[0007] Additionally or alternatively, in some such examples, a peak-to-peak variation of a thickness of the HDP barrier coating is less than or equal to 10% of an average value of the thickness.

[0008] Additionally or alternatively, in some such examples, the electrostatic chuck comprises aluminum nitride.

[0009] Another example provides a method of operating a vapor deposition tool. The method comprises placing a substrate on an electrostatic chuck comprising a HDP barrier coating. The method further comprises depositing an HDP film on the substrate using HDP-CVD.

[0010] In some such examples, depositing the HDP film on the substrate using HDP-CVD comprises forming an oxide layer in a fully depleted silicon-on-insulator substrate fabrication process.

[0011] Additionally or alternatively, in some such examples, the HDP barrier coating comprises one or more of silicon oxide, fluorine-doped silicon oxide, silicon oxynitride, silicon oxycarbide, silicon oxycarbonitride, or silicon carbide.

[0012] Additionally or alternatively, in some such examples, the HDP barrier coating has a thickness of 3 microns to 5 microns.

[0013] Additionally or alternatively, in some such examples, the method comprises, after depositing HDP oxide films on a plurality of substrates including the substrate, removing a pre-coating and the HDP barrier coating, and then applying a new pre-coating and a new HDP barrier coating on the electrostatic chuck.

[0014] Additionally or alternatively, in some such examples, removing the pre-coating and the HDP barrier coating comprises removing the pre-coating and the HDP barrier coating using a fluoride plasma.

[0015] Additionally or alternatively, in some such examples, the method comprises applying the HDP barrier coating to the electrostatic chuck using the vapor deposition tool.

[0016] Additionally or alternatively, in some such examples, the method comprises adjusting a processing gas mixture before applying the HDP barrier coating.

[0017] Another example provides a method of operating a HDP-CVD tool. The method comprises applying an HDP barrier coating to the electrostatic chuck.

[0018] In some such examples, the method comprises, before applying the HDP barrier coating to the electrostatic chuck, covering a top surface of one or more substrate contact areas of the electrostatic chuck with a protective cover, applying a pre-coating

to surfaces within a processing chamber of the HDP-CVD tool, and then uncovering the top surface of the one or more substrate contact areas of the electrostatic chuck.

[0019] Additionally or alternatively, in some such examples, the method comprises adjusting a processing gas mixture between applying the pre-coating and applying the HDP barrier coating to the electrostatic chuck.

[0020] Additionally or alternatively, in some such examples, the HDP barrier coating comprises one or more of silicon oxide, fluorine-doped silicon oxide, silicon oxynitride, silicon oxycarbide, silicon oxycarbonitride, or silicon carbide.

[0021] Additionally or alternatively, in some such examples, applying the HDP barrier coating comprises applying an HDP barrier coating having a thickness of 3 microns to 5 microns.

[0022] Additionally or alternatively, in some such examples, the method comprises, removing the HDP barrier coating, and then applying a new HDP barrier coating on the electrostatic chuck.

[0023] Additionally or alternatively, in some such examples, removing the HDP barrier coating comprises removing the HDP barrier coating using a fluoride plasma.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. 1 shows an example of an HDP-CVD (high-density plasma chemical vapor deposition) tool.

[0025] FIG. 2 shows a flow diagram depicting an example method of forming an HDP barrier coating on an electrostatic chuck.

[0026] FIG. 3 shows a flow diagram depicting an example method of operating a HDP-CVD tool.

[0027] FIG. 4 shows a flow diagram depicting another example method of operating a HDP-CVD tool.

[0028] FIGS. 5A-5F schematically show a cross-sectional view of a substrate at various stages in an example HDP-CVD process.

[0029] FIG. 6 shows an example of a silicon-on-insulator (SOI) wafer and an fully depleted SOI (FDSOI) device that can be produced using the HDP-CVD tool of FIG. 1.

[0030] FIG. 7 shows a chart illustrating example Al contamination levels of an HDP-CVD film deposited using an uncoated electrostatic chuck compared to an HPD-CVD film deposited using an electrostatic chuck coated with an HDP-CVD barrier coating.

[0031] FIG. 8 shows a flow diagram depicting another example method of operating a HDP-CVD tool.

[0032] FIG. 9 shows a schematic diagram of an example computing system.

DETAILED DESCRIPTION

[0033] The term "chemical vapor deposition" (CVD) generally represents a process in which a solid phase film is formed on a substrate by directing a flow of one or more precursor gases over the substrate surface under conditions configured to cause the chemical conversion of the precursor gases to the solid phase film. The term "plasma-enhanced chemical-vapor deposition" (PECVD) generally represents a CVD process in which a plasma is used to facilitate the chemical conversion of one or more precursor gases to a solid phase film on a substrate. The term "high-density plasma CVD" (HDP-CVD) generally represents a CVD process that uses an inductively coupled plasma to form a higher-density plasma than conventional PECVD. The terms "growth", "deposition", and variants thereof, also may be used to refer to film formation.

[0034] The term "electrostatic chuck" generally represents a physical structure configured to securely hold a substrate during a process by application of an electrostatic force.

[0035] The term "flow control hardware" generally represents components configured to place one or more chemical sources in fluid connection with a processing chamber. Flow control hardware may comprise one or more mass flow controllers and/or valves, for example.

[0036] The term "fully depleted silicon-on-insulator" (FDSOI) generally represents a semiconductor process technology utilizing a substrate with a base silicon layer, a thin "buried" oxide layer, and a top silicon layer covering the buried oxide layer. FDSOI transistor devices include channels built above the buried oxide layer. Due to the buried oxide layer, the channels can be undoped. The term "silicon-on-insulator" (SOI) refers generally to a substrate comprising a base silicon layer, a buried oxide layer, and a top silicon layer.

In some examples, the dielectric material can comprise aluminum nitride (AlN). An electric current conducted through the bipolar electrode and the substrate creates a charge layer at the dielectric-substrate interface. This charge layer creates an attractive electrostatic force to clamp the substrate to substrate contact areas 507 of the ESC. In some examples, the protective cover 504 is clamped in a similar manner. In other examples, the protective cover 504 is held in place by gravity, without an electrostatic clamping force. In some examples, other protective mechanism(s) can be used to shield the top surface of the substrate contact areas 507.

[0074] Referring again to FIG. 2, in examples that include optionally applying a precoating, after covering the ESC at 202, the method 200 comprises, at 204, applying the pre-coating to surfaces within a processing chamber of the HDP-CVD tool. For example, FIG. 5B schematically illustrates a pre-coating 508 within the processing chamber 500 of FIG. 5A. In the example of FIG. 5B, the pre-coating 508 is deposited on interior chamber surfaces, including exposed surfaces of the ESC 502 and the protective cover 504. The pre-coating 508 also is deposited on walls of the processing chamber 500, as well as other structures within the processing chamber.

[0075] The pre-coating 508 can be formed by introducing suitable precursor gases into the processing chamber while a plasma is ignited. In some examples, the pre-coating comprises one or more of SiO_2, fluorine-doped SiO_2, SiO_xN_y, SiO_xC_y, $SiO_xC_yN_z$, and/or SiC. The pre-coating is configured to prevent contamination of a substrate by materials from components of the processing chamber. As a more specific example, an SiO_2 pre-coating can be formed by introducing a Si-containing precursor gas (e.g., silane) in an oxygen-containing plasma.

[0076] Referring again to FIG. 2, after depositing the pre-coating, the method 200 comprises uncovering the electrostatic chuck at 206. FIG. 5C shows the processing tool 500 after pre-coating with the protective cover 504 removed. As illustrated in the example of FIG. 5C, the protective cover 504 prevents the pre-coating 508 from depositing on the substrate contact areas (SCAs) 507 of the ESC 502.

[0077] At 208, the method 200 of FIG. 2 comprises applying a HDP barrier coating to an electrostatic chuck of the HDP-CVD tool. FIG. 5D shows an example of a HDP barrier coating 510 on the substrate-facing surface of the ESC 502. In some examples, the HDP barrier coating 510 comprises a silicon oxide. Example silicon oxides include SiO_2, doped SiO_2 (e.g., fluorine-doped SiO_2), SiO_xN_y, SiO_xC_y, and/or

[0085] In some examples, the substrate 514 comprises a base layer of an SOI wafer. In some such examples, the HDP film 516 comprises an oxide layer of the SOI wafer. FIG. 6 shows an example of an SOI wafer 600 that can be produced using the methods and processing tools described herein. FIG. 6 also shows an example of an FDSOI device 602 that can be produced from the SOI wafer 600. The FDSOI device 602 comprises a device layer 604 and an insulating layer 606 on a substrate 608. The device layer 604 comprises a source 610 and a drain 612 separated by a fully depleted channel region 614. The FDSOI device 602 further comprises a gate 616 and a gate insulator 618. The insulating layer 606 can be silicon oxide formed using HDP-CVD, for example.

[0086] Referring again to FIG. 5F, in some examples, the HDP film 516 has a different composition and/or different physical properties (e.g., thickness, density, and/or electrical permittivity) than the HDP barrier coating 510 and/or the pre-coating 508. Some examples of suitable materials for the HDP film 516 include SiO_2 and fluorine-doped SiO_2. As described above, the different composition of the HDP film 516 can be achieved by adjusting the processing gas mixture between applying the pre-coating 508 and the HDP barrier coating 510.

[0087] In experiments, the presence of the HDP barrier coating resulted in a five-fold reduction in aluminum (Al) contamination in the HDP film from an AlN ESC relative to an HDP film deposited in the presence of a bare ESC. FIG. 7 shows an example chart of Al contents of an HDP film. As illustrated in FIG. 7, an HDP film deposited using a bare ESC had higher backside and in-film Al contamination than that deposited using an ESC with an HDP barrier coating.

[0088] Referring again to FIG. 3, steps 310 and 312 of the method 300 can be repeated for any suitable number of cycles 314 to deposit HDP films on a plurality of substrates. After a number of depositions of HDP films on substrates, the pre-coating and the HDP barrier coating can be removed and reapplied.

[0089] FIG. 4 shows a flow diagram depicting an example method 400 of operating a HDP-CVD tool, such as the HDP-CVD tool 100 of FIG. 1, to remove and reapply a HDP barrier coating. The method 400 comprises, at 416, removing the pre-coating and the HDP barrier coating after depositing an HDP film on a plurality of substrates. In some examples, the pre-coating and the HDP barrier coating are removed using a fluoride plasma. In other examples, any other suitable cleaning process can be used. Other examples of suitable cleaning processes include oxygen plasma cleaning

However, the purity may plateau with increasing thickness (e.g., at a thickness of greater than 5 microns).

[0096] The method 800 further comprises, at 812, placing a substrate on the electrostatic chuck comprising the HDP barrier coating. For example, FIG. 5E shows an example of a substrate 514 provided on the ESC 502 and the HDP barrier coating 510.

[0097] At 814, the method 800 further comprises depositing an HDP film on the substrate using HDP-CVD. FIG. 5F shows an example HDP film 516 deposited on the substrate 514.

[0098] In some examples, at 816, depositing the HDP film on the substrate using HDP-CVD comprises forming an oxide layer in an SOI wafer fabrication process. For example, FIG. 6 shows an example of an FDSOI device that includes an insulating layer 606. The insulating layer 606 can be formed by the processes and tools disclosed herein.

[0099] At 818, the method 800 optionally comprises, after depositing HDP oxide films on a plurality of substrates including the substrate, removing the pre-coating and the HDP-CVD barrier coating, and then applying a new pre-coating and a new HDP barrier coating on the electrostatic chuck. For example, the pre-coating and the HDP barrier coating 510 can be removed, the processing chamber 500 can be cleaned, and the pre-coating and the HDP barrier coating 510 can be rebuilt on the ESC 502.

[00100] In some examples, at 820, removing the HDP barrier coating comprises removing the HDP barrier coating using a fluoride plasma. In other examples, any other suitable cleaning technique can be used. For example, the processing chamber 102 of FIG. 1 can be cleaned using an oxygen plasma or a hydrogen plasma.

[00101] FIG. 9 schematically shows a non-limiting example of a computing system 900 that can enact one or more of the methods and processes described above. Computing system 900 is shown in simplified form. Computing system 900 can take the form of one or more personal computers, workstations, computers integrated with substrate processing tools, and/or network accessible server computers.%

[00102] Computing system 900 includes a logic machine 902 and a storage machine 904. Computing system 900 can optionally include a display subsystem 906, input subsystem 908, communication subsystem 910, and/or other components not shown in FIG. 9. Controller 134 is an example of computing system 900.

CLAIMS:

1. An electrostatic chuck, comprising:

a substrate-facing surface comprising one or more substrate contact areas; and

a high-density plasma (HDP) barrier coating on at least a portion of the one or more substrate contact areas.

2. The electrostatic chuck of claim 1, wherein the HDP barrier coating comprises one or more of silicon oxide, fluorine-doped silicon oxide, silicon oxynitride, silicon oxycarbide, silicon oxycarbonitride, or silicon carbide.

3. The electrostatic chuck of claim 1, wherein the HDP barrier coating has a thickness of 3 microns to 5 microns.

4. The electrostatic chuck of claim 1, wherein a peak-to-peak variation of a thickness of the HDP barrier coating is less than or equal to 10% of an average value of the thickness.

5. The electrostatic chuck of claim 1, wherein the electrostatic chuck comprises aluminum nitride.

6. A method of operating a vapor deposition tool, the method comprising:

placing a substrate on an electrostatic chuck comprising a high-density plasma (HDP) barrier coating; and

depositing an HDP film on the substrate using high-density plasma chemical vapor deposition (HDP-CVD).

7. The method of claim 6, wherein depositing the HDP film on the substrate using HDP-CVD comprises forming an oxide layer in a fully depleted silicon-on-insulator substrate fabrication process.

8. The method of claim 6, wherein the HDP barrier coating comprises one or more of silicon oxide, fluorine-doped silicon oxide, silicon oxynitride, silicon oxycarbide, silicon oxycarbonitride, or silicon carbide.

9. The method of claim 6, wherein the HDP barrier coating has a thickness of 3 microns to 5 microns.

10. The method of claim 6, further comprising, after depositing HDP oxide films on a plurality of substrates including the substrate, removing the pre-coating and the HDP barrier coating, and then applying a new pre-coating and a new HDP barrier coating on the electrostatic chuck.

11. The method of claim 10, wherein removing the pre-coating and the HDP barrier coating comprises removing the pre-coating and the HDP barrier coating using a fluoride plasma.

12. The method of claim 6, further comprising applying the HDP barrier coating to the electrostatic chuck using the vapor deposition tool.

13. The method of claim 12, further comprising adjusting a processing gas mixture before applying the HDP barrier coating.

14. A method of operating a high-density plasma chemical vapor deposition (HDP-CVD) tool, the method comprising:

applying an HDP barrier coating to an electrostatic chuck.

15. The method of claim 14, further comprising, before applying the HDP barrier coating to the electrostatic chuck, covering a top surface of one or more substrate contact areas of the electrostatic chuck with a protective cover, applying a pre-coating to surfaces within a processing chamber of the HDP-CVD tool, and then uncovering the top surface of the one or more substrate contact areas of the electrostatic chuck.