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DEVICE FOR ETCHING OR PRECIPITATION USING A PLASMA

Field of Invention

The present invention relates to a device for etching and precipitation using a plasma with a reaction chamber. Furthermore, the invention also relates to a shielding element for application in such a device.

Prior Art

Known devices are used for processing semi-conductor wafers for the manufacture of integrated circuits. Their application in a so-called down-stream-etching method is described in the technical book titled "Prozeβtechnologie; Fertigumgsverfahren Für integrierte MOS-Schaltungen" ("Process Technology; Manufacturing Methods for Integrated MOS Circuits") by G. Schumicki and P Seegebrecht, Springer Publishers (1991). With the down-stream-etching method, a gas is fed into a feeding tube which is connected to a reactor chamber in which a semi-conductor wafer to be etched is arranged. By means of a suitable plasma generator, a microwave or HF plasma is generated within the feeding tube, where long-lived reactive particles are generated and led through the feeding tube to the wafer to be etched. The material of the feeding tube walls is chosen such that as many ions as possible recombine on the way of transport. This is why the choice of suitable materials is limited. The reactor chamber and feeding tube often consists of quartz glass. A known plasma etching device is shown schematically in Figure 1 of this patent application.

With the known plasma etching device, the feeding tube is exposed to continuous mechanical and chemical attacks by collisions of reactive ions and free radicals. This leads to erosion of the wall material so that a replacement of the feeding tube is necessary after a certain time. For this, time-consuming and cost-extensive quartz glass blower works are necessary. Often, the whole reaction chamber is replaced, at the same time as replacing the feeding tube. This, too, is time-consuming and cost-extensive exercise. This is especially due to the adjustment and keeping up of a high-vacuum in an atmosphere of high-purity in the reaction chamber which are necessary after the replacement.

By applying a known device for precipitation of SiO_2 -containing material on a substrate arranged in the reactor chamber, a Si-containing gas, for example, a silane or $SiCl_4$ gas is fed into the feeding tube. During this process, a problem of sedimentations on the inner walls of the gas feeding tube 2 can occur which can only be removed with a great expenditure of time and money.

An object of the present invention is to of provide for a simple and low-priced device for etching and precipitation using a plasma that overcomes or substantially ameliorates at least some of the disadvantage discussed in relation to the above prior art.

Summary of Invention

According to the present invention, there is provided a device for etching or precipitation using a plasma, with a reaction chamber for the uptake of a substrate to be treated, comprising a gas inlet nozzle of quartz glass for feeding a gas into the reaction chamber, and a plasma generator for the generation of plasma within the gas inlet nozzle, characterized in that a shielding element is arranged between the inner walls of the inlet nozzle and plasma to be generated.

The shielding element in the inlet nozzle may be mounted exchangeably.

The shielding element may have the form of a sheath.

The shielding element may consist of quartz glass.

The shielding element may consist of synthetic quartz glass.

Preferably, a gap is to be between the shielding element and the inner walls of the inlet nozzle.

The shielding reactor element may project into the reaction chamber.

On the front side of the inlet nozzle facing away from the reaction chamber a sealing element may be arranged onto which the shielding element may be fixed.

According to another aspect of the present invention, there is provided a tube-like shielding element for application in a device mentioned above consisting of synthetic quartz glass the inside surfaces of which have been smoothed during a melting process.

Drawings

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

Figure 1 illustrates a section of a plasma dry etching plant according to known prior art;

Figure 2 illustrates a section of a plasma dry etching plant constructed according to an embodiment of the present invention; and

Figure 3 illustrates a shielding element being mounted exchangeably in the inlet nozzle of the embodiment in Figure 2.

The drawings are provided for the sake of illustration and are not necessarily drawn to scale.

Embodiments

Referring to the drawings, a known plasma dry etching plant is shown in the schematic of Figure 1 which comprises a reactor chamber 1 of quartz glass into which a gas inlet nozzle 2 of quartz glass runs, as well. Reactor chamber 1 and gas inlet nozzle 2 are melted together vacuum-tight. Fluorine-containing caustic gases are fed into the gas inlet nozzle 2 which is surrounded by a high-frequency coil 3. In Figure 1, the flow direction is marked with the direction arrow 4. By means of the coil 3, a plasma 5 is ignited within the gas inlet nozzle 2. The particles generated in the plasma 5 are led through the gas inlet nozzle 2 into the reaction chamber, where they serve for etching a semi-conductor wafer. The semi-conductor wafer as well as the part of the reactor chamber 1 facing away from the gas inlet nozzle 2 do not

facilitate understanding of the embodiment of the invention and are therefore not shown in Figure 1.

In the drawing of an embodiment of the plasma dry etching plant in Figure 2, for the sake of clarity, the same reference numbers as in Figure 1 are used for the designation of components or parts of the dry etching plant if they are to be seen as equal or equivalent. Please refer to the above component descriptions.

Referring to Figure 3, in the dry etching plant, a shielding element in the form of a protecting tube 6 is arranged exchangeably within and coaxially to the gas inlet nozzle 2. The protective tube is arranged between the inner walls of the inlet nozzle 2 and the plasma to be generated. The front side of the gas inlet nozzle 2 is covered by a sealing member 9 made preferably from quartzglass. The sealing member 9 comprises two main parts. The first part is a disk-like element 10 which closes the open end 11 of the protective tube 6 facing away from the reaction chamber 1. The disk-like element 10 is melted tightly so as to be fused to the protective tube 6, as best seen in the cross-hatching portion in Figure 3. The disk-like element 10 is provided with an external screw-thread 12 on its outer cylindrical surface and it is provided with a central bore 16 serving as a gas inlet.

The second part of the sealing member 9 is a screw-ring 13 which engages the screw-thread 12 of the disk-like element 10. By fastening the screw-ring 13, an O-ring 15 is pressed against the outer walls of the gas inlet nozzle 2 and the disk-like element 10.

The free end of the gas inlet nozzle 2 is fixed and engaged by a groove 14 of the disk-like element 2. Another function of the groove 14 is to stabilize the gap between the gas inlet nozzle 2 and the protective tube 6.

By removing the screw-ring 13, the disk-like element 10 as well as the protective tube 6 are removed. Hence, the protective tube 6 is mounted exchangeably in the device.

The protecting tube 6 is made from synthetically manufactured quartz glass. It is manufactured by being drawn out of the melting by means of an ordinary tube-drawing method and, thus, its surface is especially smooth. The protecting tube 6 is approximately 200 mm long and has an inside diameter of approximately 20 mm and a wall thickness of approximately 6 mm. The wall thickness of the gas inlet nozzle 2 is approximately 3 mm. A

gap 8 with a width of approximately 1 mm is maintained between the protecting tube 6 and the inner walls of the gas inlet nozzle 2.

In the embodiment, the protective tube 6 expands over the whole length of the gas inlet nozzle 2 and, moreover, with a small part 7 that projects slightly into the reaction chamber 1, as seen in Figure 1. The front side of the gas inlet nozzle 2 facing away from the reaction chamber 1 is sealed with the sealing member 9 (not shown in figure 2, but illustrated in Figure 3). As mentioned, the protective tube 6 is connected with this sealing with a screw thread, but a bayonet socket may also be used.

The protective tube 6 impedes contact of the plasma 5 generated by the coil 3 with the inner walls of the gas inlet nozzle 2. Thus, erosion of the gas inlet nozzle 2 by the caustic gases and ions of the plasma 5 is avoided. Instead, an erosion of the protective tube 6 takes place, especially in the area of the direct plasma corrosion. Due to the high purity of the protective tube 6, this erosion does not essentially contribute to contamination of the reaction chamber 1.

Moreover, the protective tube 6 shields the area of connection of reactor chamber 1 and gas inlet nozzle 2 from the plasma 5.

As soon as the protective tube 6 is consumed it is exchanged. In the embodiment the exchange takes place by means of easy removal of the lid from the gas inlet nozzle 2, pulling out of the protective tube 6, loosening the bajonet socket and mounting of a new protective tube.

Flushing the gap 8 with a protective gas (argon) impeding a chemical attack of reactive gases or ions onto the inner walls of the gas inlet nozzle 2, additionally contributes to a prolongated service life of the dry etching plant according to the invention.

For application of the device shown in a schematic of Figure 2 for precipitation of SiO_2-containing material on a substrate arranged in the reactor chamber a Si-containing gas, for example, a silane or $SiCl_4$ gas, is fed into the gas inlet nozzle 2 instead of a fluorine - containing caustic gas or in addition to a fluorine-containing gas. With this application of the device according to the invention the protective tube 6 protects the gas inlet nozzle 2 from the chemical attack by particles generated in the plasma 5. Moreover, the protective tube 6

impedes sedimentations on the inner walls of the gas inlet nozzle 2 . Possible sedimentations take place on the inside of the protective tube 6 instead of on the gas inlet nozzle 2. After exchange of the protective tube 2 it can be cleaned and the sedimentations can be removed.

In summary, a shielding element is arranged between the inner walls of the inlet nozzle and the plasma to be generated.

With this shielding element the inner walls of the gas inlet nozzle are protected from the mechanical and chemical attacks by reactive ions and free radicals of the plasma, and erosion of the gas inlet nozzle walls is avoided.

The shielding element consists of a non-conductive material impeding the plasma excitation by the plasma generator and, in addition, the spatial expansion of the plasma as little as possible.

Moreover, with the device according to embodiments of the invention, the shielding element can be selected according to other criteria than an optimum ion yield. For example, it can be optimized with respect to its chemical resistance and mechanical sputtering strength. Thus, a longer service life of the device and/ or feeding tube is achieved.

It is essential that the shielding element covers the inner walls of the gas inlet nozzle at least in the area of the plasma generator at least partially from the plasma. The shielding element can extend in the direction of the reaction chamber, as well.

Particularly advantageous is an embodiment of the device in which the shielding element in the inlet nozzle is mounted exchangebly. With such an embodiment a consumed shielding element can be exchanged easily. The shielding element is only held mechanically in the inlet nozzle. With a purely mechanical mounting device of the shielding element the exchange does not require quartz glass works and therefore, only little time and cost expenditure. Due to the easy exchangeability of this embodiment it is not necessary to design the shielding element with high chemical and mechanical resistance features. So far, the shielding element can be optimized with respect to the desired plasma characteristics.

Moreover, the easy exchangeability of the shielding element allows a larger variability of the device as a whole. Depending on the plasma and flow conditions to be observed in the inlet

nozzle mounting of different shielding elements is possible. Here, the shielding elements can be designed differently with respect to their geometry, arrangement and material. This is why the device according to embodiments of the invention is especially well-suited for experimental purposes.

A shielding element in the form of a sheath guarantees easy exchangeability. Due to its simple geometrical form such a shielding element can be manufactured at low costs.

Preferably, a shielding element of quartz glass is used. During transportation of the particles generated in the plasma in the inlet nozzle as many ions as possible, but as few free radicals as possible are recombined due to collisions with the negatively charged quartz glass wall surfaces. This is particularly the case with a longitudinal shielding element, for example, in the form of a tube. A shielding element of quartz glass has proven especially suitable with respect to a plasma contamination as low as possible. This has positive effects on the process yield.

A device has proven to be successful in which a gap is to be between the shielding element and the inner walls of the inlet nozzle. A gas can be fed into the gap that differs from the plasma gas, for example, a protective gas for the inner walls of the gas inlet nozzle.

Advantageously, the shielding element projects into the reaction chamber. A such arranged and designed shielding element leads the plasma more to the center of the reaction chamber, thus, the inner walls of the reaction chamber neighbouring the gas inlet nozzle are protected considerably from plasma corrosion. This method has positive effects on the service life of the etching device, as well.

It has proven to be especially suitable to arrange a sealing element - to which the shielding element is fixed - on the front side of the inlet nozzle facing away from the reaction chamber. This embodiment of the device makes the exchange of the shielding element especially easy. For example, the shielding element can be fixed to the sealing element by means of a bayonet socket.

With respect to the shielding element the above mentioned task is solved according to the embodiment of invention such that the shielding element consists of synthetic quartz glass the inside surface of which has been smoothed in a melting process.

It has shown that a shielding element of synthetic quartz glass is particularly little damaged by the plasma to be generated, if the inside surface facing the plasma has been smoothed in a melting process. It is sufficient when the part of the shielding element surface that faces the plasma has been smoothed that way. Smoothing during a melting process can, for example, take place during the manufacturing of a shielding element by means of an ordinary melting method like drawing from the melting or from a preform, or it can be achieved by subsequent hot polishing, for example, flame polishing.

The embodiment has 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.

* C L M S *

CLAIMS

1. A device for etching or precipitation using a plasma, with a reaction chamber for the uptake of a substrate to be treated, comprising a gas inlet nozzle of quartz glass for feeding a gas into the reaction chamber, and a plasma generator for the generation of plasma within the gas inlet nozzle, characterized in that a shielding element (6) is arranged between the inner walls of the inlet nozzle (2) and plasma to be generated (5).

2. A device according the Claim 1, characterized in that the shielding element (6) in the inlet nozzle (2) is mounted exchangeably.

3. A device according to Claim 1 or 2, characterized in that the shielding element (6) has the form of a sheath.

4. A device according to any one of the above Claims, characterized in that the shielding element (6) consists of quartz glass.

5. A device according to Claim 4, characterized in that the shielding element (6) consists of synthetic quartz glass.

6. A device according to any one of the above Claims, characterized in that a gap (8) is to be between the shielding element (6) and the inner walls of the inlet nozzle (2).

7. A device according to any one of the above Claims, characterized in that the shielding reactor element (6) projects into the reaction chamber (1).

8. A device according to any one of the above Claims, characterized in that on the front side of the inlet nozzle (2) facing away from the reaction chamber (1) a sealing element is arranged onto which the shielding element (6) is fixed.

9. A tube-like shielding element for application in a device according to any of the Claims 1 to 8 consisting of synthetic quartz glass the inside surfaces of which have been smoothed during a melting process.