METHOD FOR REMOVING PHOTORESIST IN SEMICONDUCTOR MANUFACTURING PROCESS

Technical Field

The present invention relates to a method for removing a photoresist in a semiconductor manufacturing process, and more particularly to a method for removing a photoresist in a semiconductor manufacturing process wherein the removal of a photoresist, i.e., ashing, is carried out using plasma generated from a hydrogen (H_2)-containing mixed gas.

Background Art

A photolithographic process, which is one of semiconductor manufacturing processes, comprises the steps of spin coating a photoresist onto a semiconductor substrate to form a photoresist layer on the substrate, selectively exposing the photoresist layer to light, developing the exposed photoresist layer to form a photoresist pattern on top of the semiconductor substrate, etching or implanting an impurity into exposed portions of the semiconductor substrate, and removing the photoresist pattern (i.e. ashing) acting as a mask during the etching or impurity implantation.

After completion of the ashing, some steps follow, for example, wiring for interconnecting devices formed on the wafer, and formation of a metal wiring layer for forming a metal film used as a bond pad, etc., in order to connect to the outside of the chip.

Among these steps, ashing is an etching process for removing a photoresist after etching or ion implantation. As used herein, the photoresist refers to a mask which is used to etch a pattern on the underlying substrate or selectively implant ions into exposed portions of the substrate.

Since such ashing is commonly carried out using oxygen (O_2) plasma, the

photoresist removal is an oxidation reaction wherein the photoresist is reacted with oxygen. Also, since oxidation is associated with burning, the photoresist removal is called 'ashing'. An apparatus for carrying out the ashing is defined as an 'asher'.

As high integration and high speed of devices are required with the recent development of semiconductor manufacturing techniques, wafer fabrication processes become more and more strict, causing a problem that the amount of silicon as a main component of a wafer is lost little by little.

In the case where oxygen is used as a process gas for generating plasma during ashing, a portion of the wafer surface reacts with the oxygen to form an oxide film. The oxide film formed on the portion of the wafer surface results in considerable loss of doped polycrystalline silicon used as a material for devices and electrodes requiring a shallow junction.

In addition, the phenomenon of popping may take place after high-dose ion implantation into a wafer in a conventional photoresist ashing process. In order to avoid the popping phenomenon, the process temperature is lowered or a pin-up process is further performed after high-dose ion implantation. However, the popping phenomenon remains unsolved.

In a high-density silicon substrate, G-line light having a wavelength band of 436nm or I-line light having a wavelength band of 365nm has such a long wavelength that the line width is too large to be defined on the substrate. Accordingly, for more accuracy, the use of high-dose ion implanted deep ultraviolet (DUV) light and X-ray having wavelength bands of 248nm and 193nm, respectively, is more advantageously used.

Further, since conventional I-line photoresists are composed of large molecules and are highly viscous, they are replaced with high-dose ion implanted DUV photoresists in high-density silicon substrates.

However, these high-dose ion implanted DUV photoresists have a problem that

photoresist residues are not completely removed by the conventional ashing process using oxygen.

Disclosure of the Invention

Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a method for removing a photoresist in a semiconductor manufacturing process wherein the removal of a photoresist, i.e., ashing, is carried out using plasma generated from a hydrogen (H_2)-containing mixed gas.

It is another object of the present invention to provide a method for removing a photoresist in a semiconductor manufacturing process wherein the formation of a silicon oxide film is minimized, thereby preventing silicon loss without no popping, and even residues of a high-dose ion implanted DUV photoresist are completely removed.

It is yet another object of the present invention to provide a method for removing a photoresist in a semiconductor manufacturing process wherein ashing efficiency is enhanced.

In order to accomplish the above objects of the present invention, the present invention proposes the use of hydrogen (H_2) plasma during ashing in order to remove a photoresist from a semiconductor structure. The present invention is applicable to all photoresist ashing processes, and is particularly effective in high-dose ion implanted substrates.

According to the present invention, the above objects can be accomplished by a method for removing a photoresist, in a semiconductor manufacturing process comprising the steps of: spin coating a photoresist onto a semiconductor substrate to form a photoresist layer on the substrate; selectively exposing the photoresist layer to light; developing the exposed photoresist layer to form a photoresist pattern on top of the semiconductor substrate; etching or implanting an impurity into exposed portions of the

semiconductor substrate; and removing the photoresist pattern (ashing) acting as a mask during the etching or impurity implantation, wherein the ashing is carried out using plasma generated from a hydrogen (H_2)-containing mixed gas so that no popping occurs even at high temperatures and thus generation of particles is prevented.

Particularly, since the use of the plasma generated from a hydrogen-containing mixed gas minimizes the formation of an oxide film, silicon loss can be minimized.

Further, the semiconductor substrate is preferably a substrate manufactured by high-dose ion implantation.

Further, the photoresist preferably includes a DUV (deep ultraviolet) photoresist.

Further, the hydrogen (H_2)-containing mixed gas is preferably a gas mixture of hydrogen and nitrogen (N_2) or helium (He).

Further, the hydrogen (H_2) content in the mixed gas is preferably in the range of 2~100% by volume, based on the total volume of the mixed gas.

Still further, the ashing is preferably carried out at a temperature of 100~200°C.

In accordance with another aspect of the present invention, the above objects can be accomplished by a method for removing a photoresist, in a semiconductor manufacturing process comprising the steps of: spin coating a photoresist onto a semiconductor substrate to form a photoresist layer on the substrate; selectively exposing the photoresist layer to light; developing the exposed photoresist layer to form a photoresist pattern on top of the semiconductor substrate; etching or implanting an impurity into exposed portions of the semiconductor substrate; and removing the photoresist pattern (ashing) acting as a mask during the etching or impurity implantation, wherein the ashing is carried out using plasma generated from a hydrogen (H_2)-containing mixed gas or ammonia (NH_3) so that no popping occurs even at high temperatures and thus generation of particles is prevented.

Brief Description the Drawings

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a transmission electron micrograph (TEM) of a silicon substrate taken after ashing is carried out in accordance with a conventional method; and

Fig. 2 is a transmission electron micrograph (TEM) of a silicon substrate taken after ashing is carried out in accordance with an embodiment of the present invention.

Best Mode for Carrying Out the Invention

The present invention will now be described in more detail with reference to the accompanying drawings illustrating preferred embodiments. Ashing was carried out under the conditions summarized in Table 1 below.

Table 1

No.	O_2 (sccm)	N_2 (sccm)	H_2/N_2 (sccm)	Process temperature (°C)	Process time (Sec.)	Thickness of oxide film (Å)	TEM Image
Process A	7,000	800	-	250	75	17	Fig. 1
Process B	-	-	8,000	250	285	0	Fig. 2

To put it briefly, process A is a conventional ashing process wherein O_2 at a flow rate of 7,000 sccm and N_2 at a flow rate of 800 sccm were used at a process temperature of 250°C for 75 seconds. After completion of the ashing, the thickness of the formed oxide film was measured using a transmission electron microscope. The results are shown in Fig. 1. The oxide film was measured to have a thickness of 17Å.

Next, process B is an ashing process according to an embodiment of the present invention wherein H_2/N_2 at a flow rate of 8,000 sccm was used at a process temperature

of 250°C for 285 seconds. After completion of the ashing, the thickness of the formed oxide film was measured using a transmission electron microscope. The results are shown in Fig. 2. The thickness of the oxide film was so small as to be immeasurable.

After processes A and B were performed under the conditions summarized in Table 1, the inside of each process chamber was observed through viewports. As a result, popping phenomenon was observed in the conventional process (process A), whereas no popping occurred in the process according to one embodiment of the present invention (B process) using the hydrogen-containing mixed gas (H_2/N_2).

Table 2

No.	Pressure (Torr)	O_2 (sccm)	N_2 (sccm)	H_2/N_2 (sccm)	Process temperature (°C)	Process time (Sec.)
Process C	2	17,000	1,900	-	250	150
Process D	2	8,000	-	8,000	150	150

After ashing each wafer including a high-dose ion implanted DUV photoresist under the conditions summarized in Table 2, the amount of photoresist residues remaining on the wafers was measured.

Process C is a conventional process wherein O_2 at a flow rate of 17,000 sccm and N_2 at a flow rate of 1,900 sccm were used at a process pressure of 2 Torr and a process temperature of 250°C for 150 seconds to remove the photoresist.

Process D is a process according to the present invention wherein O_2 at a flow rate of 8,000 sccm and H_2/N_2 at a flow rate of 8,000 sccm were used at a process pressure of 2 Torr and a process temperature of 150°C for 150 seconds to remove the photoresist.

As a result of removing the photoresists under the respective conditions, a large quantity of photoresist residues remained by process C, whereas photoresist residues were completely removed by process D.

Specifically, when hydrogen or a hydrogen-containing gas, e.g., a mixture of

hydrogen and nitrogen (N_2) or helium (He) shown in Table 2, was used to remove the photoresist, photoresist residues were completely removed. Likewise, even when a hydrogen-based gas such as ammonia (NH_3) is used, photoresist residues can be expected to be completely removed.

Photoresist residues were completely removed even at a process (reaction) temperature of 100~200°C.

Industrial Applicability

As can be seen from the above results, since the method of the present invention prevents the formation of an oxide film during removal of a photoresist, it can prevent loss of doped single crystalline or polycrystalline silicon used as a material for devices and electrodes requiring a shallow junction.

In addition, when the method of the present invention is used to remove a high-dose ion implanted photoresist during ashing, no popping occurs even at 200°C or higher and thus generation of particles can be prevented, contributing to an improvement in semiconductor manufacturing yield.

According to the method of the present invention, even when a hydrogen-based compound or mixture is used at low temperature in order to remove residues of a high-dose ion implanted DUV photoresist, which is essentially used in a high-density silicon substrate, the photoresist residues can be completely removed.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Claims:

1. A method for removing a photoresist, in a semiconductor manufacturing process comprising the steps of: spin coating a photoresist onto a semiconductor substrate to form a photoresist layer on the substrate; selectively exposing the photoresist layer to light; developing the exposed photoresist layer to form a photoresist pattern on top of the semiconductor substrate; etching or implanting an impurity into exposed portions of the semiconductor substrate; and removing the photoresist pattern (ashing) acting as a mask during the etching or impurity implantation,

wherein the ashing is carried out using plasma generated from a hydrogen (H_2)-containing mixed gas so that no popping occurs even at high temperatures and thus generation of particles is prevented.

2. The method according to claim 1, wherein the semiconductor substrate is a substrate manufactured by high-dose ion implantation.

3. The method according to claim 1, wherein the photoresist includes a DUV (deep ultraviolet) photoresist.

4. The method according to claim 1, wherein the hydrogen (H_2)-containing mixed gas is a gas mixture of hydrogen and nitrogen (N_2) or helium (He).

5. The method according to any one of claims 1 to 4, wherein the hydrogen (H_2) content in the mixed gas is in the range of 2~100% by volume, based on the total volume of the mixed gas.

6. The method according to any one of claims 1 to 4, wherein the ashing is carried out at a temperature of 100~200°C.

7. A method for removing a photoresist, in a semiconductor manufacturing process comprising the steps of: spin coating a photoresist onto a semiconductor substrate to form a photoresist layer on the substrate; selectively exposing the photoresist layer to light; developing the exposed photoresist layer to form a photoresist pattern on top of the semiconductor substrate; etching or implanting an impurity into exposed portions of the semiconductor substrate; and removing the photoresist pattern (ashing) acting as a mask during the etching or impurity implantation, wherein the ashing is carried out using plasma generated from a hydrogen (H_2)-containing mixed gas or ammonia (NH_3) so that no popping occurs even at high temperatures and thus generation of particles is prevented

8. The method according to claim 7, wherein the semiconductor substrate is a substrate manufactured by high-dose ion implantation.

9. The method according to claim 7, wherein the photoresist includes a DUV (deep ultraviolet) photoresist.

10. The method according to claim 7, wherein the hydrogen (H_2)-containing mixed gas is a gas mixture of hydrogen and nitrogen (N_2) or helium (He).

11. The method according to any one of claims 7 to 10, wherein the hydrogen (H_2) content in the mixed gas is in the range of 2~100% by volume, based on the total volume of the mixed gas.

12. The method according to any one of claims 7 to 11, wherein the ashing is carried out at a temperature of 100~200°C.