

Quartz Glass Component For Use
During Manufacture Of Semi-Conductors

Field of Invention

The invention concerns a quartz glass component for use during manufacture of semi-conductors with a rough surface formed by irregular, raised structural elements extending between a first upper level and a second lower level, a multitude of such structural elements having an essentially plane cover surface running on the first level and being limited on all sides in a facetting way by essentially plane lateral faces extending between the first and the second level.

Prior Art

Substrate coatings applying so-called CVD methods are usually used for the manufacture of semi-conductor elements. Thus, for example, layers of silicon oxide, silicon nitride or silicon are precipitated onto silicon wafers. The coating materials do not only precipitate onto the substrate but also on the walls of the reaction chamber and the equipment arranged in it. From a certain layer thickness on, these layers flake off leading to particle problems. In order to avoid these problems, the respective surfaces are cleaned from time to time.

Cleaning the surfaces is time-consuming and expensive. In order to reduce this expenditure of time and money, time intervals as long as possible are required between the consecutive cleaning phases. Particularly in the case of CVD methods at higher temperatures, the difference between the thermal expansion coefficients of quartz glass and the coating material leads to a flaking off of the layers even at relatively small layer thicknesses.

It is known that roughened surfaces are able to bond thicker CVD layers. Usually sand blasting or chemical etching methods are applied for roughening quartz glass components. By means of the sand blasting method structures are produced on the quartz glass surface that contribute to a firm bonding of the CVD layers. However, the sand blasting method also induces fissures on the component surface which in return lead to a flaking off of the CVD

layers. In addition, the homogeneous treatment of the entire component surface as well as the observance of exact dimensions when carrying out the sand blasting method have proved to be problematic.

As an alternative, the quartz glass component surfaces are roughened by means of chemical etching solutions. By etching the surface often rounded surface structures, e. g. round or oval pits are produced. In contrast to sand blasted surfaces these surface structures show a reduced bonding force for CVD layers.

A component in accordance with the indicated genesis is described in the published Japanese patent application with the application no. JP 6-332956. From this patent application an etching solution for roughening quartz glass surfaces is known by application of which it is possible to produce irregular, raised, essentially sharp-edged structural elements on a component surface of quartz glass. In horizontal projection of a surface treated with the known etching solution, a granular morphology can be seen consisting of an arrangement of structural elements in the form of mesas or truncated pyramids. The structural elements extend between an upper level, for example, the original component surface, and a lower level that is, for example, defined by the maximum etching depth. The average sizes of the structural elements range from 5 mm to 15 mm. Although no microfissures are visible on the quartz glass surface it has proven that a such designed surface is not suitable for firm bonding of thick CVD layers.

It is an object of the present invention to overcome or at least substantially ameliorate at least some of the above problems in the prior art.

Summary of Invention

According to the present invention, there is provided a quartz glass component for use during manufacture of semi-conductors with a rough surface formed by irregular, raised structural elements extending between a first upper level and a second lower level, a multitude of such structural elements having an essentially plane cover surface running on the first level and being limited on all sides in a faceting way by essentially plane lateral faces running between the first and the second level, characterised in that the mean roughness height R_a of the surface is within the range of 0.1 μm to 10 μm , and the size of the projection

of the structural elements onto the first level has a mean value within the range of 30 μm to 180 μm .

The mean roughness height R_a of the surface may lie between 1 μm and 5 μm , and the mean size of the projection of the structural elements onto the first level may lie in the range of 50 μm to 100 μm .

At least one part of the lateral faces may be arranged by forming step elements.

The step elements may present step depths within the range of 0.5 μm to 5 μm .

Between adjacent structural elements a gap may be formed having a width of at least 1 μm .

The gap may be formed by a variety of pits arranged in a row.

The structural elements may have sharp corners or edges.

Drawings

In order that the present invention might be more fully understood, embodiments of the invention will be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 a schematic of a cross-section through the quartz-glass component according to an embodiment of the invention in a view vertical to the surface;

Figure 2 a scanning electron microscopic photograph of a surface of the component according to an embodiment of the invention in 100-fold magnification;

Figure 3 the section marked in Figure 2 in 500-fold magnification;

Embodiments

Referring to the drawings, in Figure 1 the structural elements within the meaning of this embodiment are shown as raised areas 1 in a schematic. The raised areas 1 extend between a first upper level 2 and a second lower level 3. In cross-section the raised areas 1 have the shape of truncated cones. They have a plane cover surface 4 running with the upper level 2. The cover surface 4 is bordered by lateral faces all of which are described by reference number 5 in Figure 1. The lateral faces 5 are partially shaped as smooth bordering areas 6, or they are composed in steps of individual step elements 7. The shapes of the individual step elements 7 vary. The lateral walls 5 of adjoining raised areas 1 do not share a common border, but between any two of them there is a gap 8 with a level base area. The gap 8 separates adjoining raised areas 1.

The dimension for determination of the dimension of raised areas 1 is marked "L" in Figure 1. The mean width of the gap results from dimension "D". For determination of the surface roughness the distance "R" between upper level 2 and lower level 3 is measured in several locations; and, accordingly, the mean value R_a is calculated in correspondence to DIN 4768.

From the scanning electron microscopic photograph according to Figure 2 it is evident that the surface of a quartz glass component according to the embodiment of the invention is determined by a multitude of irregular raised areas 1, which are characterized by sharp corners and edges and which are separated from each other by gaps 8. In the photograph the raised areas 1 can be seen as dark surfaces, the gaps as bright bordering lines. In the embodiment described by way of example the means dimension of raised areas 1 is approximately 100 μm . In the surface represented in Figure 2, the value R_a is approximately 2 μm .

Figure 3 shows an enlargement of the cutout "A" of the photograph. From this enlargement details of the surface microstructure of the quartz glass component according to the embodiment of the invention can be seen, which are described in detail in the following.

In the photograph essentially five irregular raised areas shaped like truncated pyramids are to be seen, which are marked by reference numbers 1a through 1e. The raised area 1a for example has a distinct cover surface 4a in the form of a polygon bordered by the lateral walls 5a, 5b, 5c having downward slopes. The lateral walls 5a, 5b, 5c are in the form of steps. The

step-like shape is also easily discernible in the lateral wall marked 5b. The depths of the individual steps are not uniform in the lateral wall 5d; the mean depth is approximately 1 μm . The height of the individual steps varies, as well.

The individual raised areas 1a through 1e are separated by gaps 8. The gaps 8 have a mean width "D" of roughly 2 μm . In the embodiment described by way of example, their base area is not level but of irregular shape because of a multitude of adjoining small pits with diameters of under 1 μm .

The described microstructure of the component surface offers a multitude of bonding locations to a CVD layer precipitated onto it. This is achieved, on the one hand, by the mean surface roughness described above, which is determined essentially by the heights "R" of the respective raised areas, and, on the other hand, by their lateral dimensions "L". The tightness and distribution of the raised areas is likewise reflected in the value for the mean surface roughness R_a .

On a quartz glass component according to an embodiment of the invention, silicon nitride layers of five to ten times the thickness of those on a component according to the prior art could, for example, be precipitated by means of a CVD method at temperatures of approximately 600° C without any flaking off of layers becoming evident. The service life of a component according to an embodiment of the invention is correspondingly longer.

In the following, a method for manufacture of a component according to an embodiment of the invention is described:

A previously flame polished quartz glass hurdle for the support of silicon semiconductor plates is cleaned in alcohol solution and afterwards in etching solution containing hydrofluoric acid. A clean, homogenous surface contributes to the generation of an even roughness and the small-grained microstructure described above over the whole surface of the component.

An etching solution of the following composition is prepared:

23.6 weight % HF (weighed-in as 50% HF solution)

17.4 weight % ammonium fluoride (weighed-in as solid matter)

35.4 weight % acetic acid (weighed-in as 100% acetic acid; crystallizable acetic acid)
and 23.6 weight % water

The etching solution is left to stabilize for one hour. The stabilization of the etching solution, as well, contributes to the generation of an even roughness and the small-grained microstructure described above over the whole surface of the component.

The hurdle is tempered to approx. 15° C. After that, the quartz glass hurdle is immersed into the etching solution. To achieve an even etching effect and to prevent any deposits on the hurdle surface, immersion is done as quickly as possible.

With an etching solution temperature of 15° C, the period of treatment is 60 minutes. After that, the hurdle is cleaned for 10 minutes in 5 % hydrofluoric acid. Following this etching and cleaning process, the surface has the microstructure shown in Figures 2 and 3 with a mean roughness height R_a of 2 μm .

Hurdle and etching solution can also be tempered at other temperatures, for example, to approx. 20° C. The composition of the etching solution may need adjustment. With higher temperatures, higher diluted etching solutions are favourable.

In summary, embodiments of the present invention is based on the task to provide for a quartz glass component with a rough surface especially well-suited for the bonding of CVD layers.

Based on the above mentioned quartz glass component the task is solved in exemplary embodiments of the invention in that the mean roughness height R_a of the surface is within the range of 0.1 μm to 10 μm , and the size of the projection of the structural elements onto the first level has a mean value within the range of 30 μm to 180 μm .

It has shown that the mean roughness height of the surface and particularly the mean size of the structural elements are decisive factors for bonding of CVD layers. Optimized results can be achieved with a mean roughness height R_a within the range of 0.1 μm to 10 μm . The value for roughness height R_a is determined in accordance with DIN 4768.

It is essential that in addition to the mean roughness height of the surface within the above mentioned range the size of the structural elements in projection onto the first upper level has a mean value within the range of 30 μm to 180 μm . The size of the structural elements is determined by means of horizontal projection. From horizontal projection it can be seen that the structural elements adjoin each other directly and are only separated by means of bordering lines. As the structural elements are raised, the bordering lines can easily be recognised. In this patent application the size of the structural elements is meant to be the longest distance between two opposite bordering lines. For evaluation a part of the component surface of 10 mm^2 is taken into account. The arithmetical mean of the size measured is to be the mean size. Structural elements of a size of less than 5 μm are not considered for determination of the mean size.

A quartz glass component equipped with such a surface microstructure shows excellent bonding of CVD layers, particularly of those CVD layers precipitated during a method at a higher temperature. This reaction can be explained by means of the special type of the surface roughness that contributes to a favourable stress distribution between the quartz glass and the CVD layer material. The micro-structure of the surface leads to a three-dimensional stress distribution. For this, the structural elements have to be composed of essentially plane area elements in a facetting way having a mean size of not more than 180 μm . The result is a density and distribution of the structural elements and the cover and lateral faces forming them which enables an appropriate stress distribution. This result cannot be observed any more with a mean size of structural elements of less than 30 μm .

In embodiments of this invention, it is also implied that a plane cover face can be a vaulted cover face as it develops, for example, after removal by etching on the non-etched areas of the cylinder envelope of a quartz glass component shaped like a tube or rod. When producing the structural elements by means of etching, the upper level can be defined by the surface of non-etched areas or by the surface of the areas where the least material has been removed by etching.

Advantageously, the mean roughness height R_a of the surface is between 1 μm and 5 μm , and the size of the projection of the structural elements onto the first level has a mean value within the range of 50 μm and 100 μm .

A component has proven to be especially suitable in which at least a part of the lateral faces

is arranged by forming step elements. A step element is formed by means of arranging pairs of lateral faces in a row, one lateral face extending in parallel or at a small angle to the cover face, and the adjacent lateral face extending at a larger angle to the cover face. Keeping up a right angle between the adjacent lateral faces is not necessary. A step-like form of the lateral bordering areas of the structural elements is established by arranging numerous step elements in a row. Such a step-like form of lateral bordering faces additionally contributes to stress reduction by means of three-dimensional stress distribution. This effect can already be recognized if such a step-like form and arrangement of the lateral faces is present in some of the structural elements. In this respect it is not necessary for all step elements of one lateral bordering wall to show the same geometrical dimensions. Step elements with a step depth within the range of 0.5 μm to 5 μm show an especially distinct effect with respect to the bonding force of CVD layers.

An embodiment of a quartz glass component is preferred in which on the second level between adjacent structural elements a gap is formed having a width of at least 1 μm . Such gaps formed between the raised areas of adjacent structural elements have proven especially favorable with respect to a firm bonding of CVD layers. Here, the width is meant to be the mean width of the gap along the longitudinal section, as it separates any two adjacent structural elements from each other. The base area of the gap can be of plane or vaulted shape.

An arrangement of pits in a row in a gap has proven advantageous with respect to the bonding of CVD layers. Such pits in a gap can, for example, be generated in an etching solution containing hydrofluoric acid by means of subsequent etching of the quartz glass component structured according to an embodiment of the invention.

A quartz glass component has proven to be especially favorable the structural elements of which have sharp edges or corners. Such edges and corners have, for example, undercuts that serve as a hook for the CVD layer bonding to the component.

The embodiments have been advanced by way of example only, and modifications are possible within the spirit and scope of the invention as defined by the appended claims.



Claims

1. A quartz glass component for use during manufacture of semi-conductors with a rough surface formed by irregular, raised structural elements extending between a first upper level and a second lower level, a multitude of such structural elements having an essentially plane cover surface running on the first level and being limited on all sides in a faceting way by essentially plane lateral faces running between the first and the second level, characterised in that the mean roughness height R_a of the surface is within the range of $0.1\text{ }\mu\text{m}$ to $10\text{ }\mu\text{m}$, and the size of the projection of the structural elements (1) onto the first level (2) has a mean value within the range of $30\text{ }\mu\text{m}$ to $180\text{ }\mu\text{m}$.
2. A quartz glass component according to Claim 1, characterized in that the mean roughness height R_a of the surface lies between $1\text{ }\mu\text{m}$ and $5\text{ }\mu\text{m}$, and the mean size of the projection of the structural elements (1) onto the first level (2) lies in the range of $50\text{ }\mu\text{m}$ to $100\text{ }\mu\text{m}$.
3. A quartz glass component according to Claim 1 or 2, characterized in that at least one part of the lateral faces (5) is arranged by forming step elements (7).
4. A quartz glass component according to Claim 3, characterized in that the step elements (7) present step depths within the range of $0.5\text{ }\mu\text{m}$ to $5\text{ }\mu\text{m}$.
5. A quartz glass component according to any one of the above Claims, characterized in that between adjacent structural elements (1) a gap (8) is formed having a width of at least $1\text{ }\mu\text{m}$.
6. A quartz glass component according to Claim 5, characterized in that the gap (8) is formed by a variety of pits arranged in a row.
7. A quartz glass component according to any one of the above Claims, characterized in that the structural elements (1) have sharp corners or edges.