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REPLACED SHEETS SG
☑ Description : paged ....1... to paged ....6....
☑ Claim(s) : paged ....7.... to paged ....9....
☐ Drawing(s) : paged ....1/2.... to paged ....3/2....
☐ Abstract : paged ....10.... to paged ....10....

METHOD FOR FABRICATING SHALLOW TRENCH ISOLATION STRUCTURE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a fabrication method for an integrated circuit. More particularly, the present invention relates to a fabrication method for a shallow trench isolation structure.

Description of the Related Art

The reduction of the device dimensions and the expansion of the circuit integration are the developmental trend in today's integrated circuit (IC) industry. As the device dimension becomes smaller and the integration grows higher, the device isolation structure also needs to be decreased, and hence the technical difficulty for the design of a device isolation structure also increases. The device isolation structure includes a field oxide layer formed by local oxidation (LOCOS). Since the field oxide layer is limited by its bird's beak structure, to further reduce its dimension poses some difficulties. As a result, other device isolation methods are gradually being developed and the shallow trench isolation structure is most commonly applied, especially in the manufacturing of the deep sub-micron integrated circuit.

The fabrication of a shallow trench isolation structure is typically accomplished by using silicon nitride as a hard mask and defining a steep trench in a semiconductor substrate by an anisotropic etching method. An oxide material is further filled in the

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trench to form an oxide plug, which becomes the shallow trench isolation structure of the device. In the conventional practice, however, it is inevitable that the border of the silicon oxide plug is partly recessed and resulted in a corner effect. As a result, in the subsequent manufacturing process, for example, the formation of the source electrode and the drain electrode by ion implantation, an accumulation of charges may develop at the border corners of the recessed region. Consequently, an abnormal subthreshold in the transistor channel is developed and a kink effect is resulted, leading to an improper functioning of the transistor or the development of a poly-stringer.

In order to resolve the above problem, after forming the trench, a liner oxide layer is formed along the inner wall of the trench, followed by conducting a high density plasma chemical vapor deposition (HDPCVD) process to form a silicon oxide plug.

In the conventional practice, a liner oxide layer is simply formed via a thermal oxidation by placing the wafer in a furnace. The entire heating/cooling cycle using a furnace is long. The heating/cooling cycle requires at least several hours, however for each cycle, the furnace can only accommodate a limited quantity of wafers. The throughput of the entire process becomes limited. In addition, the thickness of the oxide layer which grows with time, therefore is not easy to control.

SUMMARY OF THE INVENTION

The present invention provides a fabrication method for a shallow trench isolation structure using the ozone gas to form a liner oxide layer to mitigate the corner effect, thereby resolving the related problems derived from the corner effect. In addition, the application of the present invention reduces the processing time and enhances the throughput. The thickness of the liner layer can also be effectively

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controlled.

The present invention provides a fabrication method for a shallow trench isolation structure. This method includes forming a pad oxide layer on the substrate, followed by the formation of a hard mask on the pad oxide layer. A trench is then defined, through the hard mask and the pad oxide layer, in the substrate. After the formation of the trench, the substrate is placed in an ozone gas environment. The ozone gas is irradiated with an ultraviolet light to form a liner oxide layer of approximately 30 Å to 200Å thick. An insulation plug is further deposited, filling the trench.

According to the method mentioned above, by irradiating with an ultraviolet light, the ozone gas directly reacts with the silicon on the exposed surface of the trench to form a liner oxide layer. The duration of the process in forming the liner oxide layer decreases from the traditional several hours to a few seconds. As a result, the throughput is improved.

It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention. In the drawings,

Figures 1A to 1F are schematic, cross-sectional views showing the

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manufacturing steps of a shallow trench isolation structure.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Figures 1A to 1F are schematic, cross-sectional views showing the manufacturing steps of a shallow trench isolation structure.

Referring to Figure 1A, a pad oxide layer 102 is formed on a silicon substrate 100 to protect the surface of the substrate 100. The pad oxide layer 102 is going to be removed in a subsequent process before the formation of the gate oxide layer. The pad oxide layer 102 is, generally formed by chemical vapor deposition, and is preferably to have a thickness of approximately 100 to 150Å. A hard mask layer 104, for example, a nitride layer of approximately 1000 to 3000Å thick, is formed covering the pad oxide layer. By means of photolithography and etching, the hard mask layer 102 is defined to expose a portion of the pad oxide layer 102, followed by a sequential etching of the exposed pad oxide layer 102 and the silicon substrate 100 to form a trench 106. The depth of the trench 106 is approximately between 0.2 micron to 0.8 micron, preferably around 0.4 micron. The actual depth of the trench 106 is dependent on the dimensions of the desired device.

As shown in Figure 1B, a thermal oxidation is conducted to form a liner oxide layer 108 along the exposed surface of the substrate in the trench 106. The thickness of the liner oxide layer 108 is approximately between 30 to 200Å, and is more preferable to be between 30 to 50 Å. The formation of the liner oxide layer 108 includes placing the substrate 100 in an ozone gas environment, followed by an irradiation with an ultraviolet (UV) light to decompose the ozone gas and to react with the exposed silicon surface. The ratio of the ozone gas volume to the total gas volume

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(oxygen + ozone) is approximately 5 to 13%. The wavelength for the UV light source is approximately between 193nm to 254nm.

The oxygen density of the liner oxide layer 108 formed by the UV light irradiated ozone gas can be determined by the Gracing Incidence X-Ray Reflectrometry (GIXR). Result form the x-ray reflectrometry study indicates that the oxygen density of the liner oxide layer 108 formed according to the present invention is similar to the oxide layer formed by thermal oxidation. In addition, an etching conducted on a liner oxide layer 108 formed by the ultraviolet light and chlorine (UV/Cl_2) results in an improved surface roughness for the silicon surface. These results further support that the oxide layer formed by the ozone gas has better integrity. Furthermore, using the UV light irradiated ozone gas to form the liner oxide layer 108 only requires placing the substrate 100 in an ozone gas environment for a few seconds or less, thereby can effectively increase the throughput.

As shown in Figure 1C, an insulation layer 110 of approximately 9000 to 11000Å thick is formed on the hard mask layer 104. The insulation layer 110, which fills the trench 106, is typically formed by atmospheric pressure chemical vapor deposition (APCVD) with, for example, an oxide material. After a densification process, conducted below a temperature of 1000°C for approximately 10 to approximatley 30 minutes, an insulation layer 110 with a denser structure is formed. An important point to note is that the actual thickness of the insulation layer 110 is dependent on the actual depth of the trench 106 and the actual thickness of other deposited layers.

As shown in Figure 1D, after the densification process, with the hard mask layer serving as an etch stop layer, chemical mechanical polishing (CMP) or etching-back is

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conducted to remove the insulation layer 110 on the hard mask layer 104, leaving an insulation plug 110a in the trench.

Referring to Figure 1E, the hard mask layer 104 is further removed to expose the pad oxide layer 102 and the insulation plug 110a that is higher than the pad oxide layer surface. The hard mask layer 104 is removed by, for example, a hot phosphorous solution.

As shown in Figure 1F, the pad oxide layer 102 is removed, for example, by soaking in a hydrogen fluoride (HF) solution. Along the removal of the pad oxide layer 102, a portion of the insulation plug 110a is also removed.

It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed.

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WHAT IS CLAIMED IS:

1. A fabrication method for a shallow trench isolation structure comprising the steps of:

providing a substrate;

forming a pad oxide layer on the substrate;

forming a hard mask layer on the substrate;

removing a portion of the hard mask layer, the pad oxide layer and the substrate to form a trench in the substrate;

subjecting the substrate in an ozone gas environment and irradiating with an ultraviolet light; and

filling an insulation plug in the trench.

2. The fabrication method for a shallow trench isolation structure according to claim 1, wherein the pad oxide layer is approximately 100 to 150Å.

3. The fabrication method for a shallow trench isolation structure according to claim 1, wherein the hard mask layer is a silicon nitride layer.

4. The fabrication method for a shallow trench isolation structure according to claim 1, wherein the hard mask layer is approximately 1000 to 3000Å thick.

5. The fabrication method for a shallow trench isolation structure according to claim 1, wherein the trench is approximately between 0.2 micron to 08 micron deep.

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6. The fabrication method for a shallow trench isolation structure according to claim 1, wherein the trench is approximately 0.4 micron deep.

7. The fabrication method for a shallow trench isolation structure according to claim 1, wherein a liner oxide layer is formed along the surface of the trench in an ozone environment, which is under an irradiation by an ultraviolet light.

8. The fabrication method for a shallow trench isolation structures according claim 7, wherein the liner oxide layer is approximately 30 to 200Å thick.

9. The fabrication method for a shallow trench isolation structure according to claim 7, wherein the liner oxide layer is approximately 30Å to 50Å.

10. The fabrication method for a shallow trench isolation structure according to claim 1, wherein the insulation layer is approximately 9000Å to 11000Å thick.

11. The fabrication method for a shallow trench isolation structure according to claim 1, wherein after the formation of the insulation layer further includes conducting a densification process.

12. The fabrication method for a shallow trench isolation structure according to claim 1, wherein the ozone environment includes an ozone gas and an oxygen gas, and the ozone gas is approximately 5% to 13% of a total gas volume.

13. A fabrication method for a shallow trench isolation structure, the method comprising the steps of:

providing a substrate, wherein the substrate comprises an pad oxide layer;

forming a hard mask layer on the pad oxide layer;

forming a trench, which passes through the hard mask layer and the pad oxide layer to expose a portion of the substrate;

decomposing the ozone gas by an ultraviolet light to react with an exposed portion of the substrate, so as to form a liner oxide layer along a surface of the trench;

forming an insulation plug in the trench.

14. The fabrication method for a shallow trench isolation structure according to claim 13, wherein the liner layer is approximately 30Å to 200Å thick.

15. The fabrication method for a shallow trench isolation structure according to claim 13, wherein the liner oxide layer is approximately 30Å to 50Å thick.

16. The fabrication method for a shallow trench isolation structure according to claim 13, wherein an ozone environment includes an ozone gas and an oxygen gas and the ozone gas is approximately 5% to 13% of the total volume.