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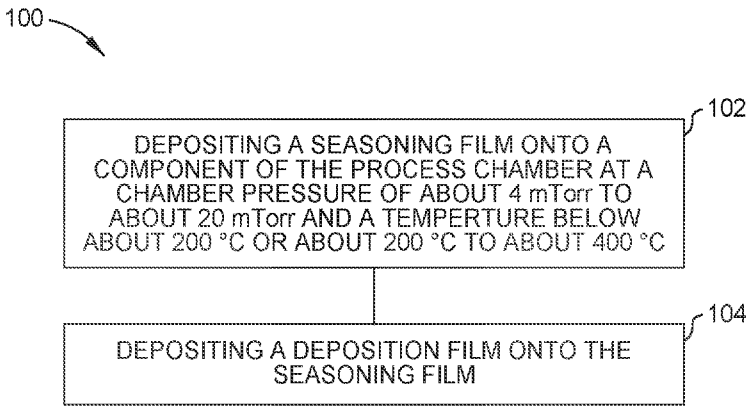


FIG. 1

(57) Abstract: Embodiments of the present disclosure relate to semiconductor processing. More specifically, embodiments of the present disclosure relate to methods for seasoning one or more components of a process chamber. In at least one embodiment, a method for seasoning a process chamber includes depositing a seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C. The method includes depositing a deposition film onto the seasoning film. In at least one embodiment, a method includes introducing a nitrogen-containing gas to the seasoning film to form a nitrogen-treated seasoning film. Introducing the nitrogen-containing gas to the seasoning film is performed before depositing the deposition film onto the seasoning film.

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METHODS OF SEASONING PROCESS CHAMBERS

BACKGROUND

Field

[0001] Embodiments of the present disclosure relate to semiconductor processing. More specifically, embodiments of the present disclosure relate to methods for seasoning one or more components of a process chamber.

Description of the Related Art

[0002] Semiconductor processing involves a number of different chemical and physical processes where small integrated circuits are created on a substrate. Layers of materials which make up the integrated circuit are created by chemical vapor deposition, physical vapor deposition, epitaxial growth, chemical treatment, electrochemical process and the like.

[0003] A typical semiconductor process chamber includes a chamber body defining a process zone, a gas distribution assembly adapted to supply a gas from a gas supply into the process zone, a gas energizer, e.g., a plasma generator, utilized to energize the process gas to process a substrate positioned on a substrate support assembly, and a gas exhaust. During plasma processing, the energized gas is often comprised of ions, radicals, and/or other highly reactive species which etch and erode exposed portions of the process chamber components, for example, an electrostatic chuck that holds the substrate during processing. Additionally, processing by-products are often deposited on chamber components which must be periodically cleaned typically with highly reactive fluorine. Accordingly, in order to maintain cleanliness of the process chamber, a periodic cleaning process is performed to remove the by-products from the process chamber. Attack from the reactive species during processing and cleaning reduces the lifespan of the chamber components and increases service frequency. Additionally, flakes, such as aluminum fluoride (AlF), from the eroded parts of the chamber component may become a source of particulate contamination during substrate processing. Furthermore, AlF3 formed on a relatively high temperature component surface during cleaning process could sublimate but

later deposit on a relatively low temperature chamber component surface, such as showerhead, after the cleaning process. This residual deposit can result in premature chamber component failure and frequent chamber maintenance.

[0004] Attempts have been made to protect ("season") chamber components by depositing protective materials (e.g., layers) onto one or more of the process chamber components. However, conventional seasoning methods do not work for CVD chambers that operate at low pressure (and/or low temperature). Such low pressure/low temperature CVD chambers can be advantageously used for depositing advanced patterning films onto a substrate, such as hardmask films, for example amorphous carbon hardmask films. Because of the low pressure, low temperature, and/or larger processing volume used for such chambers, conventional seasoning methods (of chamber components) provide materials (e.g., layers) that are prone to flaking and have inferior adhesion to the component(s) of the process chamber. Such flaking and inferior adhesion can promote contamination of substrates during processing.

[0005] Therefore, there is a need for improved processes for maintaining cleanliness of the process chamber and integrity of the chamber components to increase the lifetime of chamber components and provide high quality processed wafers.

SUMMARY

[0006] Embodiments of the present disclosure relate to semiconductor processing. More specifically, embodiments of the present disclosure relate to methods for seasoning one or more components of a process chamber.

[0007] In at least one emodiment, a method for seasoning a process chamber includes depositing a seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C. The method includes depositing a deposition film onto the seasoning film.

[0008] In at least one embodiment, a method includes depositing the seasoning film onto the component includes flowing the first carbon-containing precursor gas and the first inert precursor gas at a first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas. The method includes adjusting the first flow ratio to a second flow ratio of the first carbon-containing precursor gas and the first inert precursor gas.

[0009] In at least one embodiment, a method for seasoning a process chamber includes depositing a first seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C. The method includes depositing a second seasoning film onto the first seasoning film. The method includes depositing a deposition film onto the second seasoning film. Depositing the first seasoning film includes flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber.

[0010] In at least one embodiment, a method for seasoning a process chamber includes depositing a first seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C. The method includes depositing a plurality of additional seasoning films onto the first seasoning film. The method includes depositing a deposition film onto the plurality of additional seasoning films. Depositing the first seasoning film comprises flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only exemplary

embodiments and are therefore not to be considered limiting of scope, as the disclosure may admit to other equally effective embodiments.

[0012] Figure 1 is a process flow diagram of process for seasoning a process chamber, according to one aspect of the disclosure.

[0013] Figure 2 is a schematic side cross sectional view of a process chamber, according to one aspect of the disclosure.

[0014] Figure 3A is a schematic side cross sectional view of a portion of a lid coupled to a conduit, according to one aspect of the disclosure.

[0015] Figure 3B is a perspective view of a showerhead of the lid of Figure 2A.

[0016] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

[0017] Embodiments of the present disclosure relate to semiconductor processing. More specifically, embodiments of the present disclosure relate to methods for seasoning one or more components of a process chamber.

[0018] Methods of the present disclosure can provide reduced flaking of protective materials (a deposition film) and improved adhesion of the deposition film to a chamber component by providing a seasoning film disposed between the deposition film and the chamber component. For example, a deposition film can have an intrinsic stress of about 400 MPa or less (compressive), such as about 100 MPa to about 300 MPa (compressive), whereas a chamber component (e.g., an aluminum-containing component) can have an intrinsic stress of about 800 MPa or greater (compressive), such as about 900 MPa to about 1,200 MPa (compressive). Additionally or alternatively, the chamber component can have an intrinsic stress of about 100 MPa or greater (tensile),

such as about 200 MPa to about 500 MPa (tensile). Such a mismatch of intrinsic stress of the deposition film and the chamber component promotes flaking and inferior adhesion of the deposition film and the chamber component. However, the inventors have discovered that by controlling the intrinsic stress of a seasoning film, a seasoning film can be tailored to beneficially adhere to the deposition film on one side of the seasoning film and adhere to the chamber component on an opposite side of the seasoning film. The inventors have discovered a number of approaches to accomplish such improvements. For purposes of the present disclosure, intrinsic stress can be determined by sticking a coupon on a chamber component, depositing the film to be measured on the coupon, removing the coupon with film deposited thereon, and analyzing the film using any suitable optical spectroscopy technique. Examples of process chambers that may be adapted to benefit from exemplary aspects of the disclosure include the PIONEER™ PECVD system commercially available from Applied Materials, Inc., located in Santa Clara, California. It is contemplated that other process chambers and/or processing platforms, including those from other manufacturers, may be adapted to benefit from aspects of the disclosure.

[0019] In some embodiments, as shown in FIG. 1, a method **100** for seasoning a process chamber (e.g., one or more components of a process chamber) includes depositing **102** a seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C. The method can include depositing **104** a deposition film onto the seasoning film. In at least one embodiment, the temperature is from about 100 °C to about 200 °C. Alternatively, the temperature may be about 200 °C to about 400 °C, such as about 250 °C to about 350 °C. A higher temperature can provide better film quality, adhesion, and/or lower intrinsic stress (as compared to processes using a lower temperature). For example, adhesion can be improved because (1) a seasoning film and a deposition film and/or (2) a seasoning film and a chamber component can to some extent diffuse with each other better (as compared to processes using a lower temperature). However, use of a higher temperature increases cost of performing a method.

[0020] Depositing the seasoning film can include flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber. Depositing the deposition film can include flowing a second carbon-containing precursor gas and a second inert precursor gas into the process chamber. The second carbon-containing precursor gas is the same as or different than the first carbon-containing precursor gas, and the second inert precursor gas is the same as or different than the first inert precursor gas. In some embodiments, the first carbon-containing precursor gas and/or the second carbon-containing precursor gas is acetylene. In some embodiments, the first inert precursor gas and/or the second inert precursor gas is helium.

[0021] Flowing the first carbon-containing precursor gas and the first inert precursor gas into the process chamber can include flowing the first carbon-containing precursor gas into the process chamber at a flow rate of about 100 sccm to about 600 sccm, and flowing the first inert precursor gas into the process chamber at a flow rate of about 150 sccm to about 800 sccm. These flow rates are based on chambers designed to process 300mm wafers.

[0022] The deposition film can be an amorphous carbon-containing film. In some embodiments, the deposition film has an intrinsic stress of about 400 MPa or less (compressive), such as about 100 MPa to about 300 MPa (compressive). The chamber component is a metal-containing component, such as aluminum or an aluminum alloy. The chamber component can have an intrinsic stress of about 800 MPa or greater (compressive), such as about 900 MPa to about 1,200 MPa (compressive). Additionally or alternatively, the chamber component can have an intrinsic stress of about 100 MPa or greater (tensile), such as about 200 MPa to about 500 MPa (tensile).

[0023] Depositing the deposition film onto the seasoning film is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 ^{o}C. Depositing the deposition film onto the seasoning film is performed by flowing the second carbon-containing precursor gas into the process chamber at a flow rate of about 200 sccm to about 400 sccm. In some

embodiments, depositing the deposition film onto the seasoning film includes providing an RF power of about 1 kW to about 6 kW to the process chamber.

[0024] Methods may further include introducing a nitrogen-containing gas to the seasoning film to form a nitrogen-treated seasoning film. Introducing the nitrogen-containing gas to the seasoning film can be performed before depositing the deposition film onto the seasoning film.

[0025] Introducing the nitrogen-containing gas to the seasoning film can be performed at a chamber pressure of about 4 mTorr to about 20 mTorr and/or a temperature below about 200 °C. The nitrogen-containing gas can include any suitable nitrogen-containing gas, such as ammonia. Introducing the nitrogen-containing gas to the seasoning film can include flowing the nitrogen-containing gas into the process chamber at a flow rate of about 25 sccm to about 1,000 sccm, such as about 50 sccm to about 600 sccm. Introducing the nitrogen-containing gas to the seasoning film may include providing an RF power of about 100 kW to about 4,000 kW to the process chamber to activate the nitrogen-containing gas.

[0026] Introducing nitrogen-containing gas to a seasoning film(s) of the present disclosure can provide a nitrogen terminated surface that provides a nucleation site for the deposition film, providing improved adhesion to the deposition film and controlled bonding structure of the deposition film (e.g., low intrinsic stress of the deposition layer). Because introducing nitrogen-containing gas to a seasoning film(s) can be performed at low temperature and/or low pressure, the nitrogen treatment can occur predominantly at the surface of the seasoning film(s), promoting bonding to and nucleation of the deposition film. In addition, because the deposition film can be deposited at low temperature and/or low pressure, the deposition layer can have a low nitrogen content, reducing instrinsic stress and flaking of the deposition film.

[0027] The component of the process chamber can be any suitable component, such as a wall of the chamber, a spacer, a substrate support (such as an edge ring), and the like. In at least one embodiment, the component is

not a wafer, e.g., not a semiconductor wafer. For example, processes can include placing an inert substrate on a pedestal of the chamber and performing a seasoning method. In some embodiments, a component of the process chamber is an interior wall of the process chamber. Interior walls can be larger than the walls of conventional CVD chambers, such as the walls of the Pioneer™ process chamber. Large walls are conventionally very difficult to season properly, and methods of the present disclosure can overcome such limitations.

Graded Seasoning Films

[0028] In some embodiments which may be combined with other embodiments, depositing the seasoning film onto the component includes flowing the first carbon-containing precursor gas and the first inert precursor gas at a first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas. Methods include adjusting the first flow ratio to a second flow ratio of the first carbon-containing precursor gas and the first inert precursor gas. Adjusting the first flow ratio to a second flow ratio provides control of the bonding structure (e.g., sp^2 vs. sp^3 carbon-content) of surfaces of the seasoning film. For example, adjusting the first flow ratio slowly to the second flow ratio can provide a graded seasoning film with a progressive change in bonding structure from the side of the seasoning film disposed on the component to the side of the seasoning film having the deposition film disposed thereon. The hybridization of surfaces of a seasoning film can affect adhesion of a surface of the seasoning film to the chamber component and the deposition layer. Higher sp^2 character provides increased intrinsic stress. For example, a first flow ratio can promote high intrinsic stress (of a first surface of a seasoning film) for beneficial adhesion to a chamber component, whereas a second flow ratio can provide low intrinsic stress (of a second side of a seasoning provides reduced flaking of the deposition film and/or seasoning film, as compared to materials of conventional seasoning methods.

[0029] In some embodiments, a seasoning film is an amorphous carbon-containing film. In some embodiments, the seasoning film has an intrinsic

stress of about 300 MPa to about 800 MPa (compressive). The seasoning film can progress from about 300 MPa to about 550 MPa (compressive) on a first side to about 550 MPa to about 800 MPa (compressive) on a second side. The gradient of intrinsic stress of the seasoning film provides improved adhesion and reduced flaking (as compared to conventional seasoning films of high temperature/high pressure CVD chambers).

[0030] In at least one embodiment, the first flow ratio is about 1:1 to about 1:2. In some embodiments, the second flow ratio is about 10:1 to about 1:1 or about 1:2 to about 1:10. For example, a high acetylene to helium ratio can provide higher intrinsic stress (as compared to a lower ratio). The more acetylene is diluted (e.g., 1:10 ratio) then material having lower intrinsic stress will form.

[0031] Adjusting the first flow ratio to the second flow ratio may be performed at a rate of about 1 sccm/sec to about 20 sccm/sec.

[0032] Depositing the seasoning film onto the component can include providing a first RF power to the chamber (e.g., provided from a bottom electrode of the chamber (e.g., pedestal)), and adjusting the first RF power to a second RF power. Adjusting the first RF power to a second RF power provides control of the bonding structure (e.g., sp^2 vs. sp^3 carbon-content) of surfaces of the seasoning film. For example, adjusting the first RF power slowly to the second RF power can provide a graded seasoning film with a progressive change in bonding structure from the side of the seasoning film disposed on the component to the side of the seasoning film having the deposition film disposed thereon. For example, a first RF power can promote high intrinsic stress (of a first surface of a seasoning film) for beneficial adhesion to a chamber component, whereas a second RF power can provide low intrinsic stress (of a second side of a seasoning film) for beneficial adhesion to a deposition layer. The beneficial adhesion provides reduced flaking of the deposition film and/or seasoning film, as compared to materials of conventional seasoning methods.

[0033] In some embodiments, methods include adjusting the first RF power to the second RF power at a rate of about 20 W/sec to about 500 W/sec. In at least one embodiment, the first RF power and the second RF power are independently about 1 kW to about 6 kW. For example, the first RF power may be from about 1 kW to about 4 kW and the second RF power may be from about 4 kW to about 6 kW. Low RF power provides material having high intrinsic stress, whereas high RF power provides material having low intrinsic stress.

[0034] In some embodiments, the seasoning film can have a thickness of about 100 nm to about 700 nm. The deposition film may have a thickness of about 500 nm to about 3 microns.

[0035] Methods may further include introducing a nitrogen-containing gas to the seasoning film to form a nitrogen-treated seasoning film. Introducing the nitrogen-containing gas to the seasoning film can be performed before depositing the deposition film onto the seasoning film. In some embodiments, introducing the nitrogen-containing gas to the seasoning film is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 ^{o}C. The nitrogen-containing gas can include any suitable nitrogen-containing gas, such as ammonia.

[0036] Introducing the nitrogen-containing gas to the seasoning film can include flowing the nitrogen-containing gas into the process chamber at a flow rate of about 25 sccm to about 1,000 sccm, such as about 50 sccm to about 600 sccm. In some embodiments, introducing the nitrogen-containing gas to the seasoning film comprises providing an RF power of about 100 kW to about 4,000 kW to the process chamber.

Bilayer Seasoning Films

[0037] In some embodiments, a method for seasoning a process chamber includes depositing a first seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 ^{o}C or from about 200 ^{o}C to about 400 ^{o}C. In some embodiments, the temperature is about 100 ^{o}C to about 200 ^{o}C. Alternatively,

in some embodiments, the temperature is about 200 °C to about 400 °C, such as about 250 °C to about 300 °C. Depositing the first seasoning film includes flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber. The methods include depositing a second seasoning film onto the first seasoning film.

[0038] In some embodiments, a first seasoning film and/or a second seasoning film is an amorphous carbon-containing film. In some embodiments, a first seasoning film and/or a second seasoning film has an intrinsic stress of independently about 300 MPa to about 800 MPa (compressive). In some embodiments, a first seasoning film has an intrinsic stress of about 550 MPa to about 800 MPa (compressive). In at least one embodiment, a second seasoning film has an intrinsic stress of about 300 MPa to about 550 MPa (compressive).

[0039] Depositing the second seasoning film onto the first seasoning film can be performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C. Depositing the second seasoning film can include flowing a second carbon-containing precursor gas and a second inert precursor gas into the process chamber.

[0040] Methods may further include depositing a deposition film onto the second seasoning film. Depositing the deposition film can include flowing a third carbon-containing precursor gas and a third inert precursor gas into the process chamber. The second carbon-containing precursor gas is the same as or different than the first or third carbon-containing precursor gas, and the second inert precursor gas is the same as or different than the first or third inert precursor gas. Likewise, the third carbon-containing precursor gas is the same as or different than the first or second carbon-containing precursor gas and the third inert precursor gas is the same as or different than the first or second inert precursor gas. In some embodiments, the first carbon-containing precursor gas and/or the second carbon-containing precursor gas include acetylene. In some embodiments, the first inert precursor gas and/or the second inert precursor gas include helium.

[0041] Depositing the first seasoning film onto the component can include flowing the first carbon-containing precursor gas and the first inert precursor gas at a first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas. Depositing the second seasoning film onto the first seasoning film can include adjusting the first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas to a second flow ratio. Adjusting the first flow ratio to a second flow ratio provides control of the bonding structure (e.g., sp^2 vs. sp^3 carbon-content) of surfaces of the seasoning film. For example, adjusting the first flow ratio quickly to the second flow ratio can provide a bilayer seasoning film with a change in bonding structure from the side of the first seasoning film disposed on the component to the side of the second seasoning film having the deposition film disposed thereon. For example, a first flow ratio can promote high intrinsic stress (of a first seasoning film) for beneficial adhesion to a chamber component, whereas a second flow ratio can provide low intrinsic stress (of a second seasoning film) for beneficial adhesion to a deposition layer. The beneficial adhesion provides reduced flaking of the deposition film and/or seasoning film, as compared to materials of conventional seasoning methods.

[0042] In some embodiments, the first flow ratio is about 1:1 to about 1:2. In at least one embodiment, the second flow ratio is about 10:1 to about 1:1 or about 1:2 to about 1:10.

[0043] Adjusting the first flow ratio to the second flow ratio can performed at a rate of about 1 second or less, such as about 0.5 seconds or less.

[0044] In some embodiments, depositing the first seasoning film onto the component includes providing a first RF power to the chamber. Depositing the second seasoning film onto the first seasoning film can include adjusting the first RF power to a second RF power. Adjusting the first RF power to the second RF power may be performed at a rate of about 1 second or less, such as about 0.5 seconds or less.

[0045] Depositing the deposition film onto the second seasoning film can be performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C. Depositing the deposition film onto the second seasoning film can be performed by flowing a third carbon-containing precursor gas into the process chamber at a flow rate of about 200 sccm to about 400 sccm.

[0046] In some embodiments, the first carbon-containing precursor gas, the second carbon-containing precursor gas, and/or the third carbon-containing precursor gas include acetylene. In some embodiments, the first inert precursor gas, the second inert precursor gas, and/or the third inert precursor gas include helium. Depositing the deposition film onto the second seasoning film can include providing an RF power of about 1 kW to about 6 kW to the process chamber.

[0047] In at least one embodiment, flowing the first carbon-containing precursor gas and the first inert precursor gas into the process chamber can include flowing the first carbon-containing precursor gas into the process chamber at a flow rate of about 100 sccm to about 600 sccm, and/or flowing the first inert precursor gas into the process chamber at a flow rate of about 150 sccm to about 800 sccm. Flowing the second carbon-containing precursor gas and the second inert precursor gas into the process chamber can include flowing the second carbon-containing precursor gas into the process chamber at a flow rate of about 100 sccm to about 600 sccm. The flow rate of the second carbon-containing precursor gas can be different than the flow rate of the first carbon-containing precursor gas. Flowing the second inert precursor gas into the process chamber can be performed at a flow rate of about 150 sccm to about 800 sccm. The flow rate of the second inert precursor gas can be different than the flow rate of the first inert precursor gas.

[0048] Depositing the first seasoning film onto the component can include providing a first RF power to the chamber. Depositing the second seasoning film onto the first seasoning film can include providing a second RF power to the chamber, where the second RF power is different than the first RF power.

The first RF power can be adjusted to the second RF power. Providing a second RF power different than the first RF power provides control of the bonding structure (e.g., sp^2 vs. sp^3 carbon-content) of surfaces of the seasoning film. For example, adjusting the first RF power quickly to the second RF power can provide a graded seasoning film with a change in bonding structure from the side of the seasoning film disposed on the component to the side of the seasoning film having the deposition film disposed thereon. For example, a first RF power can promote high intrinsic stress (of a first seasoning film) for beneficial adhesion to a chamber component, whereas a second RF power can provide low intrinsic stress (of a second seasoning film) for beneficial adhesion to a deposition layer. The beneficial adhesion provides reduced flaking of the deposition film and/or seasoning film, as compared to materials of conventional seasoning methods.

[0049] In some embodiments, the first RF power and the second RF power are independently about 1 kW to about 6 kW. In at least one embodiment, the first RF power is from about 1 kW to about 3 kW and the second RF power is from about 3 kW to about 6 kW.

[0050] In some embodiments, the first seasoning film and the second seasoning film can have a combined thickness of about 100 nm to about 700 nm. A thickness ratio of first seasoning film to second seasoning film can be from about 2:1 to about 1:10, such as about 1:1. The deposition film can have a thickness of about 500 nm to about 3 microns.

[0051] Methods may further include introducing a nitrogen-containing gas to the second seasoning film to form a nitrogen-treated seasoning film. Introducing the nitrogen-containing gas to the second seasoning film can be performed before depositing the deposition film onto the second seasoning film. In some embodiments, introducing the nitrogen-containing gas to the second seasoning film is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 ^oC. The nitrogen-containing gas can include any suitable nitrogen-containing gas, such as ammonia.

[0052] Introducing the nitrogen-containing gas to the second seasoning film can include flowing the nitrogen-containing gas into the process chamber at a flow rate of about 25 sccm to about 1,000 sccm, such as about 50 sccm to about 600 sccm. In some embodiments, introducing the nitrogen-containing gas to the second seasoning film includes providing an RF power of about 100 kW to about 4,000 kW to the process chamber.

Multilayer Seasoning Films

[0053] Methods of the present disclosure can include depositing a first seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C. The temperature can be from about 100 °C to about 200 °C. Alternatively, the temperature can be about 200 °C to about 400 °C, such as about 250 °C to about 300 °C. Methods include depositing a plurality of additional seasoning films onto the first seasoning film. Methods can include depositing a deposition film onto the plurality of additional seasoning films.

[0054] In some embodiments, a first seasoning film and/or one or more films of a plurality of additional seasoning films is an amorphous carbon-containing film. In some embodiments, a first seasoning film and/or one or more films of a plurality of additional seasoning films has an intrinsic stress of independently about 300 MPa to about 800 MPa (compressive). In some embodiments, a first seasoning film has an intrinsic stress of about 550 MPa to about 800 MPa (compressive). In at least one embodiment, one or more films of a plurality of additional seasoning films has an intrinsic stress of independently about 300 MPa to about 550 MPa (compressive).

[0055] Depositing the first seasoning film can include flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber.

[0056] A plurality of additional seasoning films may be about 3 additional seasoning films to about 14 additional seasoning films, such as about 4 additional seasoning films to about 10 additional seasoning films, such as about 4 additional seasoning films to about 8 additional seasoning films. In some embodiments, depositing the plurality of additional seasoning films includes depositing a second seasoning film onto the first seasoning film by flowing a second carbon-containing precursor gas and a second inert precursor gas into the process chamber. Depositing the plurality of additional seasoning films can include depositing a third seasoning film onto the second seasoning film by flowing a third carbon-containing precursor gas and a third inert precursor gas into the process chamber. Depositing the plurality of additional seasoning films can include depositing a fourth seasoning film onto the third seasoning film by flowing a fourth carbon-containing precursor gas and a fourth inert precursor gas into the process chamber. The second, third, and fourth carbon-containing precursor gases are independently the same as or different than each other. In some embodiments, the first carbon-containing precursor gas, the second carbon-containing precursor gas, the third carbon-containing precursor gas, and/or the fourth carbon-containing precursor gas include acetylene. The second, third, and fourth inert precursor gases are independently the same as or different than each other. In some embodiments, the first inert precursor gas, the second inert precursor gas, the third inert precursor gas, and/or the fourth inert precursor gas comprise helium.

[0057] In some embodiments, depositing the plurality of additional seasoning films includes depositing a fifth seasoning film onto the fourth seasoning film by flowing a fifth carbon-containing precursor gas and a fifth inert precursor gas into the process chamber. Methods can include depositing a sixth seasoning film onto the fifth seasoning film by flowing a sixth carbon-containing precursor gas and a sixth inert precursor gas into the process chamber. Methods can include depositing a seventh seasoning film onto the sixth seasoning film by flowing a seventh carbon-containing precursor gas and a seventh inert precursor gas into the process chamber. Methods can include depositing an eighth seasoning film onto the seventh seasoning film by flowing

an eighth carbon-containing precursor gas and an eighth inert precursor gas into the process chamber. The fifth, sixth, seventh, and eighth carbon-containing precursor gases are independently the same as or different than each other. In some embodiments, the first carbon-containing precursor gas, the second carbon-containing precursor gas, the third carbon-containing precursor gas, the fourth carbon-containing precursor gas, the fifth carbon-containing precursor gas, the sixth carbon-containing precursor gas, the seventh carbon-containing precursor gas, and/or the eighth carbon-containing precursor gas include acetylene. The fifth, sixth, seventh, and eighth inert precursor gases are independently the same as or different than each other. In some embodiments, the first inert precursor gas, the second inert precursor gas, the third inert precursor gas, the fourth inert precursor gas, the fifth inert precursor gas, the sixth inert precursor gas, the seventh inert precursor gas, and/or eighth inert precursor gas include helium.

[0058] In some embodiments, depositing one or more seasoning film of the plurality of additional seasoning films is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and/or a temperature below about 200 ^{o}C. In at least one embodiment, depositing each seasoning film of the plurality of additional seasoning films is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 ^{o}C.

[0059] In some embodiments, each seasoning film of the plurality of additional seasoning films has a different intrinsic stress than an adjacent seasoning film of the plurality of additional seasoning films. For example, a third seasoning film has a different intrinsic stress than a second seasoning film and a fourth seasoning film. Likewise, in some embodiments, a second seasoning film has a different intrinsic stress than a first seasoning film and a third seasoning film. In some embodiments, a first seasoning film has substantially the same intrinsic stress as a third seasoning film, a fifth seasoning film, and/or a seventh seasoning film. In at least one embodiment, a second seasoning film has substantially the same intrinsic stress as a fourth seasoning film, a sixth seasoning film, and/or an eigth seasoning film.

[0060] Depositing the first seasoning film onto the component can include flowing the first carbon-containing precursor gas and the first inert precursor gas at a first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas. Depositing a second seasoning film onto the first seasoning film comprises adjusting the first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas to a second flow ratio. Depositing a third seasoning film onto the second seasoning film can include adjusting the second flow ratio of the second carbon-containing precursor gas and the second inert precursor gas to a third flow ratio. Depositing a fourth seasoning film onto the third seasoning film can include adjusting the third flow ratio of the third carbon-containing precursor gas and the third inert precursor gas to a fourth flow ratio. In some embodiments, the first flow ratio and the third flow ratio are independently about 1:1 to about 1:2. The second flow ratio and the fourth flow ratio can be about 10:1 to about 1:1 or about 1:2 to about 1:10.

[0061] Adjusting the first flow ratio to the second flow ratio, the second flow ratio to the third flow ratio, and/or the third flow ratio to the fourth flow ratio can be performed at a rate of independently about 1 second or less, such as about 0.5 seconds or less.

[0062] Depositing a fifth seasoning film onto the fourth seasoning film can include flowing the fifth carbon-containing precursor gas and the fifth inert precursor gas at a fifth flow ratio of the fifth carbon-containing precursor gas and the fifth inert precursor gas. Depositing a sixth seasoning film onto the fifth seasoning film comprises adjusting the fifth flow ratio of the fifth carbon-containing precursor gas and the fifth inert precursor gas to a sixth flow ratio. Depositing a seventh seasoning film onto the sixth seasoning film can include adjusting the sixth flow ratio of the sixth carbon-containing precursor gas and the sixth inert precursor gas to a seventh flow ratio. Depositing an eighth seasoning film onto the seventh seasoning film can include adjusting the seventh flow ratio of the seventh carbon-containing precursor gas and the seventh inert precursor gas to an eighth flow ratio. In some embodiments, the fifth flow ratio and the seventh flow ratio are independently about 1:1 to about

1:2. The sixth flow ratio and the eighth flow ratio may be about 10:1 to about 1:1 or about 1:2 to about 1:10.

[0063] Adjusting the first flow ratio to the second flow ratio, the second flow ratio to the third flow ratio, the third flow ratio to the fourth flow ratio, the fourth flow ratio to the fifth flow ratio, the fifth flow ratio to the sixth flow ratio, the sixth flow ratio to the seventh flow ratio, and/or the seventh flow ratio to the eight flow ratio can be performed at a rate of independently about 1 second or less, such as about 0.5 seconds or less.

[0064] Adjusting the first flow ratio to a second flow ratio, the second flow ratio to a third flow ratio, the third flow ratio to a fourth flow ratio, etc. provides control of the bonding structure (e.g., sp^2 vs. sp^3 carbon-content) of surfaces of the overall seasoning film structure. For example, adjusting a flow ratio quickly to another flow ratio (e.g., alternating flow ratios 1 to 2 to 3 (e.g., same as 1) to 4 (e.g., same as 2), etc.) can provide an alternating seasoning film structure with an alternating change in bonding structure from one seasoning film to an adjacent seasoning film. The hybridization of surfaces of the seasoning films (of the overall seasoning film structure) can affect adhesion of a surface of the seasoning film structure to the chamber component and the deposition layer. Higher sp^2 character provides increased intrinsic stress. For example, a first flow ratio, a third flow ratio, a fifth flow ratio, and/or a seventh flow ratio can promote high intrinsic stress (of a surface of a seasoning film) for beneficial adhesion to a chamber component, whereas a second flow ratio, a fourth flow ratio, a sixth flow ratio, and/or an eigth flow ratio can provide low intrinsic stress (of the overall seasoning film structure) for beneficial adhesion to a deposition layer. The alternating deposition films provide low intrinsic stress of the overall seasoning film structure (and low intrinsic stress among the individual films due to thinness of each film), which promotes adhesion to adjacent components (such as the chamber component and the deposition film). The beneficial adhesion provides reduced flaking of the deposition film and/or seasoning film, as compared to materials of conventional seasoning methods.

[0065] Methods can include depositing the first seasoning film onto the component by providing a first RF power to the chamber. Depositing the second seasoning film onto the first seasoning film can include adjusting the first RF power to a second RF power. Depositing the third seasoning film onto the second seasoning film can include adjusting the second RF power to a third RF power. Depositing the fourth seasoning film onto the third seasoning film can include adjusting the third RF power to a fourth RF power. Adjusting the first RF power to the second RF power, the second RF power to the third RF power, and/or the third RF power to the fourth RF power can be performed at a rate of independently about 1 second or less, such as about 0.5 seconds or less. In some embodiments, the first RF power, the second RF power, the third RF power, and/or the fourth RF power are independently about 1 kW to about 6 kW. In some embodiments, the first RF power and/or third RF power are from independently about 1 kW to about 3 kW. In at least one embodiment, the second RF power and/or the fourth RF power are from independently about 3 kW to about 6 kW.

[0066] In some embodiments, depositing a fifth seasoning film onto the fourth seasoning film includes adjusting the fourth RF power to a fifth RF power. Depositing a sixth seasoning film onto the fifth seasoning film can include adjusting the fifth RF power to a sixth RF power. Depositing a seventh seasoning film onto the sixth seasoning film can include adjusting the sixth RF power to a seventh RF power. Depositing an eighth seasoning film onto the seventh seasoning film comprises adjusting the seventh RF power to an eigth RF power. Adjusting the first RF power to the second RF power, the second RF power to the third RF power, the third RF power to the fourth RF power, the fourth RF power to the fifth RF power, the fifth RF power to the sixth RF power, the sixth RF power to the seventh RF power, and/or the seventh RF power to the eigth RF power can be performed at a rate of independently about 1 second or less, such as about 0.5 seconds or less. In some embodiments, the first RF power, the second RF power, the third RF power, the fourth RF power, the fifth RF power, the sixth RF power, the seventh RF power, and/or the eighth RF power are independently about 1 kW to about 6 kW. In at least one

embodiment, the first RF power, the third RF power, the fifth RF power, and/or the seventh RF power are from independently about 1 kW to about 3 kW. The second RF power, the fourth RF power, the sixth RF power, and/or the eigth RF power may be from independently about 3 kW to about 6 kW.

[0067] Adjusting the first RF power to a second RF power, the second RF power to a third RF power, the third RF power to a fourth RF power, etc. provides control of the bonding structure (e.g., sp^2 vs. sp^3 carbon-content) of surfaces of the overall seasoning film structure. For example, adjusting an RF power quickly to another RF power (e.g., alternating RF power 1 to 2 to 3 (e.g., same as 1) to 4 (e.g., same as 2), etc.) can provide an alternating seasoning film structure with an alternating change in bonding structure from one seasoning film to an adjacent seasoning film. The hybridization of surfaces of the seasoning films (of the overall seasoning film structure) can affect adhesion of a surface of the seasoning film structure to the chamber component and the deposition layer. Higher sp^2 character provides increased intrinsic stress. For example, a first RF power, a third RF power, a fifth RF power, and/or a seventh RF power can promote high intrinsic stress (of a surface of a seasoning film) for beneficial adhesion to a chamber component, whereas a second RF power, a fourth RF power, a sixth RF power, and/or an eighth RF power can provide low intrinsic stress (of a second side of the overall seasoning film structure) for beneficial adhesion to a deposition layer. The alternating deposition films provide low intrinsic stress of the overall seasoning film structure, which promotes adhesion to adjacent components (such as the chamber component and the deposition film). The beneficial adhesion provides reduced flaking of the deposition film and/or seasoning film, as compared to materials of conventional seasoning methods.

[0068] In some embodiments, flowing the first carbon-containing precursor gas and the first inert precursor gas into the process chamber includes flowing the first carbon-containing precursor gas into the process chamber at a flow rate of about 100 sccm to about 600 sccm, and/or flowing the first inert precursor gas into the process chamber at a flow rate of about 150 sccm to about 800 sccm.

[0069] In some embodiments, flowing the first inert precursor gas, the second carbon-containing precursor gas, the third carbon-containing precursor gas, and/or the fourth carbon-containing precursor gas into the process chamber are performed at a flow rate of independently about 100 sccm to about 600 sccm. Flowing the first inert precursor gas, the second inert precursor gas, the third inert precursor gas, and the fourth inert precursor gas into the process chamber can be performed at a flow rate of independently about 150 sccm to about 800 sccm.

[0070] In some embodiments, flowing the first inert precursor gas, the second carbon-containing precursor gas, the third carbon-containing precursor gas, the fourth carbon-containing precursor gas, the fifth carbon-containing precursor gas, the sixth carbon-containing precursor gas, the seventh carbon-containing precursor gas, and/or the eighth carbon-containing precursor gas into the process chamber are performed at a flow rate of independently about 100 sccm to about 600 sccm. Flowing the first inert precursor gas, the second inert precursor gas, the third inert precursor gas, the fourth inert precursor gas, the fifth inert precursor gas, the sixth inert precursor gas, the seventh inert precursor gas, and/or the eighth inert precursor gas into the process chamber can be performed at a flow rate of independently about 150 sccm to about 800 sccm.

[0071] The first seasoning film and the plurality of additional seasoning films have a combined thickness of about 100 nm to about 700 nm. For example, the first seasoning film can have a thickness of about 10 nm to about 100 nm. One or more films of the plurality of additional seasoning films can have a thickness of independently about 10 nm to about 100 nm. The deposition film may have a thickness of about 500 nm to about 3 microns.

[0072] In some emodiments, depositing the deposition film onto the plurality of additional seasoning films is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 ^{o}C. Depositing the deposition film onto the plurality of additional seasoning films can be performed by flowing a carbon-containing precursor gas into the process

chamber at a flow rate of about 200 sccm to about 400 sccm. Depositing the deposition film onto the plurality of additional seasoning films may include providing an RF power of about 1 kW to about 6 kW to the process chamber.

[0073] Methods may further include introducing a nitrogen-containing gas to one or more films of the plurality of additional seasoning films to form a nitrogen-treated seasoning film. For example, a film of the plurality may have a surface exposed to the interior chamber volume, e.g. the film is a film/the film to which the deposition film is deposited thereon. Introducing the nitrogen-containing gas to the film of the plurality of additional seasoning films can be performed before depositing the deposition film onto the film of the plurality of additional seasoning films. In some embodiments, introducing the nitrogen-containing gas to the film is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 ^{o}C. The nitrogen-containing gas can include any suitable nitrogen-containing gas, such as ammonia.

[0074] Introducing the nitrogen-containing gas to the film can include flowing the nitrogen-containing gas into the process chamber at a flow rate of about 25 sccm to about 1,000 sccm, such as about 50 sccm to about 600 sccm. In some embodiments, introducing the nitrogen-containing gas to the second seasoning film includes providing an RF power of about 100 kW to about 4,000 kW to the process chamber.

Chamber Hardware

[0075] Methods of the present disclosure can be performed in a substrate process chamber utilized in substrate processing in the manufacture of electronic devices. Substrate processing includes deposition processes, etch processes, as well as other low pressure processes, plasma processes, and thermal processes used to manufacture electronic devices on substrates.

[0076] Figure 2 is a schematic side cross sectional view of an illustrative process chamber **200** suitable for conducting a seasoning process. In one embodiment, the process chamber **200** may be configured to deposit advanced patterning films onto a substrate, such as hardmask films, for example

amorphous carbon hardmask films. The process chamber **200** includes a lid **300**, a spacer **210** disposed on a chamber body **292**, a substrate support **215**, and a variable pressure system **220**. A processing volume **260** exists inside the spacer **210** between the lid **300** and the substrate support **215**.

[0077] The lid **300** is coupled to a first process gas source **240**. The first process gas source **240** may contain a process gas, such as precursor gas for forming films on a substrate **218** supported on the substrate support **215**. As an example, the precursor gas may include carbon-containing gas. As an example, the precursor gas may include an inert gas. As an example, the precursor gas may include helium. As an example, the precursor gas may include one or more other gases. As an example, the precursor gas may include a combination of gases. In some embodiments, the precursor gas includes acetylene (C_2H_2).

[0078] A second process gas source **242** is fluidly coupled to the processing volume **260** via an inlet **244** disposed through the spacer **210**. As an example, the second process gas source **242** may contain a process gas, such as precursor gas. As an example, the precursor gas may include carbon-containing gas. As an example, the precursor gas may include an inert gas. As an example, the precursor gas may include helium. As an example, the precursor gas may include one or more other gases. As an example, the precursor gas may include a combination of gases. In some embodiments, the precursor gas includes C_2H_2.

[0079] In some embodiments, for deposition on a substrate such as a wafer, a total flow rate of precursor gas into the processing volume **260** may be about **200** sccm to about 2 slm. In some embodiments, a flow rate of precursor gas into the processing volume 160 from the second processing gas source **242** may modulate a flow rate of precursor gas into the processing volume **260** from the first processing gas source **240** such that the combined precursor gas is uniformly distributed in the processing volume **260**. A plurality of inlets **244** are distributed circumferentially about the spacer **210**. In one example, gas flow to

each of the inlets **244** may be separately controlled to further facilitate the uniform distribution of precursor gas within the processing volume **260**.

[0080] The lid **300** includes a plate **302**. The plate **302** is coupled to the spacer **210** via a riser **205**, but it is contemplated that the riser **205** may be omitted and the plate **302** may be directly coupled to the spacer **210**. In some embodiments, which may be combined with other embodiments, the riser **205** may be integrated with the plate **302**. The lid **300** includes a heat exchanger **224**. The heat exchanger **224** may be attached to the plate **302** or integrated with the plate **302**. The heat exchanger **224** includes an inlet **226** and an outlet **228**. In embodiments in which the heat exchanger **224** is integrated with the plate **302**, heat exchange fluids may flow from the inlet **226**, through channels **230** formed in the plate **302**, and out of the outlet **228**.

[0081] The plate **302** is coupled to or integrated with a manifold **246**. The plate **302** is coupled to a remote plasma source **262** by a conduit **250**, such as a mixing ampoule, having an axial throughbore **252** to facilitate flow of plasma through the conduit **250**. Although the conduit **250** is illustrated as coupled to the manifold **246**, it is contemplated that the manifold **246** may be integrated with the conduit **250** such that the conduit **250** may be directly coupled to the plate **302**. The manifold **246** is coupled to the first process gas source **240** and a purge gas source **256**. Both of the first process gas source **240** and the purge gas source **256** may be coupled to the manifold **246** by valves (not shown).

[0082] Although the lid **300** may be coupled to a remote plasma source **262**, in some embodiments, the remote plasma source **262** may be omitted. When present, the remote plasma source **262** may be coupled to a cleaning gas source **266** via a feed line for providing cleaning gas to the processing volume **260**. When the remote plasma source **262** is absent, the cleaning gas source **266** may be directly coupled to the conduit **250**. When the remote plasma source **262** is absent, the cleaning gas source **266** may be indirectly coupled to the conduit **250**. Cleaning gas may be provided through the conduit **250**. Additionally, or alternatively, in some embodiments, cleaning gas is provided through a channel that also conveys precursor gas into the processing volume

260. As an example, the cleaning gas may include an oxygen-containing gas, such as molecular oxygen (O_2) and/or ozone (O_3). As an example, the cleaning gas may include a fluorine-containing gas, such as NF_3. As an example, the cleaning gas may include one or more other gases. As an example, the cleaning gas may include a combination of gases.

[0083] The substrate support **215** is coupled to a RF power source **270**. The RF power source **270** may be a low frequency RF power source (for example, about 2 MHz to about 13.56 MHz). It is to be noted that other frequencies are also contemplated. In some implementations, the RF power source **270** is a mixed frequency RF power source, providing both high frequency and low frequency power. Utilization of a dual frequency RF power source, improves film deposition. In one example, utilizing a RF power source **270** provides dual frequency powers. A first frequency of about 2 MHz to about 13.56 MHz improves implantation of chemical species into the deposited film, while a second frequency of about 13.56 MHz to about 120 MHz increases ionization and deposition rate of the film.

[0084] The RF power source **270** may be utilized in creating or maintaining a plasma in the processing volume **260**. For example, the RF power source **270** may be utilized during a deposition process. During a deposition or etch process, the RF power source **270** provides a power of about 100 Watts (W) to about 20,000 W in the processing volume **260** to facilitate ionization of a precursor gas. In one embodiment, which can be combined with other embodiments described herein, the RF power source **270** is pulsed. In another embodiment, which can be combined with other embodiments described herein, the precursor gas for deposition includes helium and acetylene. In one embodiment, which can be combined with other embodiments described herein, for deposition acetylene is provided at a flow rate of about 10 sccm to about 1,000 sccm and helium is provided at a flow rate of about 50 sccm to about 10,000 sccm.

[0085] The substrate support **215** is coupled to an actuator **272** (i.e., a lift actuator) that provides movement thereof in the Z direction. The substrate

support **215** is also coupled to a facilities cable **278** that is flexible which allows vertical movement of the substrate support **215** while maintaining communication with the second RF power source **270** as well as other power and fluid connections. The spacer **210** is disposed on the chamber body **292**. A height of the spacer **210** allows movement of the substrate support **215** vertically within the processing volume **260**. Process volume **260** defines an inner diameter of the chamber. In some embodiments, an inner diameter of the chamber is about 10 inches to about 25 inches, such as about 15 inches to about 20 inches. The height of the spacer **210** may be from about 0.5 inches to about 20 inches, such as about 3 inches to about 20 inches, such as about 5 inches to about 15 inches, such as about 7 inches to about 10 inches. In one example, the substrate support **215** is movable from a first distance **274** to a second distance **276** relative to the lid **300** (for example, relative to a datum **280** of the plate **302**). In one embodiment which may be combined with other embodiments, the second distance **276** is about two-thirds of the first distance **274**. For example, the difference between the first distance **274** and the second distance may be about 5 inches to about 6 inches. Thus, from the position shown in Figure 1, the substrate support **215** is movable by about 5 inches to about 6 inches relative to a datum **280** of the plate **302**. In another example, the substrate support **215** is fixed at one of the first distance **274** and the second distance **276**.

[0086] In contrast to conventional plasma enhanced chemical vapor deposition (PECVD) processes, the spacer **210** greatly increases the distance between (and thus the volume between) the substrate support **215** and the lid **300**. The increased distance between the substrate support **215** and the lid **300** reduces collisions of ionized species in the process volume **260**, resulting in deposition of film with less intrinsic stress. Films deposited with less intrinsic stress facilitate improved planarity (e.g., less bowing) of substrates upon which the film is formed. Reduced bowing of substrates results in improved precision of downstream patterning operations.

[0087] The variable pressure system **220** includes a first pump **282** and a second pump **284**. The first pump **282** is a roughing pump that may be utilized

during a cleaning process and/or substrate transfer process. A roughing pump is generally configured for moving higher volumetric flow rates and/or operating a relatively higher (though still sub-atmospheric) pressure. In one example, the first pump **282** maintains a pressure within the process chamber **200** less than 50 mTorr during a cleaning process. In another example, the first pump **282** maintains a pressure within the process chamber **200** of about 0.5 mTorr to about 10 Torr. Utilization of a roughing pump during cleaning operations facilitates relatively higher pressures and/or volumetric flow of cleaning gas (as compared to a deposition operation). The relatively higher pressure and/or volumetric flow during the cleaning operation improves cleaning of chamber surfaces.

[0088] The second pump **284** may be a turbo pump or a cryogenic pump. The second pump **284** is utilized during a deposition process. The second pump **284** is generally configured to operate a relatively lower volumetric flow rate and/or pressure. For example, the second pump **284** is configured to maintain the processing volume **260** of the process chamber at a pressure of less than about 50 mTorr. In another example, the second pump **284** maintains a pressure within the process chamber of about 0.5 mTorr to about 10 Torr. The reduced pressure of the processing volume **260** maintained during deposition facilitates deposition of a film having reduced neutral stress and/or increased sp^2-sp^3 conversion, when depositing carbon-based hardmasks. Thus, process chamber **200** is configured to utilize both relatively lower pressure to improve deposition or seasoning and relatively higher pressure to improve cleaning.

[0089] In some embodiments, which can be combined with other embodiments described herein, both of the first pump **282** and the second pump **284** are utilized during a deposition process to maintain the processing volume **260** of the process chamber at a pressure of less than about 50 mTorr. In other embodiments, the first pump **282** and the second pump **284** maintain the processing volume **260** at a pressure of about 0.5 mTorr to about 10 Torr. A valve **286** is utilized to control a conductance path to one or both of the first

pump **282** and the second pump **284**. The valve **286** also provides for symmetrical pumping from the processing volume **260**.

[0090] The process chamber **200** also includes a substrate transfer port **285**. The substrate transfer port **285** is selectively sealed by an interior door **290** and/or an exterior door **291**. Each of the doors **290** and **291** are coupled to actuators **288** (i.e., a door actuator). The doors **290** and **291** facilitate vacuum sealing of the processing volume **260**. The doors **290** and **291** also provide symmetrical RF application and/or plasma symmetry within the processing volume **260**. In one example, at least the interior door **290** is formed of a material that facilitates conductance of RF power, such as stainless steel, aluminum, or alloys thereof. Seals **293**, such as O-rings, disposed at the interface of the spacer **210** and the chamber body **292** further seal the processing volume **260**. A controller **294** is configured to control aspects of the process chamber **200** during processing.

[0091] Controller **294** may be a processor based system controller. For example, the controller **294** may be configured to control process chamber **200** parts and processing parameters. The controller **294** may include a programmable central processing unit (CPU) that is operable with a memory and a mass storage device, an input control unit, a display unit, power supplies, clocks, cache, input/output (I/O) circuits, and the like, coupled to the various components of the process chamber **200** to facilitate control of the processes.

[0092] Figure 3A is a cross section partial view of a lid **300** of some embodiments. As shown in Figure 3A, the baffle **258** may be omitted. The lid **300** includes a plate **302**. The plate **302** has an first surface **304** and a second surface **306** opposite the first surface **304**. In some embodiments, the second surface **306** of the plate **302** may be shaped or contoured. The plate **302** may have a recess **308** in the first surface **304**. The recess **308** has an opening **310** and a sidewall **312** extending from the opening **310** to a floor **316** within the plate **302**. In some embodiments, the opening **310** defines a circle. For the purpose of the following geometrical description, the plate **302** may have an

axis **314** that is generally perpendicular to the first surface **304** and thus extends between the first surface **304** and the second surface **306**.

[0093] As shown in Figure 3A, the sidewall **312** extends from the opening **310** to the floor **316** at an acute angle **318** to datum line **314'** which is parallel to the axis **314**. Thus, the sidewall **312** extends from the opening **310** to the floor **316** at an acute angle **318** to the axis **314**. However, it is contemplated that the sidewall **312** may extend from the opening **310** to the floor **316** substantially parallel to the axis **314**. The acute angle **318** may be between zero and 80 degrees, such as between zero and 70 degrees, such as between zero and 60 degrees, such as between zero and 50 degrees, such as between zero and 40 degrees, such as zero and 30 degrees, such as between zero and 20 degrees, such as between zero and 10 degrees. In some embodiments, as shown in Figure 3A, the sidewall **312** may extend from the opening **310** to the floor **316** such that a cross sectional area of the opening **310** is less than a cross sectional area of the floor **316**, defining a frustoconical shape.

[0094] An array **320** of holes **322** extends from the recess **308** through the plate **302** to the second surface **306**. Each hole **322** extends from a corresponding entrance **324** at the recess **308** to a corresponding exit **326** at the second surface **306**. Each entrance **324** is located at the floor **316** of the recess **308**. However, it is contemplated that each entrance **324** may be located at the sidewall **312** of the recess **308**, or that each entrance **324** may be located at an intersection of the sidewall **312** and the floor **316** of the recess **308**. In some embodiments, which may be combined with other embodiments, an entrance **324** of one or more hole **322** of the array **320** of holes **322** may be located at one of the floor **316**, the sidewall **312**, or the intersection of the floor **316** and the sidewall **312**, and an entrance **324** of one or more other hole **322** of the array **320** of holes **322** may be located at another of the floor **316**, the sidewall **312**, or the intersection of the floor **316** and the sidewall **312**. In other words, array **320** has a plurality of holes **322** each having an entrance **324**, where the entrances **324** are independently located at one of the floor **316**, the sidewall **312**, or the intersection of the floor **316** and the sidewall **312**.

[0095] Each hole **322** has a trajectory that extends through the plate **302** at an acute angle **328** to the axis **314**. The acute angle **328** is between zero and 80 degrees, such as between zero and 70 degrees, such as between zero and 60 degrees, such as between zero and 50 degrees, such as between zero and 40 degrees, such as between zero and 30 degrees, such as between zero and 20 degrees, such as between zero and 10 degrees. However, it is contemplated that at least one hole **322** may have a trajectory that is parallel to the axis **314**. It is further contemplated that each hole **322** may have a trajectory that is parallel to the axis **314**.

[0096] As shown in Figure 3A, the second surface **306** includes a protrusion **330**. In some embodiments, which may be combined with other embodiments, each exit **326** may be located at the protrusion **330**. However other configurations are contemplated. For example, each exit **326** may not be located at the protrusion **330**, or each exit **326** may be located at a base of the protrusion **330**. In some embodiments, which may be combined with other embodiments, an exit **326** of one or more hole **322** of the array **320** of holes **322** may be located at one of the protrusion **330**, the base of the protrusion **330**, or a portion of the second surface **306** away from the protrusion **330**, and an exit **326** of one or more other hole **322** of the array **320** of holes **322** may be located at another of the protrusion **330**, the base of the protrusion **330**, or a portion of the second surface **306** away from the protrusion **330**. In other words, the array **320** has a plurality of holes **322** each having an exit **326**, where each exit **326** is independently located at the protrusion **330**, the base of the protrusion **330**, or a portion of the second surface **306** away from the protrusion **330**.

[0097] The protrusion **330** is frustoconical in shape having a side face **332** and an end face **334**, but other configurations are contemplated. In some embodiments, the protrusion **330** may be shaped like a portion of a sphere, an ellipsoid, or a cylinder. In some embodiments, which may be combined with other embodiments, each exit **326** may be located at the side face **332**, or each exit **326** may be located at the end face **334**, or, each exit **326** may be located at an intersection of the side face **332** and the end face **334**. In some

embodiments, which may be combined with other embodiments, an exit **326** of one or more hole **322** of the array **320** of holes **322** may be located at one of the side face **332**, the end face **334**, or the intersection of the side face **332** and the end face **334**, and an exit **326** of one or more other hole **322** of the array **320** of holes **322** may be located at another of the side face **332**, the end face **334**, and the intersection of the side face **332** and the end face **334**. In other words, array **320** has a plurality of holes **322** each having an exit **326** that is independently located at one of the side face **332**, the end face **334**, or the intersection of the side face **332** and the end face **334**. In some embodiments, which may be combined with other embodiments, an angle **336** at which the trajectory of each hole **322** whose exit **326** is located at the side face **332** intersects the side face **332** may be substantially 90 degrees.

[0098] The plate **302** includes a centrally located showerhead **340**, which includes the protrusion **330** (when present) and the array **320** of holes **322**. As shown in Figure 3A, the showerhead **340** is integral with the plate **302**. However, it is contemplated that the showerhead **340** may be permanently attached to the plate **302** or removably attached to the plate **302**. The arrangement of the showerhead **340** and the plate **302**, particularly in embodiments in which the showerhead **340** is integral with the plate **302**, may facilitate the entire enclosure of processing volume **260** (including plate **302**, riser **205** (when present), and spacer **210**) being fully grounded during use, thereby inhibiting the generation of parasitic plasma.

[0099] The array **320** of holes **322** may be arranged as a single ring of holes **322** or into multiple rings of holes **322**. The holes **322** of the array **320** of holes **322** can be arranged at a substantially uniform spacing in a ring. The holes **322** of the array **320** of holes **322** can be arranged at a non-uniform spacing in a ring. When utilizing the multiple rings of holes **322**, the multiple rings of holes **322** may be concentric, non-concentric, or arranged as clusters. In some embodiments, which may be combined with other embodiments, some rings of the multiple rings of holes **322** may be arranged as one of concentric, non-concentric, and clustered, and other rings of the multiple rings of holes **322** may be arranged as another of concentric, non-concentric, and clustered.

[00100] Other arrangements of the holes **322** are also contemplated. For example, at least some of the holes **322** of the array **320** of holes **322** may be arranged into other geometric patterns, such as a line, a triangle, a quadrilateral, a pentagon, a hexagon, and the like. Additionally, or alternatively, at least some holes **322** of the array **320** of holes **322** may be arranged as a cluster of holes **322** defining a regular pattern, such as a pattern displaying one or more uniform spacing dimension between pairs of adjacent holes **322**. Additionally, or alternatively, at least some holes **322** of the array **320** of holes **322** may be arranged as a cluster of holes **322** defining an irregular pattern, such as a pattern displaying non-uniform spacing dimensions between pairs of adjacent holes **322**.

[00101] As shown in Figure 3B, the array **320** of holes **322** is arranged as two rings of holes **322**, a first ring **342** and a second ring **348**. In some embodiments, which may be combined with other embodiments, the angle **328** of the trajectory of each hole **322** of the array **320** of holes **322** may be substantially the same, for example, within 1 degree of one another. However, it is contemplated, the angle **328** of the trajectory of some holes **322** of the array **320** of holes **322** may differ from the angle **328** of the trajectory of other holes **322** of the array **320** of holes **322**.

[00102] A diameter of each hole **322** of the array **320** of holes **322** may be substantially the same as the diameter of each other hole **322**, as determined by standard manufacturing tolerances. However, it is contemplated that the diameter of some holes **322** of the array **320** of holes **322** may differ from the diameter of other holes **322** of the array **320** of holes **322**. For example, holes **322** having a first diameter may be arranged into a first cluster or geometric shape or pattern, and holes **322** having a second diameter different from the first diameter may be arranged into a second cluster or geometric shape or pattern. In such examples, the first cluster or geometric shape or pattern may have a size, shape, and/or pattern similar to a size, shape, and/or pattern of the second cluster or geometric shape or pattern. Additionally, or alternatively, the first cluster or geometric shape or pattern may have a size, shape, and/or

pattern different from a size, shape, and/or pattern of the second cluster or geometric shape or pattern.

[00103] In some embodiments, which may be combined with other embodiments, the diameter of each hole **322** of the array **320** of holes **322** may be substantially uniform. In some embodiments, the diameter of each hole **322** of the array **320** of holes **322** may be substantially non-uniform. For example, the diameter of each hole **322** may taper from a larger diameter at each entrance **324** to a smaller diameter at each exit **326**. Alternatively, the diameter of each hole **322** may taper from a smaller diameter at each entrance **324** to a larger diameter at each exit **326**. Alternatively, the diameter of each hole **322** may be uniform along part of the length of each hole **322**, and may transition to a different diameter such that the diameter of each hole **322** at the entrance **324** may be greater than or less than the diameter of each hole **322** at the exit **326**. In some embodiments, which may be combined with other embodiments, the diameter of some holes **322** of the array **320** of holes **322** may be substantially uniform, and the diameter of other holes **322** of the array **320** of holes **322** may be substantially non-uniform.

[00104] The sizing of each hole **322** of the array **320** of holes **322** may be selected by determining any one or more of a hole **322** length, a hole **322** diameter, a variation of hole **322** diameter along the hole **322** length, or a trajectory of each hole **322**. In some embodiments, which may be combined with other embodiments, the number and/or sizing of the holes **322** of the array **320** of holes **322** may be selected according to one or more predetermined operational parameters or constraints. For example, the number and/or sizing of the holes **322** of the array **320** of holes **322** may be selected according to one or more ranges of values of one or more predetermined operational parameters or constraints. Example operational parameters and constraints may include, without limitation, any one or more of a sheath thickness of plasma created during operation, a pressure of gas at the entrance **324** of each hole **322**, a pressure of gas at the exit **326** of each hole **322**, an average velocity of gas through each hole **322**, a velocity of gas within each hole **322** at the entrance **324** of each hole **322**, a velocity of gas within each hole **322** at the exit

326 of each hole **322**, a total volumetric flow rate of gas through the holes **322**, a total volumetric flow rate of gas through a group of holes **322** of the array **320** of holes **322**, and the like.

[00105] The number of holes **322** and/or sizing of the holes **322** of the array **320** of holes **322** may be selected according to a pressure of gas at the entrance **324** of each hole **322** being about 0.01 Torr to about 10 Torr, such as about 0.01 Torr to about 5 Torr, such as about 0.01 Torr to about 3 Torr, such as about 0.1 Torr to about 3 Torr, such as about 1 Torr to about 3 Torr.

[00106] The number of holes **322** and/or sizing of the holes **322** of the array **320** of holes **322** may be selected according to a pressure of gas at the exit **326** of each hole **322** being about 1 mTorr to about 1 Torr, such as about 1 mTorr to about 0.5 Torr, such as about 1 mTorr to about 0.1 Torr, such as about 1 mTorr to about 50 mTorr, such as about 1 mTorr to about 20 mTorr.

[00107] It is further contemplated that the number of holes **322** of the array **320** of holes **322** may be selected according to one or more predetermined operational parameters or constraints, and the sizing of the holes **322** may be selected according to one or more other predetermined operational parameters or constraints. For example, a diameter of each hole **322** may be selected according to any one or more of a sheath thickness of plasma created during operation, a pressure of gas at the entrance **324** of each hole **322**, a pressure of gas at the exit **326** of each hole **322**, an average velocity of gas through each hole **322**, a velocity of gas within each hole **322** at the entrance **324** of each hole **322**, a velocity of gas within each hole **322** at the exit **326** of each hole **322**, and the like; and the number of holes **322** of the array **320** of holes **322** may be selected according to another of any one or more of a pressure of gas at the entrance **324** of each hole **322**, a pressure of gas at the exit **326** of each hole **322**, an average velocity of gas through each hole **322**, a velocity of gas within each hole **322** at the entrance **324** of each hole **322**, a velocity of gas within each hole **322** at the exit **326** of each hole **322**, a total volumetric flow rate of gas through the holes **322**, a total volumetric flow rate of gas through a group of holes **322** of the array **320** of holes **322**, and the like.

[00108] In some embodiments, which may be combined with other embodiments, each hole **322** of the array **320** of holes **322** may be sized to have a diameter no greater than five times a sheath thickness of plasma created during operation, such as no greater than four times a sheath thickness of plasma created during operation, such as no greater than three times a sheath thickness of plasma created during operation, such as no greater than two times a sheath thickness of plasma created during operation, such as no greater than a sheath thickness of plasma created during operation.

[00109] It is further contemplated that the number and/or diameter of holes **322** of the array **320** of holes **322** may be selected such that a velocity of gas within each hole **322** at the exit **326** of each hole **322** is less than Mach 1 but greater than or equal to a half of Mach 1. It is further contemplated that the number and/or diameter of holes **322** of the array **320** of holes **322** may be selected such that a velocity of gas within each hole **322** at the exit **326** of each hole **322** is substantially equal to Mach 1. It is further contemplated that the number and/or diameter of holes **322** of the array **320** of holes **322** may be selected such that a velocity of gas within each hole **322** at the exit **326** of each hole **322** is greater than Mach 1 but no greater than Mach 2.

[00110] It is further contemplated that the number and/or diameter of holes **322** of the array **320** of holes **322** may be selected such that a velocity of gas within each hole **322** at the entrance **324** of each hole **322** is less than Mach 1. It is further contemplated that the number and/or diameter of holes **322** of the array **320** of holes **322** may be selected such that a velocity of gas within each hole **322** at the entrance **324** of each hole **322** is substantially equal to Mach 1. It is further contemplated that the number and/or diameter of holes **322** of the array **320** of holes **322** may be selected such that a velocity of gas within each hole **322** at the entrance **324** of each hole **322** is greater than Mach 1 but no greater than Mach 2.

[00111] As shown in Figure 3A, part of an assembly includes plate **302** of lid **300**. A conduit **250** is attached to the first surface **304** of plate **302**. The conduit **250** has a throughbore **252** that is substantially aligned with the recess **308**.

The conduit **250** is attached to the first surface **304** of the plate **302** by one or more fasteners **358**. As illustrated, the first surface **304** of the plate **302** includes one or more openings **362** for receiving corresponding fasteners **358**, such as bolts, screws, studs, dowel pins, or the like. Additionally, or alternatively, it is contemplated that the first surface **304** may include one or more projections for connecting the plate **302** to the conduit **250**, and the projections may be threaded. A seal groove **364** in the first surface **304** of the plate **302** is located between the one or more fasteners **358** and the recess **308**, and surrounds the opening **310** to the recess **308**. It is contemplated that where multiple fasteners **358** are utilized, the fasteners **358** surround the seal groove **364**. As shown in Figure 3A, a seal member **366**, such as an O-ring, is installed in the seal groove **364**, thereby sealing an interface between the plate **302** and the conduit **250**. It is contemplated that the seal member **366** may contact a portion of the conduit **250** or a flange or other structure associated with the conduit **250**, such as manifold **246**.

[00112] The conduit **250** is shown coupled to a remote plasma source **262**, part of which is shown in Figure 3A. The throughbore **252** may be substantially aligned with an outlet **368** of the remote plasma source **262**. It is contemplated that the throughbore **252** may have a substantially uniform inner diameter along a length of the conduit **250** from the outlet **368** of the remote plasma source **262** to the first surface **304** of the plate **302**, however, as shown in the example of Figure 3A, the throughbore **252** may include a restriction **370** part-way along the length of the conduit **250** from the outlet **368** of the remote plasma source **262** to the first surface **304** of the plate **302**.

[00113] As shown in Figure 3A, the conduit **250** incorporates a manifold **246**. The manifold **246** is coupled to the first process gas source **240** via a valve **372**. In some embodiments, the manifold **246** may provide a single point of entry of process gas into the conduit **250**, however it is contemplated that the manifold **246** may provide multiple points of entry of process gas into the conduit **250**. In some embodiments, the manifold **246** may be coupled to the purge gas source **256**, however it is contemplated that the conduit **250** may be coupled to the purge gas source **256** at a location of the conduit **250** other than at the

manifold **246**. For example, the conduit **250** may be coupled to the purge gas source **256** at a location at or near an upper end of the conduit **250**. As shown in Figure 3A, the conduit **250** includes a heat exchanger **374**, such as a tube configured to convey heat exchange fluid. It is contemplated, however, that the heat exchanger **374** may be omitted.

[00114] In operation, purge gas (inert gas(es)) from the purge gas source **256** enters the conduit **250** and becomes mixed with gas from the first process gas source **240**. The combined gases flow out of the conduit **250** and through the holes **322** in the plate **302** into the processing volume **260**. A cleaning cycle of operation involves cleaning gas flowing through the conduit **250** and through the holes **322** in the plate **302** into the processing volume **260**. It is contemplated that the cleaning gas may become mixed with the purge gas in the conduit **250** before the combined gases flow through the holes **322** in the plate **302** into the processing volume **260**. It is further contemplated that plasma from the remote plasma source **262** enters the conduit **250** and becomes mixed with the purge gas in the conduit **250** before the combined plasma and gas flow through the holes **322** in the plate **302** into the processing volume **260**.

[00115] The embodiments of the present disclosure provide a number of benefits for the operation of the process chamber **200**, such as the reduction or elimination of certain undesirable effects. An example undesirable effect concerns the plate **302** providing a path for the RF applied to the process chamber **200** to traverse through components that are upstream of the lid **300**. For example, the RF may traverse through the conduit **250**, the remote plasma source **262**, and into a feed line leading to the remote plasma source **262** from the source **266** of the cleaning gas. This may lead to the establishment of a standing wave plasma, and thereby may cause deposition within the conduit **250**, the remote plasma source **262**, and the feed line.

[00116] Another undesirable effect mitigated by the embodiments of the present disclosure concerns the low operation pressure of the processing volume **260** and low gas velocities giving rise to back diffusion of radicals into

the conduit **250**, the remote plasma source **262**, and the feed line. Such back diffusion of radicals may cause or contribute to deposition within the conduit **250**, the remote plasma source **262**, and the feed line.

[00117] Further still, the above undesirable effects may impact operation of the process chamber **200** to the extent of causing stray depositions inside the processing volume **260**, such as on the lid **300**, the spacer **210**, and/or even on the substrate **218** and on films deposited on the substrate **218**. Such stray depositions may result in defects in a substrate **218** and in films deposited on the substrate **218**.

[00118] The arrangement of the showerhead **340** and the plate **302**, particularly in embodiments in which the showerhead **340** is integral with the plate **302**, may facilitate the entire enclosure of processing volume **260** (including plate **302**, riser **205** (when present), and spacer **210**) being fully grounded during use, thereby inhibiting the generation of parasitic plasma. Thus, the embodiments of the present disclosure may inhibit unwanted RF traversal upstream, thereby hindering the creation of standing wave plasma and deterring parasitic deposition.

[00119] Additionally, the embodiments of the present disclosure may promote a velocity of the gas entering the processing volume **260** through the lid **300** to be of a magnitude sufficient to inhibit back diffusion of radicals. Thus, the embodiments of the present disclosure may deter upstream stray depositions. Furthermore, the velocity of the gas entering the processing volume **260** through the lid **300** may be of a magnitude sufficient to inhibit stray deposition within the processing volume **260**, thereby reducing the incidence and magnitude of defects in a substrate **218** and in films deposited on the substrate **218**.

ADDITIONAL ASPECTS

[00120] The present disclosure provides, among others, the following aspects, each of which may be considered as optionally including any alternate aspects.

Clause 1. A method for seasoning a process chamber, comprising:

depositing a seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C; and

depositing a deposition film onto the seasoning film.

Clause 2. The method of Clause 1, wherein the temperature is from about 100 °C to about 200 °C.

Clause 3. The method of Clauses 1 or 2, wherein the temperature is about 250 °C to about 300 °C.

Clause 4. The method of any of Clauses 1 to 3, wherein:

depositing the seasoning film comprises flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber; and

depositing the deposition film comprises flowing a second carbon-containing precursor gas and a second inert precursor gas into the process chamber, wherein the second carbon-containing precursor gas is the same as or different than the first carbon-containing precursor gas and the second inert precursor gas is the same as or different than the first inert precursor gas.

Clause 5. The method of any of Clauses 1 to 4, wherein depositing the deposition film onto the seasoning film is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C.

Clause 6. The method of any of Clauses 1 to 5, wherein depositing the deposition film onto the seasoning film is performed by flowing the second carbon-containing precursor gas into the process chamber at a flow rate of about 200 sccm to about 400 sccm.

Clause 7. The method of any of Clauses 1 to 6, wherein depositing the deposition film onto the seasoning film comprises providing an RF power of about 1 kW to about 6 kW to the process chamber.

Clause 8. The method of any of Clauses 1 to 7, wherein the first carbon-containing precursor gas and the second carbon-containing precursor gas comprise acetylene.

Clause 9. The method of any of Clauses 1 to 8, wherein the first inert precursor gas and the second inert precursor gas comprise helium.

Clause 10. The method of any of Clauses 1 to 9, wherein flowing the first carbon-containing precursor gas and the first inert precursor gas into the process chamber comprises:

flowing the first carbon-containing precursor gas into the process chamber at a flow rate of about 100 sccm to about 600 sccm, and

flowing the first inert precursor gas into the process chamber at a flow rate of about 150 sccm to about 800 sccm.

Clause 11. The method of any of Clauses 1 to 10, wherein depositing the seasoning film onto the component comprises:

flowing the first carbon-containing precursor gas and the first inert precursor gas at a first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas; and

adjusting the first flow ratio to a second flow ratio of the first carbon-containing precursor gas and the first inert precursor gas.

Clause 12. The method of any of Clauses 1 to 11, wherein the first flow ratio is about 1:1 to about 1:2.

Clause 13. The method of any of Clauses 1 to 12, wherein the second flow ratio is about 10:1 to about 1:1 or about 1:2 to about 1:10.

Clause 14. The method of any of Clauses 1 to 13, wherein adjusting the first flow ratio to the second flow ratio is performed at a rate of about 1 sccm/sec to about 20 sccm/sec.

Clause 15. The method of any of Clauses 1 to 14, wherein depositing the seasoning film onto the component comprises:

providing a first RF power to the chamber, and

adjusting the first RF power to a second RF power.

Clause 16. The method of any of Clauses 1 to 15, wherein adjusting the first RF power to the second RF power is performed at a rate of about 20 W/sec to about 500 W/sec.

Clause 17. The method of any of Clauses 1 to 16, wherein the first RF power and the second RF power are independently about 1 kW to about 6 kW.

Clause 18. The method of any of Clauses 1 to 17, wherein the first RF power is from about 1 kW to about 4 kW and the second RF power is from about 4 kW to about 6 kW.

Clause 19. The method of any of Clauses 1 to 18, wherein depositing the seasoning film onto the component comprises:

providing a first RF power to the chamber, and

adjusting the first RF power to a second RF power.

Clause 20. The method of any of Clauses 1 to 19, wherein the first RF power and the second RF power are independently about 1 kW to about 6 kW.

Clause 21. The method of any of Clauses 1 to 20, wherein the seasoning film has a thickness of about 100 nm to about 700 nm and the deposition film has a thickness of about 500 nm to about 3 microns.

Clause 22. The method of any of Clauses 1 to 21, wherein the component of the process chamber is not a wafer.

Clause 23. The method of any of Clauses 1 to 22, wherein the component of the process chamber is a wall of the process chamber.

Clause 24. The method of any of Clauses 1 to 23, further comprising introducing a nitrogen-containing gas to the seasoning film to form a nitrogen-treated seasoning film, wherein introducing the nitrogen-containing gas to the seasoning film is performed before depositing the deposition film onto the seasoning film.

Clause 25. The method of any of Clauses 1 to 24, wherein introducing the nitrogen-containing gas to the seasoning film is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 ^{o}C.

Clause 26. The method of any of Clauses 1 to 25, wherein the nitrogen-containing gas comprises ammonia.

Clause 27. The method of any of Clauses 1 to 26, wherein introducing the nitrogen-containing gas to the seasoning film comprises flowing the nitrogen-containing gas into the process chamber at a flow rate of about 25 sccm to about 1,000 sccm.

Clause 28. The method of any of Clauses 1 to 27, wherein introducing the nitrogen-containing gas to the seasoning film comprises providing an RF power of about 100 kW to about 4,000 kW to the process chamber.

Clause 29. The method of any of Clauses 1 to 28, wherein the nitrogen gas comprises ammonia.

Clause 30. The method of any of Clauses 1 to 29, further comprising introducing a nitrogen-containing gas to the seasoning film to form a nitrogen-treated seasoning film, wherein introducing the nitrogen-containing gas to the seasoning film is performed before depositing the deposition film onto the seasoning film.

Clause 31. The method of any of Clauses 1 to 30, wherein introducing the nitrogen-containing gas to the seasoning film is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C.

Clause 32. The method of any of Clauses 1 to 31, wherein the nitrogen-containing gas comprises ammonia.

Clause 33. The method of any of Clauses 1 to 32, wherein introducing the nitrogen-containing gas to the seasoning film comprises flowing the nitrogen-containing gas into the process chamber at a flow rate of about 25 sccm to about 1,000 sccm.

Clause 34. The method of any of Clauses 1 to 33, wherein introducing the nitrogen-containing gas to the seasoning film comprises providing an RF power of about 100 kW to about 4,000 kW to the process chamber.

Clause 35. The method of any of Clauses 1 to 34, wherein the nitrogen gas comprises ammonia.

Clause 36. A method for seasoning a process chamber, comprising:

depositing a first seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C;

depositing a second seasoning film onto the first seasoning film; and

depositing a deposition film onto the second seasoning film,

wherein depositing the first seasoning film comprises flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber.

Clause 37. The method of Clause 36, wherein the temperature is about 100 °C to about 200 °C.

Clause 38. The method of Clauses 36 or 37, wherein the temperature is about 250 °C to about 300 °C.

Clause 39. The method of any of Clauses 36 to 38, wherein depositing the second seasoning film onto the first seasoning film is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C.

Clause 40. The method of any of Clauses 36 to 39, wherein:

depositing the second seasoning film comprises flowing a second carbon-containing precursor gas and a second inert precursor gas into the process chamber; and

depositing the deposition film comprises flowing a third carbon-containing precursor gas and a third inert precursor gas into the process chamber,

wherein:

the second carbon-containing precursor gas is the same as or different than the first or third carbon-containing precursor gas and the second inert precursor gas is the same as or different than the first or third inert precursor gas, and

the third carbon-containing precursor gas is the same as or different than the first or second carbon-containing precursor gas and the third inert precursor gas is the same as or different than the first or second inert precursor gas.

Clause 41. The method of any of Clauses 36 to 40, wherein:

depositing the first seasoning film onto the component comprises flowing the first carbon-containing precursor gas and the first inert precursor gas at a first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas; and

depositing the second seasoning film onto the first seasoning film comprises adjusting the first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas to a second flow ratio.

Clause 42. The method of any of Clauses 36 to 41, wherein the first flow ratio is about 1:1 to about 1:2.

Clause 43. The method of any of Clauses 36 to 42, wherein the second flow ratio is about 10:1 to about 1:1 or about 1:2 to about 1:10.

Clause 44. The method of any of Clauses 36 to 43, wherein adjusting the first flow ratio to the second flow ratio is performed at a rate of about 1 second or less.

Clause 45. The method of any of Clauses 36 to 44, wherein:

depositing the first seasoning film onto the component comprises providing a first RF power to the chamber; and

depositing the second seasoning film onto the first seasoning film comprises adjusting the first RF power to a second RF power.

Clause 46. The method of any of Clauses 36 to 45, wherein adjusting the first RF power to the second RF power is performed at a rate of about 1 second or less.

Clause 47. The method of any of Clauses 36 to 46, wherein depositing the deposition film onto the second seasoning film is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 ^{o}C.

Clause 48. The method of any of Clauses 36 to 47, wherein depositing the deposition film onto the second seasoning film is performed by flowing a third carbon-containing precursor gas into the process chamber at a flow rate of about 200 sccm to about 400 sccm.

Clause 49. The method of any of Clauses 36 to 48, wherein depositing the deposition film onto the second seasoning film comprises providing an RF power of about 1 kW to about 6 kW to the process chamber.

Clause 50. The method of any of Clauses 36 to 49, wherein the first carbon-containing precursor gas, the second carbon-containing precursor gas, and the third carbon-containing precursor gas comprise acetylene.

Clause 51. The method of any of Clauses 36 to 50, wherein the first inert precursor gas, the second inert precursor gas, and the third inert precursor gas comprise helium.

Clause 52. The method of any of Clauses 36 to 51, wherein flowing the first carbon-containing precursor gas and the first inert precursor gas into the process chamber comprises:

flowing the first carbon-containing precursor gas into the process chamber at a flow rate of about 100 sccm to about 600 sccm, and

flowing the first inert precursor gas into the process chamber at a flow rate of about 150 sccm to about 800 sccm.

Clause 53. The method of any of Clauses 36 to 52, wherein flowing the second carbon-containing precursor gas and the second inert precursor gas into the process chamber comprises:

flowing the second carbon-containing precursor gas into the process chamber at a flow rate of about 100 sccm to about 600 sccm, wherein the flow rate of the second carbon-containing precursor gas is different than the flow rate of the first carbon-containing precursor gas, and

flowing the second inert precursor gas into the process chamber at a flow rate of about 150 sccm to about 800 sccm, wherein the flow rate of the second inert precursor gas is different than the flow rate of the first inert precursor gas.

Clause 54. The method of any of Clauses 36 to 53, wherein:

depositing the first seasoning film onto the component comprises providing a first RF power to the chamber, and

depositing the second seasoning film onto the first seasoning film comprises providing a second RF power to the chamber, wherein the second RF power is different than the first RF power.

Clause 55. The method of any of Clauses 36 to 54, wherein the first RF power and the second RF power are independently about 1 kW to about 6 kW.

Clause 56. The method of any of Clauses 36 to 55, wherein the first RF power is from about 1 kW to about 3 kW and the second RF power is from about 3 kW to about 6 kW.

Clause 57. The method of any of Clauses 36 to 56, wherein the first seasoning film and the second seasoning film have a combined thickness of about 100 nm to about 700 nm and the deposition film has a thickness of about 500 nm to about 3 microns.

Clause 58. The method of any of Clauses 36 to 57, wherein the component of the process chamber is not a wafer.

Clause 59. The method of any of Clauses 36 to 58, wherein the component of the process chamber is a wall of the process chamber.

Clause 60. The method of any of Clauses 36 to 59, further comprising introducing a nitrogen-containing gas to the second seasoning film to form a nitrogen-treated seasoning film, wherein introducing the nitrogen-containing gas to the second seasoning film is performed before depositing the deposition film onto the second seasoning film.

Clause 61. The method of any of Clauses 36 to 60, wherein introducing the nitrogen-containing gas to the second seasoning film is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C.

Clause 62. The method of any of Clauses 36 to 61, wherein the nitrogen-containing gas comprises ammonia.

Clause 63. The method of any of Clauses 36 to 62, wherein introducing the nitrogen-containing gas to the second seasoning film comprises flowing the nitrogen-containing gas into the process chamber at a flow rate of about 25 sccm to about 1,000 sccm.

Clause 64. The method of any of Clauses 36 to 63, wherein introducing the nitrogen-containing gas to the second seasoning film comprises providing an RF power of about 100 kW to about 4,000 kW to the process chamber.

Clause 65. The method of any of Clauses 36 to 64, wherein the nitrogen gas comprises ammonia.

Clause 66. A method for seasoning a process chamber, comprising:

depositing a first seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C;

depositing a plurality of additional seasoning films onto the first seasoning film; and

depositing a deposition film onto the plurality of additional seasoning films,

wherein:

depositing the first seasoning film comprises flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber.

Clause 67. The method of Clause 66, wherein the temperature is from about 100 °C to about 200 °C.

Clause 68. The method of Clauses 66 or 67, wherein the temperature is about 250 °C to about 300 °C.

Clause 69. The method of any of Clauses 66 to 68, wherein depositing the plurality of additional seasoning films comprises:

depositing a second seasoning film onto the first seasoning film by flowing a second carbon-containing precursor gas and a second inert precursor gas into the process chamber,

depositing a third seasoning film onto the second seasoning film by flowing a third carbon-containing precursor gas and a third inert precursor gas into the process chamber,

depositing a fourth seasoning film onto the third seasoning film by flowing a fourth carbon-containing precursor gas and a fourth inert precursor gas into the process chamber,

wherein:

the second, third, and fourth carbon-containing precursor gases are independently the same as or different than each other, and

the second, third, and fourth inert precursor gases are independently the same as or different than each other.

Clause 70. The method of any of Clauses 66 to 69, wherein depositing the plurality of additional seasoning films comprises:

depositing a fifth seasoning film onto the fourth seasoning film by flowing a fifth carbon-containing precursor gas and a fifth inert precursor gas into the process chamber,

depositing a sixth seasoning film onto the fifth seasoning film by flowing a sixth carbon-containing precursor gas and a sixth inert precursor gas into the process chamber,

depositing a seventh seasoning film onto the sixth seasoning film by flowing a seventh carbon-containing precursor gas and a seventh inert precursor gas into the process chamber, and

depositing an eigth seasoning film onto the seventh seasoning film by flowing an eigth carbon-containing precursor gas and an eigth inert precursor gas into the process chamber,

wherein:

the fifth, sixth, seventh, and eigth carbon-containing precursor gases are independently the same as or different than each other, and

the fifth, sixth, seventh, and eigth inert precursor gases are independently the same as or different than each other.

Clause 71. The method of any of Clauses 66 to 70, wherein each seasoning film of the plurality of additional seasoning films has a different intrinsic stress than an adjacent seasoning film of the plurality of additional seasoning films.

Clause 72. The method of any of Clauses 66 to 71, wherein depositing one or more seasoning film of the plurality of additional seasoning films is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C.

Clause 73. The method of any of Clauses 66 to 72, wherein depositing each seasoning film of the plurality of additional seasoning films is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C.

Clause 74. The method of any of Clauses 66 to 73, wherein:

depositing the first seasoning film onto the component comprises flowing the first carbon-containing precursor gas and the first inert precursor gas at a first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas;

depositing the second seasoning film onto the first seasoning film comprises adjusting the first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas to a second flow ratio;

depositing the third seasoning film onto the second seasoning film comprises adjusting the second flow ratio of the second carbon-containing precursor gas and the second inert precursor gas to a third flow ratio; and

depositing the fourth seasoning film onto the third seasoning film comprises adjusting the third flow ratio of the third carbon-containing precursor gas and the third inert precursor gas to a fourth flow ratio.

Clause 75. The method of any of Clauses 66 to 74, wherein the first flow ratio and the third flow ratio are independently about 1:1 to about 1:2.

Clause 76. The method of any of Clauses 66 to 75, wherein the second flow ratio and the fourth flow ratio are about 10:1 to about 1:1 or about 1:2 to about 1:10.

Clause 77. The method of any of Clauses 66 to 76, wherein adjusting the first flow ratio to the second flow ratio, the second flow ratio to the third flow ratio, and the third flow ratio to the fourth flow ratio are performed at a rate of independently about 1 second or less.

Clause 78. The method of any of Clauses 66 to 77, wherein:

depositing the fifth seasoning film onto the fourth seasoning film comprises flowing the fifth carbon-containing precursor gas and the fifth inert precursor gas at a fifth flow ratio of the fifth carbon-containing precursor gas and the fifth inert precursor gas;

depositing the sixth seasoning film onto the fifth seasoning film comprises adjusting the fifth flow ratio of the fifth carbon-containing precursor gas and the fifth inert precursor gas to a sixth flow ratio;

depositing the seventh seasoning film onto the sixth seasoning film comprises adjusting the sixth flow ratio of the sixth carbon-containing precursor gas and the sixth inert precursor gas to a seventh flow ratio; and

depositing the eigth seasoning film onto the seventh seasoning film comprises adjusting the seventh flow ratio of the seventh carbon-containing precursor gas and the seventh inert precursor gas to an eigth flow ratio.

Clause 79. The method of any of Clauses 66 to 78, wherein the fifth flow ratio and the seventh flow ratio are independently about 1:1 to about 1:2.

Clause 80. The method of any of Clauses 66 to 79, wherein the sixth flow ratio and the eigth flow ratio are about 10:1 to about 1:1 or about 1:2 to about 1:10.

Clause 81. The method of any of Clauses 66 to 80, wherein adjusting the first flow ratio to the second flow ratio, the second flow ratio to the third flow ratio, the third flow ratio to the fourth flow ratio, the fourth flow ratio to the fifth flow ratio, the fifth flow ratio to the sixth flow ratio, the sixth flow ratio to the seventh

flow ratio, and the seventh flow ratio to the eight flow ratio are performed at a rate of independently about 1 second or less.

Clause 82. The method of any of Clauses 66 to 81, wherein:

depositing the first seasoning film onto the component comprises providing a first RF power to the chamber;

depositing the second seasoning film onto the first seasoning film comprises adjusting the first RF power to a second RF power;

depositing the third seasoning film onto the second seasoning film comprises adjusting the second RF power to a third RF power; and

depositing the fourth seasoning film onto the third seasoning film comprises adjusting the third RF power to a fourth RF power.

Clause 83. The method of any of Clauses 66 to 82, wherein adjusting the first RF power to the second RF power, the second RF power to the third RF power, and the third RF power to the fourth RF power is performed at a rate of independently about 1 second or less.

Clause 84. The method of any of Clauses 66 to 83, wherein the first RF power, the second RF power, the third RF power, and the fourth RF power are independently about 1 kW to about 6 kW.

Clause 85. The method of any of Clauses 66 to 84, wherein:

the first RF power and third RF power are from independently about 1 kW to about 3 kW, and

the second RF power and the fourth RF power are from independently about 3 kW to about 6 kW.

Clause 86. The method of any of Clauses 66 to 85, wherein:

depositing the fifth seasoning film onto the fourth seasoning film comprises adjusting the fourth RF power to a fifth RF power;

depositing the sixth seasoning film onto the fifth seasoning film comprises adjusting the fifth RF power to a sixth RF power;

depositing the seventh seasoning film onto the sixth seasoning film comprises adjusting the sixth RF power to a seventh RF power; and

depositing the eighth seasoning film onto the seventh seasoning film comprises adjusting the seventh RF power to an eigth RF power.

Clause 87. The method of any of Clauses 66 to 86, wherein adjusting the first RF power to the second RF power, the second RF power to the third RF power, the third RF power to the fourth RF power, the fourth RF power to the fifth RF power, the fifth RF power to the sixth RF power, the sixth RF power to the seventh RF power, and the seventh RF power to the eigth RF power is performed at a rate of independently about 1 second or less.

Clause 88. The method of any of Clauses 66 to 87, wherein the first RF power, the second RF power, the third RF power, the fourth RF power, the fifth RF power, the sixth RF power, the seventh RF power, and the eighth RF power are independently about 1 kW to about 6 kW.

Clause 89. The method of any of Clauses 66 to 88, wherein:

the first RF power, the third RF power, the fifth RF power, and the seventh RF power are from independently about 1 kW to about 3 kW, and

the second RF power, the fourth RF power, the sixth RF power, and the eigth RF power are from independently about 3 kW to about 6 kW.

Clause 90. The method of any of Clauses 66 to 89, wherein the first carbon-containing precursor gas, the second carbon-containing precursor gas, the third carbon-containing precursor gas, and the fourth carbon-containing precursor gas comprise acetylene.

Clause 91. The method of any of Clauses 66 to 90, wherein the first carbon-containing precursor gas, the second carbon-containing precursor gas, the third carbon-containing precursor gas, the fourth carbon-containing precursor gas, the fifth carbon-containing precursor gas, the sixth carbon-containing precursor gas, the seventh carbon-containing precursor gas, and the eigth carbon-containing precursor gas comprise acetylene.

Clause 92. The method of any of Clauses 66 to 91, wherein the first inert precursor gas, the second inert precursor gas, the third inert precursor gas, and the fourth inert precursor gas comprise helium.

Clause 93. The method of any of Clauses 66 to 92, wherein the first inert precursor gas, the second inert precursor gas, the third inert precursor gas, the fourth inert precursor gas, the fifth inert precursor gas, the sixth inert precursor gas, the seventh inert precursor gas, and the eigth inert precursor gas comprise helium.

Clause 94. The method of any of Clauses 66 to 93, wherein flowing the first carbon-containing precursor gas and the first inert precursor gas into the process chamber comprises:

flowing the first carbon-containing precursor gas into the process chamber at a flow rate of about 100 sccm to about 600 sccm, and

flowing the first inert precursor gas into the process chamber at a flow rate of about 150 sccm to about 800 sccm.

Clause 95. The method of any of Clauses 66 to 94, wherein:

flowing the first inert precursor gas, the second carbon-containing precursor gas, the third carbon-containing precursor gas, and the fourth carbon-containing precursor gas into the process chamber are performed at a flow rate of independently about 100 sccm to about 600 sccm, and

flowing the first inert precursor gas, the second inert precursor gas, the third inert precursor gas, and the fourth inert precursor gas into the process chamber are performed at a flow rate of independently about 150 sccm to about 800 sccm.

Clause 96. The method of any of Clauses 66 to 95, wherein:

flowing the first inert precursor gas, the second carbon-containing precursor gas, the third carbon-containing precursor gas, the fourth carbon-containing precursor gas, the fifth carbon-containing precursor gas, the sixth carbon-containing precursor gas, the seventh carbon-containing precursor gas, and the eigth carbon-containing precursor gas into the process chamber are performed at a flow rate of independently about 100 sccm to about 600 sccm, and

flowing the first inert precursor gas, the second inert precursor gas, the third inert precursor gas, the fourth inert precursor gas, the fifth inert precursor gas, the sixth inert precursor gas, the seventh inert precursor gas, and the eigth inert precursor gas into the process chamber are performed at a flow rate of independently about 150 sccm to about 800 sccm.

Clause 97. The method of any of Clauses 66 to 96, wherein the first seasoning film and the plurality of additional seasoning films have a combined thickness of about 100 nm to about 700 nm and the deposition film has a thickness of about 500 nm to about 3 microns.

Clause 98. The method of any of Clauses 66 to 97, wherein depositing the deposition film onto the plurality of additional seasoning films is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C.

Clause 99. The method of any of Clauses 66 to 98, wherein depositing the deposition film onto the plurality of additional seasoning films is performed by flowing a third carbon-containing precursor gas into the process chamber at a flow rate of about 200 sccm to about 400 sccm.

Clause 100. The method of any of Clauses 66 to 99, wherein depositing the deposition film onto the plurality of additional seasoning films comprises providing an RF power of about 1 kW to about 6 kW to the process chamber.

Clause 101. The method of any of Clauses 66 to 100, wherein the component of the process chamber is not a wafer.

Clause 102. The method of any of Clauses 66 to 101, wherein the component of the process chamber is a wall of the process chamber.

Clause 103. The method of any of Clauses 66 to 102, further comprising introducing a nitrogen-containing gas to a film of the plurality of additional seasoning films to form a nitrogen-treated seasoning film, wherein introducing the nitrogen-containing gas to the film of the plurality of additional seasoning films is performed before depositing the deposition film onto the plurality of additional seasoning films.

Clause 104. The method of any of Clauses 66 to 103, wherein introducing the nitrogen-containing gas to the plurality of additional seasoning films is performed at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C.

Clause 105. The method of any of Clauses 66 to 104, wherein the nitrogen-containing gas comprises ammonia.

Clause 106. The method of any of Clauses 66 to 105, wherein introducing the nitrogen-containing gas to the plurality of additional seasoning films comprises flowing the nitrogen-containing gas into the process chamber at a flow rate of about 25 sccm to about 1,000 sccm.

Clause 107. The method of any of Clauses 66 to 106, wherein introducing the nitrogen-containing gas to the plurality of additional seasoning films comprises

providing an RF power of about 100 kW to about 4,000 kW to the process chamber.

Clause 108. The method of any of Clauses 66 to 107, wherein the nitrogen gas comprises ammonia.

[00121] Overall, methods of the present disclosure can provide reduced flaking of protective materials (a deposition film) and improved adhesion of the deposition film to a chamber component by providing a seasoning film disposed between the deposition film and the chamber component. For example, a deposition film can have an intrinsic stress of about 300 MPa or less (compressive) whereas a chamber component (e.g., an aluminum-containing component) can have an intrinsic stress of about 800 MPa or greater (compressive). Such a mismatch of intrinsic stress of the deposition film and the chamber component promotes flaking and inferior adhesion of the deposition film and the chamber component. However, the inventors have discovered that by controlling the intrinsic stress of a seasoning film, a seasoning film can be tailored to beneficially adhere to the deposition film on one side of the seasoning film and adhere to the chamber component on an opposite side of the seasoning film. The inventors have discovered a number of approaches to accomplish such improvements.

[00122] While the foregoing is directed to embodiments of the present disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

What is claimed is:

1. A method for seasoning a process chamber, comprising:

depositing a seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C; and

depositing a deposition film onto the seasoning film.

2. The method of claim 1, wherein the temperature is from about 100 °C to about 200 °C.

3. The method of claim 1, wherein:

depositing the seasoning film comprises flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber; and

depositing the deposition film comprises flowing a second carbon-containing precursor gas and a second inert precursor gas into the process chamber, wherein the second carbon-containing precursor gas is the same as or different than the first carbon-containing precursor gas and the second inert precursor gas is the same as or different than the first inert precursor gas.

4. The method of claim 3, wherein:

the first carbon-containing precursor gas and the second carbon-containing precursor gas comprise acetylene, and

the first inert precursor gas and the second inert precursor gas comprise helium.

5. The method of claim 3, wherein depositing the seasoning film onto the component comprises:

flowing the first carbon-containing precursor gas and the first inert precursor gas at a first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas; and

adjusting the first flow ratio to a second flow ratio of the first carbon-containing precursor gas and the first inert precursor gas.

6. The method of claim 5, wherein the first flow ratio is about 1:1 to about 1:2.

7. The method of claim 5, wherein adjusting the first flow ratio to the second flow ratio is performed at a rate of about 1 sccm/sec to about 20 sccm/sec.

8. The method of claim 3, wherein depositing the seasoning film onto the component comprises:

providing a first RF power to the chamber, and

adjusting the first RF power to a second RF power.

9. The method of claim 8, wherein adjusting the first RF power to the second RF power is performed at a rate of about 20 W/sec to about 500 W/sec.

10. The method of claim 9, wherein the first RF power is from about 1 kW to about 4 kW and the second RF power is from about 4 kW to about 6 kW.

11. A method for seasoning a process chamber, comprising:

depositing a first seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C;

depositing a second seasoning film onto the first seasoning film; and

depositing a deposition film onto the second seasoning film,

wherein depositing the first seasoning film comprises flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber.

12. The method of claim 11, wherein:

depositing the first seasoning film onto the component comprises flowing the first carbon-containing precursor gas and the first inert precursor gas at a first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas, and

depositing the second seasoning film onto the first seasoning film comprises adjusting the first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas to a second flow ratio.

13. The method of claim 12, wherein adjusting the first flow ratio to the second flow ratio is performed at a rate of about 1 second or less.

14. The method of claim 11, wherein:

depositing the first seasoning film onto the component comprises providing a first RF power to the chamber, and

depositing the second seasoning film onto the first seasoning film comprises adjusting the first RF power to a second RF power.

15. The method of claim 14, wherein adjusting the first RF power to the second RF power is performed at a rate of about 1 second or less.

16. A method for seasoning a process chamber, comprising:

depositing a first seasoning film onto a component of the process chamber at a chamber pressure of about 4 mTorr to about 20 mTorr and a temperature below about 200 °C or about 200 °C to about 400 °C;

depositing a plurality of additional seasoning films onto the first seasoning film; and

depositing a deposition film onto the plurality of additional seasoning films, wherein:

depositing the first seasoning film comprises flowing a first carbon-containing precursor gas and a first inert precursor gas into the process chamber.

17. The method of claim 16, wherein depositing the plurality of additional seasoning films comprises:

depositing a second seasoning film onto the first seasoning film by flowing a second carbon-containing precursor gas and a second inert precursor gas into the process chamber,

depositing a third seasoning film onto the second seasoning film by flowing a third carbon-containing precursor gas and a third inert precursor gas into the process chamber,

depositing a fourth seasoning film onto the third seasoning film by flowing a fourth carbon-containing precursor gas and a fourth inert precursor gas into the process chamber,

wherein:

the second, third, and fourth carbon-containing precursor gases are independently the same as or different than each other, and

the second, third, and fourth inert precursor gases are independently the same as or different than each other.

18. The method of claim 17, wherein:

depositing the first seasoning film onto the component comprises flowing the first carbon-containing precursor gas and the first inert precursor gas at a first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas;

depositing the second seasoning film onto the first seasoning film comprises adjusting the first flow ratio of the first carbon-containing precursor gas and the first inert precursor gas to a second flow ratio;

depositing the third seasoning film onto the second seasoning film comprises adjusting the second flow ratio of the second carbon-containing precursor gas and the second inert precursor gas to a third flow ratio; and

depositing the fourth seasoning film onto the third seasoning film comprises adjusting the third flow ratio of the third carbon-containing precursor gas and the third inert precursor gas to a fourth flow ratio.

19. The method of claim 18, wherein the first flow ratio and the third flow ratio are independently about 1:1 to about 1:2.

20. The method of claim 17, wherein:

depositing the first seasoning film onto the component comprises providing a first RF power to the chamber;

depositing the second seasoning film onto the first seasoning film comprises adjusting the first RF power to a second RF power;

depositing the third seasoning film onto the second seasoning film comprises adjusting the second RF power to a third RF power; and

depositing the fourth seasoning film onto the third seasoning film comprises adjusting the third RF power to a fourth RF power.

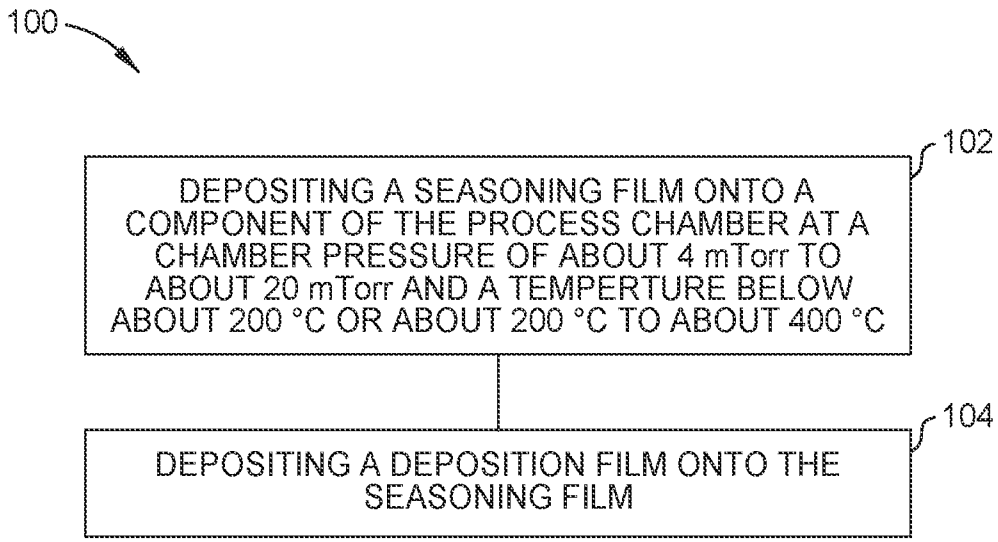

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DEPOSITING A SEASONING FILM ONTO A COMPONENT OF THE PROCESS CHAMBER AT A CHAMBER PRESSURE OF ABOUT 4 mTorr TO ABOUT 20 mTorr AND A TEMPERTURE BELOW ABOUT 200 °C OR ABOUT 200 °C TO ABOUT 400 °C
104
DEPOSITING A DEPOSITION FILM ONTO THE SEASONING FILM

FIG. 1

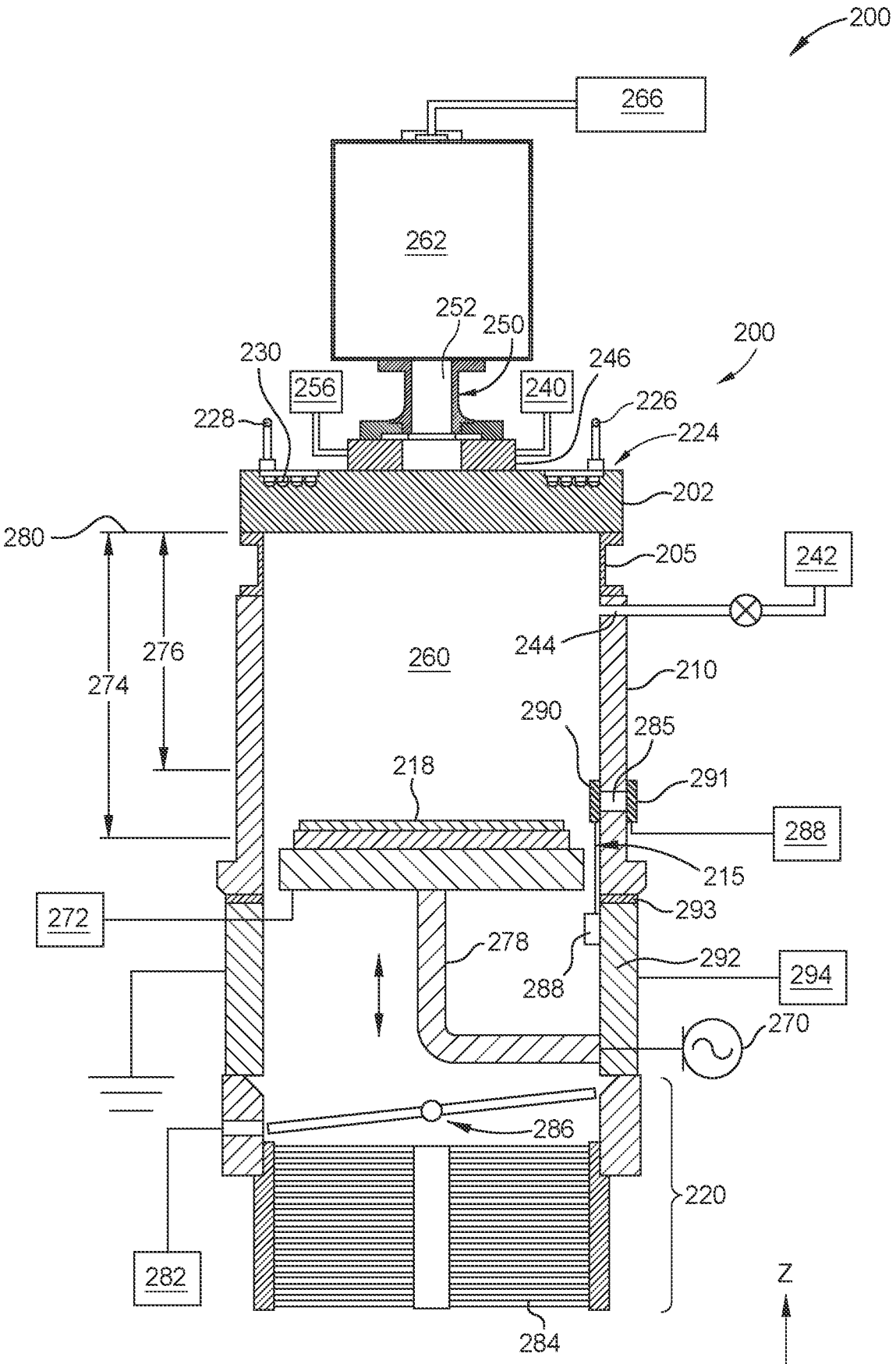

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FIG. 2

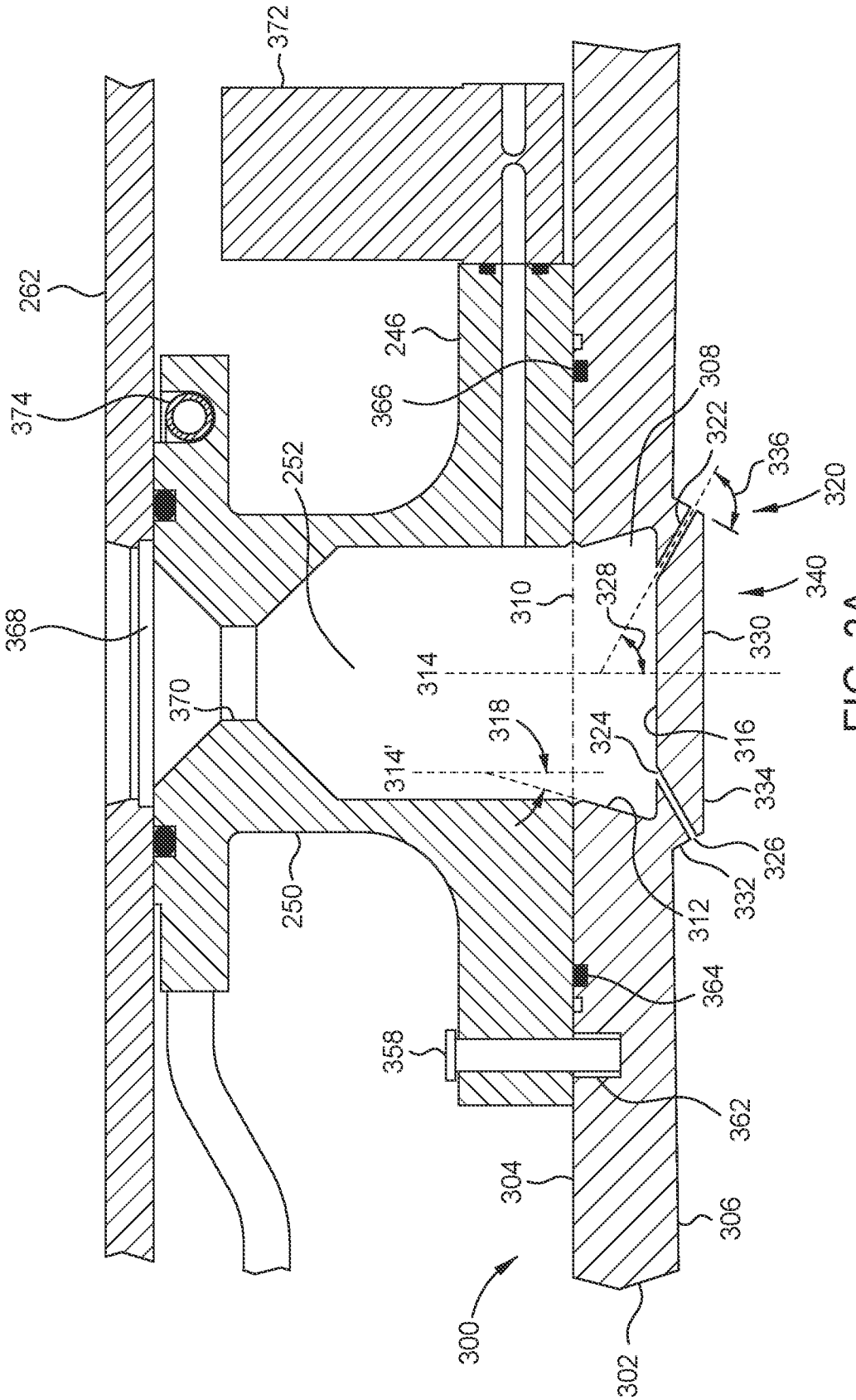

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FIG. 3A

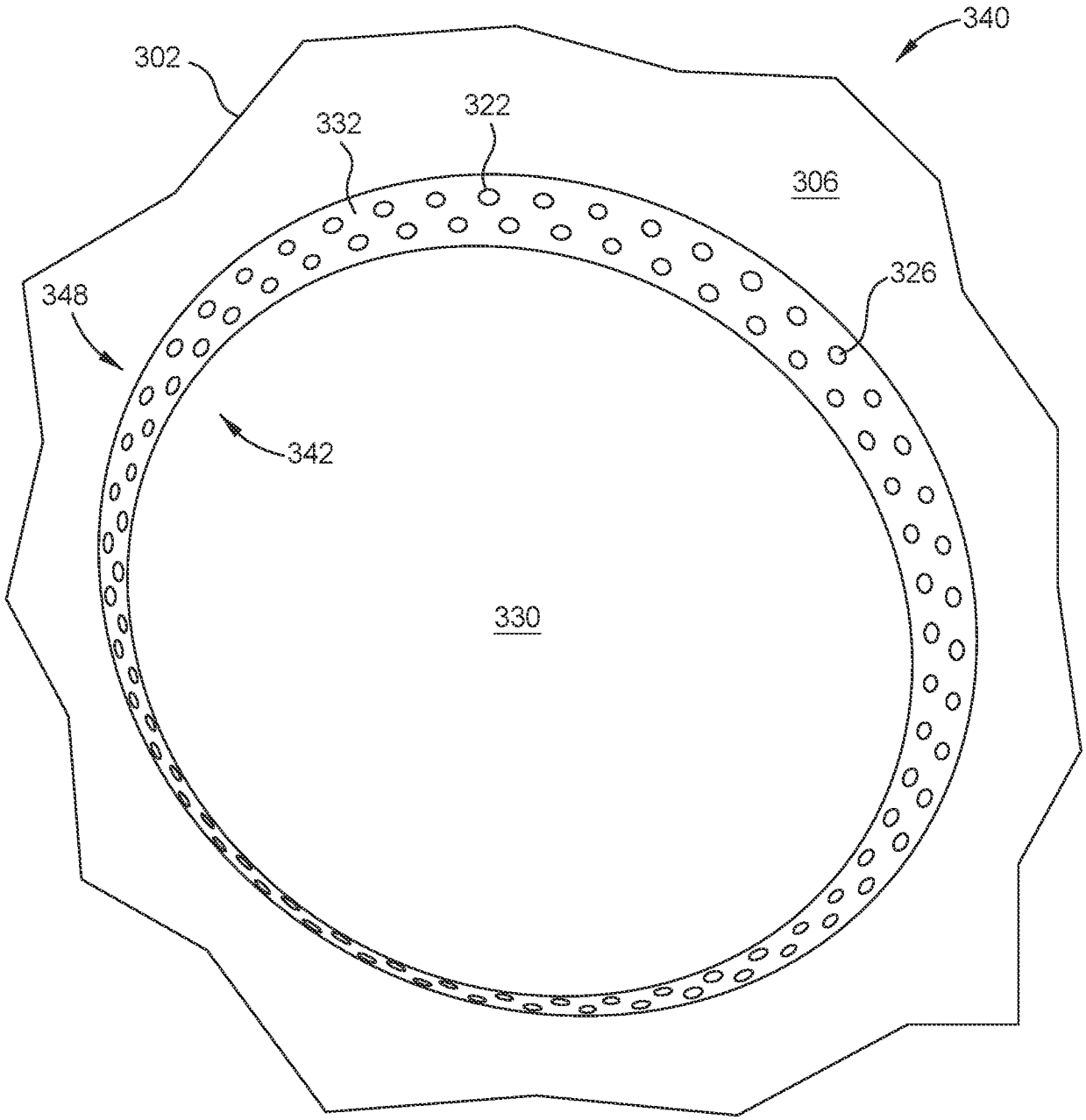


FIG. 3B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2021/055029

A. CLASSIFICATION OF SUBJECT MATTER

C23C 16/44(2006.01)i; **C23C 16/505**(2006.01)i; **H01J 37/32**(2006.01)i; **C23C 16/26**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C23C 16/44(2006.01); C23C 14/28(2006.01); H01J 37/32(2006.01); H01L 21/3065(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: seasoning, carbon, film, chamber, depositing, inert gas, acetylene, helium

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2005-103327 A1 (TOKYO ELECTRON LIMITED) 03 November 2005 (2005-11-03) paragraphs [0085], [0090]-[0093] and claims 1, 14, 16, 25-26	1-3,5-10
Y		4,11-20
Y	US 2008-0254233 A1 (LEE et al.) 16 October 2008 (2008-10-16) paragraphs [0028], [0034]	4
Y	US 6589868 B2 (ROSSMAN, KENT) 08 July 2003 (2003-07-08) claims 9, 11	11-20
A	US 2005-0214455 A1 (LI et al.) 29 September 2005 (2005-09-29) claim 10	1-20
A	JP 2002-184754 A (SEIKO EPSON CORP.) 28 June 2002 (2002-06-28) claims 1-3	1-20

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 January 2022	**28 January 2022**

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