

MULTI-LID STRUCTURE FOR SEMICONDUCTOR PROCESSING SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

- 5 [0001] This application claims the benefit of priority to U.S. Provisional Patent Application No. 62/873,518 filed July 12, 2019, the contents of which are hereby incorporated by reference in their entirety for all purposes.
- [0002] The present technology is related to the following applications, all concurrently filed 12 July 2019, and titled: “ROBOT FOR SIMULTANEOUS SUBSTRATE TRANSFER” (U.S. Provisional Application No. 62/873,400), “ROBOT FOR SIMULTANEOUS SUBSTRATE TRANSFER” (U.S. Provisional Application No. 62/873,432), “ROBOT FOR SIMULTANEOUS SUBSTRATE TRANSFER” (U.S. Provisional Application No. 62/873,458), “ROBOT FOR SIMULTANEOUS SUBSTRATE TRANSFER” (U.S. Provisional Application No. 62/873,480), and “HIGH-DENSITY SUBSTRATE PROCESSING SYSTEMS AND METHODS” (U.S. Provisional Application No. 62/873,503). Each of these applications is hereby incorporated by reference in their entirety for all purposes.

TECHNICAL FIELD

- [0003] The present technology relates to semiconductor processes and equipment. More specifically, the present technology relates to substrate processing systems and components.

BACKGROUND

- [0004] Semiconductor processing systems often utilize cluster tools to integrate a number of process chambers together. This configuration may facilitate the performance of several sequential processing operations without removing the substrate from a controlled processing environment, or it may allow a similar process to be performed on multiple substrates at once in the varying chambers. These chambers may include, for example, degas chambers, pretreatment chambers, transfer chambers, chemical vapor deposition chambers, physical vapor deposition

chambers, etch chambers, metrology chambers, and other chambers. The combination of chambers in a cluster tool, as well as the operating conditions and parameters under which these chambers are run, are selected to fabricate specific structures using particular process recipes and process flows.

5 **[0005]** Cluster tools often process a number of substrates by continuously passing substrates through a series of chambers and process operations. The process recipes and sequences will typically be programmed into a microprocessor controller that will direct, control, and monitor the processing of each substrate through the cluster tool. Once an entire cassette of wafers has been successfully processed through the cluster tool, the cassette may be passed to yet another
10 cluster tool or stand-alone tool, such as a chemical mechanical polisher, for further processing.

[0006] Robots are typically used to transfer the wafers through the various processing and holding chambers. The amount of time required for each process and handling operation has a direct impact on the throughput of substrates per unit of time. Substrate throughput in a cluster tool may be directly related to the speed of the substrate handling robot positioned in a transfer
15 chamber. As processing chamber configurations are further developed, conventional wafer transfer systems may be inadequate. Additionally, as cluster tools scale, component configurations may no longer adequately support processing or maintenance operations.

[0007] Thus, there is a need for improved systems and methods that can be used to efficiently direct substrates within cluster tool environments. These and other needs are addressed by the
20 present technology.

SUMMARY

[0008] Exemplary substrate processing systems may include a chamber body defining a transfer region. The systems may include a first lid plate seated on the chamber body along a
25 first surface of the first lid plate. The first lid plate may define a plurality of apertures through the first lid plate. The first lid plate may also define a recessed ledge about each aperture of the plurality of apertures in a second surface of the first lid plate opposite the first surface of the first lid plate. The systems may include a plurality of lid stacks equal to a number of apertures of the plurality of apertures. Each lid stack of the plurality of lid stacks may be seated on the first lid
30 plate on a separate recessed ledge defined in the second surface of the first lid plate. The

plurality of lid stacks may at least partially define a plurality of processing regions vertically offset from the transfer region. The systems may also include a second lid plate coupled with the plurality of lid stacks. The plurality of lid stacks may be positioned between the first lid plate and the second lid plate.

5 **[0009]** In some embodiments, the systems may also include a plurality of substrate supports disposed about the transfer region. Each substrate support of the plurality of substrate supports may be vertically translatable along a central axis of the substrate support between a first position and a second position. Each substrate support of the plurality of substrate supports may be aligned with a lid stack of the plurality of lid stacks. Each processing region of the plurality
10 of processing regions may be defined from below by an associated substrate support in the second position. Each processing region of the plurality of processing regions may be fluidly coupled with the transfer region and fluidly isolated from above from each other processing region of the plurality of processing regions. The transfer region may include a transfer apparatus rotatable about a central axis and configured to engage substrates and transfer
15 substrates among a plurality of substrate supports within the transfer region. The second lid plate may define a plurality of apertures through the second lid plate. Each aperture of the plurality of apertures may access a lid stack of the plurality of lid stacks. The systems may also include a remote plasma unit fluidly coupled with each aperture of the plurality of apertures defined in the second lid plate. Each lid stack of the plurality of lid stacks may include a pumping liner
20 defining an exhaust plenum positioned along the recessed ledge of an associated aperture through the first lid plate. Each lid stack may also include a faceplate seated on the pumping liner and at least partially defining an associated processing region from above. Each lid stack may also include a blocker plate seated on the faceplate. The systems may also include an annular faceplate heater seated on the faceplate radially outward of the blocker plate.

25 **[0010]** Some embodiments of the present technology may also encompass substrate processing systems. The systems may include a chamber body defining a transfer region. The systems may include a plurality of substrate supports distributed about the transfer region within the chamber body. The systems may include a first lid plate seated on the chamber body. The first lid plate may define a plurality of apertures through the first lid plate equal to a number of substrate
30 supports of the plurality of substrate supports. Each aperture of the plurality of apertures may be

axially aligned with a substrate support of the plurality of substrate supports. Each aperture of the plurality of apertures may be characterized by a diameter greater than a diameter of an associated substrate support of the plurality of substrate supports. The systems may include a plurality of lid stacks equal to a number of apertures of the plurality of apertures. Each lid stack of the plurality of lid stacks may be seated on the first lid plate overlying an aperture of the plurality of apertures of the first lid plate. The systems may include a second lid plate coupled with the plurality of lid stacks. The plurality of lid stacks may be positioned between the first lid plate and the second lid plate.

[0011] In some embodiments, the plurality of lid stacks may at least partially define a plurality of processing regions vertically offset from the transfer region. Each lid stack may include a faceplate at least partially defining from above an associated processing region of the plurality of processing regions. Each substrate support of the plurality of substrate supports may be vertically translatable along a central axis of the substrate support between a first position and a second position. The systems may also include a transfer apparatus positioned within the transfer region and rotatable about a central axis. The transfer apparatus may be configured to engage substrates and transfer substrates among the plurality of substrate supports within the transfer region. The second lid plate may define a plurality of apertures through the second lid plate. Each aperture of the plurality of apertures may be axially aligned with a substrate support of the plurality of substrate supports. The systems may also include a remote plasma unit seated on the second lid plate and fluidly coupled with each aperture of the plurality of apertures defined in the second lid plate.

[0012] Some embodiments of the present technology may also encompass substrate processing systems. The systems may include a chamber body defining a transfer region. The systems may include a first lid plate seated on the chamber body along a first surface of the first lid plate. The first lid plate may define a plurality of apertures through the first lid plate. The systems may include a plurality of faceplates. Each faceplate of the plurality of faceplates may be seated on the first lid plate overlying an aperture of the plurality of apertures of the first lid plate. The plurality of faceplates may at least partially define a plurality of processing regions vertically offset from the transfer region. The systems may also include a second lid plate coupled with the plurality of faceplates. The plurality of faceplates may be positioned between the first lid plate

and the second lid plate. At least one structural support may extend between the first lid plate and the second lid plate about the plurality of faceplates.

[0013] Such technology may provide numerous benefits over conventional systems and techniques. For example, the processing systems may provide multi-substrate processing capabilities that may be scaled well beyond conventional designs. Additionally, each chamber system may include multiple lid components facilitating separation and access to components of individual lid stacks. These and other embodiments, along with many of their advantages and features, are described in more detail in conjunction with the below description and attached figures.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0014] A further understanding of the nature and advantages of the disclosed technology may be realized by reference to the remaining portions of the specification and the drawings.

[0015] FIG. 1 shows a schematic top plan view of an exemplary processing system according to some embodiments of the present technology.

[0016] FIG. 2 shows a schematic isometric view of a transfer region of an exemplary chamber system according to some embodiments of the present technology.

[0017] FIG. 3 shows a schematic isometric view of a transfer region of an exemplary chamber system according to some embodiments of the present technology.

[0018] FIG. 4 shows a schematic isometric view of a transfer region of an exemplary chamber system according to some embodiments of the present technology.

[0019] FIG. 5 shows a schematic partial isometric view of a chamber system according to some embodiments of the present technology.

[0020] FIG. 6 shows a schematic partial cross-sectional view of an exemplary chamber system according to some embodiments of the present technology.

[0021] FIGS. 7A-7B show schematic views of exemplary chamber systems according to some embodiments of the present technology.

[0022] FIGS. 8A-8B show schematic views of exemplary chamber systems according to some embodiments of the present technology.

[0023] Several of the figures are included as schematics. It is to be understood that the figures are for illustrative purposes, and are not to be considered of scale or proportion unless
5 specifically stated to be of scale or proportion. Additionally, as schematics, the figures are provided to aid comprehension and may not include all aspects or information compared to realistic representations, and may include exaggerated material for illustrative purposes.

[0024] In the appended figures, similar components and/or features may have the same reference label. Further, various components of the same type may be distinguished by
10 following the reference label by a letter that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the letter.

DETAILED DESCRIPTION

[0025] Substrate processing can include time-intensive operations for adding, removing, or otherwise modifying materials on a wafer or semiconductor substrate. Efficient movement of the substrate may reduce queue times and improve substrate throughput. To improve the number of substrates processed within a cluster tool, additional chambers may be incorporated onto the mainframe. Although transfer robots and processing chambers can be continually added by
20 lengthening the tool, this may become space inefficient as the footprint of the cluster tool scales. Accordingly, the present technology may include cluster tools with an increased number of processing chambers within a defined footprint. To accommodate the limited footprint about transfer robots, the present technology may increase the number of processing chambers laterally outward from the robot. For example, some conventional cluster tools may include one or two
25 processing chambers positioned about sections of a centrally located transfer robot to maximize the number of chambers radially about the robot. The present technology may expand on this concept by incorporating additional chambers laterally outward as another row or group of chambers. For example, the present technology may be applied with cluster tools including three, four, five, six, or more processing chambers accessible at each of one or more robot access
30 positions.

[0026] However, as additional process locations are added, accessing these locations from a central robot may no longer be feasible without additional transfer capabilities at each location. Some conventional technologies may include wafer carriers on which the substrates remain seated during transition. However, wafer carriers may contribute to thermal non-uniformity and particle contamination on substrates. The present technology overcomes these issues by incorporating a transfer section vertically aligned with processing chamber regions and a carousel or transfer apparatus that may operate in concert with a central robot to access additional wafer positions. The present technology may not use conventional wafer carriers in some embodiments, and may transfer specific wafers from one substrate support to a different substrate support within the transfer region.

[0027] Additionally, as more process locations are added, access to one or more components may be restricted in each chamber system. For example, a single lid plate supporting lid stacks for multiple processing regions may challenge accessing some of the lid stack components, which may be more prone to replacement. The present technology overcomes these issues by incorporating a dual lid configuration, which may include a lid on each end of the lid stack. The lids may be removed together to provide access to an underlying transfer region, or a top lid may be removed separately providing access to lid stack components disposed between the two lids.

[0028] Although the remaining disclosure will routinely identify specific structures, such as four-position chamber systems, for which the present structures and methods may be employed, it will be readily understood that the systems and methods are equally applicable to any number of structures and devices that may benefit from the structural capabilities explained. Accordingly, the technology should not be considered to be so limited as for use with any particular structures alone. Moreover, although an exemplary tool system will be described to provide foundation for the present technology, it is to be understood that the present technology can be incorporated with any number of semiconductor processing chambers and tools that may benefit from some or all of the operations and systems to be described.

[0029] FIG. 1 shows a top plan view of one embodiment of a substrate processing tool or processing system 100 of deposition, etching, baking, and curing chambers according to some embodiments of the present technology. In the figure, a set of front-opening unified pods 102 supply substrates of a variety of sizes that are received within a factory interface 103 by robotic

arms 104a and 104b and placed into a load lock or low pressure holding area 106 before being delivered to one of the substrate processing regions 108, positioned in chamber systems or quad sections 109a-c, which may each be a substrate processing system having a transfer region fluidly coupled with a plurality of processing regions 108. Although a quad system is illustrated, it is to be understood that platforms incorporating standalone chambers, twin chambers, and other multiple chamber systems are equally encompassed by the present technology. A second robotic arm 110 housed in a transfer chamber 112 may be used to transport the substrate wafers from the holding area 106 to the quad sections 109 and back, and second robotic arm 110 may be housed in a transfer chamber with which each of the quad sections or processing systems may be connected. Each substrate processing region 108 can be outfitted to perform a number of substrate processing operations including any number of deposition processes including cyclical layer deposition, atomic layer deposition, chemical vapor deposition, physical vapor deposition, as well as etch, pre-clean, anneal, plasma processing, degas, orientation, and other substrate processes.

[0030] Each quad section 109 may include a transfer region that may receive substrates from, and deliver substrates to, second robotic arm 110. The transfer region of the chamber system may be aligned with the transfer chamber having the second robotic arm 110. In some embodiments the transfer region may be laterally accessible to the robot. In subsequent operations, components of the transfer sections may vertically translate the substrates into the overlying processing regions 108. Similarly, the transfer regions may also be operable to rotate substrates between positions within each transfer region. The substrate processing regions 108 may include any number of system components for depositing, annealing, curing and/or etching a material film on the substrate or wafer. In one configuration, two sets of the processing regions, such as the processing regions in quad section 109a and 109b, may be used to deposit material on the substrate, and the third set of processing chambers, such as the processing chambers or regions in quad section 109c, may be used to cure, anneal, or treat the deposited films. In another configuration, all three sets of chambers, such as all twelve chambers illustrated, may be configured to both deposit and/or cure a film on the substrate.

[0031] As illustrated in the figure, second robotic arm 110 may include two arms for delivering and/or retrieving multiple substrates simultaneously. For example, each quad section 109 may

include two accesses 107 along a surface of a housing of the transfer region, which may be laterally aligned with the second robotic arm. The accesses may be defined along a surface adjacent the transfer chamber 112. In some embodiments, such as illustrated, the first access may be aligned with a first substrate support of the plurality of substrate supports of a quad section. Additionally, the second access may be aligned with a second substrate support of the plurality of substrate supports of the quad section. The first substrate support may be adjacent to the second substrate support, and the two substrate supports may define a first row of substrate supports in some embodiments. As shown in the illustrated configuration, a second row of substrate supports may be positioned behind the first row of substrate supports laterally outward from the transfer chamber 112. The two arms of the second robotic arm 110 may be spaced to allow the two arms to simultaneously enter a quad section or chamber system to deliver or retrieve one or two substrates to substrate supports within the transfer region.

[0032] Any one or more of the transfer regions described may be incorporated with additional chambers separated from the fabrication system shown in different embodiments. It will be appreciated that additional configurations of deposition, etching, annealing, and curing chambers for material films are contemplated by processing system 100. Additionally, any number of other processing systems may be utilized with the present technology, which may incorporate transfer systems for performing any of the specific operations, such as the substrate movement. In some embodiments, processing systems that may provide access to multiple processing chamber regions while maintaining a vacuum environment in various sections, such as the noted holding and transfer areas, may allow operations to be performed in multiple chambers while maintaining a particular vacuum environment between discrete processes.

[0033] As noted, processing system 100, or more specifically quad sections or chamber systems incorporated with processing system 100 or other processing systems, may include transfer sections positioned below the processing chamber regions illustrated. **FIG. 2** shows a schematic isometric view of a transfer section of an exemplary chamber system 200 according to some embodiments of the present technology. **FIG. 2** may illustrate additional aspects or variations of aspects of the transfer region described above, and may include any of the components or characteristics described. The system illustrated may include a transfer region housing 205, which may be a chamber body as discussed further below, defining a transfer

region in which a number of components may be included. The transfer region may additionally be at least partially defined from above by processing chambers or processing regions fluidly coupled with the transfer region, such as processing chamber regions 108 illustrated in quad sections 109 of FIG. 1. A sidewall of the transfer region housing may define one or more access locations 207 through which substrates may be delivered and retrieved, such as by second robotic arm 110 as discussed above. Access locations 207 may be slit valves or other sealable access positions, which include doors or other sealing mechanisms to provide a hermetic environment within transfer region housing 205 in some embodiments. Although illustrated with two such access locations 207, it is to be understood that in some embodiments only a single access location 207 may be included, as well as access locations on multiple sides of the transfer region housing. It is also to be understood that the transfer section illustrated may be sized to accommodate any substrate size, including 200 mm, 300 mm, 450 mm, or larger or smaller substrates, including substrates characterized by any number of geometries or shapes.

[0034] Within transfer region housing 205 may be a plurality of substrate supports 210 positioned about the transfer region volume. Although four substrate supports are illustrated, it is to be understood that any number of substrate supports are similarly encompassed by embodiments of the present technology. For example, greater than or about three, four, five, six, eight, or more substrate supports 210 may be accommodated in transfer regions according to embodiments of the present technology. Second robotic arm 110 may deliver a substrate to either or both of substrate supports 210a or 210b through the accesses 207. Similarly, second robotic arm 110 may retrieve substrates from these locations. Lift pins 212 may protrude from the substrate supports 210, and may allow the robot to access beneath the substrates. The lift pins may be fixed on the substrate supports, or at a location where the substrate supports may recess below, or the lift pins may additionally be raised or lowered through the substrate supports in some embodiments. Substrate supports 210 may be vertically translatable, and in some embodiments may extend up to processing chamber regions of the substrate processing systems, such as processing chamber regions 108, positioned above the transfer region housing 205.

[0035] The transfer region housing 205 may provide access 215 for alignment systems, which may include an aligner that can extend through an aperture of the transfer region housing as illustrated and may operate in conjunction with a laser, camera, or other monitoring device

protruding or transmitting through an adjacent aperture, and that may determine whether a substrate being translated is properly aligned. Transfer region housing 205 may also include a transfer apparatus 220 that may be operated in a number of ways to position substrates and move substrates between the various substrate supports. In one example, transfer apparatus 220 may
5 move substrates on substrate supports 210a and 210b to substrate supports 210c and 210d, which may allow additional substrates to be delivered into the transfer chamber. Additional transfer operations may include rotating substrates between substrate supports for additional processing in overlying processing regions.

[0036] Transfer apparatus 220 may include a central hub 225 that may include one or more
10 shafts extending into the transfer chamber. Coupled with the shaft may be an end effector 235. End effector 235 may include a plurality of arms 237 extending radially or laterally outward from the central hub. Although illustrated with a central body from which the arms extend, the end effector may additionally include separate arms that are each coupled with the shaft or central hub in various embodiments. Any number of arms may be included in embodiments of
15 the present technology. In some embodiments a number of arms 237 may be similar or equal to the number of substrate supports 210 included in the chamber. Hence, as illustrated, for four substrate supports, transfer apparatus 220 may include four arms extending from the end effector. The arms may be characterized by any number of shapes and profiles, such as straight profiles or arcuate profiles, as well as including any number of distal profiles including hooks,
20 rings, forks, or other designs for supporting a substrate and/or providing access to a substrate, such as for alignment or engagement.

[0037] The end effector 235, or components or portions of the end effector, may be used to contact substrates during transfer or movement. These components as well as the end effector may be made from or include a number of materials including conductive and/or insulative
25 materials. The materials may be coated or plated in some embodiments to withstand contact with precursors or other chemicals that may pass into the transfer chamber from an overlying processing chamber.

[0038] Additionally, the materials may be provided or selected to withstand other environmental characteristics, such as temperature. In some embodiments, the substrate supports
30 may be operable to heat a substrate disposed on the support. The substrate supports may be

configured to increase a surface or substrate temperature to temperatures greater than or about 100° C, greater than or about 200° C, greater than or about 300° C, greater than or about 400° C, greater than or about 500° C, greater than or about 600° C, greater than or about 700° C, greater than or about 800° C, or higher. Any of these temperatures may be maintained during
5 operations, and thus components of the transfer apparatus 220 may be exposed to any of these stated or encompassed temperatures. Consequently, in some embodiments any of the materials may be selected to accommodate these temperature regimes, and may include materials such as ceramics and metals that may be characterized by relatively low coefficients of thermal expansion, or other beneficial characteristics.

10 **[0039]** Component couplings may also be adapted for operation in high temperature and/or corrosive environments. For example, where end effectors and end portions are each ceramic, the coupling may include press fittings, snap fittings, or other fittings that may not include additional materials, such as bolts, which may expand and contract with temperature, and may cause cracking in the ceramics. In some embodiments the end portions may be continuous with
15 the end effectors, and may be monolithically formed with the end effectors. Any number of other materials may be utilized that may facilitate operation or resistance during operation, and are similarly encompassed by the present technology. The transfer apparatus 220 may include a number of components and configurations that may facilitate the movement of the end effector in multiple directions, which may facilitate rotational movement, as well as vertical movement, or
20 lateral movement in one or more ways with the drive system components to which the end effector may be coupled.

[0040] FIG. 3 shows a schematic isometric view of a transfer region of a chamber system 300 of an exemplary chamber system according to some embodiments of the present technology. Chamber system 300 may be similar to the transfer region of chamber system 200 described
25 above, and may include similar components including any of the components, characteristics, or configurations described above. FIG. 3 may also illustrate certain component couplings encompassed by the present technology along with the following figures.

[0041] Chamber system 300 may include a chamber body 305 or housing defining the transfer region. Within the defined volume may be a plurality of substrate supports 310 distributed about
30 the chamber body as previously described. As will be described further below, each substrate

support 310 may be vertically translatable along a central axis of the substrate support between a first position illustrated in the figure, and a second position where substrate processing may be performed. Chamber body 305 may also define one or more accesses 307 through the chamber body. A transfer apparatus 335 may be positioned within the transfer region and be configured to engage and rotate substrates among the substrate supports 310 within the transfer region as previously described. For example, transfer apparatus 335 may be rotatable about a central axis of the transfer apparatus to reposition substrates. The transfer apparatus 335 may also be laterally translatable in some embodiments to further facilitate repositioning substrates at each substrate support.

10 **[0042]** Chamber body 305 may include a top surface 306, which may provide support for overlying components of the system. Top surface 306 may define a gasket groove 308, which may provide seating for a gasket to provide hermetic sealing of overlying components for vacuum processing. Unlike some conventional systems, chamber system 300, and other chamber systems according to some embodiments of the present technology, may include an open transfer region within the processing chamber, and processing regions may be formed overlying the transfer region. Because of transfer apparatus 335 creating an area of sweep, supports or structure for separating processing regions may not be available. Consequently, the present technology may utilize overlying lid structures to form segregated processing regions overlying the open transfer region as will be described below. Hence, in some embodiments sealing between the chamber body and an overlying component may only occur about an outer chamber body wall defining the transfer region, and interior coupling may not be present in some embodiments. Chamber body 305 may also define apertures 315, which may facilitate exhaust flow from the processing regions of the overlying structures. Top surface 306 of chamber body 305 may also define one or more gasket grooves about the apertures 315 for sealing with an overlying component. Additionally, the apertures may provide locating features that may facilitate stacking of components in some embodiments.

[0043] FIG. 4 shows a schematic isometric view of overlying structures of chamber system 300 according to some embodiments of the present technology. For example, in some embodiments a first lid plate 405 may be seated on chamber body 305. First lid plate 405 may be characterized by a first surface 407 and a second surface 409 opposite the first surface. First

surface 407 of the first lid plate 405 may contact chamber body 305, and may define companion grooves to cooperate with grooves 308 discussed above to produce a gasket channel between the components. First lid plate 405 may also define apertures 410, which may provide separation of overlying regions of the transfer chamber to form processing regions for substrate processing.

5 [0044] Apertures 410 may be defined through first lid plate 405, and may be at least partially aligned with substrate supports in the transfer region. In some embodiments, a number of apertures 410 may equal a number of substrate supports in the transfer region, and each aperture 410 may be axially aligned with a substrate support of the plurality of substrate supports. As will be described further below, the processing regions may be at least partially defined by the
10 substrate supports when vertically raised to a second position within the chamber systems. The substrate supports may extend through the apertures 410 of the first lid plate 405. Accordingly, in some embodiments apertures 410 of the first lid plate 405 may be characterized by a diameter greater than a diameter of an associated substrate support. Depending on an amount of clearance, the diameter may be less than or about 25% greater than a diameter of a substrate
15 support, and in some embodiments may be less than or about 20% greater, less than or about 15% greater, less than or about 10% greater, less than or about 9% greater, less than or about 8% greater, less than or about 7% greater, less than or about 6% greater, less than or about 5% greater, less than or about 4% greater, less than or about 3% greater, less than or about 2% greater, less than or about 1% greater than a diameter of a substrate support, or less, which may
20 provide a minimum gap distance between the substrate support and the apertures 410.

[0045] First lid plate 405 may also include a second surface 409 opposite first surface 407. Second surface 409 may define a recessed ledge 415, which may produce an annular recessed shelf through the second surface 409 of first lid plate 405. Recessed ledges 415 may be defined about each aperture of the plurality of apertures 410 in some embodiments. The recessed shelf
25 may provide support for lid stack components as will be described further below. Additionally, first lid plate 405 may define second apertures 420, which may at least partially define pumping channels from overlying components described below. Second apertures 420 may be axially aligned with apertures 315 of the chamber body 305 described previously.

[0046] FIG. 5 shows a schematic partial isometric view of chamber system 300 according to
30 some embodiments of the present technology. The figure may illustrate a partial cross-section

through two processing regions and a portion of a transfer region of the chamber system. For example, chamber system 300 may be a quad section of processing system 100 described previously, and may include any of the components of any of the previously described components or systems.

5 [0047] Chamber system 300, as developed through the figure, may include a chamber body 305 defining a transfer region 502 including substrate supports 310, which may extend into the chamber body 305 and be vertically translatable as previously described. First lid plate 405 may be seated overlying the chamber body 305, and may define apertures 410 producing access for processing region 504 to be formed with additional chamber system components. Seated about
10 or at least partially within each aperture may be a lid stack 505, and chamber system 300 may include a plurality of lid stacks 505, including a number of lid stacks equal to a number of apertures 410 of the plurality of apertures. Each lid stack 505 may be seated on the first lid plate 405, and may be seated on a shelf produced by recessed ledges through the second surface of the first lid plate. The lid stacks 505 may at least partially define processing regions 504 of the
15 chamber system 300.

[0048] As illustrated, processing regions 504 may be vertically offset from the transfer region 502, but may be fluidly coupled with the transfer region. Additionally, the processing regions may be separated from the other processing regions. Although the processing regions may be fluidly coupled with other processing regions through the transfer region from below, the
20 processing regions may be fluidly isolated, from above, from each of the other processing regions. Each lid stack 505 may also be aligned with a substrate support in some embodiments. For example, as illustrated, lid stack 505a may be aligned over substrate support 310a, and lid stack 505b may be aligned over substrate support 310b. When raised to operational positions, such as a second position, the substrates may deliver substrates for individual processing within
25 the separate processing regions. When in this position, as will be described further below, each processing region 504 may be at least partially defined from below by an associated substrate support in the second position.

[0049] FIG. 5 also illustrates embodiments in which a second lid plate 510 may be included for the chamber system. Second lid plate 510 may be coupled with each of the lid stacks, which
30 may be positioned between the first lid plate 405 and the second lid plate 510 in some

embodiments. As will be explained below, the second lid plate 510 may facilitate accessing components of the lid stacks 505. Second lid plate 510 may define a plurality of apertures 512 through the second lid plate. Each aperture of the plurality of apertures may be defined to provide fluid access to a specific lid stack 505 or processing region 504. A remote plasma unit 515 may optionally be included in chamber system 300 in some embodiments, and may be supported on second lid plate 510. In some embodiments, remote plasma unit 515 may be fluidly coupled with each aperture 512 of the plurality of apertures through second lid plate 510. Isolation valves 520 may be included along each fluid line to provide fluid control to each individual processing region 504. For example, as illustrated, aperture 512a may provide fluid access to lid stack 505a. Aperture 512a may also be axially aligned with any of the lid stack components, as well as with substrate support 310a in some embodiments, which may produce an axial alignment for each of the components associated with individual processing regions, such as along a central axis through the substrate support or any of the components associated with a particular processing region 504. Similarly, aperture 512b may provide fluid access to lid stack 505b, and may be aligned, including axially aligned with components of the lid stack as well as substrate support 310b in some embodiments.

[0050] FIG. 6 shows a schematic cross-sectional elevation view of one embodiment of chamber system 300 according to some embodiments of the present technology. FIG. 6 may illustrate the cross-sectional view shown above in FIG. 5, and may further illustrate components of the system. The figure may include components of any of the systems illustrated and described previously, and may also show further aspects of any of the previously described systems. It is to be understood that the illustration may also show exemplary components as would be seen through any two adjacent processing regions 108 in any quad section 109 described above. The elevation view may illustrate the configuration or fluid coupling of one or more processing regions 504 with a transfer region 502. For example, a continuous transfer region 502 may be defined by chamber body 305. The housing may define an open interior volume in which a number of substrate supports 310 may be disposed. For example, as illustrated in FIG. 1, exemplary processing systems may include four or more, including a plurality of substrate supports 310 distributed within the chamber body about the transfer region. The substrate supports may be pedestals as illustrated, although a number of other configurations may also be used. In some embodiments the pedestals may be vertically translatable between the

transfer region 502 and the processing regions 504 overlying the transfer region. The substrate supports may be vertically translatable along a central axis of the substrate support along a path between a first position and a second position within the chamber system. Accordingly, in some embodiments each substrate support 310 may be axially aligned with an overlying processing
5 region 504 defined by one or more chamber components.

[0051] The open transfer region may afford the ability of a transfer apparatus 635, such as a carousel, to engage and move substrates, such as rotationally, between the various substrate supports. The transfer apparatus 635 may be rotatable about a central axis. This may allow substrates to be positioned for processing within any of the processing regions 504 within the
10 processing system. The transfer apparatus 635 may include one or more end effectors that may engage substrates from above, below, or may engage exterior edges of the substrates for movement about the substrate supports. The transfer apparatus may receive substrates from a transfer chamber robot, such as robot 110 described previously. The transfer apparatus may then rotate substrates to alternate substrate supports to facilitate delivery of additional substrates.

[0052] Once positioned and awaiting processing, the transfer apparatus may position the end effectors or arms between substrate supports, which may allow the substrate supports to be raised past the transfer apparatus 635 and deliver the substrates into the processing regions 504, which may be vertically offset from the transfer region 502. For example, and as illustrated, substrate support 310a may deliver a substrate into processing region 504a, while substrate support 310b
20 may deliver a substrate into processing region 504b. This may occur with the other two substrate supports and processing regions, as well as with additional substrate supports and processing regions in embodiments for which additional processing regions are included. In this configuration, the substrate supports may at least partially define a processing region 504 from below when operationally engaged for processing substrates, such as in the second position, and
25 the processing regions may be axially aligned with an associated substrate support. The processing regions may be defined from above by the components of the lid stacks 505, which may each include one or more of the illustrated components. In some embodiments, each processing region may have individual lid stack components, although in some embodiments components may accommodate multiple processing regions 504. Based on this configuration, in
30 some embodiments each processing region 504 may be fluidly coupled with the transfer region,

while being fluidly isolated from above from each other processing region within the chamber system or quad section.

5 **[0053]** The lid stack 505 may include a number of components, which may facilitate flow of precursors through the chamber system, and may be at least partially contained between the first lid plate 405 and the second lid plate 510. A liner 605 may be seated directly on the shelf formed by each recessed ledge in first lid plate 405. For example, liner 605 may define a lip or flange, which may allow liner 605 to extend from the shelf of first lid plate 405. Liner 605 may extend vertically below the first surface of first lid plate 405 in some embodiments, and may at least partially extend into the open transfer region 502. The liner 605 may be made of materials
10 similar or different from the chamber body materials, and may be or include materials that limit deposition or retention of materials on the surface of liner 605. Liner 605 may define an access diameter for substrate support 310, and may be characterized by any of the gap amounts described above for clearance between the substrate support 310 and the liner 605 when included.

15 **[0054]** Seated on the liner 605 may be a pumping liner 610, which may at least partially extend within the recess or along the recessed ledge defined in the second surface of first lid plate 405. In some embodiments, pumping liner 610 may be seated on liner 605 on the shelf formed by the recessed ledge. Pumping liner 610 may be an annular component, and may at least partially define the processing region 504 radially, or laterally depending on the volume geometry. The
20 pumping liner may define an exhaust plenum within the liner, which may define a plurality of apertures on an inner annular surface of the pumping liner providing access to the exhaust plenum. The exhaust plenum may at least partially extend vertically above a height of the first lid plate 405, which may facilitate delivering exhausted materials through an exhaust channel formed through the first lid plate and chamber body as previously described. A portion of the
25 pumping liner may at least partially extend across the second surface of the first lid plate 405 to complete the exhaust channel between the exhaust plenum of the pumping liner, and the channel formed through the chamber body and first lid plate.

30 **[0055]** A faceplate 615 may be seated on the pumping liner 610, and may define a plurality of apertures through the faceplate 615 for delivering precursors into the processing region 504. Faceplate 615 may at least partially define an associated processing region 504 from above,

which may at least partially cooperate with the pumping liner and substrate support in a raised position to generally define the processing region. Faceplate 615 may operate as an electrode of the system for producing a local plasma within the processing region 504, and thus in some embodiments, faceplate 615 may be coupled with an electrical source or may be grounded. In
5 some embodiments the substrate support 310 may operate as the companion electrode for generating a capacitively-coupled plasma between the faceplate and the substrate support.

[0056] A blocker plate 620 may be seated on the faceplate 615, which may further distribute processing fluids or precursors to produce a more uniform flow distribution to a substrate. Blocker plate 620 may also define a number of apertures through the plate. In some
10 embodiments the blocker plate 620 may be characterized by a diameter less than a diameter of the faceplate as illustrated, which may provide an annular access on the surface of the faceplate radially outward from the blocker plate 620. In some embodiments a faceplate heater 625 may be seated on the annular access, and may contact faceplate 615 to heat the component during processing or other operations. In some embodiments, blocker plate 620 and faceplate heater
15 625 may be characterized together as having an outer radial diameter equal to or substantially equal to an outer radial diameter of faceplate 615. Similarly, faceplate heater 625 may be characterized as having an outer radial diameter equal to or substantially equal to an outer radial diameter of faceplate 615 in some embodiments. Faceplate heater 625 may extend about blocker plate 620, and may or may not directly contact blocker plate 620 on an outer radial edge of the
20 blocker plate 620.

[0057] A gas box 630 may be positioned above the blocker plate 620, and the gas box 630 of each of the lid stacks 505 may at least partially support the second lid plate 510. Gas box 630 may define a central aperture that is aligned with an associated aperture 512 of the plurality of apertures defined through second lid plate 510. Second lid plate 510 may support a remote
25 plasma unit 515 in some embodiments, which may include piping to each of the apertures 512, and into each processing region 504. Adapters may be positioned through apertures 512 to couple the remote plasma unit piping to the gas boxes 630. Additionally, isolation valves 520 may be positioned within the piping to meter flow to each individual processing region 504 in some embodiments.

[0058] O-rings or gaskets may be seated between each component of the lid stack 505, which may facilitate vacuum processing within chamber system 300 in some embodiments. The specific component coupling between the first lid plate 405 and the second lid plate 510 may occur in any number of ways, which may facilitate accessing system components. For example, 5 a first set of couplings may be incorporated between the first lid plate 405 and the second lid plate 510, which may facilitate removal of both lid plates and each lid stack 505, which may provide access to the substrate supports or transfer apparatus within the transfer region of the chamber system. These couplings may include any number of physical and removable couplings extending between the two lid plates, which may allow them to be separated from the chamber 10 body 405 as a whole. For example, a drive motor on a mainframe containing the chamber system 300 may be removably coupled with the second lid plate 510, which may lift the components away from the chamber body 305.

[0059] When the couplings between the first lid plate 405 and second lid plate 510 are disengaged, second lid plate 510 may be removed while first lid plate 405 may remain on 15 chamber body 305, which may facilitate access to one or more components of the lid stacks 505. The break within the lid stack 505 may occur between any two components described previously, some of which may be coupled with first lid plate 405, and some of which may be coupled with second lid plate 510. For example, in some embodiments each of the gas boxes 630 may be coupled with second lid plate 510. Thus, when the second lid plate is lifted from the 20 chamber system, the gas boxes may be removed, providing access to the blocker plate and faceplate. Continuing this example, the blocker plate 620 and faceplate 615 may or may not be coupled with the first lid plate 405. For example, although mechanical coupling may be included, the components may be decoupled and sit floating on the first lid plate 405, such as with locating features maintaining proper alignment of the components. It is to be understood 25 that the example is intended to be non-limiting, and illustrative of any number of break configurations between any two components of the lid stack when the second lid plate 510 is separated from the first lid plate 405. Consequently, depending on the coupling between the first lid plate and second lid plate, the entire lid stack and both lid plates may be removed providing access to the transfer region, or the second lid plate may be removed providing access to the lid 30 stack components.

[0060] FIGS. 7A-7B show schematic views of exemplary chamber systems according to some embodiments of the present technology, and may illustrate the formation of a processing region by translating a substrate support. The figures may illustrate simplified schematics, but it is to be understood that the figures may illustrate operational capabilities of any of the previously described systems, and may include any of the components, characteristics, or configurations of any structure or system previously described.

[0061] FIG. 7A may illustrate a cross-sectional elevation view through a chamber system 700, such as through substrate supports 710a and 710b within a transfer region 705, and overlying processing regions 725a and 725b, which may be similar to the transfer regions and processing regions described previously. The chamber system and each processing region may include any of the components previously described, including lid stack components such as a faceplate 730, a blocker plate 735, and lid components which may define access for delivering precursors into the individual processing regions. For example, chamber system 700 may include a first lid plate 740 between the lid stack components and the chamber body defining the transfer region 705, and a second lid plate 745 extending across the lid stacks. FIG. 7A may illustrate the elevation view after a substrate 701 has been transferred to a substrate support 710b within transfer region 705. Transfer apparatus 720 may be rotated away from the substrate supports, such as to a recessed position, or any other position in which the end effector may not interfere with vertical translation of one or more of the substrate supports.

[0062] The substrate support may be raised, as illustrated in FIG. 7B, to deliver the substrate to processing region 725b for processing, which may position the substrate support at a second vertical position relative to the first. As illustrated, transfer apparatus 720 may not interfere or be contacted by the substrate support, which may extend vertically along a central axis of the substrate support to the overlying, and axially aligned processing region. When positioned for processing, substrate support 710b may at least partially define the substrate processing region from below, which may illustrate the fluid coupling between the individual processing regions and transfer region. Substrate 701 may be processed in any number of processing operations that may be performed in processing regions according to the present technology, which may include, as one non-limiting example, depositing one or more layers of material on the substrate. In some embodiments substrate support 710b and faceplate 730 or other lid stack components may

operate as electrodes to produce a plasma within processing region 725b. The substrate supports may also be configured to heat the substrates as previously described. Although illustrated as a single substrate being processed, it is to be understood that any number of substrates may be simultaneously processed, including a substrate on each substrate support within the chamber system. Each of the substrate supports may be configured for similar operation as substrate support 710b as described.

[0063] Chamber systems according to some embodiments of the present technology may include additional features to support processing with the multiple processing regions of the system. By incorporating the transfer region, which may be open to facilitate a sweep of the transfer apparatus, support for the first lid plate may be limited to exterior edges as previously described. Because the chamber system may be operated under vacuum, the open transfer region may develop a substantial load within the open volume. Depending on the processing pressures as well as component weights, the first lid plate may be exposed to vacuum loads of several tons or more. Because central supports may not exist within the transfer region in some embodiments, the first lid plate may exhibit a deflection if not properly supported. Accordingly, chamber systems according to some embodiments of the present technology may include additional structural supports for the first lid plate to improve rigidity.

[0064] **FIGS. 8A-8B** show schematic views of exemplary chamber systems 800 according to some embodiments of the present technology, and may include schematic views of structural supports that may be incorporated with first lid plates as described in conjunction with any of the previous figures, as well as other chamber systems according to embodiments of the present technology. As illustrated, in some embodiments first lid plates may include one or more structural supports extending between the lid stacks.

[0065] FIG. 8A illustrates an exemplary first lid plate 805 along with lid stacks 810 positioned on the first lid plate. The figure also shows a first structural support 815a positioned on the first lid plate 805, and extending about the lid stacks 810. The first structural support 815 may include material that may resist deflection of the first lid plate 805, and may be any number of materials including aluminum, steel, or other materials that may be attached to the first lid plate to improve a resistance to deflection. The first structural support 815 may extend partially about the first lid plate, and in some embodiments may maintain access for pumping liners to extend

and access pumping channels through the first lid plate and chamber body as previously described. A second structural support 820a may also be positioned across the first structural support 815, which may at least partially extend along a height between the first structural support and the second lid plate. The second structural support 820 may be similar or different
5 in materials or geometry to the first structural support in embodiments of the present technology.

[0066] FIG. 8B illustrates an additional variation where structural supports may be monolithically formed with the first lid plate. As illustrated, a profile of first lid plate 805 may extend vertically about the lid stacks to define a first structural support 815b. In some
10 embodiments the first lid plate may continue to extend vertically to define a second structural support, or in some embodiments a second structural support 820b may be coupled with the lid plate. As illustrated in FIG. 8B, the first and second structural supports may be any number of materials to improve rigidity of the first lid plate to limit or prevent deflection of the first lid plate within the chamber system.

[0067] The present technology includes substrate processing systems that may accommodate
15 multiple substrate supports distributed in a chamber system providing multiple processing regions coupled with a transfer region. Additionally, some embodiments of the present technology incorporate a dual-lid configuration providing joint removal of the two lids or separate removal of a second lid plate, which may provide access to lid stack components of each processing region.

[0068] In the preceding description, for the purposes of explanation, numerous details have
20 been set forth in order to provide an understanding of various embodiments of the present technology. It will be apparent to one skilled in the art, however, that certain embodiments may be practiced without some of these details, or with additional details.

[0069] Having disclosed several embodiments, it will be recognized by those of skill in the art
25 that various modifications, alternative constructions, and equivalents may be used without departing from the spirit of the embodiments. Additionally, a number of well-known processes and elements have not been described in order to avoid unnecessarily obscuring the present technology. Accordingly, the above description should not be taken as limiting the scope of the technology. Additionally, methods or processes may be described as sequential or in steps, but it

is to be understood that the operations may be performed concurrently, or in different orders than listed.

[0070] Where a range of values is provided, it is understood that each intervening value, to the smallest fraction of the unit of the lower limit, unless the context clearly dictates otherwise,
5 between the upper and lower limits of that range is also specifically disclosed. Any narrower range between any stated values or unstated intervening values in a stated range and any other stated or intervening value in that stated range is encompassed. The upper and lower limits of those smaller ranges may independently be included or excluded in the range, and each range where either, neither, or both limits are included in the smaller ranges is also encompassed
10 within the technology, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also included.

[0071] As used herein and in the appended claims, the singular forms “a”, “an”, and “the” include plural references unless the context clearly dictates otherwise. Thus, for example,
15 reference to “a substrate” includes a plurality of such substrates, and reference to “the arm” includes reference to one or more arms and equivalents thereof known to those skilled in the art, and so forth.

[0072] Also, the words “comprise(s)”, “comprising”, “contain(s)”, “containing”, “include(s)”, and “including”, when used in this specification and in the following claims, are intended to
20 specify the presence of stated features, integers, components, or operations, but they do not preclude the presence or addition of one or more other features, integers, components, operations, acts, or groups.