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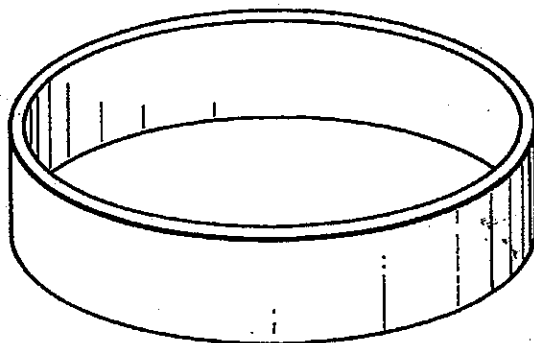
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(54) Title: LINER FOR SEMICONDUCTOR ETCHING CHAMBER



(57) Abstract: A liner is provided for protecting the inside chamber and dome used in semiconductor fabrication. This liner is capable of protecting the dome and chamber against corrosion caused by plasma field generation and byproducts of dry etching processes. In addition, the liner described in this invention has a long life under conditions induced by plasma field generation.

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TITLE

LINER FOR SEMICONDUCTOR ETCHING CHAMBER

FIELD OF THE INVENTION

5 The present invention relates to dome liners and chamber liners for use in processes involving dry etching of semiconductor devices.

BACKGROUND OF THE INVENTION

10 Dry etching processes using chambers with dome-shaped ceramic or aluminum tops and aluminum sides and bottoms, in part, are used to manufacture semiconductor wafers. The dry etch process uses plasma state gases to perform chemical and physical erosion on unprotected surfaces of a semiconductor wafer surface. The mixture of gases used, as well as other variables such as the electrical power and
15 pressure settings, will alter the aggressiveness and uniformity of erosion of the semiconductor surface and the chamber. The chamber is filled with gas and semiconductor wafers are placed inside the chamber. Gas is then ionized with a plasma field to make the gas reactive so as to etch wafers inside the chambers. A plasma field is
20 usually made of chemically active species of gaseous compounds such as fluorine, oxygen and chlorine. The exact mixture of gaseous compounds is chosen to balance the functions of the individual gases so as to achieve a desired etch activity. Etching can result in the generation of etching by-products that, if not removed, will eventually
25 contact and damage the wafers in the chamber. These byproducts can also damage the interior sides and top of the etching chamber.

 A thin-walled, seamless, polymer liner placed snugly inside the chamber so as to cover the aluminum sides of the chamber was
30 reported to draw etching by-products away from the semiconductor devices. Sakai, et al., Japan Application No. 10-150137, May 16, 1999. Using a thin polymer liner to maintain uniform chamber surface temperatures during etching processes, the Sakai patent application reports the transfer of etched by-products away from semiconductor
35 wafers by the deposition of the by-products on the polymer liner surfaces in the interior of the chamber. The polymer liner was

reported to be thin, 2.0 mm or less in thickness, so that the temperature within the chamber is accurately regulated by the cooling means located outside of the chamber. As reported in the Sakai patent application, a liner having a wall thickness greater than 2.0 mm would insulate the contents of the chamber from the exterior cooling means allowing chamber surface temperatures to increase during etching processes. For this reason, higher surface temperatures would decrease the deposition of by-products on the polymer liner surfaces.

The Sakai patent application reports a solution to the problem of removing by-products away from semiconductor devices located in a chamber, however, other problems associated with etching still exist. Gas generated in the chamber can be highly toxic and could escape if the chamber integrity is compromised. Consequently, a device capable of protecting the walls and the top of chamber from the gas would be desirable. The device should have a long service life and be able to survive many hours of each individual operation because the removal and replacement of a chamber component slows down the production process and significantly increases manufacturing costs.

In view of the foregoing, a liner for a chamber interior for etching semiconductor devices that has a long life and protects against chamber corrosion has been developed.

SUMMARY OF THE INVENTION

In one aspect, the present invention relates to dome and chamber liners that may be used during numerous dry etching processes while protecting the inside walls and top of the chamber.

The liners of the present invention are prepared from high performance resins, the liners being juxtaposed to the inside top of the chambers. The liners have a wall thickness greater than 2.0 mm, and preferably in the range of 3 mm to 8 mm. High performance resins are characteristically stable at high temperatures (above 100°C), resistant to wear, resistant to plasma and oxidative stress and dimensionally stable, i.e., tending not to creep or deform. The service life of a liner correlates directly with the thickness of a liner.

Dome liners of the present invention fit to an inside top of a chamber of a dry etching

apparatus used in semiconductor manufacture and comprise high performance resin.

5 In another aspect, the present invention relates to chamber liners that fit to an inside wall of a chamber of a dry etching apparatus used in semiconductor manufacture, said liners comprising a high performance resin having a wall thickness of at least 3 mm to fit an inside wall of a chamber of a dry etching apparatus.

10 The present invention also relates to a chamber of a dry etching apparatus comprising a dome liner of the present invention. The dome liner fits to an inside top of the chamber. The chamber may also include a chamber liner of the present invention.

15 As used herein, with respect to the present invention, the following shall apply:

"dome liner" refers to a covering used to cover the top interior portion of the chamber.

"chamber liner" refers to a covering used to cover the interior chamber sidewalls.

20 A liner for the top interior portion of a dry etching chamber may be prepared from a high performance resin, the resin being juxtaposed to the inside top of the chamber. A liner for the interior sidewalls of a dry etching chamber may be prepared from a high performance resin and may have a wall thickness of at least 3 mm to fit an
25 inside wall of a chamber of a dry etching apparatus.

DESCRIPTION OF THE FIGURES

Figure 1 illustrates a dome liner of the present invention.

Figure 2 illustrates a chamber liner of the present invention.

30 Figure 3 illustrates an overhead view of a variation of a dome liner and the chamber liner in the present invention.

Figure 4 illustrates a side view of the dome liner and the chamber liner pictured in Figure 3.

35 Figure 5 illustrates the joint between the dome liner and the chamber liner pictured in Figure 4.

DETAILED DESCRIPTION OF THE INVENTION

Dome and chamber liners of the present invention are prepared from high performance polymer resins, preferably a high-performance thermoplastic resin. Suitable resins include polybenzimidazole, polyimide, polyetherimide, polyamideimide, polyaryletherketone, polycarbonate, polyarylate, polyethersulfone, aromatic polyamide, tetrafluoroethylene/perfluoroalkylvinyl ether copolymer (PFA), polytetrafluoroethylene (PTFE), polychlorotrifluoroethylene (PCTFE), tetrafluoroethylene/hexafluoropropylene copolymer (FEP), polyvinylidene fluoride (PVDF), polyvinylfluoride (PVF), ethylene/tetrafluoroethylene copolymer (ETFE). It is preferred that the high performance resin contain no halogen atoms.

The high performance resins used in this invention may be readily processed by methods and processing equipment normally used in industry to form high performance polymers. Typical methods for forming dome liners and chamber liners include spray coating, machining, injection molding, compression molding, plasma coating, rotomolding, strip bending and welding. The forming conditions required to produce satisfactory articles depends on several process variables, such as mold complexity and dimensions, sheet thickness and polymer variables such as melt viscosity and glass transition temperature (T_g). These conditions can be determined by techniques typically used by those skilled in the art.

As shown in Figure 1, a dome liner is preferably in the shape of a dome that corresponds to the shape of the ceramic top of a chamber used in a dry etch process. However, the dome liner may be molded into any shape that corresponds to the top of a chamber used in a dry etch process.

The chamber and dome liners of the present invention have a wall thickness preferably greater than 2.0 mm, and most preferably in the range of 3 mm to 8 mm. The service life of a dome liner correlates directly with the thickness of the dome liner.

As shown in Figure 2, the chamber liner is preferably in the shape of the chamber.

5 A typical chamber liner would be cylindrical and 34.5 cm outer diameter and 10.2 cm high. On top of the chamber liner would be a dome liner in the shape of a dome having an outer diameter of 34.5 cm and a 10.2 cm deep. Preferably, the dome liner has less than 0.8 mm clearance with the dome to prevent the generation of plasma between the dome and the dome liner. Similarly, the chamber liner preferably
10 has less than 0.8 mm clearance with chamber to prevent formation of plasma fields between the chamber and the liner. Also preferably, the dome liner is not mechanically attached to the dome.

15 To use a dome liner, the dome liner is placed inside of the dome so that the convex side of the dome liner is juxtaposed with the concave inner part of the chamber. To use the chamber liner, the chamber liner is placed inside of the chamber such that the annular surface of the liner with the greatest radius is juxtaposed with the inner radial surface of the chamber. Dome and chamber liners of the present
20 invention at 5 mm thickness may last at least 1000 RF (radio frequency) hours in a conventional dry etching process. Dome liners and chamber liners may be used separately or in conjunction with each other.

25 The dome liner of Figure 3 has an opening at the top of the dome. This open dome liner offers protection to domes in which the top of the dome of the plasma generation chamber is not involved in plasma generation and has no contact with harmful byproducts of the plasma generation process.

30 The dome liner of Figure 4 shows a dome liner 1 resting on top of the chamber liner 3. As show in Figure 5 and described in Dome Liner 2 and Chamber Liner 1 below, the dome liner may have a groove system comprising a groove 5 on the dome liner that is complimentary
35 to a groove 7 on the chamber liner. This groove system would aid in

fitting the dome liner 1 with the chamber liner 3 when the dome liner 1 rests on top of the chamber liner 3.

EXAMPLES

5 Dome Liner 1

1400 g of an amorphous, aromatic thermoplastic polyimide resin having a Tg of 239°C were placed into a 43.2 cm x 43.2 cm plaque mold. The top plate of the plaque mold was added and the mold was placed into a preheated (296°C) platen press having a platen size of 61 cm x 61 cm. A thermocouple was inserted into the plaque mold and the plaque mold allowed to heat up without pressure to 288°C. At this point 3.44×10^6 Pascal of pressure was applied. After 1 minute the cooling cycle on the press was started and the plaque mold allowed to cool to room temperature under pressure. Once cool, a compression molded plaque of 5 mm thickness was removed from the mold.

The plaque was vacuum thermoformed using a standard industrial thermoformer equipped with ceramic heaters and a remote pyrometer to measure the surface temperature of the plaque while it is in the oven. Using a vacuum of about 95 kPa, a mold temperature between 246°C and 275°C and a sheet forming temperature between 250 and 275°C, the compression-molded plaque was formed into a dome having an outer diameter of 34.5 cm and a 10.2 cm deep draw and a minimum thickness of 2.5 mm. A top lip of the dome, formed through the molding process, was removed to provide the final article. The dome showed good mold surface replication. The dome was subsequently trimmed using conventional milling machines into the desired final part.

30 Dome Liner 2 and Chamber Liner 1

For this example, liner material was not provided at the very apex of the dome since most significant erosion of the dome was occurring at the periphery of the dome immediately under the RF coils that induce the plasma. Two 50.8 mm high annular plates of pyromellitic dianhydride 4,4'-diaminodiphenylether polyimide (as used in DuPont Vespel® SP-1 parts and shapes), having outer diameters of

360 mm and inner diameters of 196 mm, were machined and assembled together to line the lower 100 mm of the chamber dome.

5 The lower plate was machined into a cylinder of outer diameter 345 mm and a wall thickness of 3 mm. A mating groove was cut into the top surface from the middle of the wall to the outer diameter.

10 An upper plate covered all the critical areas of the curvature of the dome. The outer surface was turned on a lathe to match the surface shape of the particular dome. The thickness of the liner was set at 5 mm when the inner surface was turned. An extra tab of material was left on the lower surface around the outer diameter to interlock with the lower plate. When the upper machined plate was placed on the lower machined plate in the chamber, the upper
15 machined plate was held in place by gravity and the restraints of the dome immediately above and around it.

Chamber Liner 2

20 A dome of the type in Dome Liner 1 was prepared. An untrimmed part was then trimmed on both the top and the bottom with a cutting tool to form a seamless ring 5.1 cm high, 3 mm thickness and having an outer diameter of 345 cm. The chamber liner was then machined to uniform thickness.

25 Chamber Liner 3

A plaque of the type in Dome Liner 1 was prepared. The plaque had the dimensions 740mm x 740mm x 450mm. This plaque was placed in a drying oven set at 200°C for 48 hours. The dry plaque was vacuum thermoformed using a standard industrial thermoformer
30 equipped with ceramic heaters and a remote pyrometer to measure the surface temperature of the plaque while in the oven. Using a vacuum of about 95 kPa, a mold temperature between 215°C and 238°C and a sheet forming temperature 275°C, the compression-molded plaques

were formed into domes having an outer diameter of 60.8 cm and a 12.7cm deep draw.

5 An open untrimmed end of the dome was then trimmed on both the top and the bottom with a cutting tool to form a seamless ring 11.4 cm high having an outer diameter of 60.8 cm and a minimum wall thickness of 4.85mm. The chamber liner was then machined to uniform thickness.

CLAIMS

- 5 1. A liner for the top interior portion of a dry etching chamber comprising a high performance resin, said liner being juxtaposed to the inside top of the chamber.
2. A liner according to Claim 1 which is in the shape of a
10 dome.
3. A liner according to Claim 1 which is open at the top.
4. A liner according to Claim 1 which has a wall thickness of
15 greater than 2.0 mm.
5. A liner according to Claim 1 which has a wall thickness greater than 3.0 mm and less than 8.0 mm.
- 20 6. A liner according to Claim 1 wherein the high performance resin is a thermoplastic.
7. A liner according to Claim 1 wherein the high performance resin is selected from the group consisting of
25 polybenzimidazole, polyimide, polyetherimide, polyamideimide, polyaryletherketone, polycarbonate, polyarylate, polyethersulfone, aromatic polyamide, tetrafluoroethylene/perfluoroalkylvinyl ether copolymer (PFA), polytetrafluoroethylene (PTFE), polychlorotrifluoroethylene (PCTFE),
30 tetrafluoroethylene/hexafluoropropylene copolymer (FEP), polyvinylidene fluoride (PVDF), polyvinyl fluoride (PVF), and ethylene/tetrafluoroethylene copolymer (ETFE).
8. A liner according to Claim 1 wherein the high
35 performance resin is a polyimide or a polyetherimide.

9. A liner according to Claim 1 wherein the high performance resin contains no halogen atoms.

10. A liner for the interior sidewalls of a dry etching chamber comprising a high performance resin and having a wall thickness of at least 3 mm to fit an inside wall of a chamber of a dry etching apparatus.

11. A liner according to Claim 10 which is in the shape of a cylinder.

12. A liner according to Claim 10 which has a wall thickness greater than 3.0 mm and less than 8.0 mm.

13. A liner according to Claim 10 wherein the high performance resin is a thermoplastic.

14. A liner according to Claim 10 wherein the high performance resin is selected from the group consisting of polybenzimidazole, polyimide, polyetherimide, polyamideimide, polyaryletherketone, polycarbonate, polyarylate, polyethersulfone, aromatic polyamide, tetrafluoroethylene/perfluoroalkylvinyl ether copolymer (PFA), polytetrafluoroethylene (PTFE), polychlorotrifluoroethylene (PCTFE), tetrafluoroethylene/hexafluoropropylene copolymer (FEP), polyvinylidene fluoride (PVDF), polyvinylfluoride (PVF), and ethylene/tetrafluoroethylene copolymer (ETFE).

15. A liner according to Claim 10 wherein the high performance resin is a polyimide or a polyetherimide.

16. A liner according to Claim 10 wherein the high performance resin contains no halogen atoms.

17. A dry etching chamber comprising the liner of Claim 1.

18. A dry etching chamber comprising the liner of Claim 10.

19. A dry etching chamber according to Claim 17 further comprising the liner of Claim 10.

5

20. A dry etching chamber according to Claim 17 wherein there is less than 0.8 mm clearance between the liner and the top of the chamber.

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21. A dry etching chamber according to Claim 18 wherein there is less than 0.8 mm clearance between the liner and the sidewalls of the chamber.

15 22. A dry etching chamber according to Claim 17 wherein the liner is not mechanically attached to the top of the chamber.