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(71) Applicant (for all designated States except US): **APPLIED MATERIALS, INC.** [US/US]; 3050 Bowers Avenue, Santa Clara, California 95054 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **VOLFOVSKI, Leon** [US/US]; 2149 Junction Avenue #4, Mountain View, California 94043 (US). **KULKARNI, Mayur G.** [IN/US]; 3200 Payne Avenue #106, San Jose, California 95117 (US).

(74) Agent: **TABOADA, Alan**; Moser Taboada, 1030 Broad Street, Suite 203, Shrewsbury, New Jersey 07702 (US).

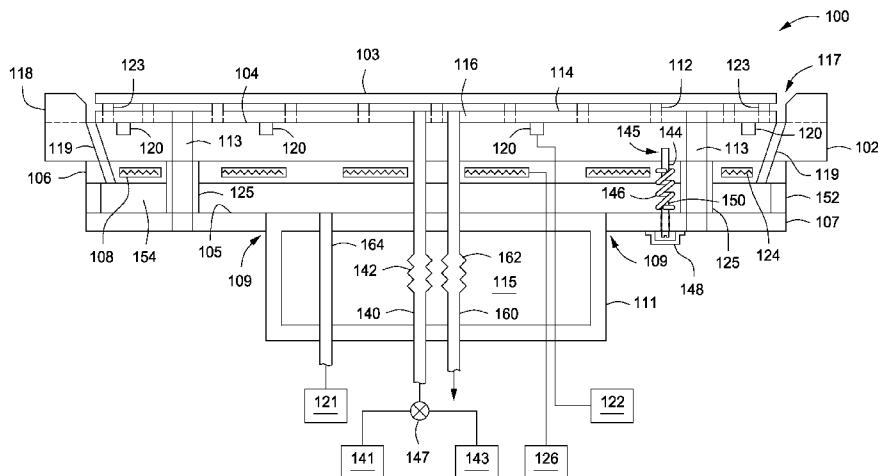
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(54) Title: SUBSTRATE SUPPORT WITH HEATER



## SUBSTRATE SUPPORT WITH HEATER

### FIELD

[0001] Embodiments of the present invention generally relate to substrate processing equipment, and more specifically to a substrate support.

### BACKGROUND

[0002] As the critical dimensions of devices continue to shrink, improved control over processes, such as heating, cooling, or the like may be required. For example, a substrate support may include a heater to provide a desired temperature of a substrate disposed on the substrate support during processing.

[0003] Thus, the inventors have provided an improved substrate support having a heater to facilitate control of the temperature of a substrate.

### SUMMARY

[0004] Embodiments of substrate supports with a heater are provided herein. In some embodiments, a substrate support may include a first member to distribute heat to a substrate when present above a first surface of the first member; a heater coupled to the first member and having one or more heating zones to provide heat to the first member; a second member disposed beneath the first member; a tubular body disposed between the first and second members, wherein the tubular body forms a gap between the first and second members; and a plurality of substrate support pins disposed a first distance above the first surface of the first member, the plurality of substrate support pins to support a backside surface of a substrate when present on the substrate support.

[0005] In some embodiments, a substrate support may include a first member to distribute heat to a substrate when present above a first surface of the first member; a plurality of substrate support pins extending from the first surface of the first member to support a backside surface of a substrate when present on the substrate support; one or more resistive heating elements disposed in the first member; a second member disposed below the first member; and a tubular body disposed

between the first and second members and forming a gap between a lower surface of the first member and an upper surface of the second member.

[0006] In some embodiments, a substrate support may include a first member to distribute heat to a substrate when present above an upper surface of the first member; a plurality of substrate support pins extend from a surface of the first member to support a backside surface of a substrate when present on the substrate support; one or more heating zones each having one or more resistive heating elements, wherein the one or more heating zones are disposed on a lower surface of the first member; a second member disposed below the first member; and a tubular body disposed between the first and second members and forming a gap between the lower surface of the first member and an upper surface of the second member.

[0007] Other and further embodiments of the present invention are described below.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0008] Embodiments of the present invention, briefly summarized above and discussed in greater detail below, can be understood by reference to the illustrative embodiments of the invention depicted in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0009] Figure 1 depicts a schematic side view of a substrate support in accordance with some embodiments of the present invention.

[0010] Figures 2A-C depict cross-sectional side views of portions of substrate supports in accordance with some embodiments of the present invention.

[0011] Figures 3A-C depict cross-sectional side views of portions of substrate supports in accordance with some embodiments of the present invention.

[0012] Figure 4 depicts a top view of a multi-zone heater in accordance with some embodiments of the present invention.

[0013] Figure 5 depicts a schematic side view of a substrate support in accordance with some embodiments of the present invention.

[0014] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. The figures are not drawn to scale and may be simplified for clarity. It is contemplated that elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

### **DETAILED DESCRIPTION**

[0015] Embodiments of substrate supports having a heater are disclosed herein. The inventive substrate support may advantageously facilitate one or more of heating a substrate, maintaining the temperature of a substrate, or distributing heat to a substrate in a desired profile.

[0016] Figure 1 depicts a substrate support 100 in accordance with some embodiments of the present invention. The substrate support 100 may include a first member 102 to distribute heat to a substrate 103 when present above a first surface 104 (e.g., an upper surface) of the first member 102 and a heater 106 having one or more heating zones 108 to provide heat to the first member 102. Optionally, the heater 106 may further include a second heating zone 301 (as illustrated in Figures 3A-B) which underlies and spans the one or more heating zones 108. The second heating zone 301 may be utilized to achieve a base temperature across the first member 102 and the one or more heating zones 108 may be utilized for fine adjustment of the temperature in each location of the first member 102, for example, to achieve a uniform distribution of temperature on the substrate 103 or to achieve a desired non-uniform distribution of temperature on the substrate 103. As shown in Figure 1, the heater 106 can be disposed below the first member 102. However, this is merely one exemplary embodiment of the heater 106. The heater 106 may be disposed in the first member 102, on a surface of the first member 102, or below the first member 102. Embodiments of the heater 106 are discussed with respect to Figures 3A-B, below.

[0017] In some embodiments, the substrate support may provide temperatures ranging from about 450 degrees Celsius to about 600 degrees Celsius. However, embodiments of the substrate support disclosed herein are not limited to the above-mentioned temperature range. For example, the temperature may be lower, such as from about 150 degrees Celsius to about 450 degrees Celsius, or higher, such as greater than about 600 degrees Celsius.

[0018] The substrate support 100 may include a second member 107 disposed beneath the first member 102. The second member 107 may function as a facilities management plate, such as for wire and/or piping management to the one or more heating zones 108 or the like. In some embodiments, the second member 107 may serve as a thermal insulator, preventing convective losses to environment below. For example, when used as a thermal insulator, the second member 107 may comprise a thermally resistive material, such as MACOR® or any suitable thermally resistive material, such as a ceramic material or the like.

[0019] The second member 107 may include an opening 109, for example, centrally disposed through the second member 107. The opening 109 may be utilized to couple a feedthrough assembly 111 to the members 102, 107 of the substrate support 100. The feedthrough assembly 111 may feed various sources and/or control devices, such as a power source 126 to the one or more heating zones 108, or a controller 122 as discussed below. In some embodiments, the feedthrough assembly 111 may include a conduit 140 which can at least one of provide a gas from a gas source 141 to the backside of the substrate 103 or provide a vacuum from a vacuum pump 143 to secure the substrate 103 to the substrate support 100. For example, the vacuum or gas may be alternately provided by a multi-way valve 147 coupling the vacuum pump 143 and gas source 141 to the conduit 140. For example, the gas provided by the conduit 140 may be utilized to improve heat transfer between the first member 102 and the substrate 103. In some embodiments, the gas is helium (He). For example, in operation, the vacuum pump 143 may be used to secure the substrate 103 to the substrate support 103. After the substrate 103 is secured, the gas source 141 may provide a gas to the space between the substrate 103 and the first member 102 to improve heat transfer.

[0020] The conduit 140 may include a flexible section 142, such as a bellows or the like. Such flexibility in the conduit 140 may be helpful, for example, when the substrate support 100 is leveled, and/or during thermal deformation or expansion of the substrate support 100 during heating. For example, the substrate support 100 may be leveled by one or more leveling devices (not shown) disposed about the feedthrough assembly 111 and through one or more members of the substrate support 100. For example, such leveling devices may include kinematic jacks or the like. Further, the feedthrough assembly 111 may include a second conduit 160 having a flexible section 162 to exhaust the gas provided by the gas source 141 through the conduit 140 as illustrated in Figure 1.

[0021] A tubular body 152 may be disposed between the first and second members 102, 107. The tubular body 152 and may be utilized to provide a gap 154 between the first and second members 102, 107 and/or to provide an additional space for electrical wires, fluid or gas conduits, or the like to be provided to components of the substrate support 100 disposed above. For example, in some embodiments, the gap 154 may be formed between a lower surface (e.g., a lower surface 302 as illustrated in Figure 3A-B) of the first member 102 and an upper surface 105 of the second member 105. The gap 154 may be filled with a gas, such as air, helium (He) or the like. The gas may be used as a thermally resistive gas or a heat transfer gas. For example, the composition of the gas may be selected based on the desired temperature profiles required for processes being performed a processing system using the support 100. Thus, the gap 154 may be used to conduct heat from the one or more heating zones 108 coupled to the first layer 102 to the second member 107 by providing a gas that is a good thermal conductor. An exemplary gas for heat conduction may be helium (He). Alternatively, the gap 154 may be used to insulate the support 100 from heat loss, for example, by creating a vacuum in the gap 154. For example, the gap 154 may be coupled to a vacuum pump, such as the vacuum pump 141 (coupling not illustrated in Figure 1) or another vacuum pump (not shown). The tubular body 152 may comprise stainless steel or the like. Further, the tubular body 152 may be fitted to the first and second members 102, 107 in any suitable manner, for example, such as disposed in recesses (not shown) about the peripheral edges of tubular body-

facing surfaces of the first and second members 102, 107 or the like. Alternatively, the tubular member 152 may be a lip or protrusion extending from the first member 102 or the second member 107.

[0022] The feedthrough assembly 111 may include a volume 115. The volume 115 may be isolated from the gap 154 and have an atmosphere that may be independently controlled. For example, the volume 115 may be coupled to one or more of a gas source, such as the gas source 141 (coupling not illustrated in Figure 1) or another gas source (not shown), or a vacuum pump, such as vacuum pump 143 (coupling not illustrated in Figure 1) or another vacuum pump (not shown) to provide a gas and/or vacuum in the volume 115.

[0023] The feedthrough assembly 111 may include additional conduits for providing vacuum and/or gas to regions in the substrate support 100. For example, the feedthrough assembly may include a conduit 164 to provide one or more of a vacuum, or a gas to the gap 154. For example, the conduit 164 may include a flexible section (not shown) similar to other conduits mentioned above for similar reasoning. For example, the conduit 164 may be used to couple the gap 154 to one or more of a vacuum pump, such as the vacuum pump 143 (coupling not illustrated in Figure 1) or another vacuum pump (not shown), or a gas source, such as the gas source 141 (coupling not illustrated in Figure 1 and/or another gas source, for example, such as a purge gas source 121. For example, the purge gas source 121 may be used to provide a purge gas to limit the deposition of materials on the backside of the substrate 103 during processing. For example, the purge gas may provide to the backside of the substrate 103 via one or more purge gas channels 119 disposed in the first member 102. As illustrated in Figure 1, the one or more purge gas channels 119 may fluidly couple the purge gas provided by the conduit 164 to the gap 154 to a gap 117 disposed proximate the edge of the substrate 103. For example, as illustrated in Figure 1, the gap 117 may be formed between an alignment guide 118 and the peripheral edge of the substrate 103 on the first surface 104 of the first member 102. The purge gas may include one or more of helium (He), nitrogen (N<sub>2</sub>), or any suitable inert gas. The purge gas may be exhausted via the gap 117 and may limit or prevent process gases from reaching and reacting with a backside of the substrate 103 during processing. The purge gas

may be exhausted from the process chamber via the exhaust system of the process chamber (not shown) to appropriately handle the exhausted purge gas. Alternatively, (not shown) the one or more purge gas channels may be disposed through and about the alignment guide 118 to provide a purge gas to the gap 117.

[0024] The members of the substrate support 100 may be coupled together by any number of suitable mechanisms. For example, suitable mechanisms may include gravity, adhesives, bonding, brazing, molding, mechanical compression (such as by screws, springs, one or more clamps, vacuum, or the like), or the like. A non-limiting exemplary form of mechanical compression is illustrated in Figure 1. For example, a compression assembly 145 may include a rod 144 disposed through one or several members of the substrate support 100 and used to compress first member 102 (and any members between the first and second members 102, 107) with the second member 107. The rod 144 is illustrated as a single piece, but may be multiple pieces (not shown) connected together by a hinge, ball and socket structure or the like to facilitate relative movement between the multiple pieces, if necessary. The rod 144 may provide flexibility for leveling the substrate support 100, similar to as discussed above for the conduit 140.

[0025] The rod 144 may be coupled to the first member 102 for example through brazing, welding, or the like, or the rod 144 may be threaded and screwed into a corresponding threaded opening in the first member 102 that is configured to receive the rod 144 (not shown). An opposing end of the rod 144 may be coupled to the second member 107 via a spring 146 or other suitable resilient structure. For example, a first end of the spring 146 may be coupled to the rod 144 and an opposing second end of the spring 146 may be coupled to the second member 107. As shown in Figure 1, a bolt 150 disposed in the second member 107 is coupled to the second end of the spring 146. In some embodiments, a cover 148 may be provided over the bolt 150. Although the spring 146 is shown providing a compressive force to pull the rod 144 towards the second member 107, the rod 144 and spring 146 could also be configured to provide the desired coupling force by expansion of the spring 146. Although only one compression assembly 150 is illustrated in Figure 1, a plurality of compression assemblies 150 may be provided, for example, disposed about a central axis of the support 100. In some

embodiments, three compression assemblies 145 may be disposed symmetrically about the central axis of the support 100.

[0026] Alternatively, the members of the substrate support 100 may be coupled together by sintering the members together. For example, sintering the members together may improve heat transfer between members. For example, an embodiment of the substrate support 100 having members sintered together is illustrated in Figure 5. For example, as shown in Figure 5, the compression assembly(s) 145 may be absent and the first member 102, the heater 106, the tubular body 152 and the second member 107 may be sintered together. For example, each member may be formed individually and then sintered together. For example, the tubular body 152 and the second member 107 may be formed separated and then sintered together after formation. For example, in some embodiments, each member may be formed from aluminum nitride (AlN) or any suitable ceramic material. Further, although illustrated in Figure 5 as structural member, the heater 106 may be any suitable embodiment of a heater as illustrated in Figures 3A-C and discussed below. Similarly, although the first member 102 may be illustrated in Figure 5 to have aspects consistent with embodiments of the first member 102 as illustrated in Figure 2A and discussed below, the first member 102 may be any suitable embodiment of a first member as illustrated in Figures 2A-C and discussed below.

[0027] In some embodiments, the substrate support 100 may include a plurality of substrate support pins 112 disposed a first distance above the first surface 104 of the first member 102, the plurality of substrate support pins 112 can support a backside surface of the substrate 103 when present on the substrate support. The plurality of substrate support pins 112 may be surrounded by a support ring 123. The support ring 123 may contact the backside of the substrate 103 proximate the peripheral edge of the substrate 103. For example, the support ring 123 may be used, for example, to define a space or volume between the backside of the substrate 103 and the substrate support 100. For example, the space may be used to form a vacuum for securing the substrate 103 to support 100 and/or to provide a gas for heat transfer between the support 100 and the substrate 102 as discussed above.

[0028] In some embodiments, (as illustrated by the dotted lines proximate each support pin 112 and the support ring 123) each of the plurality of substrate support pins and support ring 123 may extend from the first surface 104 of the first member 102 (e.g., the substrate support pins 112 and support ring 123 may be a part of, and formed in the first member 102). Alternatively, in some embodiments, a support layer 116 may be disposed on the first surface 104 of the first member 102 and each of the plurality of substrate support pins 112 and the support ring 123 may extend from a surface 114 of the support layer 116. In some embodiments, the support layer 116 and each of the plurality of substrate support pins 112 and the support ring 123 may be formed from the same material. For example, the support layer 116 and the each of the substrate support pins 112 and the support ring 123 may be a one-piece structure (illustrated in Figure 2A and discussed below). The support layer and each of the plurality of substrate support pins 112 and the support ring 123 can be formed of suitable process-compatible materials having wear resistant properties. For example, materials may be compatible with the substrate, with processes to be performed on the substrate, or the like. In some embodiments, the support layer 116 and/or the substrate support pins 112 and/or the support ring 123 may be fabricated from a dielectric material. In some embodiments, the materials used to form the support layer 116 and/or the substrate support pins 112 and/or the support ring 123 may include one or more of a polyimide (such as KAPTON®), aluminum oxide (Al<sub>2</sub>O<sub>3</sub>), aluminum nitride (AlN), silicon dioxide (SiO<sub>2</sub>), silicon nitride (Si<sub>3</sub>N<sub>4</sub>), silicon carbon (SiC) or the like. In some embodiments, for example for low temperature applications (e.g., at temperatures below about 200 degrees Celsius), the support layer 116 and/or the substrate support pins 112 and/or the support ring 123 may comprise KAPTON®.

[0029] In some embodiments, the substrate support 100 may include the alignment guide 118 extending from the first surface 104 of the first member 102 and about the plurality of substrate support pins 112. The alignment guide 118 may serve to guide, center, and/or align the substrate 103, such as with respect to the one or more heating zones 108 disposed below the substrate 103, for example, when the substrate is lowered onto the substrate support pins 112 by a plurality of lift pins (not shown - lift pins holes 113 are illustrated in Figure 1 and may extend through

support layer 116 and first and second member 102, 107). The lift pin holes 113 may be isolated from the gap 154, for example, by any suitable structure, such as tubes 125, which isolate the lift pin holes 113 from the gap 154. For example, the tubes 125 may prevent a gas provided to the gap 154 from reaching the backside of the substrate 103 via the lift pin holes 113.

[0030] The alignment guide 118 may be formed of suitable process compatible materials, such as materials having wear resistant properties and/or a low coefficient of thermal expansion. The alignment guide 118 may be a single piece or an assembly of multiple components. In some embodiments, the alignment guide 118 may be fabricated from a dielectric material. For example, suitable materials used to form the alignment guide 118 may include one or more of CELAZOLE® PBI (polybenzimidazole), aluminum oxide ( $Al_2O_3$ ), or the like. Generally, materials for any of the various components of the substrate support 100 may be selected based on chemical and thermal compatibility of the materials with each other and/or with a given process application.

[0031] The first member 102 may be utilized to distribute heat to the substrate 103. For example, the first member may act as a heat spreader to diffuse the heat provided by the one or more heating zones 108. In some embodiments, the first member 102 may include one or more temperature monitoring devices 120 embedded in the first member 102 or extending through the first member 102 to monitor the temperature being provided to the substrate 103 at one or more positions along the first surface 104 of the first member 102. The temperature monitoring devices 120 may include any suitable device for monitoring temperature, such as one or more of a temperature sensor, resistance temperature device (RTD), optical sensor, or the like. The one or more temperature monitoring devices 120 may be coupled to a controller 122 to receive temperature information from each of the plurality of the temperature monitoring devices 120. The controller 122 may further be used to control the heating zones 108 in response to the temperature information, as discussed further below. The first member 102 may be formed of suitable process-compatible materials, such as materials having one or more of high thermal conductivity, high rigidity, and a low coefficient of thermal expansion. In some embodiment, the first member 102 may have a thermal conductivity of at least

about 140 W/mK. In some embodiment, the first member 102 may have a coefficient of thermal expansion of about  $9 \times 10^{-6}/^{\circ}\text{C}$  or less. Examples of suitable materials used to form the first member 102 may include one or more of aluminum (Al), copper (Cu) or alloys thereof, aluminum nitride (AlN), beryllium oxide (BeO), pyrolytic boron nitride (PBN), silicon nitride ( $\text{Si}_3\text{N}_4$ ), aluminum oxide ( $\text{Al}_2\text{O}_3$ ), silicon carbide (SiC), graphite coated with PBN, AlN coated with yttria ( $\text{Y}_2\text{O}_3$ ), or the like. Other suitable coating that may be utilized with the first member 102 include diamond like coatings (DLCs) or the like.

[0032] Variations of the first member 102, the plurality of substrate support pins 112, and the alignment guide 118 are possible. For example, such variations may depend on the process being performed on the substrate 103 and/or the composition of the substrate 103. For example, depending on temperature requirements for a given process, the first member 102 may be formed of a material having a specific thermal conductivity or the like; however, such a material may contaminate the substrate 103 if the backside of the substrate 103 is exposed to the first surface 104 of the first member 102. Accordingly, the support layer 116 may be utilized under such conditions and be formed of a different material than the first member 102, where the different material will not contaminate the substrate 103. Similarly, the alignment guide 118 may be formed of a different material than the first member 102 for a similar reason. For example, Figure 2A depicts an embodiment of the substrate support 102 which includes the alignment guide 118, the support layer 116 and the plurality of support pins extending from the support layer 116, and the first member 102, wherein the alignment guide 118 and the support layer 116 and support pins 112 are formed from different materials than the first member 102.

[0033] Alternatively, depending on the process being performed on the substrate 103 and/or the composition of the substrate 103, the first member 102, the plurality of substrate support pins 112, and the alignment guide 118 may be formed of the same material as illustrated in Figure 2B. For example, wherein the material of the first member is compatible with the process being performed on the substrate 103 and/or the composition of the substrate 103, then embodiments of the substrate support 100 as shown in Figure 2B may be used. As the support layer 116 is integral with the first member 102 in Figure 2B, a separate support layer 116 is not

shown in Figure 2B. However, the support layer 116 may be considered to be an upper portion of the first member 102.

[0034] Alternatively, depending on the process being performed on the substrate 103 and/or the composition of the substrate, the first member 102 may vary in thickness as illustrated in Figure 2C. For example, the thickness variation along the first member 102 may facilitate a desired heating profile along the substrate 103 and/or compensate for non-uniformities in a process being performed on the frontside surface of the substrate 103, such as deposition, curing, baking, annealing, etching, and others. For example, in some embodiments, as illustrated in Figure 2C, the first member 102 may increase in thickness from the center to an edge of the first member 102. However, the embodiments of Figure 2C are merely illustrative, and the thickness of the first member 102 may be varied in any suitable manner to provide a desired heating profile along the substrate 103. As illustrated in Figure 2C, when the thickness of the first member 102 is varied, the plurality of support pins 112 may have varying lengths to compensate for the thickness variation in the first member 102. As shown in Figure 2C, each support pin 112 has a length such that it contacts a backside surface of the substrate 103 at about the same vertical height. The plurality of support pins 112 may be individually fashioned and coupled to the first member 102 as illustrated in Figure 2C. Alternatively, (not shown) the plurality of support pins 112 may be integral with the first member 102, for example, similar to the embodiments of the support pins 112 shown in Figure 2B.

[0035] Returning to Figure 1, the heater 106 may include one or more resistive heating elements 124. For example, each of the one or more heating zones 108 includes one or more resistive heating elements 124. Although illustrated in Figures 1 and 3A-D as being uniformly distributed, the one or more heating zones 108 may be distributed in any suitable configuration that is desired to provide a desired temperature profile on the substrate 103. Each of the resistive heating elements 124 may be coupled to a power source 126. The power source 126 may provide any suitable type of power, such as direct current (DC) or alternating current (AC), which is compatible with the resistive heating elements 124. The power source 126 may be coupled to and controlled by the controller 122 or by another controller (not shown) such as a system controller for controlling a process chamber having the

substrate support disposed therein, or the like. In some embodiments, the power source 126 may further include a power divider (not shown) that divides the power provided to the resistive heating elements 124 in each heating zone 108. For example, the power divider may act in response to one or more of the temperature monitoring devices 120 to selectively distribute power to the resistive heating elements 124 in specific heating zones 108. Alternatively, in some embodiments, multiple power sources may be provided for the resistive heating elements in each respective heater zone.

[0036] For example, one embodiment of a configuration of the one or more heating zones 108 arranged into six zones is illustrated in Figure 4, although greater or fewer zones may also be used. As shown in a top view, the heating zones 108 may be disposed about a central axis 402 of the substrate support 100. The one or more heating zones 108 may include a first heating zone 404 having a first radius 406 extending from the central axis 402 along the upper surface of the second member 106 (e.g., a central zone), a second heating zone 408 circumscribing the first heating zone 404 (e.g., a middle zone), and a third, fourth, fifth, and sixth heating zones 410 disposed about the second heating zone 408 (e.g., a plurality of outer zones). In some embodiments, and as shown, each of the four heating zones 410 may correspond to about one quarter of the outer region of the substrate support 100. In some embodiments, a temperature monitoring device (such as the temperature monitoring device 120 discussed above) may be provided to sense data corresponding to the temperature within each zone (or at a desired location within each zone). In some embodiments, each temperature monitoring device is an RTD. Each of the temperature monitoring devices may be coupled to the controller (such as controller 122 discussed above) to provide feedback control over each corresponding heating zone 108.

[0037] The compact design of the substrate support 100 and the tunability of heating to adjust for temperature non-uniformities on the substrate 103 can facilitate one or more of heating a substrate, maintaining the temperature of a substrate, uniformly distributing heat to or removing heat from a substrate, or create temperature non-uniformities on a substrate.

[0038] The heater 106 may be coupled to the first member 102 in any suitable manner, such as disposed in the first member 102, disposed on a surface of the first member 102, or disposed in a separate member which is coupled to the first member 102. For example, several non-limiting variations of the heater 106 are illustrated in the embodiments shown in Figures 3A-C. Figures 3A-C depict a partial cross sectional view of the support 100 in accordance with some embodiments of the invention. For example, elements, such as the compression assembly 150, the temperature monitoring device 120, support pins 112, support layer 116 or other elements of the support illustrated in Figures 1 and 2A-B have been omitted, but may be used in accordance with any of the embodiments of the heater 106 illustrated in Figures 3A-C and described below.

[0039] For example, as shown in Figure 3A, the heater 106 may be disposed in the first member 102. For example, the one or more resistive elements 124 may be disposed in the first member 102 in any suitable manner, such as arranged in heating zones 108, to provide a desired temperature profile to the substrate 103. For example, the one or more resistive elements 124 may be disposed at any suitable distance from a lower surface 302 of the first member 102 to provide the desired temperature profile. Although the heating zones 108 are illustrated as being disposed at the same distance from the lower surface 302 in Figure 3A, the distance from the lower surface 302 may vary for one or more of the heating zones 108. Optionally, as discussed above, the heater 106 may include a second heat zone 301 which may be utilized to achieve a base temperature across the first member 102. The second heat zone 301 may include one or more resistive elements 303, which may be uniformly dispersed throughout the second heat zone 301. Although drawn as a single resistive element in Figures 3A-C, the element 303 may be one or more resistive elements 303.

[0040] In some embodiments, the heater 106 may include the one or more resistive heating elements 124 deposited onto the lower surface 302 of the first member 102. For example, deposition may include any suitable deposition technique for forming a desired pattern of heating zones 108. For example, the one or more resistive heating elements 124 may comprise platinum, nichrome, INCONEL®, resistive ceramics or other suitable resistive heating materials. In some

embodiments, after the deposition of the one or more resistive heating elements 124 is complete, a coating 304 may be used to cover the one or more heating elements disposed on the lower surface 302. For example, the coating 304 may cover the entire lower surface 302 as illustrated in Figure 3B, or be limited to covering the one or more heating elements 124. The coating 304 may comprise an insulating material, such as a glass, ceramic, or the like. Optionally, prior to depositing the coating 304, the one or more resistive elements 303 may also be deposited below the one or more resistive heating elements 124. For example, the one or more resistive elements 124 and the one or more resistive elements 303 may be separated by an insulating layer (not shown) such as a dielectric layer or the like, which can be deposited prior to depositing the one or more resistive elements 303. Alternatively, the coating 304 may be deposited to cover the one or more resistive elements 124, and then the one or more resistive elements 303 may be deposited atop the coating 304. A second coating (not shown) may be deposited to cover the one or more resistive elements 303.

**[0041]** In some embodiments, as illustrated in Figure 3C, the support 100 may include a third member 306 disposed beneath the first member 102 and above the tubular body 152. The heater 106 may include the one or more resistive heating elements 124 disposed in the third member 306. For example, deposition may include any suitable deposition technique for forming a desired pattern of heating zones 108. For example, and similar to the embodiments of Figure 3A, the one or more resistive elements 124 – and optionally, the one or more resistive elements 303 – may be disposed in the third member 306 in any suitable manner, such as arranged in heating zones 108, to provide a desired temperature profile to the substrate 103. Alternatively, the third member 306 may comprise two members (not shown), for example, a first member including the one or more resistive heating elements 124 and a second member including the one or more resistive heating elements 303. For example, the one or more resistive elements 124 may be disposed at any suitable distance from a lower surface 302 of the first member 102 to provide the desired temperature profile. Although the heating zones 108 are illustrated as being disposed at the same distance from the lower surface 302 in Figure 3C, the distance from the lower surface 302 may vary for one or more of the

heating zones 108. The third member 306 may be formed of suitable process-compatible materials, such as materials having one or more of high mechanical strength (e.g., Bending strength at least about 200 MPa), high electrical resistivity (e.g., at least about  $10^{14}$  ohm-cm), a low coefficient of thermal expansion (e.g., no more than about  $5 \times 10^{-6}$  °C). Suitable materials may include one or more of silicon carbon (SiC), silicon nitride (Si<sub>3</sub>N<sub>4</sub>), aluminum nitride (AlN), aluminum oxide (Al<sub>2</sub>O<sub>3</sub>), beryllium oxide (BeO), pyrolytic boron nitride (PBN), graphite coated with PBN, AlN coated with yttria (Y<sub>2</sub>O<sub>3</sub>), or the like.. Other suitable coating that may be utilized with the third member 306 may include diamond like coatings (DLCs) or the like

**[0042]** Thus, embodiments of substrate supports have been disclosed herein. The inventive substrate support may advantageously facilitate one or more of heating a substrate, maintaining the temperature of a substrate, or uniformly distributing heat to or removing heat from a substrate, or create temperature non-uniformities on a substrate.

**[0043]** While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof.

**Claims:**

1. A substrate support, comprising:
  - a first member to distribute heat to a substrate when present above a first surface of the first member;
  - a heater coupled to the first member and having one or more heating zones to provide heat to the first member;
  - a second member disposed beneath the first member;
  - a tubular body disposed between the first and second members, wherein the tubular body forms a gap between the first and second members; and
  - a plurality of substrate support pins disposed a first distance above the first surface of the first member, the plurality of substrate support pins to support a backside surface of a substrate when present on the substrate support.
2. A substrate support, comprising:
  - a first member to distribute heat to a substrate when present above a first surface of the first member;
  - a plurality of substrate support pins extending from the first surface of the first member to support a backside surface of a substrate when present on the substrate support;
  - one or more resistive heating elements disposed in the first member;
  - a second member disposed below the first member; and
  - a tubular body disposed between the first and second members and forming a gap between a lower surface of the first member and an upper surface of the second member.
3. A substrate support, comprising:
  - a first member to distribute heat to a substrate when present above an upper surface of the first member;
  - a plurality of substrate support pins extending from a surface of the first member to support a backside surface of a substrate when present on the substrate support;

one or more heating zones each having one or more resistive heating elements, wherein the one or more heating zones are disposed on a lower surface of the first member;

a second member disposed below the first member; and

a tubular body disposed between the first and second members and forming a gap between the lower surface of the first member and an upper surface of the second member.

4. The substrate support of any of claims 1 to 3, further comprising:

an alignment guide extending from the first surface of the first member and about the plurality of substrate support pins.

5. The substrate support of any of claims 1 to 3, further comprising:

a feedthrough assembly coupled to an opening in the second member, wherein the feedthrough assembly has a volume that is separated from the gap and wherein the atmosphere of the volume is independently controllable with respect to an atmosphere of the gap.

6. The substrate support of claim 5, wherein the first member further comprises:

one or more purge gas channels disposed in the first member and fluidly coupling the first surface of the first member to the gap.

7. The substrate support of any of claims 1 to 3, wherein each of the plurality of substrate support pins extends from the first surface of the first member.

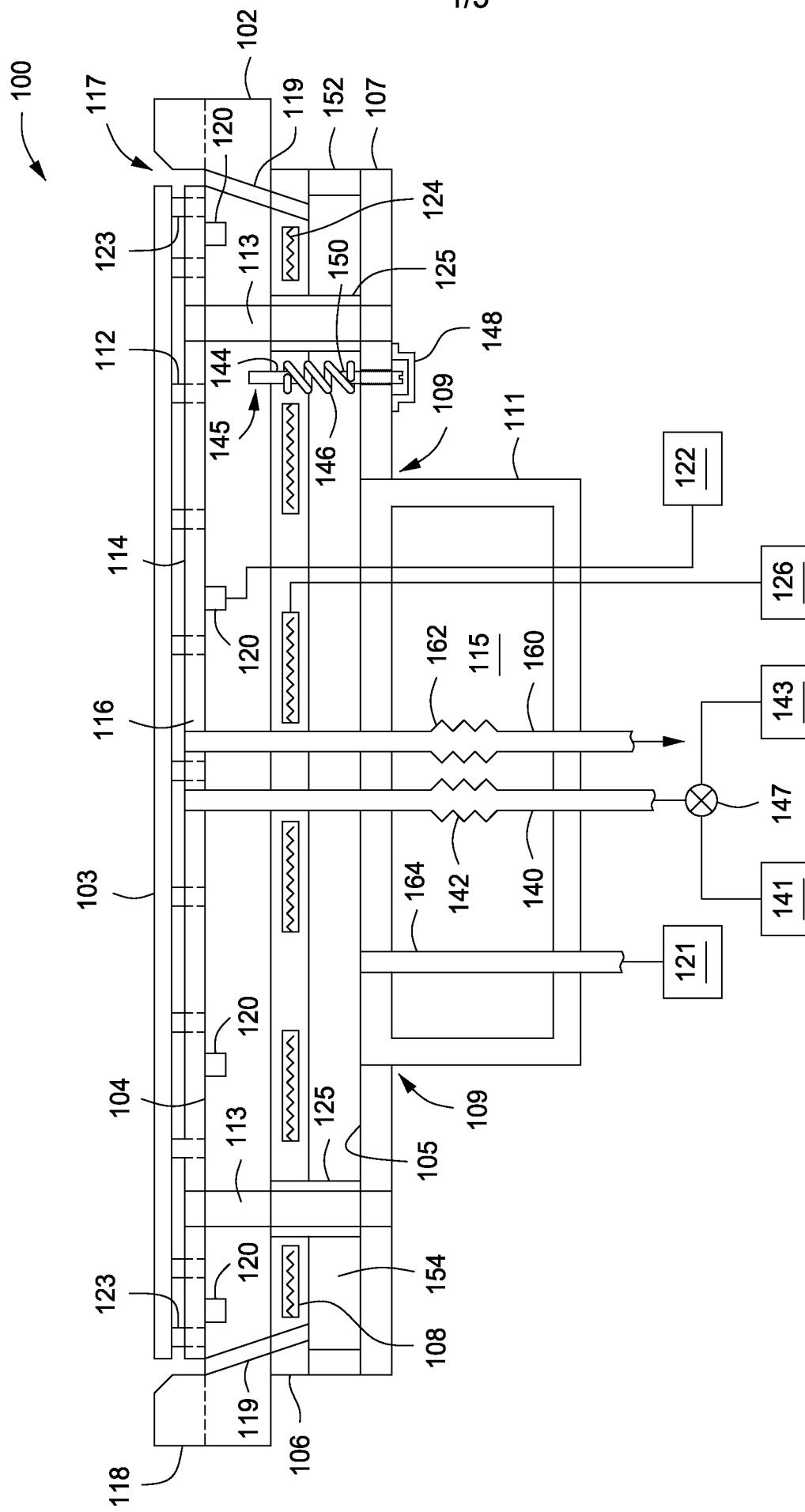
8. The substrate support of any of claims 1 to 3, wherein the first member and the second member are sintered to the tubular body.

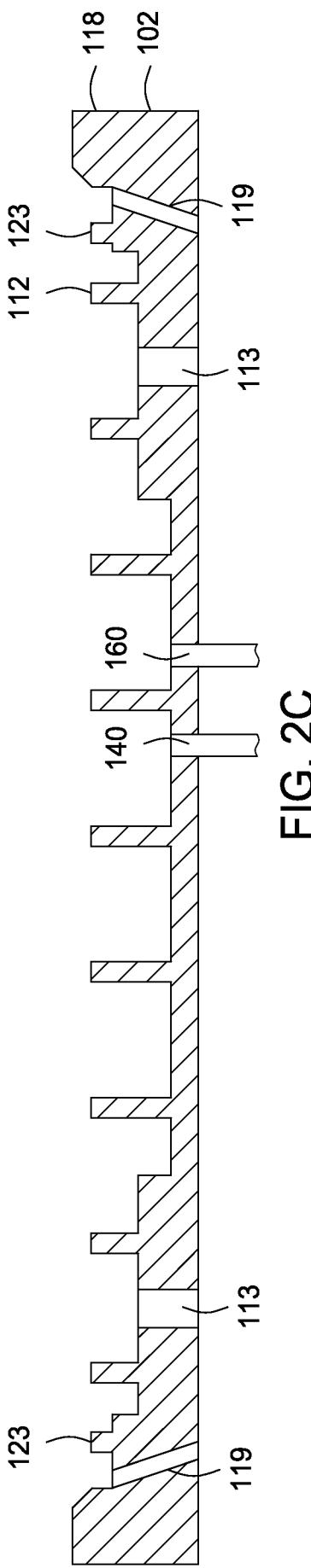
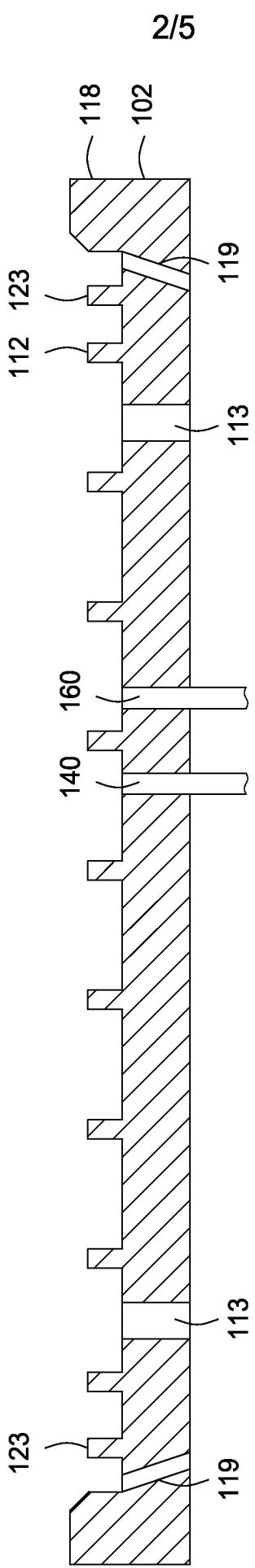
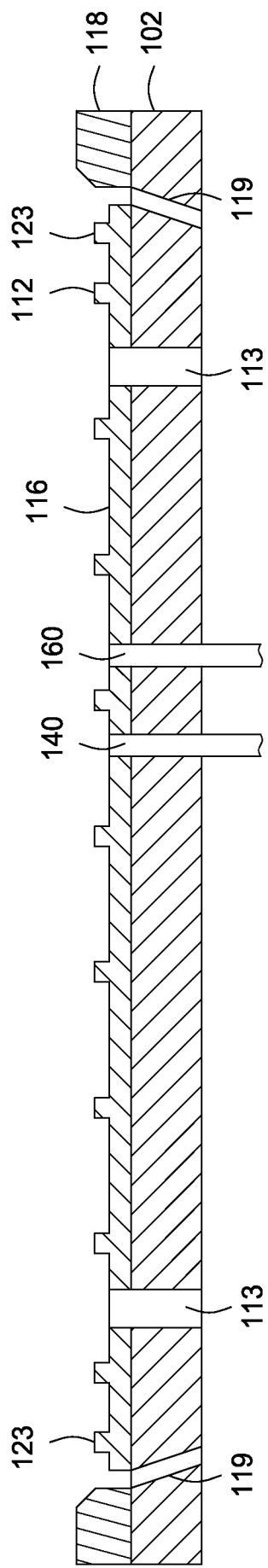
9. The substrate support of claim 1 to 3, further comprising:

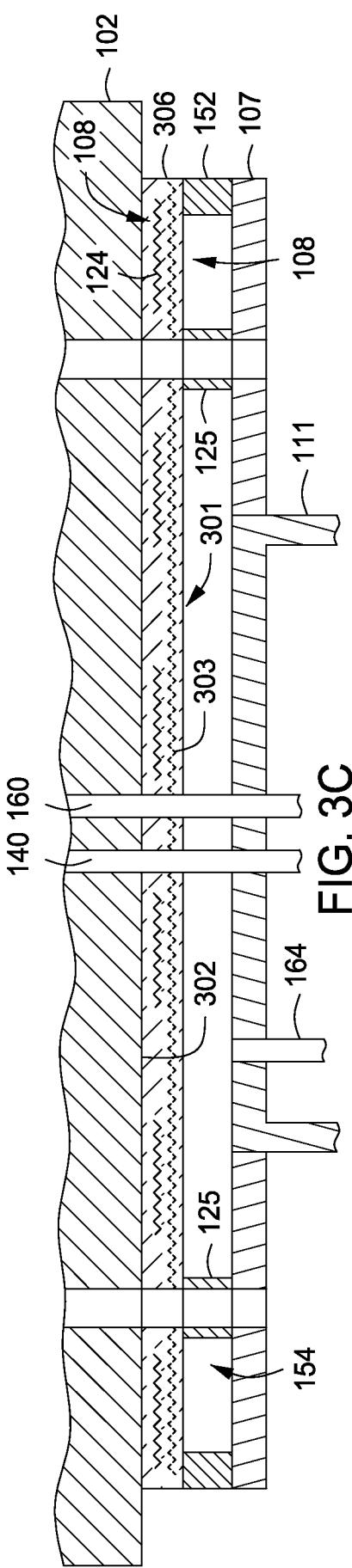
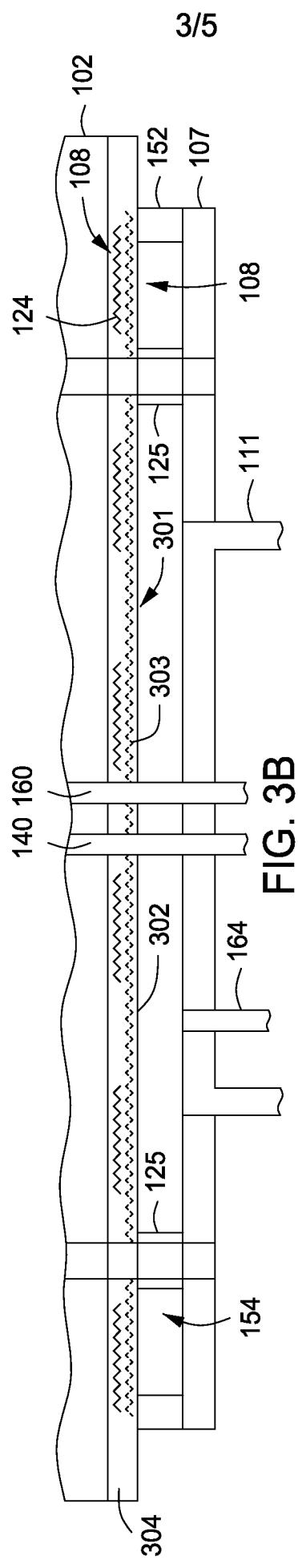
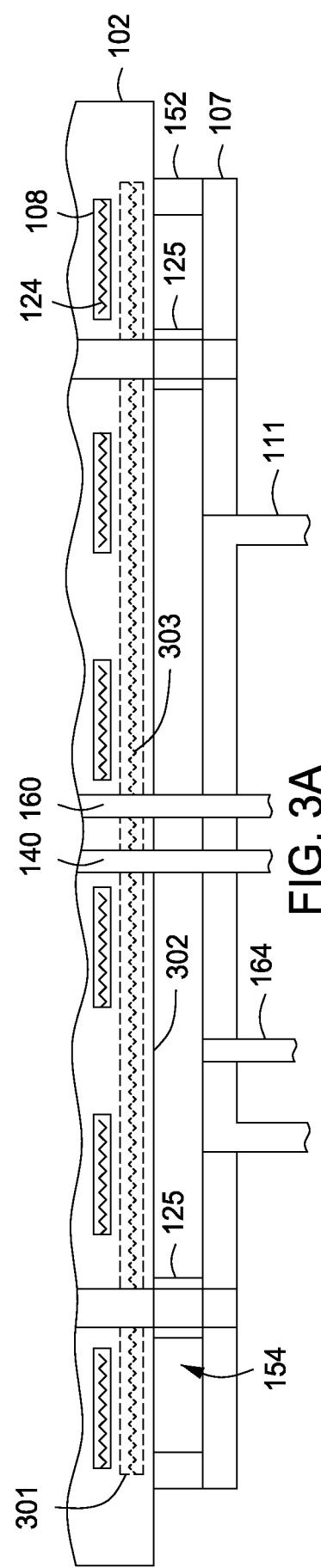
a support layer disposed on the first surface of the first member, wherein each of the plurality of substrate support pins extend from a surface of the support layer.

10. The substrate support of claim 1, wherein the heater further comprises:  
a plurality of resistive heating elements, wherein each of the one or more heating zones comprises one or more of the plurality of resistive heating elements.
11. The substrate support of claim 10, further comprising:  
a third member disposed beneath the first member and above the tubular body, wherein each of the one or more resistive heating elements are disposed in the third member.
12. The substrate support of claim 10, wherein each of the plurality of resistive heating elements are disposed in the first member.
13. The substrate support of claim 10, wherein each of the plurality of resistive heating elements is disposed on a lower surface of the first member, and further comprising:  
a coating comprising a insulating material and covering the one or more resistive heating elements disposed on the lower surface of the first member.
14. The substrate support of claim 2, wherein the one or more resistive heating elements comprise a plurality of resistive heating elements, and wherein the plurality of resistive heating elements are arranged into one or more heating zones.
15. The substrate support of claim 3, further comprising:  
a coating comprising a insulating material and covering the one or more resistive heating elements disposed on the lower surface of the first member.

1/5







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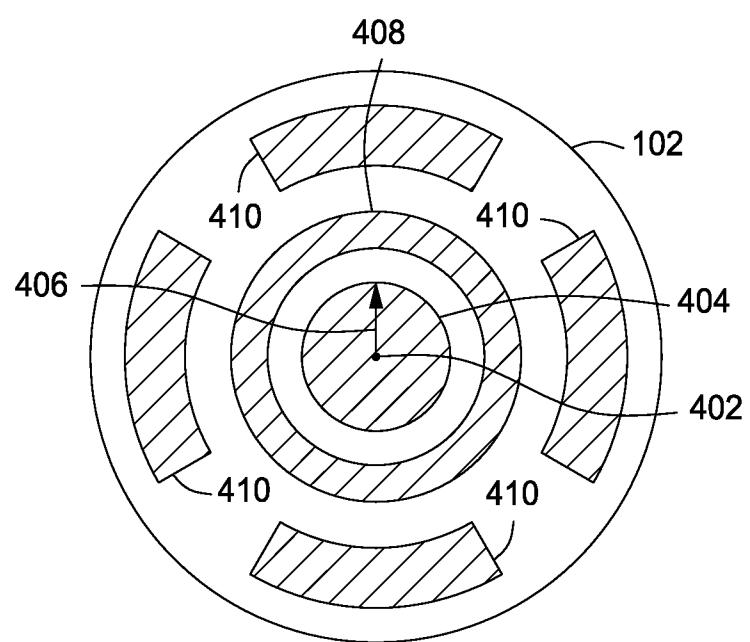


FIG. 4

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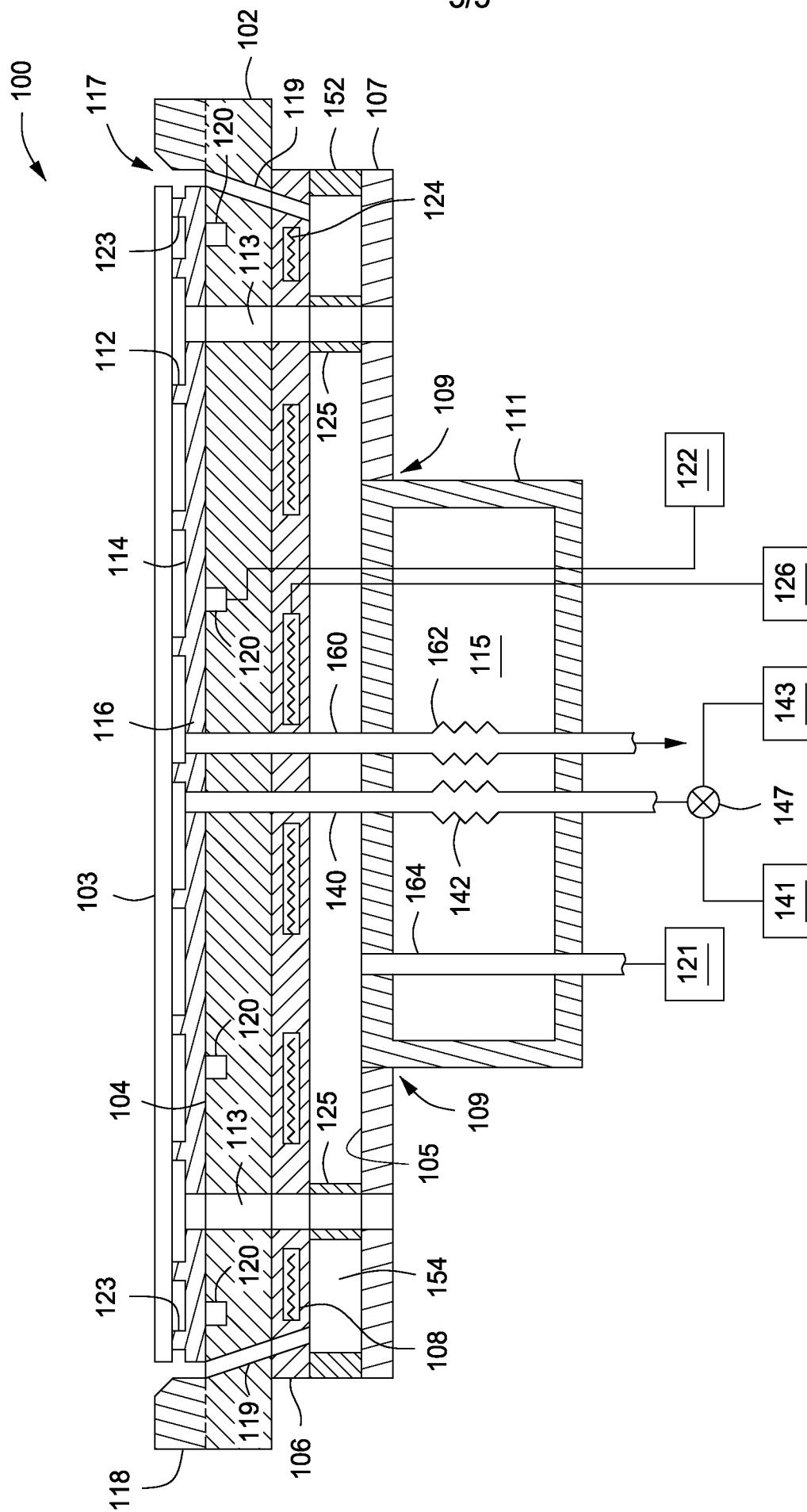


FIG. 5