer to the center by 20% (10% to 30%) of the total height from the upper end, a middle measurement point at the center of the total height (within ±15% of the center), and a lower measurement point closer to the

center by 20% (10% to 30%) of the total height from the lower end, respectively. The results of the average value, the coefficient of variation, and the like of the surface roughnesses Ra are shown in Table 1.

[0056]

In addition, the glossiness of the resultant quartz glass jig was measured at 18 points with a 60° glossmeter, that is, with a glossmeter (Gloss Checker IG-330 manufactured by HORIBA, Ltd.). The measurement points are in conformity with the measurement points for the surface roughness. The average value and the like of the glossinesses are shown in Table 2.

In addition, samples were cut out of the resultant quartz glass jig at 10 points, and a visible light transmittance was measured for each of the samples (at 10 points) with a tintometer (MJ-TM110 manufactured by Sato Shouji Inc.). The 10 points at which the samples were cut out were set as follows: as illustrated in FIG. 4a, upper, middle, and lower points (the arrows O, P, and Q) of the body portion 12 of the quartz glass jig 10 were adopted; and as illustrated in FIG. 4b, the body portion 12 of the quartz glass jig 10 was equally divided at three points in a circumferential direction (120°), and further, upper, middle, and lower points (the arrows O, P, and Q) of the body portion 12, and a top portion (the arrow U, at an opposite position to the flange portion denoted by reference numeral 14) of the quartz glass jig were adopted. The average value, the standard deviation, and the like of the visible light transmittances measured with a tintometer are shown in Table 2.

[0057]

Table 1

	Adhering substance removal step			Chemical liquid treatment step number of times	Area of unevenness (visual observation)		Surface roughness Ra (μm)				
	HF washing step	First removal step	Second removal step				Max	Min	Average	Standard deviation	Coefficient of variation
Example 1	5% HF 15 minutes	Pure water washing	Clean dryer Class 1,000	Twice	10%	Good	3.23	1.47	2.09	0.50	0.24
Example 2	5% HF 15 minutes	Pure water washing + ethanol wiping	Clean dryer Class 1,000	Twice	5%	Good	1.85	0.37	1.34	0.46	0.34
Example 3	5% HF 15 minutes	Pure water washing	Cleanroom + IR lamp + hot air dryer Class 10,000	Twice	20%	Good	2.48	0.43	1.39	0.73	0.53
Example 4	5% HF 15 minutes	Pure water washing	Cleanroom + IR lamp + hot air dryer Class 10,000	Once	20%	Good	3.63	0.88	1.70	0.92	0.54
Comparative Example 1	None	None	None	Twice	30%	Poor	4.58	0.47	2.00	1.31	0.65
Comparative Example 2	5% HF 1 minute	Pure water washing	Clean dryer Class 1,000	Twice	35%	Poor	3.41	0.38	1.87	1.15	0.61
Comparative Example 3	5% HF 15 minutes	Pure water washing	Normal drying	Twice	30%	Poor	3.33	0.39	1.35	1.02	0.76
Comparative Example 4	None	Pure water washing	Without drying	Twice	30%	Poor	4.91	0.49	1.92	1.48	0.77

[0058]

Table 2

	Glossiness (60° glossmeter)			Tintometer (%)			
	Max	Min	Average	Max	Min	Average	Standard deviation
Example 1	1	1	1.0	12.0	10.9	11.5	0.4
Example 2	1	1	1.0	11.7	11.0	11.3	0.3
Example 3	1	1	1.0	11.9	11.1	11.4	0.3
Example 4	1	1	1.0	24.9	24.0	24.4	0.4
Comparative Example 1	6	5	5.8	62.4	50.8	54.1	4.7
Comparative Example 2	5	4	4.4	44.0	40.6	41.6	1.4
Comparative Example 3	4	2	2.6	35.4	26.6	30.0	3.3
Comparative Example 4	23	6	15.0	62.3	49.0	54.4	5.8

[0059]

(Example 2)

A quartz glass jig having a smooth and transparent surface not having been subjected to surface treatment was prepared in the same manner as in Example 1. The quartz glass surface of the quartz glass jig was subjected to HF washing and rinsed with pure water in the same manner as in Example 1. After that, the quartz glass jig was wiped with a lint-free cloth impregnated with ethanol, and was subjected to clean drying in the same manner as in Example 1.

Subsequently, a first chemical liquid treatment step was started within 30 minutes after the clean drying. The surface of the quartz glass jig was subjected to chemical liquid treatment with the same treatment liquid under the same treatment conditions as those in Example 1. After the chemical liquid treatment, the quartz glass jig was rinsed with pure water.

Moreover, the quartz glass jig was subjected to clean drying in a clean dryer (Class 1,000) at 30°C and a humidity of from 50% to 60% for 3 hours or more.

Subsequently, a second chemical liquid treatment step was started within 30 minutes after the clean drying. Chemical liquid treatment, rinsing with pure water, and clean drying were performed by the same methods as those in the first chemical liquid treatment step. Thus, a quartz glass jig having an irregular surface having been subjected to chemical liquid treatment was obtained.

[0060]

The resultant quartz glass jig was subjected to measurements by the same measurement methods as those in Example 1. The results are shown in Table 1 and Table 2. The quartz glass jig had a cloudy and semi-transparent surface, and a large distribution in the density of cloudiness was not visually observed. In addition, irregular finish unevenness within the range of 200 mm^2 or more was not present on the surface. The average value, the coefficient of variation, and the like of the surface roughnesses Ra, the glossinesses, and the visible light transmittances measured with a tintometer were as shown in Table 1 and Table 2. In addition, the area of a non-uniformly cloudy portion in this case was 5%.

[0061]

(Example 3)

A quartz glass jig having a smooth and transparent quartz glass surface not having been subjected to surface treatment was prepared in the same manner as in Example 1. The quartz glass surface of the quartz glass jig was subjected to HF washing and rinsed with pure water in the same

manner as in Example 1. The quartz glass jig was subjected to clean drying in a space in which a cleanliness was controlled (cleanroom of Class 10,000) with an IR lamp and a hot air dryer (blowing temperature: 80°C) for 2 hours or more.

Subsequently, a first chemical liquid treatment step was started within 30 minutes after the clean drying. The surface of the quartz glass jig was subjected to chemical liquid treatment with the same treatment liquid under the same treatment conditions as those in Example 1. After the chemical liquid treatment, the quartz glass jig was rinsed with pure water, and was then subjected to clean drying in a space in which a cleanliness was controlled (cleanroom of Class 10,000) by the same method as that in the clean drying after the HF washing.

Subsequently, a second chemical liquid treatment step was started within 30 minutes after the clean drying. Chemical liquid treatment, rinsing with pure water, and clean drying were performed by the same methods as those in the first chemical liquid treatment step. Thus, a quartz glass jig having an irregular surface having been subjected to chemical liquid treatment was obtained.

[0062]

The resultant quartz glass jig was subjected to measurements by the same measurement methods as those in Example 1. The results are shown in Table 1 and Table 2. The quartz glass jig had a cloudy and semi-transparent surface, and a large distribution in the density of cloudiness was not visually observed. In addition, irregular finish unevenness within the range of 200 mm^2 or more was not present on the surface. The average value,

the coefficient of variation, and the like of the surface roughnesses Ra, the glossinesses, and the visible light transmittances measured with a tintometer were as shown in Table 1 and Table 2. In addition, the area of a non-uniformly cloudy portion in this case was 20%.

[0063]

(Example 4)

A quartz glass jig having a smooth and transparent quartz glass surface not having been subjected to surface treatment was prepared in the same manner as in Example 1. The quartz glass surface of the quartz glass jig was subjected to HF washing and rinsed with pure water in the same manner as in Example 1. The quartz glass jig was subjected to clean drying in a space in which a cleanliness was controlled (cleanroom of Class 10,000) with an IR lamp and a hot air dryer (blowing temperature: 80°C) for 2 hours or more.

Subsequently, a chemical liquid treatment step was started within 30 minutes after the clean drying. The same chemical liquid treatment with the same treatment liquid as that in Example 1 was performed. After the chemical liquid treatment, the quartz glass jig was rinsed with pure water, and was subjected to the same clean drying as the clean drying after the HF washing. Thus, a quartz glass jig having an irregular surface having been subjected to chemical liquid treatment was obtained.

[0064]

The resultant quartz glass jig was subjected to measurements by the same measurement methods as those in Example 1. The results are shown in Table 1 and Table 2. The quartz glass jig had a cloudy and semi-

transparent surface, and a large distribution in the density of cloudiness was not visually observed. In addition, irregular finish unevenness within the range of 200 mm^2 or more was not present on the surface. The average value, the coefficient of variation, and the like of the surface roughnesses Ra, the glossinesses, and the visible light transmittances measured with a tintometer were as shown in Table 1 and Table 2. In addition, the area of a non-uniformly cloudy portion in this case was 20%.

[0065]

As is apparent from Table 1 and Table 2, in each of Examples 1 to 4, the surface of the quartz glass jig became a uniformly cloudy and uniformly semi-transparent surface, and also became a uniform irregular finished surface in which irregularities were continuously formed.

Even when having a large size, the quartz glass jig had an irregular finished surface on a surface thereof, the irregular finished surface having excellent uniformity without conspicuous unevenness. Moreover, the quartz glass jig of each of Examples 1 to 4 is a good product having a ratio of the area of the non-uniformly cloudy portion with respect to the total surface area of the quartz glass jig of 25% or less, and can achieve such surface roughness that a standard deviation thereof is 1 or less and a coefficient of variation thereof is 0.6 or less.

[0066]

Further, while the irregular finished surface was formed by repeating the irregularity-forming step through the chemical liquid treatment twice in Example 1, the photograph of a quartz glass jig obtained by further repeating the irregularity-forming step through the chemical liquid treatment to

perform the irregularity-forming step through the chemical liquid treatment a total of four times is shown in FIGS. 6. As shown in FIGS. 6, the surface of the quartz glass jig was cloudy and semi-transparent, and the quartz glass jig had an irregular finished surface on a surface thereof, the irregular finished surface having more excellent uniformity without visually conspicuous unevenness than that of the quartz glass jig of FIG. 5.

[0067]

(Comparative Example 1)

A quartz glass jig having a smooth and transparent quartz glass surface not having been subjected to surface treatment was prepared in the same manner as in Example 1. The quartz glass surface of the quartz glass jig was subjected to the same chemical liquid treatment as that in Example 1 without having being subjected to the adhering substance removal step (5 mass% HF washing, pure water washing, and drying steps). After the chemical liquid treatment, the quartz glass jig was rinsed with pure water in the same manner as in Example 1, and was then subjected to normal drying.

Subsequently, the chemical liquid treatment step was started again, and the chemical liquid treatment was performed under the same concentration conditions. After the chemical liquid treatment, the quartz glass jig was rinsed with pure water, and was subjected to clean drying in the same manner as in Example 1. Thus, a quartz glass jig having an irregular surface was obtained.

[0068]

The resultant quartz glass jig was subjected to measurements by the same measurement methods as those in Example 1. The results are shown

in Table 1 and Table 2. The quartz glass jig was cloudy and semi-transparent, but was non-uniform. A densely cloudy portion and a lightly cloudy and transparent portion were observed. In addition, irregular finish unevenness, which was directional local unevenness, within the range of 200 mm^2 or more was present on the surface. FIG. 2 is an electron micrograph of the densely cloudy portion of the surface of the quartz glass jig obtained in Comparative Example 1. The scale shown in the lower right of the photograph of FIG. 2 represents 100 μm.

When the lightly cloudy and transparent portion was observed, a portion in which no irregularities were formed was found. FIG. 3 is an electron micrograph of the portion in which no irregularities were formed of the surface of the quartz glass jig obtained in Comparative Example 1. The scale shown in the lower right of the photograph of FIG. 3 represents 100 μm.

The average value, the coefficient of variation, and the like of the surface roughnesses Ra, the glossinesses, and the visible light transmittances measured with a tintometer were as shown in Table 1 and Table 2. In addition, the area of a non-uniformly cloudy portion in this case was 30%.

FIG. 7 to FIG. 9 are photographs of the quartz glass jig obtained in Comparative Example 1. A portion corresponding to an upper surface of the quartz glass jig when the quartz glass jig (quartz glass core tube for Si wafer treatment) is subjected to chemical liquid treatment by being laid on its side and immersed in a treatment liquid is shown in FIG. 7, a portion corresponding to a side surface of the quartz glass jig is shown in FIGS. 8, and a portion corresponding to a lower surface of the quartz glass jig is shown in FIG. 9. Moreover, it is found that unevennesses 16, 18, and 20 are present

in FIG. 7, FIGS. 8, and FIG. 9, respectively. In particular, in FIG. 8(b), it is found that the unevenness 18 becomes streaky unevenness, and becomes directional local unevenness.

[0069]

(Comparative Example 2)

A quartz glass jig having a smooth and transparent quartz glass surface not having been subjected to surface treatment was prepared in the same manner as in Example 1. The quartz glass surface of the quartz glass jig was subjected to 5 mass% HF washing for 1 minute (corresponding to an etching amount of 0.03 μm) in the same manner as in Example 1 except for a washing time period, and was rinsed with pure water. The quartz glass jig was subjected to clean drying by being held in a clean dryer (Class 1,000) at 30°C and a humidity of from 50% to 60% for 3 hours or more. In the quartz glass jig after the drying, the adhering substance removal through HF washing was insufficient, and an adhering substance remained on the quartz glass surface.

Subsequently, first chemical liquid treatment was performed within 30 minutes after the clean drying in the same manner as in Example 1. After the chemical liquid treatment, the quartz glass jig was rinsed with pure water and subjected to clean drying in the same manner as in Example 1, and was further subjected to chemical liquid treatment, rinsed with pure water, and subjected to clean drying once again in the same manner as in Example 1. Thus, a quartz glass jig having an irregular surface having been subjected to chemical liquid treatment was obtained.

[0070]

The resultant quartz glass jig was subjected to measurements by the same measurement methods as those in Example 1. The results are shown in Table 1 and Table 2. The quartz glass jig obtained in Comparative Example 2 had a cloudy and semi-transparent surface, but the surface was non-uniform. A densely cloudy portion and a lightly cloudy and transparent portion were observed. In addition, irregular finish unevenness, which was directional local unevenness, within the range of 200 mm^2 or more was present on the surface. When the lightly cloudy and transparent portion was observed, a portion in which no irregularities were formed was found.

The average value, the coefficient of variation, and the like of the surface roughnesses Ra, the glossinesses, and the visible light transmittances measured with a tintometer were as shown in Table 1 and Table 2. In addition, the area of a non-uniformly cloudy portion in this case was 35%. FIGS. 10 are each a photograph of the quartz glass jig obtained in Comparative Example 2. It is found that streaky unevenness 22 serving as directional local unevenness is present in FIG. 10(a), and unevenness 24 serving as an aggregate of small unevenness is present in FIG. 10(b).

[0071]

(Comparative Example 3)

A quartz glass jig having a smooth and transparent quartz glass surface not having been subjected to surface treatment was prepared in the same manner as in Example 1. The quartz glass surface of the quartz glass jig was subjected to 5 mass% HF washing in the same manner as in Example 1, and was then rinsed with pure water and subjected to normal drying.

The quartz glass jig was stored under an environment without

cleanliness control for 24 hours, and was then subjected to chemical liquid treatment in the same manner as in Example 1. After the chemical liquid treatment, the quartz glass jig was rinsed with pure water and subjected to normal drying, and was further subjected to chemical liquid treatment and rinsed with pure water once again, followed by the same clean drying as that in Example 1. Thus, a quartz glass jig having an irregular surface having been subjected to chemical liquid treatment was obtained.

[0072]

The resultant quartz glass jig was subjected to measurements by the same measurement methods as those in Example 1. The results are shown in Table 1 and Table 2. The quartz glass jig had a cloudy and semi-transparent surface, but the surface was non-uniform. A densely cloudy portion and a lightly cloudy and transparent portion were observed. In addition, irregular finish unevenness, which was directional local unevenness, within the range of 200 mm^2 or more was present on the surface. FIGS. 11 are each a photograph of the quartz glass jig obtained in Comparative Example 3. It is found that streaky unevenness 26 serving as directional local unevenness is present in FIG. 11(a), and unevenness 28 having a relatively large area is present in FIG. 11(b).

The average value, the coefficient of variation, and the like of the surface roughnesses Ra, the glossinesses, and the visible light transmittances measured with a tintometer were as shown in Table 1 and Table 2. In addition, the area of a non-uniformly cloudy portion in this case was 30%.

[0073]

(Comparative Example 4)

A quartz jig to be used in a film formation process was immersed in a pure water bath, and was immediately thereafter subjected to chemical liquid treatment in the same manner as in Example 1 without drying.

After the chemical liquid treatment, the quartz glass jig was rinsed with pure water and subjected to normal drying, and was further subjected to chemical liquid treatment and rinsed with pure water once again, followed by the same clean drying as that in Example 1. Thus, a quartz glass jig having an irregular surface having been subjected to chemical liquid treatment was obtained.

[0074]

The resultant quartz glass jig was subjected to measurements by the same measurement methods as those in Example 1. The results are shown in Table 1 and Table 2. The quartz glass jig had a cloudy and semi-transparent surface, but the surface was non-uniform. A densely cloudy portion and a lightly cloudy and transparent portion were observed. In addition, irregular finish unevenness, which was directional local unevenness, within the range of 200 mm^2 or more was present on the surface.

The average value, the coefficient of variation, and the like of the surface roughnesses Ra, the glossinesses, and the visible light transmittances measured with a tintometer were as shown in Table 1 and Table 2. In addition, the area of a non-uniformly cloudy portion in this case was 30%.

[0075]

As is apparent from Table 1 and Table 2, in each of Comparative Examples 1 to 4, the surface of the quartz glass jig is not uniformly clouded, and does not become a uniform irregular finished surface in which

irregularities are continuously formed. Moreover, the quartz glass jig of each of Comparative Examples 1 to 4 is a poor product having a ratio of the area of the non-uniformly cloudy portion with respect to the total surface area of the quartz glass jig of 30% or more, and cannot achieve such surface roughness that a standard deviation thereof is 1 or less and a coefficient of variation thereof is 0.6 or less.

[0076]

The quartz glass jig of the present invention obtained as described above can be used as a material for semiconductor treatment, for optical applications, for physical and chemical appliances, for decoration, and the like. In particular, the quartz glass jig of the present invention is suitable as a quartz glass jig to be used in a semiconductor process for manufacturing a semiconductor.

Reference Signs List

[0077]

10: quartz glass core tube, 12: body portion, 14: flange portion, 16, 18, 20, 22, 24, 26: unevenness, O, P, Q, R, S, T, O1, O2, O3, R1, R2, R3: arrow indicating measurement point of surface roughness Ra, U: arrow indicating measurement point of visible light transmittance.

Claims

1. A method of producing a quartz glass jig in which irregularities are formed on a surface through chemical liquid treatment, the method comprising:

an adhering substance removal step of removing an adhering substance on a smooth quartz glass surface; and

a finished surface-forming chemical liquid treatment step of subjecting the quartz glass surface from which the adhering substance has been removed to the chemical liquid treatment to form irregularities thereon, to thereby form an irregular finished surface,

wherein a standard deviation of surface roughnesses Ra of the irregular finished surface measured at 10 or more points is 1.00 μm or less.

2. The method of producing a quartz glass jig according to claim 1,

wherein a glossiness of the irregular finished surface measured with a 60° glossmeter is less than 2, and

wherein an average value and a standard deviation of visible light transmittances of the irregular finished surface measured at 10 or more points with a tintometer are 30% or less and 1% or less, respectively.

3. The method of producing a quartz glass jig according to claim 1, wherein a coefficient of variation of the surface roughnesses Ra of the irregular finished surface measured at 10 or more points is 0.60 or less.

4. The method of producing a quartz glass jig according to claim 1, wherein the adhering substance removal step comprises:

a HF washing step of removing the adhering substance on the smooth

quartz glass surface with a washing liquid containing HF;

a first removal step of diluting and removing a HF component remaining on the quartz glass surface with water after the HF washing step; and

a second removal step of removing an adhering water content and/or an adhering solvent remaining on the quartz glass surface after the first removal step.

5. The method of producing a quartz glass jig according to claim 4, wherein the HF washing step comprises etching and removing a glass surface layer of the quartz glass surface by 0.10 μm or more.

6. The method of producing a quartz glass jig according to claim 4, wherein the second removal step is a drying step of drying the quartz glass surface under an atmosphere at a humidity of less than 60% and under a clean environment.

7. The method of producing a quartz glass jig according to claim 1, wherein the chemical liquid treatment is performed with a treatment liquid containing HF, NH_4F, and acetic acid.

8. A quartz glass jig, comprising a chemical liquid treatment portion in which irregularities are formed in an area of at least 20 cm^2 or more of a quartz glass surface,

wherein the chemical liquid treatment portion is an irregular finished surface on which irregularities are formed, and

wherein a standard deviation of surface roughnesses Ra of the irregular finished surface measured at 10 or more points is 1.00 μm or less.

9. The quartz glass jig according to claim 8,

wherein a glossiness of the irregular finished surface measured with a 60° glossmeter is less than 2, and

wherein an average value and a standard deviation of visible light transmittances of the irregular finished surface measured at 10 or more points with a tintometer are 30% or less and 1% or less, respectively.

10. The quartz glass jig according to claim 8, wherein a coefficient of variation of the surface roughnesses Ra of the irregular finished surface measured at 10 or more points is 0.60 or less.

11. The quartz glass jig according to any one of claims 8 to 10, wherein the quartz glass jig is produced by the method of producing a quartz glass jig of any one of claims 1 to 7.