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(54) **SUBSTRATE HOLDER TO REDUCE SUBSTRATE EDGE STRESS DURING CHEMICAL MECHANICAL POLISHING**

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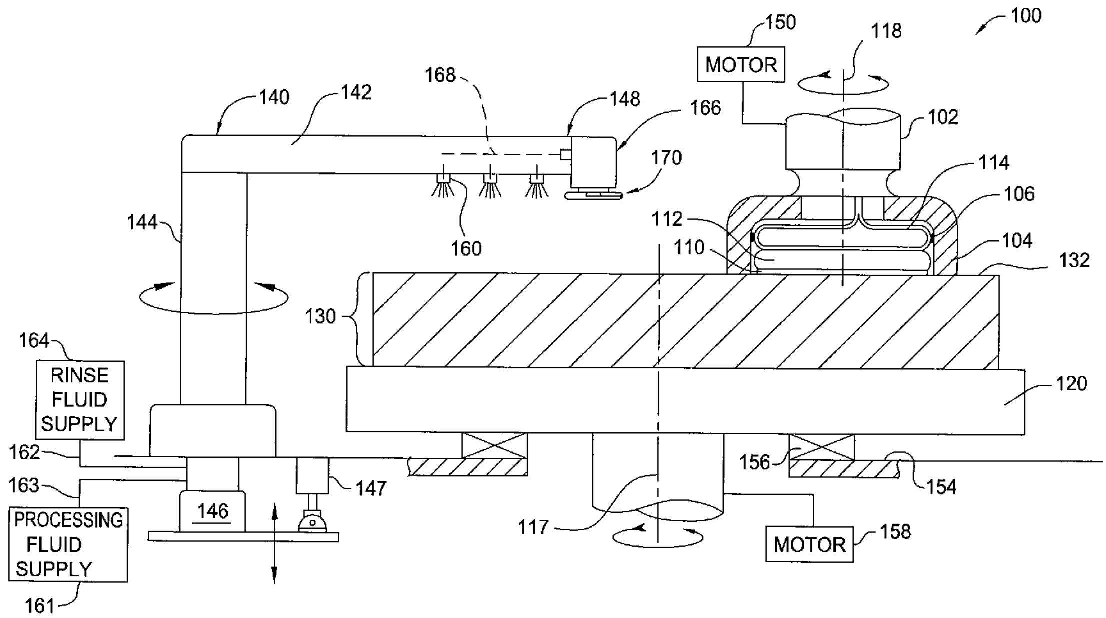
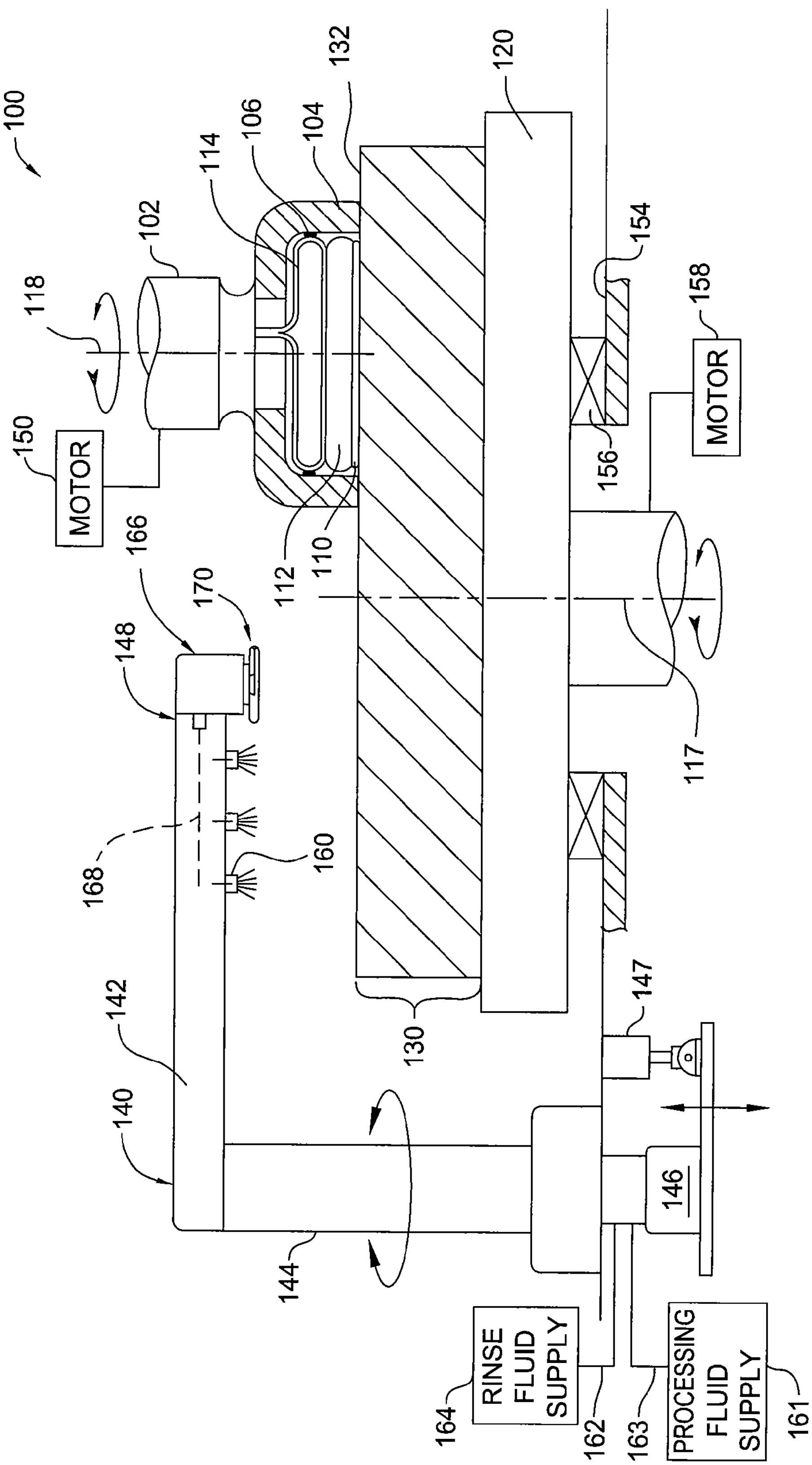
(57) **ABSTRACT**

Embodiments of the present invention generally relate to methods for chemical mechanical polishing a substrate. The methods generally include coupling a first substrate to be polished to a dummy substrate, and removing a portion of the backside of the first substrate to reduce the thickness of the first substrate. The first substrate and the dummy substrate are positioned in a carrier head assembly comprising an inflatable membrane and a support ring. The first substrate is placed in contact with a polishing pad to reduce the surface roughness of the backside of the first substrate. The support ring restricts lateral movement of the inflatable membrane to prevent the first substrate from contacting an interior surface of the carrier head assembly. The support ring is sized to allow vertical movement of the inflatable membrane within the carrier head assembly.

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MOTOR
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RINSE FLUID SUPPLY
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168
170

FIG. 1

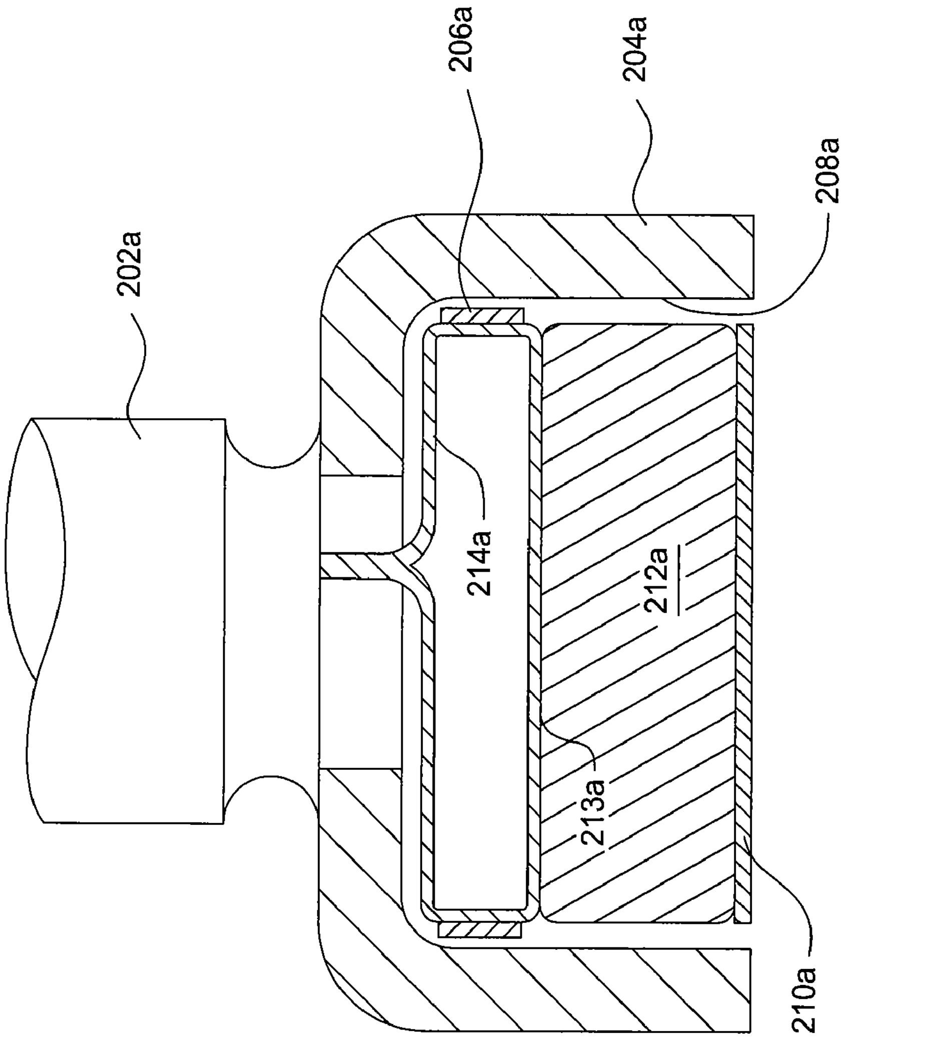


FIG. 2A

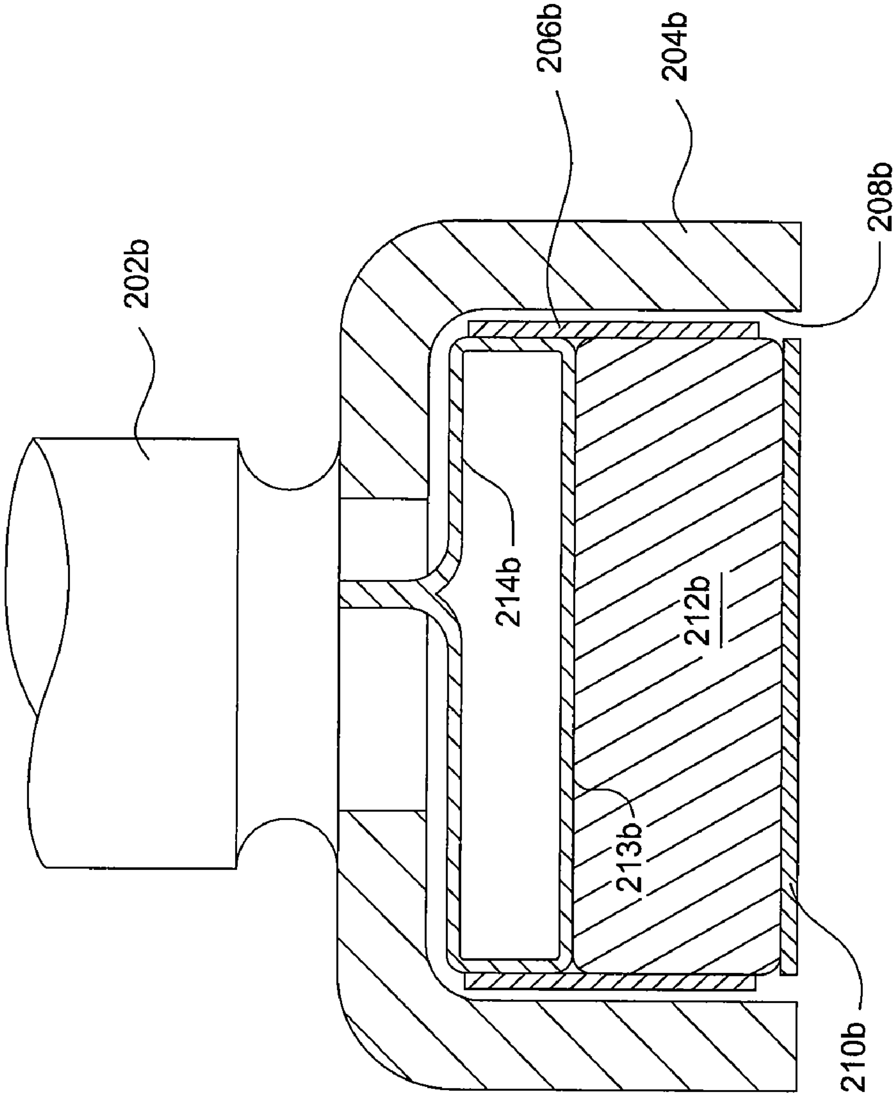


FIG. 2B

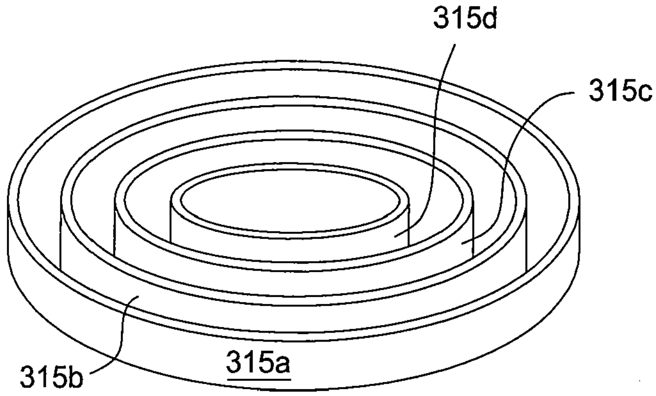


FIG. 3A

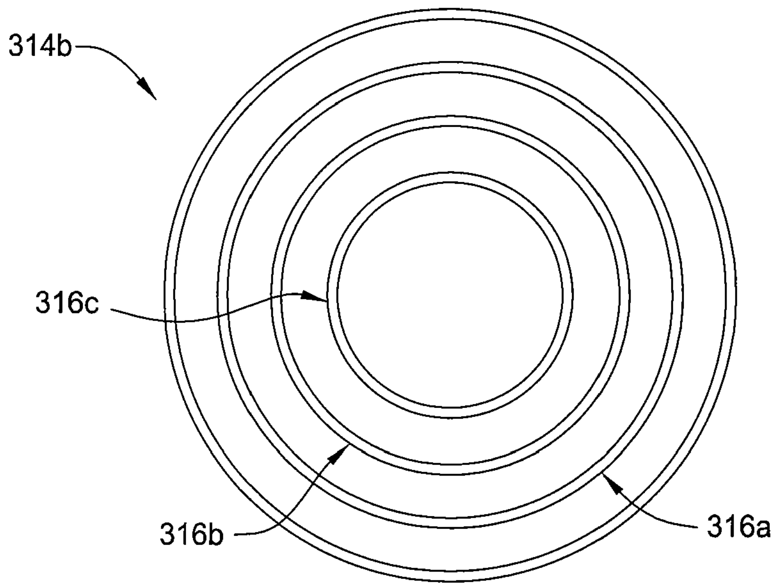


FIG. 3B

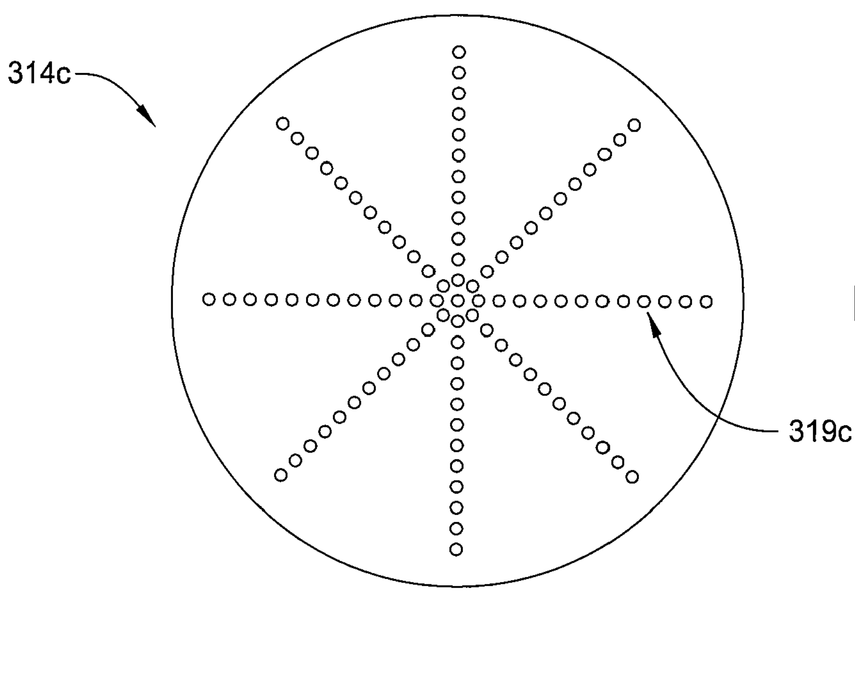
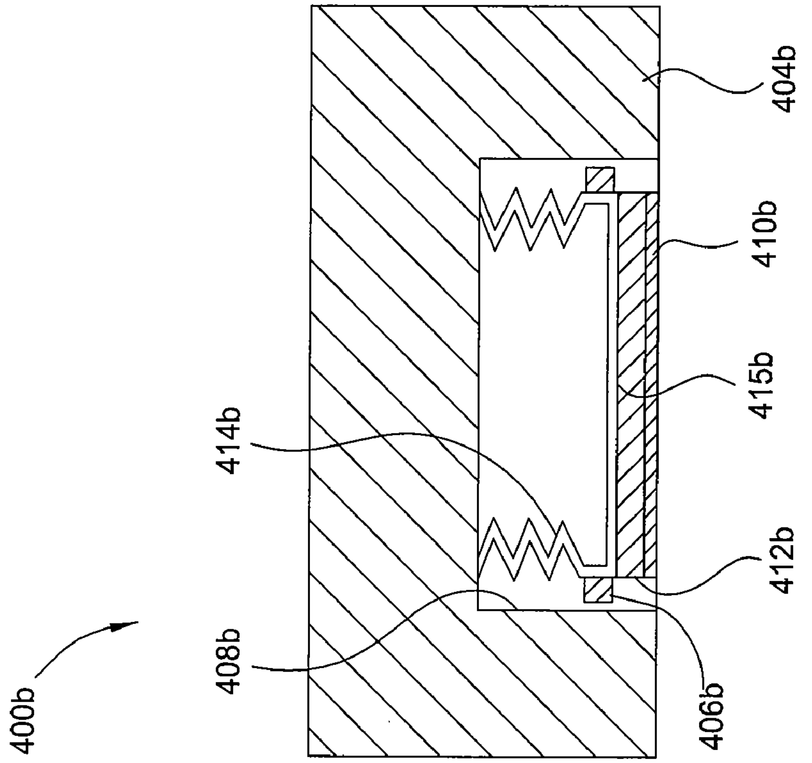


FIG. 3C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404b
410b
415b
414b
412b
408b
406b

FIG. 4B

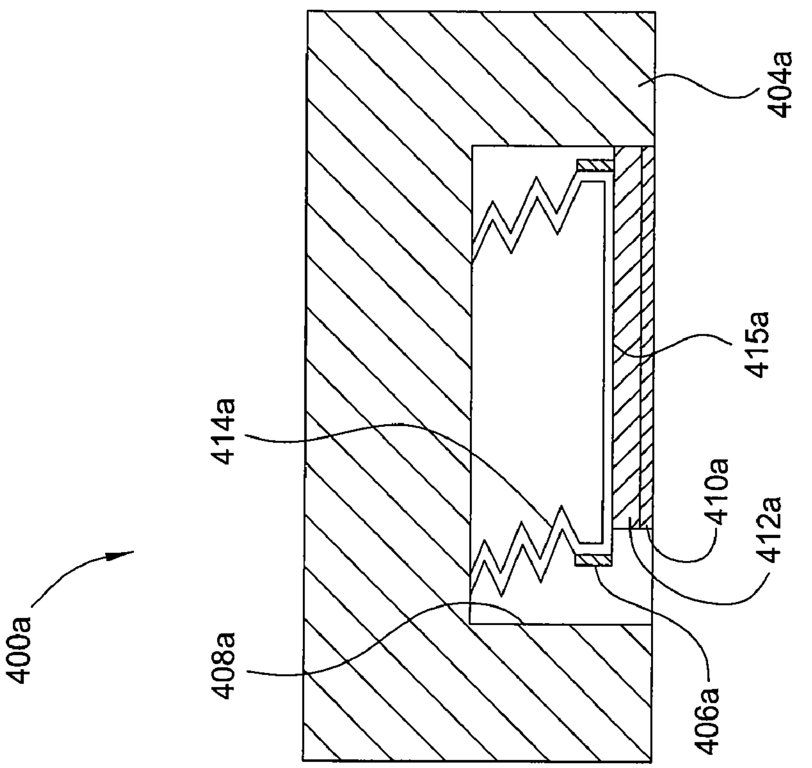
400a
404a
415a
414a
410a
412a
408a
406a

FIG. 4A

SUBSTRATE HOLDER TO REDUCE SUBSTRATE EDGE STRESS DURING CHEMICAL MECHANICAL POLISHING

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] Embodiments of the present invention generally relate to a method for chemical mechanical polishing (CMP) of a substrate and an apparatus for practicing the method.

[0003] 2. Description of the Related Art

[0004] Vias have been used in semiconductor fabrication to provide electrical coupling between one or more layers of conductive material within a semiconductor device. More recently, through-silicon vias (TSV) have arisen as an alternative method to conventional wire bonding. Through-silicon vias allow for shorter interconnects by forming an interconnect in the z-axis. The interconnect is created through a substrate by forming a via extending from a front surface to a back surface of the substrate. After creating the interconnects in the z-axis, multiple substrates can then be stacked on top of one another, and electrically coupled through the vertically extending interconnect. TSV substrates may provide a means for reducing the footprint of substrates in semiconductor applications.

[0005] Therefore, there is a need in the art for methods and apparatus for processing substrates useful in TSV applications.

SUMMARY OF THE INVENTION

[0006] Embodiments of the present invention generally relate to methods for chemical mechanical polishing a substrate. The methods generally include coupling a first substrate to be polished to a dummy substrate, and removing a portion of the backside of the first substrate to reduce the thickness of the first substrate. The first substrate and the dummy substrate are positioned in a carrier head assembly comprising an inflatable membrane and a support ring. The first substrate is placed in contact with a polishing pad to reduce the surface roughness of the backside of the first substrate. The support ring restricts lateral movement of the inflatable membrane to prevent the first substrate from contacting an interior surface of the carrier head assembly. The support ring is sized to allow vertical movement of the inflatable membrane within the carrier head assembly.

[0007] In one embodiment, a method includes coupling a first substrate to a second substrate. The first substrate has a first surface in contact with the second substrate, and the first surface is opposite a second surface. The second substrate and the first substrate are positioned in a carrier head assembly. The carrier head assembly comprises an inflatable membrane in contact with the second substrate, and a support ring disposed circumferentially around the inflatable membrane. The second surface of the first substrate is contacted with a polishing pad to reduce the surface roughness of the second surface of the first substrate.

[0008] In another embodiment, a method includes coupling a first surface of a first substrate to a second substrate. The second substrate and the first substrate are positioned in a carrier head assembly. The carrier head assembly comprises an inflatable membrane in contact with the second substrate, and a support ring disposed circumferentially around the inflatable membrane and the second substrate. The inflatable membrane comprises a textured surface. The support ring is positioned to reduce lateral movement of the inflatable membrane and the second substrate such that the first substrate does not contact an interior surface of the carrier head assembly during polishing. A second surface of the first substrate is contacted with a polishing pad to reduce the surface roughness of the second surface of the first substrate.

[0009] In another embodiment, a method includes coupling a first surface of a first substrate to a second substrate using an epoxy. The first surface of the first substrate is opposite a second surface, and the first surface has a device feature formed thereon. The second substrate and the first substrate are positioned in a carrier head assembly. The carrier head assembly comprises an inflatable membrane in contact with the second substrate, and a support ring disposed circumferentially around the inflatable membrane and the second substrate. The support ring is sized to restrict substantially all lateral movement of the inflatable membrane, but allow the inflatable membrane to travel in a vertical direction. The first substrate is contacted with a polishing pad to reduce a surface roughness of the second surface of the first substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only 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.

[0011] FIG. **1** is a schematic sectional view of one embodiment of a polishing station that includes a carrier head.

[0012] FIGS. **2**A and **2**B are schematic sectional views of carrier head assemblies for use in substrate processing.

[0013] FIG. **3**A is a schematic perspective view of one embodiment of a membrane support structure for use in a polishing head membrane.

[0014] FIGS. **3**B and **3**C are schematic views of textured surfaces of membranes for use in a polishing head.

[0015] FIGS. **4**A and **4**B are schematic sectional views of carrier head assemblies.

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

DETAILED DESCRIPTION

[0017] Embodiments of the present invention generally relate to methods for chemical mechanical polishing a substrate. The methods generally include coupling a first substrate to be polished to a dummy substrate, and removing a portion of the backside of the first substrate to reduce the thickness of the first substrate. The first substrate and the dummy substrate are positioned in a carrier head assembly comprising an inflatable membrane and a support ring. The first substrate is placed in contact with a polishing pad to reduce the surface roughness of the backside of the first substrate. The support ring restricts lateral movement of the inflatable membrane to prevent the first substrate from contacting an interior surface of the carrier head assembly. The support ring is sized to allow vertical movement of the inflatable membrane within the carrier head assembly.

[0018] Embodiments of the present invention are beneficial for processing substrates useful for through-silicon via applications. Suitable apparatus for performing chemical mechanical polishing on substrates are the REFLEXION LK™ and the REFLEXION GT CMP systems available from Applied Materials, Inc. of Santa Clara, Calif. It is contemplated that other commercially available chemical mechanical polishing systems can advantageously utilize embodiments disclosed herein.

[0019] FIG. **1** is a partial sectional view of one embodiment of a polishing station **100** that includes a carrier head body **104**. The polishing station **100** includes the carrier head assembly **102** and a platen assembly **120**. A first substrate **110** and a second substrate **112** are disposed in the carrier head assembly **102** during polishing. The carrier head assembly **102** generally retains a first substrate **110** against a polishing pad assembly **130** disposed on the platen assembly **120**. At least one of a carrier head assembly **102** or platen assembly **120** is rotated or otherwise moved to provide relative motion between the first substrate **110** and the polishing pad assembly **130**. In the embodiment depicted in FIG. **1**, the carrier head assembly **102** is coupled to an actuator or motor **150** that provides at least rotational motion to the substrate **110** about axis **118**. The motor **150** may also oscillate the carrier head assembly **102**, such that the substrate **110** is moved laterally back and forth across the surface **132** of the polishing pad assembly **130**.

[0020] The polishing pad assembly **130** may comprise a conventional material such as a foamed polymer disposed on the platen assembly **120** as a pad. In one embodiment, the conventional polishing material is foamed polyurethane. In one embodiment, the pad is an IC1010 polyurethane pad, available from Rodel Inc., of Newark, Del. IC1010 polyurethane pads typically have a thickness of about 2.05 mm and a compressibility of about 2%. Other pads that can be used include IC1000 pads with and without an additional compressible bottom layer underneath the IC1000 pad, IC1010 pads with an additional compressible bottom layer underneath the IC1010 pad, and polishing pads available from other manufacturers. The compositions described herein are placed on the pad to contribute to the chemical mechanical polishing of a substrate.

[0021] In one embodiment, the carrier head assembly **102** includes a carrier head body **104** defining a substrate receiving pocket. The substrate receiving pocket allows a first substrate **110** and a second substrate **112** to be disposed therein. A membrane **114** is disposed in the substrate receiving pocket and may be evacuated to chuck a second substrate **112** to the carrier head assembly **102**, and pressurized to control the downward force of a first substrate **110** when pressed against the polishing pad assembly **130**. The membrane **114** is circumferentially encompassed by support ring **106**. In one embodiment, the carrier head may be a multi-zone carrier head. One suitable carrier head assembly **102** is a TITAN HEAD™ carrier head available from Applied Materials, Inc., located in Santa Clara, Calif.

[0022] The platen assembly **120** is supported on a base **154** by bearings **156** that facilitate rotation of the platen assembly **120** about axis **117**. A motor **158** is coupled to the platen assembly **120** and rotates the platen assembly **120** such that the polishing pad assembly **130** is moved relative to the carrier head assembly **102**.

[0023] The combined slurry/rinse arm assembly or fluid delivery arm assembly **140** is utilized to deliver slurry from a slurry supply **161** through tube **163** to a surface **132** of the polishing pad assembly **130**. In an alternative embodiment, the rinse fluid and the processing fluid may be provided to the polishing pad assembly **130** through separate delivery arm assemblies. In the embodiment depicted in FIG. **1**, the fluid delivery arm assembly **140** includes an arm **142** extending from a stanchion **144**. A motor **146** is provided to control the rotation of the arm **142** about a center line of the stanchion **144**. An adjustment mechanism **147** may be provided to control the elevation of a distal end **148** of the arm **142** relative to the working surface of the polishing pad assembly **130**. The adjustment mechanism **147** may be an actuator coupled to at least one of the arm **142** or the stanchion **144** for controlling the elevation of the distal end **148** of the arm **142** relative to the platen assembly **120**.

[0024] The fluid delivery arm assembly **140** may include a plurality of rinse outlet ports **160** arranged to uniformly deliver a spray and/or stream of rinsing fluid to the surface of the polishing pad assembly **130**. The ports **160** are coupled by a tube **162** routed through the fluid delivery arm assembly **140** to a rinsing fluid supply **164**. In one embodiment, the fluid delivery arm may have between 12 and 15 ports. The rinsing fluid supply **164** provides a rinsing fluid to the polishing pad assembly **130** before, during, and/or after polishing the phase change alloy containing substrate and/or after the substrate **110** is removed to clean the polishing pad assembly **130**. The polishing pad assembly **130** may also be cleaned using fluid from the ports **160** after conditioning the pad using a conditioning element, such as a diamond disk or brush (not shown). The polishing station **100** can also include a pad conditioner apparatus (not shown) to maintain the condition of the polishing pad assembly **130** so that it will effectively polish the first substrate **110**. The pad conditioner may be coupled to arm **142**, or may be coupled to a separate arm (not shown).

[0025] The nozzle assembly **166** is disposed at the distal end of the arm **142**. The nozzle assembly **166** is coupled to the slurry supply **161** by a tube **168** routed through the fluid delivery arm assembly **140**. Slurry supply **161** may generally supply any processing fluid. The processing fluid supply may be a polishing slurry or polishing abrasive. The nozzle assembly **166** includes a nozzle **170** that may be selectively adjusted relative to the arm, such that the fluid exiting the nozzle **170** may be selectively directed to a specific area of the polishing pad assembly **130**.

[0026] In one embodiment, the nozzle **170** is configured to generate a spray of slurry. In another embodiment, the nozzle **170** is adapted to provide a stream of slurry. In another embodiment, the nozzle **170** is configured to provide a stream and/or spray of slurry at a rate between about 200 to about 500 ml/second to the polishing surface.

[0027] In the embodiment depicted in FIG. **1**, a first substrate **110** may be a substrate used in through-silicon via applications. The first substrate **110** typically has a thickness of about 100 microns or less. Because the substrate is thin and flexible, the first substrate **110** is coupled to a second substrate **112** for support. The second substrate may have a thickness of about two inches. If a device feature is formed on a surface of the first substrate **110**, then first substrate **110** and second substrate **112** are coupled together such that the device feature is positioned between the two substrates, e.g., the surface of the first substrate **110** having the device feature formed thereon is oriented towards the second substrate **112**. Orienting the substrate in this manner protects the device feature formed on the first substrate **110** during subsequent processes.

[0028] When coupling the first substrate **110** and the second substrate **112**, the two substrates may be fixedly coupled by epoxy, or any other suitable material that does not have an adverse effect on the substrates. The second substrate **112** is generally a glass dummy substrate or a sacrificial substrate. After coupling the first substrate **110** and the second substrate **112**, but prior to chemical mechanical polishing the first substrate **110**, a portion of the first substrate **110** may be removed. The thickness of the first substrate **110** may be reduced using mechanical grinding, or etching. The reduced thickness of the first substrate **110** allows for use in TSV and stacked chip applications. Generally, the first substrate has an initial thickness approximately equal to the second substrate prior to the reduction in thickness. The process used for reducing the thickness of the first substrate **110** typically leaves a rough surface on the backside of the first substrate. To reduce the surface roughness on the backside of the first substrate **110**, chemical mechanical polishing may be used. The reduced thickness of the first substrate **110** leaves the substrate flexible and fragile. Therefore, the first substrate **110** is coupled to a second substrate **112** as an additional means of support during grinding and polishing of the first substrate **110**.

[0029] FIG. **2**A is a schematic sectional view of a polishing head assembly for use in substrate processing. The polishing head assembly has a carrier head body **204***a* defining a substrate receiving pocket. The substrate receiving pocket is adapted to contain a first substrate **210***a* and second substrate **212***a* during a chemical mechanical polishing process.

[0030] A membrane **214***a* is disposed within the substrate receiving pocket. The membrane **214***a* may be a flexible elastic membrane. In one embodiment, the membrane **214***a* may be high strength silicone rubber. A surface **213***a* of membrane **214***a* generally is textured to increase the friction between the membrane **214***a* and a second substrate **212***a*. The friction provided by the textured surface **213***a* prevents the second substrate **212***a*, or the first substrate **210***a* coupled thereto, from moving or sliding with respect to the membrane **214***a* when placed in the substrate receiving pocket of the carrier head body **204***a*. If the second substrate **212***a* moves or slides with respect to membrane **214***a*, the first substrate **210***a* may come into contact with the carrier head body **204***a*. As previously mentioned, the first substrate **210***a* is thin and flexible, and can break easily. If the first substrate **210***a* comes into contact with the carrier head body **204***a*, the outer edge of the first substrate **210***a* is subjected to increased stress which may cause the substrate to chip, crack, fracture or break.

[0031] A support ring **206***a* is disposed circumferentially around the membrane **214***a*. The purpose of the support ring is to allow for vertical movement of the membrane **214***a*, while restricting horizontal movement of the membrane **214***a* within the carrier head assembly **202***a*. Additionally, the support ring **206***a* provides lateral support and stiffness to the membrane **214***a*, allowing the membrane **214***a* to retain its shape and not over-flex in the horizontal direction. The membrane **214***a* is formed of a flexible material, and may permit the first substrate **210***a* to come into contact with the inner sidewall **208***a* of the carrier head body **204***a* during polishing if sufficient support is not provided. For example, the first substrate **210***a* may come into contact with the carrier head body **204***a* as a result of a rocking motion applied to the carrier head assembly **202***a*.

[0032] The support ring **206***a* may be formed of an elastic material and clamped to the membrane **214***a*. The distance between support ring **206***a* and the inner sidewall **208***a* of the carrier head body **204***a* is preferably just enough to allow the membrane **214***a* to float in a vertical direction, but have substantially no vertical movement. For example, the distance between the support ring **206***a* and the carrier head body **204***a* may be about ten-thousandths of an inch when the membrane is centered in the carrier head assembly **202***a*. In another embodiment, the support ring internal diameter is reduced, and a membrane clamp is not used to secure the support ring **206***a* to the membrane **214***a*. Therefore, when pressure is applied on the membrane, the membrane expands and further reduces the gap between the membrane **214***a* and the sidewall **208***a*. Furthermore, this expansion also increases the rigidity or stiffness of the membrane, allowing the first substrate **210***a* and the second substrate **212***a* to stay substantially centered in the carrier head body **204***a*.

[0033] By having the support ring **206***a* substantially the same outer diameter as the inner diameter of the carrier head body, the movement of the membrane is restricted in the horizontal direction. This restriction in the horizontal direction is useful for protecting the first substrate **210***a* in instances where the first substrate is adhered to the second substrate **212***a* off-center. For example, if the first substrate **210***a* is coupled to the second substrate **212***a* such that a portion of the first substrate **210***a* extends past or protrudes beyond the outer diameter of the second substrate **212***a*, it would be possible in some instances that the first substrate **210***a* would contact the carrier head body **204***a*. However, if the support ring **206***a* prohibits substantially all of the horizontal movement of the membrane and the first and second substrates frictionally held thereby, then there is less likelihood that the first substrate **210***a* will contact the carrier head body **204***a*. A support ring of increased thickness, e.g., one having an outside diameter substantially the same or slightly less than the interior diameter of the carrier head body **204***a*, assists in protecting the edges of the first substrate **210***a*. The combination of increased support ring thickness to restrict lateral movement of the membrane **214***a*, and the increased friction of surface **213***a* to maintain the second substrate in the appropriate position reduces the edge-stress applied to the first substrate **210***a*.

[0034] Additionally, the inner sidewall **208***a* of carrier head body **204***a* is substantially planar. For example, the inner sidewall **208***a* of the carrier head body **204***a* may consist essentially of a substantially planar surface. It is preferable to not have any grooves to facilitate fluid flow, or any other deformations in the sidewall **208***a*. When grooves are present, it may be possible that the first substrate **210***a* or the second substrate **212***a* may contact this groove. This may cause an unevenly worn spot to form where the first or second substrate occasionally contacts the groove. Additionally, if the first substrate **210***a* contacts the groove, it may cause the first substrate to chip or crack. Since the membrane **214***a* is permitted to move in a vertical direction, it is possible that the first substrate **210***a* could rub on the sidewall **208***a* until the groove is contacted, damaging the first substrate **210***a*.

[0035] FIG. **2**B is a schematic sectional view of carrier head assembly for use in substrate processing. In the embodiment of FIG. **2**B, a carrier head assembly **202***b* has a carrier head body **204***b* defining a substrate receiving pocket. A membrane **214***b* is disposed in the substrate receiving pocket. The membrane has a textured surface **213***b* with a relatively high coefficient of friction. The textured surface **214***b* is placed in contact with a second substrate **212***b*, which is coupled to a first substrate **210***b*. The textured surface **213***b* of membrane **214***b* prevents the second substrate **212***b* from moving relative to the membrane **214***b* once placed in contact with the membrane **214***b*.

[0036] A support ring **206***b* is placed circumferentially around and in contact with the membrane **214***b* and the second substrate **212***b*. Although the support ring **206***b* in FIG. **2**B is shown as extending along most of the sidewall of the second substrate **212***b*, it is not necessary for the support ring to be in contact with substantially all of the sidewall of the second substrate **212***b*. For example, the support ring **206***b* may be in contact with at least about 25 percent, at least about 50 percent, or at least about 75 percent of the sidewall of the second substrate **212***b*.

[0037] The support ring **206***b* may be clamped to the membrane **214***b*, and allow for the second substrate to be inserted therein for polishing. The extended support ring as shown in FIG. **2**B is additionally used to hold the second substrate in the appropriate position with respect to the membrane **214***b*. For example, the support ring **206***b* may hold the second substrate **212***b* in the center of membrane **214***b*. Both the textured surface **213***b* and the support ring **206***b* may be used to prevent the first substrate **210***b* from contacting the inner sidewall **208***b* of the carrier head body **204***b*.

[0038] FIG. **3**A is a schematic perspective view of one embodiment of a membrane support structure for use in a polishing head membrane. The membrane support structure comprises a plurality of concentric circles **315***a-d*. A membrane (not shown) adapted to be inflated, for example a bladder, may surround the concentric circles. The concentric circles **315***a-d* provide additional rigidity to reduce lateral movement of the membrane during chemical mechanical polishing. The concentric circles **315***a-d* are typically formed from the same material as the membrane, and may be coupled to an interior surface of the membrane to reduce movement within the membrane. Additionally, the concentric circles **315***a-d* may have holes therethrough (not shown) for allowing spaces between the concentric circles **315***a-d* to be pressurized to inflate and hold a substrate against a polishing pad, or vacuum evacuated to chuck a substrate to a carrier head. The concentric circles **315***a-d* aid in preventing the membrane from deforming or skewing due to the rocking motion applied during chemical mechanical polishing. If the membrane skews, any substrates being polished may come into contact with the sidewall of a polishing head, thereby damaging the substrate.

[0039] FIGS. **3**B and **3**C are schematic views of textured surfaces of membranes for use in a polishing head. In FIG. **3**B, the texture is provided by a set of grooves **316***a-c* that extend radially from near the center of the surface of the membrane **314***b*. The grooves can be radially symmetric, or they could form a cross-hatch pattern, or they could be random. In the embodiment of FIG. **3**B, three grooves are shown. However, the number, size, and location of the grooves may vary depending on the particular application. In the embodiment of FIG. **3**C, the texture is provided by bumps **319***c* that project from a surface of membrane **314***c*. The bumps can form a pattern, or be randomly formed on the surface of the membrane **314***c*. For example, the bumps **319***c* may form concentric circles, a spiral, or may be formed into regions. In the embodiment of FIG. **3**C, the bumps radiate from the center of the surface of membrane **314***c* in straight lines. However, other variations are possible as long as bumps provide sufficient texture. Additionally, the bumps **319***c* can have a uniform concentration across the surface of membrane **314***c*, or the bumps **319***c* can have regions of different concentration. The bumps **319***c* can have a uniform height, or the bumps can have different heights.

[0040] FIG. **4**A is a schematic sectional view of carrier head assembly **400***a*. The membrane **414***a* disposed in carrier head body **404***a* lacks both sufficient rigidity and interior concentric circles for support. Therefore, the membrane **414***a* adopts a skewed shape in the carrier head body **404***a* when the first substrate **410***a* is subjected to a chemical mechanical polishing process. Because the membrane **414***a* skews, the first substrate **410***a* is permitted to come into contact with the sidewall **408***a* of carrier head body **404***a*. This contact increases the stress on the edge of the first substrate **410***a* leading to cracking, chipping, or breaking. It should be noted that an appropriately sized support ring **406***a* could be used to increase rigidity and reduce flexing of the membrane **414***a*.

[0041] Additionally, substrate **410***a* is permitted to come into contact with the inner sidewall **408***a* of carrier head body **404***a* because the second substrate **412***a* is permitted to move in relation to membrane **414***a*. The second substrate **412***a* can slide or move in relation to the membrane **414***a* when there is not sufficient friction between the second substrate **412***a* or the membrane surface **415***a*. Also, the membrane **414***a* has a wide range of lateral movement due to the relatively small size of the support ring **406***a*, which allows for a large gap between support ring **406***a* and the inner sidewall **408***a* of the carrier head body **404***a*. The wide range of horizontal movement allows the first substrate **410***a* to contact the inner sidewall **408***a*. This can be especially problematic in instances where the first substrate **410***a* is off-centered from the second substrate **410***b*, and/or where the second substrate **412***a* is off-centered from the membrane **414***a*.

[0042] FIG. **4**B is a schematic sectional view of carrier head assembly **400***b*. The membrane **414***b* has sufficient rigidity such that membrane **414***b* does not skew or horizontally flex during a chemical mechanical polishing process. However, membrane **414***b* is still permitted to move in a vertical direction, which may be influenced or controlled by the amount of pressure in the membrane **414***b*. The support ring **406***b* has sufficient thickness such that the first substrate **410***b* and the second substrate **412***b* cannot contact the inner sidewall **408***b* of the carrier head body **404***b*. Additionally, the membrane surface **415***b* has sufficient texturing and a sufficiently high coefficient of friction such that the second substrate **412***b* does not move with respect to the membrane **414***b* during polishing. The texturing of membrane surface **415***b* in combination with the rigidity of membrane **414***b* and the support ring **406***b* prevent the first substrate from contacting the carrier head body **404***b*.

[0043] Embodiments described herein provide methods and apparatus for chemical mechanical polishing of thin, flexible, or fragile substrates. By restricting the movement of the inflatable membrane within the carrier head, fragile substrates are not permitted to contact the carrier head, and are therefore not subjected to increased edge stress which may break the substrates. Also, a properly sized support ring assists in preventing the first substrate from contacting the carrier head when the first substrate is adhered to the second substrate off-center. Additionally, the textured surface of the inflatable membrane assists in preventing the second substrate in contact therewith from sliding off center and contacting the carrier head. By reducing the contact between the first substrate and the carrier head, the amount of damage or stress subjected upon the first substrate can be reduced. This results in a higher overall yield and higher quality substrates by minimizing damage thereto.

[0044] 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, and the scope thereof is determined by the claims that follow.

We claims:

1. A method, comprising:
coupling a first substrate to a second substrate, the first substrate having a first surface in contact with the second substrate and the first surface opposite a second surface;
positioning the second substrate and the first substrate in a carrier head assembly, the carrier head assembly comprising:
an inflatable membrane in contact with the second substrate; and
a support ring disposed circumferentially around the inflatable membrane; and
contacting the second surface of the first substrate to a polishing pad to reduce the surface roughness of the second surface of the first substrate.

2. The method of claim **1**, wherein the support ring is sized to restrict substantially all lateral movement of the inflatable membrane, but allow the inflatable membrane to travel in a vertical direction.

3. The method of claim **1**, wherein the average distance between the support ring and an interior surface of the carrier head assembly is less than about ten-thousandths of an inch.

4. The method of claim **3**, wherein the interior surface of the carrier head assembly consists essentially of a planar surface.

5. The method of claim **4**, wherein the first substrate is coupled to the second substrate using an epoxy.

6. The method of claim **5**, wherein the first substrate comprises a through-silicon via, and a device feature formed on the first surface.

7. The method of claim **6**, further comprising removing a portion of the second surface of the first substrate to decrease the thickness of the first substrate prior to the contacting the second surface of the first substrate to a polishing pad.

8. A method, comprising:
coupling a first surface of a first substrate to a second substrate;
positioning the second substrate and the first substrate in a carrier head assembly, the carrier head assembly comprising:
an inflatable membrane in contact with the second substrate, the inflatable membrane comprising a textured surface; and
a support ring disposed circumferentially around the inflatable membrane and the second substrate, the support ring positioned to reduce lateral movement of the inflatable membrane and the second substrate such that the first substrate does not contact an interior surface of the carrier head assembly during polishing; and
contacting a second surface of the first substrate to a polishing pad to reduce the surface roughness of the second surface of the first substrate.

9. The method of claim **8**, wherein there is substantially no lateral movement of the inflatable membrane in the carrier head.

10. The method of claim **9**, wherein the average distance between the support ring and an interior surface of the carrier head assembly is less that about ten-thousandths of an inch.

11. The method of claim **10**, wherein the interior surface of the carrier head assembly consists essentially of a planar surface.

12. The method of claim **11**, further comprising removing a portion of the second surface of the first substrate to decrease the thickness of the first substrate prior to the contacting a second surface of the first substrate to a polishing pad.

13. The method of claim **12**, wherein first substrate is coupled to the second substrate using an epoxy.

14. The method of claim **8**, wherein the support ring contacts at least about 25 percent of the sidewall of the second substrate.

15. The method of claim **14**, wherein the support ring contacts at least about 50 percent of the sidewall of the second substrate.

16. The method of claim **15**, wherein the first substrate comprises a through-silicon via, and a device feature formed on the first surface.

17. A method, comprising:
coupling a first surface of a first substrate to a second substrate using an epoxy, the first surface of the first substrate opposite a second surface, the first surface having a device feature formed thereon;
positioning the second substrate and the first substrate in a carrier head assembly, the carrier head assembly comprising:
an inflatable membrane in contact with the second substrate; and
a support ring disposed circumferentially around the inflatable membrane and the second substrate, the support ring sized to restrict substantially all lateral movement of the inflatable membrane, but allow the inflatable membrane to travel in a vertical direction; and
contacting the first substrate to a polishing pad to reduce a surface roughness of the second surface of the first substrate.

18. The method of claim **17**, wherein the thickness of the first substrate is about 100 microns.

19. The method of claim **18**, wherein the support ring contacts at least about 25 percent of the sidewall of the second substrate.

20. The method of claim **19**, wherein the inflatable membrane comprises a textured surface in contact with the second substrate.

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