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(54) **CONTACT PLATING APPARATUS**

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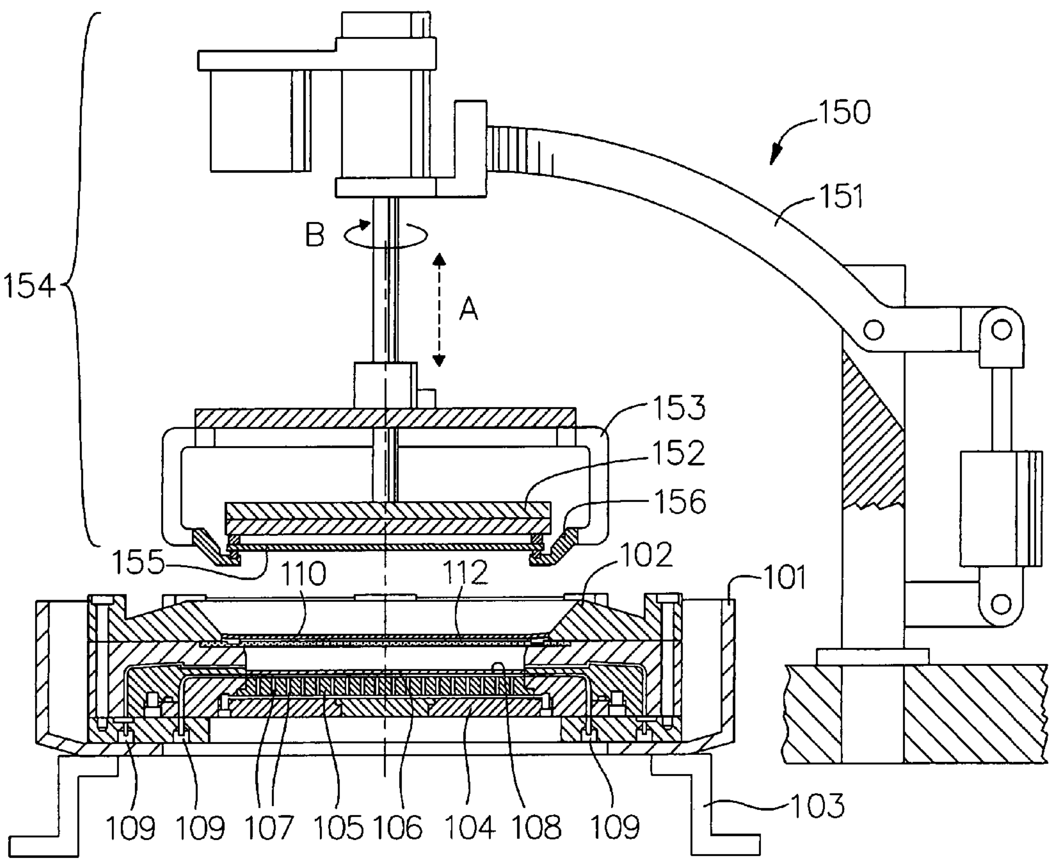
(57) **ABSTRACT**

Embodiments of the invention generally provide a substrate processing system and method. The substrate processing system generally includes a fluid basin configured to contain a plating solution therein, an anode assembly positioned in a lower portion of the fluid basin, a separation membrane positioned across the fluid basin above the anode assembly, a diffusion member positioned across the fluid basin above the separation membrane, and a plating membrane positioned across the fluid basin above the diffusion member. The plating method generally includes immersing the substrate in a plating solution, the plating solution containing metal ions to be plated, contacting a plating surface of the semiconductor substrate with a plating membrane, applying a plating bias to the semiconductor substrate to plate the metal ions in the plating solution positioned adjacent the plating surface of the substrate, removing the plating surface from contact with the plating membrane for a predetermined period of time, and recontacting the plating surface with the plating membrane to continue plating the metal ions onto the plating surface.



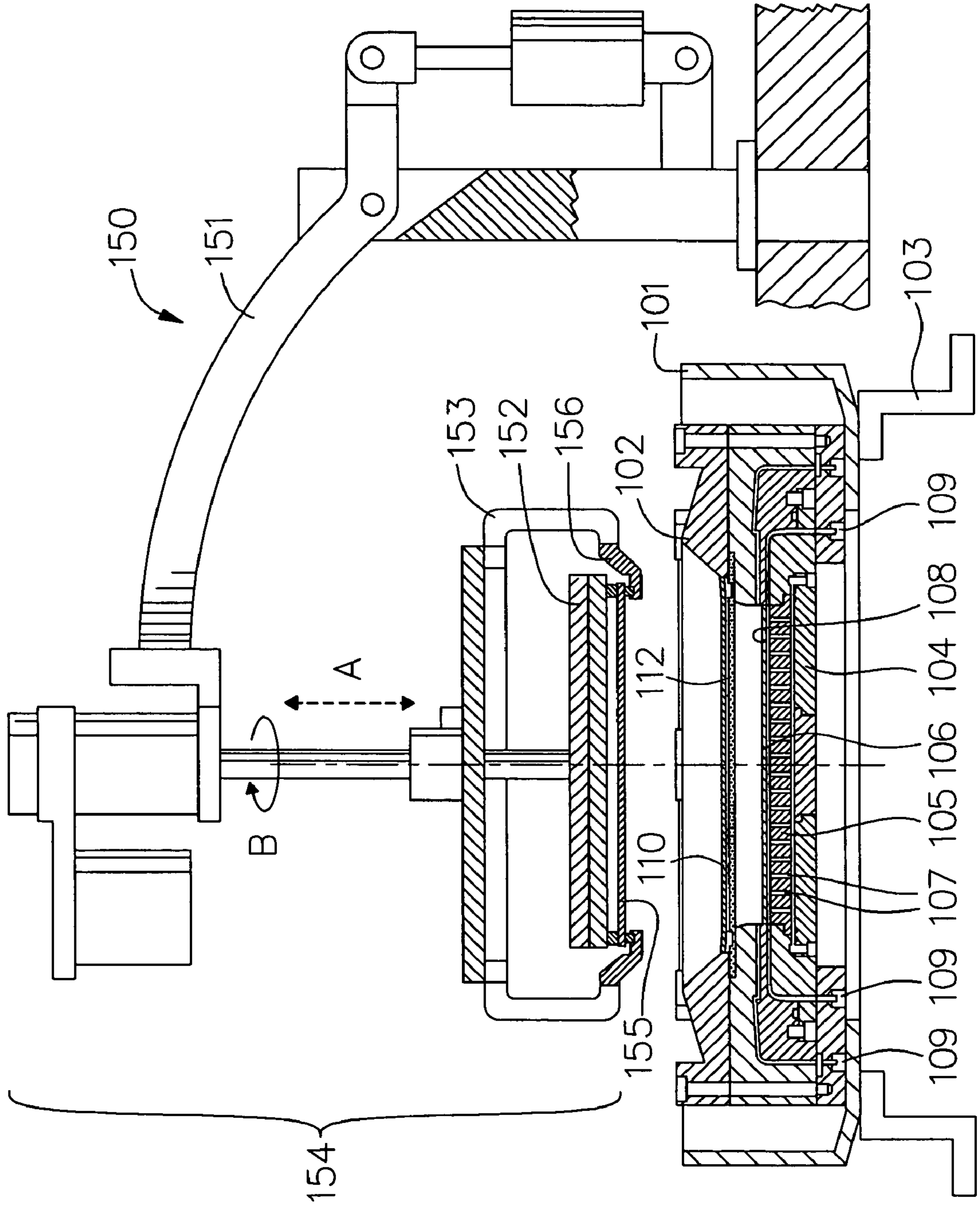

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FIG. 1

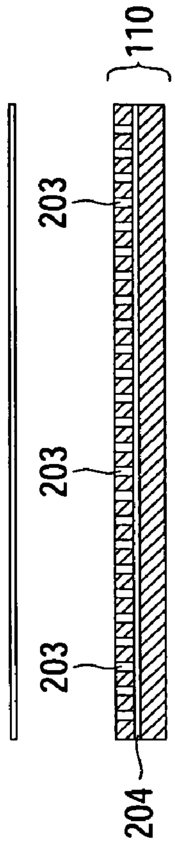

FIG. 2B

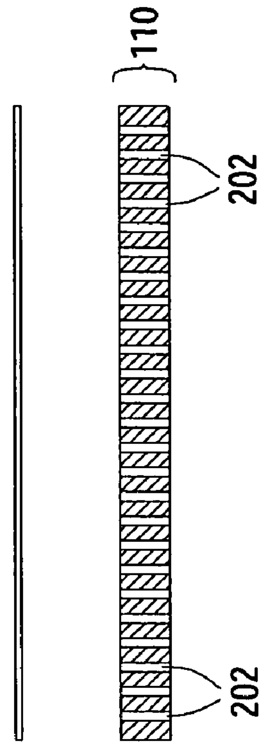

FIG. 2C

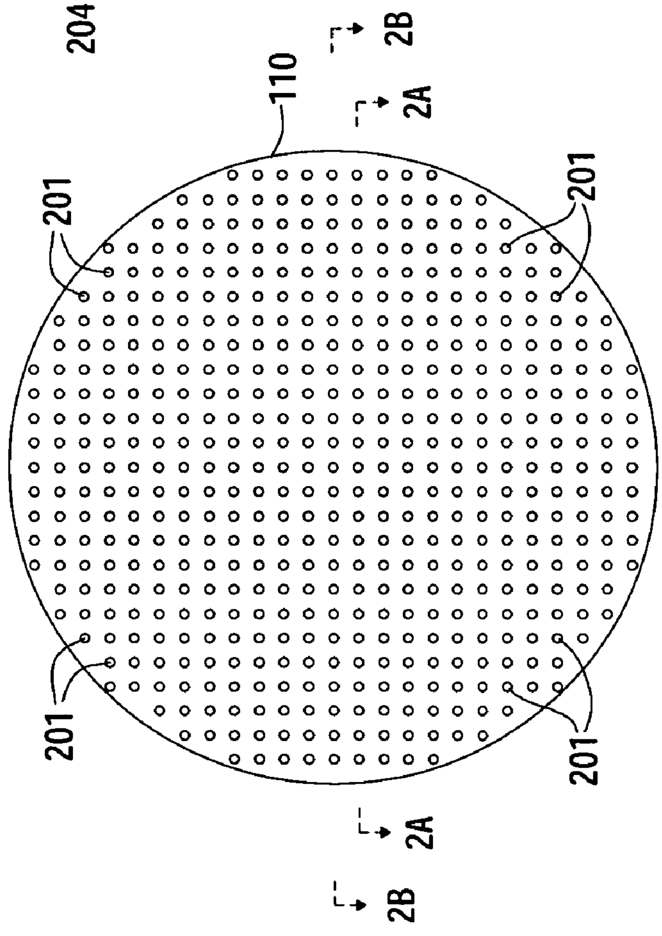

FIG. 2A

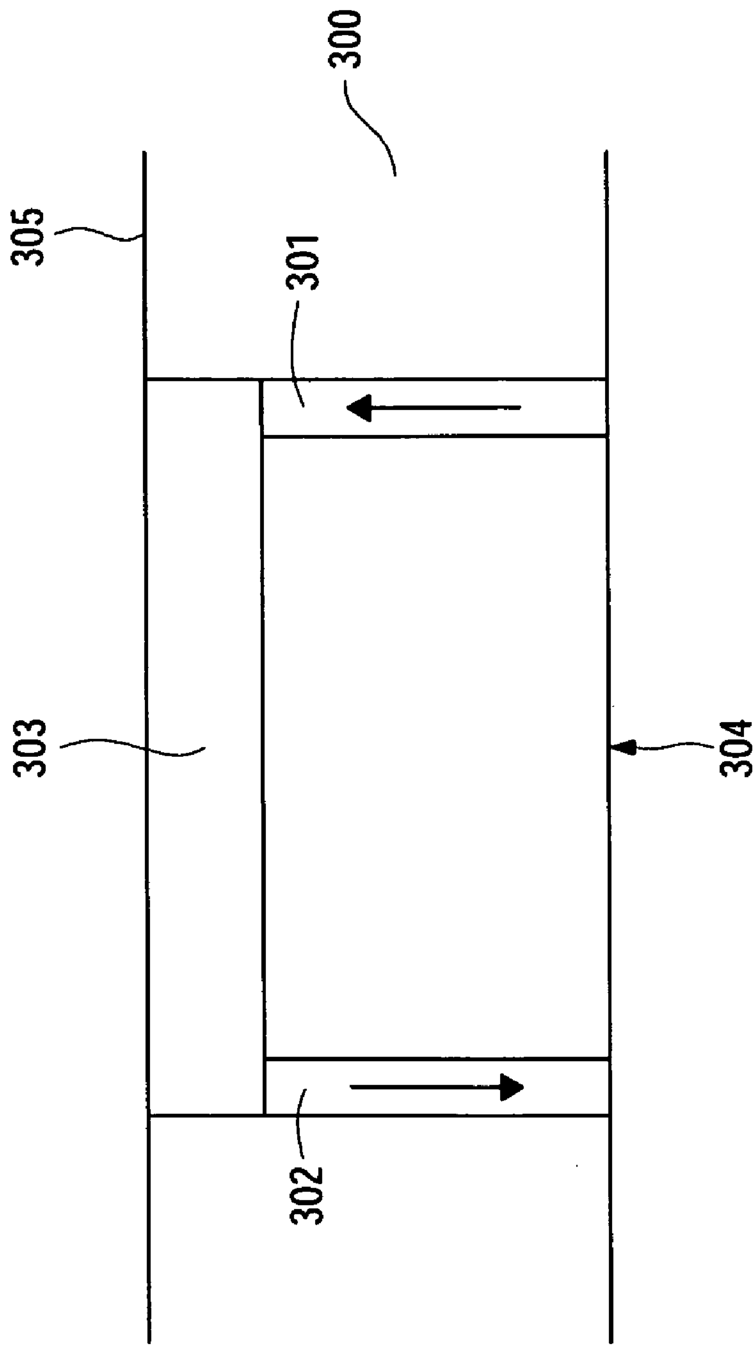

FIG. 3

CONTACT PLATING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional application of co-pending U.S. patent application Ser. No. 10/360,234, filed Feb. 6, 2003, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] Embodiments of the invention generally relate to semiconductor processing system, and more particularly, embodiments of the invention relate to a contact electrochemical plating apparatus and method.

[0004] 2. Description of the Related Art

[0005] Metallization of sub-quarter micron sized features is a foundational technology for present and future generations of integrated circuit manufacturing processes. More particularly, in devices such as ultra large scale integration-type devices, i.e., devices having integrated circuits with more than a million logic gates, the multilevel interconnects that lie at the heart of these devices are generally formed by filling high aspect ratio, i.e., greater than about 4:1, interconnect features with a conductive material, such as copper or aluminum. Conventionally, deposition techniques such as chemical vapor deposition (CVD) and physical vapor deposition (PVD) have been used to fill these interconnect features. However, as the interconnect sizes decrease and aspect ratios increase, void-free interconnect feature fill via conventional metallization techniques becomes increasingly difficult. Therefore, plating techniques, i.e., electrochemical plating (ECP) and electroless plating, have emerged as promising processes for void free filling of sub-quarter micron sized high aspect ratio interconnect features in integrated circuit manufacturing processes.

[0006] In an ECP process, for example, sub-quarter micron sized high aspect ratio features formed into the surface of a substrate (or a layer deposited thereon) may be efficiently filled with a conductive material, such as copper. ECP plating processes are generally multistage processes, wherein a substrate is prepared for plating, i.e., one or more preplating processes, brought to a plating cell for a plating process, and then the substrate is generally post treated after the plating process. The preplating process generally includes processes such as depositing a barrier/diffusion layer and/or a seed layer on the substrate, precleaning the seed layer and/or substrate surface prior to commencing plating operations, and other preplating operations that are generally known in the art. Once the preplating processes are complete, the substrate is generally transferred to a plating cell where the substrate is contacted with a plating solution and the desired plating layer is deposited on the substrate. Once the plating processes are complete, then the substrate is generally transferred to a post treatment cell, such as a rinse cell, bevel clean cell, drying cell, or other post treatment process cell generally used in the semiconductor art.

[0007] However, one challenge associated with conventional plating systems is that it is difficult to provide a uniform plating thickness above both narrow and wide features. For example, conventional plating systems are prone to a characteristic generally termed mounding, which is when the material plated over a substrate having both narrow and wide features accumulates faster or has a greater thickness over the narrow features as compared to the wider features. The result of this characteristic is a buildup or mound of the plated material above the narrow features, which is undesirable for subsequent processing steps, such as chemical mechanical polishing, edge bead removal, electrochemical polishing, and other post plating processes. In response to this challenge, contact-type plating systems have been developed. Contact-type plating systems generally include a pad or membrane in an upper portion of the plating cell, wherein the pad or membrane is configured to contact the plating surface during plating operations. This contact generally operates to minimize mounding characteristics. However, one disadvantage of contact-type plating apparatuses is that it is difficult to obtain sufficient fresh electrolyte flow to the substrate surface as a result of the fluid restriction characteristics generated by the membrane. More particularly, contact-type plating systems generally fail to provide a sufficient flow of fresh electrolyte to the center of the substrate, and as a result thereof, the center of the substrates are generally burned by the plating process.

[0008] Therefore, there is a need for a plating apparatus and method, wherein the apparatus and method are configured to supply sufficient fresh electrolyte to the substrate surface during plating operations to prevent burning characteristics.

SUMMARY OF THE INVENTION

[0009] Embodiments of the invention may generally provide an apparatus and method for electrochemically plating a layer onto a semiconductor substrate. The apparatus generally includes a plating cell configured to conduct an electrochemical plating process, however, the plating cell is configured to contact the plating surface of the substrate with a plating membrane. The plating membrane generally includes channels formed therethrough in a configuration such that a supply of fresh electrolyte may be communicated to the plating surface of the substrate, while alternative channels formed through the membrane may be used to remove used or depleted electrolyte from the surface of the substrate. The method for electrochemically plating a layer onto a substrate may generally include contacting the plating surface of the substrate with the membrane. A plating solution may be supplied to the plating surface via supply channels formed into the membrane, and used electrolyte may be communicated away from the plating surface by recirculation channels formed through the membrane. Additionally, inasmuch as the physical contact between the membrane and the substrate may inhibit electrolyte from freely flowing from the membrane supply channels, the membrane may be periodically removed from contact with the substrate for a short duration of time in order to allow fresh electrolyte to be supplied to the plating surface.

[0010] Embodiments of the invention may further provide a substrate processing system that generally includes a fluid basin configured to contain a plating solution therein, an anode assembly positioned in a lower portion of the fluid basin, and a separation membrane positioned across the fluid basin above the anode assembly. The processing system may further include a diffusion member positioned across the fluid basin above the separation membrane, and a plating membrane positioned across the fluid basin above the diffusion member.

[0011] Embodiments of the invention may further provide an electrochemical processing system. The processing system generally includes a cell configured to contain an electrolyte solution, an anode positioned in the electrolyte solution, a separation membrane sealably positioned to an inner wall of the cell above the anode, and a diffusion member sealably positioned to the inner wall of the cell above the separation membrane. The cell further includes a plating membrane sealably positioned to the inner wall of the cell above the separation membrane, the plating membrane having a top and bottom surfaces, the bottom surface being positioned adjacent the diffusion member and the top surface being positioned adjacent a plating surface of a substrate, a plurality of fluid supply channels fluidly connecting the first and second surfaces, and a plurality of fluid recirculation channels in fluid communication with the top surface and a drain channel.

[0012] Embodiments of the invention may further provide a method for plating a metal onto a semiconductor substrate. The plating method generally includes immersing the substrate in a plating solution, the plating solution containing metal ions to be plated, contacting a plating surface of the semiconductor substrate with a plating membrane, applying a plating bias to the semiconductor substrate to plate the metal ions in the plating solution positioned adjacent the plating surface of the substrate, removing the plating surface from contact with the plating membrane for a predetermined period of time, and recontacting the plating surface with the plating membrane to continue plating the metal ions onto the plating surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] 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.

[0014] **FIG. 1** illustrates a sectional view of an exemplary plating cell and head assembly of the invention.

[0015] **FIG. 2A** illustrates a plan view of an exemplary plating membrane of the invention.

[0016] **FIG. 2B** illustrates a first sectional view of an embodiment of a plating membrane of the invention.

[0017] **FIG. 2C** illustrates a second sectional view of an embodiment of a plating membrane **110** of the invention

[0018] **FIG. 3** illustrates a cross sectional view of an exemplary plating membrane of the invention, wherein a fluid supply channel is connected to a fluid drain channel of the membrane via a recess in the membrane.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0019] **FIG. 1** illustrates a perspective and partial sectional view of an exemplary contact-type electrochemical plating cell **100** and head assembly **150** of the invention. Head assembly **150** generally includes a support frame **151** configured to support a substrate contact assembly **154**. The substrate contact assembly **154** generally includes a vertically actuated thrust plate **152** and a substrate contact ring **153**. A substrate **155** to be processed is generally placed on contact ring **153**, which provides an electrical plating bias to substrate **155** via contact pins **156**. Once the substrate is placed on the contact ring **153**, the thrust plate **152** may be lowered, i.e., in the direction indicated by arrow A, to engage the backside of the substrate and secure the substrate in the contact ring **153** for plating operations. Further, head assembly **150** may also be rotated, as illustrated by arrow B, to facilitate plating, rinsing, or drying processes. In another embodiment of the invention the head assembly utilizes a vacuum chuck-type of substrate securing method. For example, in this embodiment a conductive seed layer formed on the substrate may be extended around the bevel edge of the substrate at least partially onto the backside of the substrate. Then, a vacuum chuck-type substrate support may be used to secure the substrate thereto for processing with the production surface of the substrate facing away from the vacuum chuck. Further, the substrate engaging surface of the vacuum chuck may include a plurality of electrical contact pins configured to electrically engage the substrate, and more particularly, the contact pins are generally configured to engage the substrate in the area where the seed layer is extended onto the backside of the substrate. In this embodiment there will not be any frontside or production surface contact with the substrate, which minimizes interference with the plating membrane.

[0020] Plating cell **100** generally includes an outer basin **101** and an inner basin **102** positioned within outer basin **101**. Inner basin **102** is generally configured to contain a plating solution that is used to plate a metal, e.g., copper, onto a substrate during an electrochemical plating process. During the plating process, the plating solution is generally continuously supplied to inner basin **102** (at about 1-5 gallons per minute for a 10 liter plating cell, for example), and therefore, the plating solution may overflow the uppermost point of inner basin **102** and run into outer fluid recovery basin **101** where it may be collected and recycled for subsequent use. Although not illustrated in **FIG. 1**, plating cell **100** may be positioned at a tilt angle, i.e., the frame portion **103** of plating cell **100** may be elevated on one side such that the components of plating cell **100** are tilted between about 3° and about 30° from horizontal. Therefore, in order to contain an adequate depth of plating solution within inner basin **102** during plating operations, the uppermost portion of basin **102** may be extended upward on one side of plating cell **100**, such that the uppermost point of inner basin **102** is generally horizontal and allows for contiguous overflow of the plating solution supplied thereto around the perimeter of basin **102**.

[0021] The lower portion of plating cell **100** generally includes an annular anode base member **104** that is also positioned at the aforementioned tilt angle, i.e., the upper surface of the base member is generally tilted from horizontal. Base member **104** generally includes an annular or disk shaped recess formed into a central portion thereof, wherein the annular recess is configured to receive a disk shaped or annular anode member **105**. Base member **104** may further include a plurality of fluid inlets/drains **109** positioned on a lower surface thereof. Each of the fluid inlets/drains **109** are generally configured to individually supply or drain a fluid to or from either the anode compartment or the cathode compartment of plating cell **100**. Anode member **105** generally includes a plurality of slots **107** formed therethrough, wherein the slots **107** are generally positioned in parallel orientation with each other across the surface of the anode **105**. The parallel orientation allows for dense fluids generated at the anode surface to flow downwardly across the anode surface and into one of the slots **107**. Plating cell **100** further includes a membrane support assembly configured to receive a membrane **108** thereover, i.e., the membrane may be stretched over the membrane support and use the membrane support as structural support thereof. The membrane support assembly **106** may include an o-ring type seal positioned near a perimeter of the membrane, wherein the seal is configured to prevent fluids from traveling from one side of the membrane secured on the membrane support **106** to the other side of the membrane. The membrane secured to the membrane support may be an ionic membrane, a fluid permeable membrane, or other type of membrane capable of being used in an electrochemical plating cell. Plating cell **100** further includes a diffusion member **112** positioned across an upper portion of cell **100** above membrane **108**. Diffusion member is generally a porous disk shaped member that is sealably attached to the inner wall of basin **102** such that fluid traveling upward through cell **100** must pass through diffusion member in order to reach a substrate being plated in cell **100**. Although embodiments of the invention are not limited to any particular construction of diffusion member **112**, porous ceramic materials may be used to manufacture diffusion member **112**, as these members provide a generally uniform fluid flow therethrough and offer ample flux control characteristics. Further, diffusion member **112** is generally sealably attached to the inner wall of the inner basin **102**, and therefore, fluid traveling upward must generally travel through diffusion member **112**. Diffusion member **112** generally includes a substantially planar upper surface, which is generally configured to receive a plating membrane (further discussed herein) thereon during plating operations. Further still, the outer perimeter of diffusion member **112** may include an annular channel formed therein, wherein the annular channel is sized to receive a bottom portion of a contact ring therein. This allows for a substrate being plated in cell **100** to be positioned in abutment with a plating membrane resting on the upper surface of the diffusion member **112**, as the portions of the contact ring that extend below the substrate may be received in the annular channel formed into the diffusion member **112**.

[0022] During plating operations, a plating solution is generally supplied to the volume in the plating cell **100** above membrane **108**, while a separate fluid solution is generally supplied to the volume within plating cell below membrane **108**. More particularly, generally an anolyte solution, i.e., a plating solution that does not contain plating additives (levelers, suppressors, accelerators, etc), is supplied to the anode chamber, wherein the anode chamber is generally defined as the volume of the plating cell **100** below membrane **108**. A catholyte solution, i.e., a plating solution having a chosen concentration of plating additives therein (levelers, suppressors, accelerators, etc) is supplied to the catholyte chamber, wherein the catholyte chamber is generally defined as the volume of the plating cell above membrane **108**.

[0023] In addition to membrane **108** used in the plating cell to separate the anode compartment from the cathode compartment, a secondary plating membrane or plating pad **110** may be positioned across a top portion of the plating cell **100**. Plating membrane **110**, which is generally referred to in the semiconductor plating art as a plating pad or plating membrane, is generally positioned to be in contact with or submerged in the electrolyte solution contained within inner basin **102**. In similar fashion to the membrane positioned on the membrane support **106**, plating membrane **110** may also be sealed to the outer perimeter of inner basin **102**. In this configuration the plating solution applied to the inner basin would be required to flow through the plating membrane **110** before being collected in outer basin **101** for recycling. Further, plating membrane **110** is generally positioned such that when a substrate is brought into a processing position, i.e., when a substrate is lowered into the plating solution contained within inner basin **102** by a head assembly or other means of supporting a substrate for processing steps, plating membrane **110** is generally in contact with the plating surface of the substrate. Plating membrane **110** is generally fluid permeable, and therefore, the plating solution contained within inner basin **102** generally passes through the plating membrane **110** to contact the plating surface of the substrate.

[0024] **FIG. 2A** illustrates a plan view of the topside of the plating membrane **110**. The upper surface or topside of membrane generally includes a plurality of apertures **201** formed therein. Each of apertures **201** are in fluid communication with channels **202** or **203** formed through the interior of plating membrane **110**. More particularly, as illustrated in **FIGS. 2B and 2C**, approximately half of apertures **201** are in fluid communication with fluid supply channels **202**, while the other half of apertures are in fluid communication with fluid recirculation channels **203**.

[0025] **FIG. 2B** illustrates a first sectional view of an embodiment of a plating membrane **110** of the invention. More particularly, the section of the plating membrane **110** illustrated in **FIG. 2B** is selected to illustrate the fluid recirculation channels **203** formed through the plating membrane **110** that are configured to remove plating solution from the substrate surface for recycling. Each of the fluid recirculation channels **203** generally runs vertically through the plating membrane **110** and terminates at a drain channel **204** that runs across the plating membrane **110** generally directly below the fluid recirculation channels **203**. As such, fluid received in apertures **201** that are in fluid communication with recirculation channels **203** is generally communication to drain channel **204** by the fluid recirculation channels **203**. Drain channel **204** generally operates to communicate the fluid to the perimeter of the plating membrane **110**, where the fluid may then be captured or otherwise allowed to flow into the outer basin **101** for collection and recirculation to the plating cell.

[0026] **FIG. 2C** illustrates a second sectional view of an embodiment of a plating membrane of the invention. More particularly, the section of the plating membrane **110** illustrated in **FIG. 2C** is selected to illustrate the fluid channels **202** formed through the plating membrane **110** that are configured to supply fresh electrolyte to the plating surface of the substrate. Fluid supply channels **202** are generally configured to fluidly connect the lower side of the plating membrane **110** to the upper side of the plating membrane, and as such, the plating solution supplied to the volume in the plating cell below the plating membrane **110** may generally flow the plating membrane **110** from the bottom side to the top side where a substrate is generally positioned during plating operations. The process of flowing fluid through the plating membrane **110** is generally driven by the fluid pressure generated via the supply of plating solution (catholyte) to the volume within inner basin **102** above membrane **108**, as the outer perimeter of plating membrane **110** is generally sealed to the wall of inner basin **102** and does not allow plating solution to pass from the bottom side of the plating membrane **110** to the top side of the plating membrane without passing through the membrane **110**. As such, the plating solution supplied to the catholyte compartment generally flows into the compartment and through the plating membrane **110** before being captured for recycle.

[0027] **FIG. 3** illustrates a cross sectional view of an alternative embodiment of the invention, wherein fluid supply channels of a plating membrane **300** are connected to fluid drain channels by a recess in the surface of the plating membrane that is proximate the substrate being plated. The exemplary plating membrane **300** generally includes at least one fluid supply channel **301** that originates on a first or backside **304** of membrane **300** and terminates proximate a second or frontside **305** of membrane **300**, wherein the backside **304** generally faces the anode of a plating cell and the frontside **305** is generally in contact with the substrate being plated. The exemplary plating membrane **300** also generally includes at least one fluid recirculation channel **302** that originates on the frontside **305** of membrane **300** (in recession **303**) and terminates proximate backside **304**. The frontside **305** generally includes a recession **303** formed therein, wherein the recession **303** interconnects at least one of the fluid supply channels **301** to at least one of the fluid recirculation channels **302**. The shape of recession **303** in a plan view may be square, rectangular, triangular, oval, circular, or any other shape that allows for fluid connection of at least one fluid supply channel **301** to at least one fluid recirculation channel. For example, recession may be square shaped in a plan view with a side distance of between about 5 microns and about 100 microns. Similarly, the diameter or cross sectional distance across the respective fluid channels may be between about 1 micron and about 10 microns, for example. Therefore, in this embodiment, the upper surface **305** is brought into contact with a plating surface of a substrate that is within a plating solution. The plating solution is flowed to the plating surface via fluid supply lines **301**. The plating solution enters into recession **303** and is allowed to contact and electrochemically react with the plating surface of the substrate. Simultaneously, plating solution is being removed from the recession via fluid recirculation channels **302**, which allows fresh plating solution to be continually supplied to the plating surface of the substrate.

[0028] In operation, generally a substrate is first brought into a plating position within plating cell **100**. More particularly, a head assembly (not shown) generally lowers a substrate from above cell **100** into a plating position, which generally corresponds to position where the plating surface of the substrate is in contact with the plating membrane **110**. Once the substrate is positioned in the plating position, the substrate may be rotated while an electrical plating bias is simultaneously applied between the substrate being plated and the anode **105** within plating cell **100**. Further, in conjunction with the rotation and application of the electrical plating bias, anolyte and catholyte solutions are generally circulated to the respective chambers within plating cell **100**. The application of the plating bias between the substrate and anode **105** generally operates to urge metal ions in the plating solution to plate onto the substrate surface, assuming that the substrate surface is in electrical communication with the cathode terminal of the power supply so that the positive ions in the plating solution are attractive thereto.

[0029] More particularly, once a substrate is positioned in a plating position, a plating solution or catholyte solution is generally supplied to the catholyte chamber of cell **100**, wherein the catholyte chamber generally corresponds to the volume of cell **100** above membrane **108**. Since plating membrane **110** is generally sealably attached to the inner wall of inner basin **102**, the plating solution supplied to the catholyte chamber generally causes a slight increase in fluid pressure within the catholyte chamber. This slight increase in fluid pressure is generally sufficient to drive or urge the plating solution within the catholyte chamber through the plating membrane **110**. As such, the fluid pressure in catholyte chamber essentially operates to urge the plating solution to pass through plating membrane **110** so that it may contact the plating surface of the substrate being plated and supply plating ions thereto.

[0030] The process of flowing the plating solution from the catholyte chamber to the substrate surface being plated generally includes providing sufficient fluid pressure to the catholyte chamber to urge or force the plating solution within the catholyte chamber through plating membrane **110**. More particularly, as illustrated **FIG. 2C**, plating membrane **110** generally includes a plurality of fluid supply channels **202** formed therethrough that operate to provide a fluid pass from the catholyte chamber to the surface of the substrate being plated, assuming the substrate being plated is in physical contact with the upper surface of plating membrane **110**. Thus, one fluid pressure is supplied to the light chamber, the plating solution within the catholyte chamber is caused to travel through fluid supply apertures **202** to the surface of the substrate being plated.

[0031] Once the plating solution is supplied to the substrate surface for plating operations, portions of the solution are generally consumed by the plating operation. As such, it is generally necessary to continually supply plating solution to the substrate plating surface in order to maintain plating process. However, the volume between the plating surface and the plating membrane **110** is relatively constant or fixed, and therefore, in order to provide well plating solution to the plating surface of the substrate, the depleted or used plating solution is generally removed therefrom. For example, **FIG. 2B** illustrates in the fluid recirculation channels **203**, which are in fluid communication with a fluid drain channel **204**. Fluid drain channel **204** is generally in fluid communication with outer basin **101**, and therefore, the used or depleted plating solution that is removed from the plating surface of the substrate via drain channel **204** is supplied to outer basin **101**, which operates to collect the used electrolyte and recirculated back into the plating system as required. Therefore, the combination of fluid supply channels **202** and fluid drain channels **203** operate to continually supply fresh electrolyte to the plating surface of the substrate.

[0032] Further, as illustrated in **FIG. 3**, a plating membrane **300** may be modified to interconnect fluid supply channels **301** with fluid drain channels **302** via a recession **303** formed into an upper surface **305** of the plating membrane **300**. In this configuration, the recession **303** generally operates to maintain a small volume or pocket of electrolyte in the local area between the respective inlet **301** and outlet **302**. As such, the formation of the recession **303** into the upper surface **305** of the plating membrane **300** operates to provide a larger volume of plating solution to the plating surface of the substrate, without separating or increasing the distance between the surface of the substrate and the plating membrane **110**. This additional volume of plating solution maintained within recession **303** helps prevent the electrical plating bias from burning the plating membrane.

[0033] In another embodiment of the invention, the plating process may be modified to prevent burning the plating membrane. For example, burning generally occurs when the plating solution between the plating surface and the plating membrane depletes or is not recirculated quickly enough. Since the plating membrane is generally in contact with the plating surface, conventional contact plating apparatuses have difficulty supplying fresh plating solution to the substrate surface, as the contact between the plating membrane and the substrate surface generates resistance to fluid supply. Therefore, embodiments of the invention contemplate a pulsed plating method that may be used to prevent burning of the plating membrane. More particularly, the pulse plating method generally includes contacting the substrate with the plating membrane for a first period of time, wherein the first period of time generally corresponds to the amount of time it takes to deplete a calculated volume of plating solution from between the plating membrane and the plating surface. Once the first period of time has expired, the plating membrane is removed from direct contact with the plating surface for a second period of time, wherein the second period of time is calculated to allow a sufficient amount of fresh plating solution to be circulated through the plating membrane to supplant plating operations for another period of time equal to the first period of time. In other words, the first period of time is generally the amount of time it takes to deplete the plating solution that may be supplied to the plating membrane and the plating surface, while the second period of time corresponds to the amount of time it takes to circulate to fresh plating solution into the area between the plating surface and membrane. The duration of the pulse, i.e., the duration of the separation between the plating membrane and the plating surface, may be between about 0.01 seconds and about 1 second, for example. More particularly, the pulse duration may be between about 0.1 seconds and about 0.5 seconds. The pulse or separation of the plating membrane from the plating surface of the substrate operates to reduce the fluid flow resistance generated via the contact between the plating membrane and the plating surface so that positive fluid flow through the membrane may be obtained. The positive flow is generally calculated to replenish the electrolyte depleted at the surface of the substrate.

[0034] 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

1. A method for electrochemically plating a metal on a semiconductor substrate, comprising:

immersing the substrate in a plating solution, the plating solution containing metal ions to be plated;

contacting a plating surface of the semiconductor substrate with a plating membrane;

applying a plating bias to the semiconductor substrate to plate the metal ions in the plating solution positioned adjacent the plating surface of the substrate;

removing the plating surface from contact with the plating membrane for a predetermined period of time; and

recontacting the plating surface with the plating membrane to continue plating the metal ions onto the plating surface.

2. The method of claim 1, further comprising rotating the substrate.

3. The method of claim 1, wherein removing the plating surface from contact with the plating membrane and recontacting the plating surface with the plating membrane are performed periodically.

4. The method of claim 1, further comprising positioning a diffusion member below the plating membrane, the diffusion member being configured to support the plating membrane during plating operations.

5. The method of claim 1, further comprising flowing the plating solution through the plating membrane during plating operations.

6. The method of claim 1, wherein the duration of the removing step corresponds with an amount of time required to replenish depleted plating solution at the plating surface.

7. The method of claim 1, wherein contacting a plating surface of the semiconductor substrate with a plating membrane comprises positioning the substrate adjacent a diffusion member, wherein the plating membrane is between the substrate and the diffusion member.

8. The method of claim 1, wherein the plating membrane is fluid permeable.

9. The method of claim 1, wherein the plating membrane includes fluid supply channels configured to supply electrolyte to the plating surface of the substrate and fluid recirculation channels configured to remove depleted electrolyte from the plating surface.

10. The method of claim 1, further comprising supplying electrolyte to a plurality of recessions formed in the plating membrane.

11. The method of claim 10, wherein the plurality of recessions are in fluid communication with at least one fluid supply channel and at least one fluid recirculation channel.

12. A method for electrochemically plating a metal on a substrate, comprising:

lowering the substrate toward a plating membrane to place the substrate in a plating position wherein a plating solution containing metal ions to be plated;

applying a plating bias for a first period of time to the substrate to plate the metal ions in the plating solution on a plating surface of the substrate;

increasing the distance between the plating membrane and the substrate for a second period of time; and reducing the distance between the plating membrane and the substrate.

13. The method of claim 12, wherein lowering the substrate comprises:

immersing the substrate in the plating solution; and

contacting the plating surface of the substrate with the plating membrane.

14. The method of claim 12, further comprising performing applying the plating bias, increasing the distance and reducing the distance periodically.

15. The method of claim 12, further comprising rotating the substrate.

16. The method of claim 12, wherein the first period of time is an amount of time it takes to deplete the plating solution between the plating membrane and the substrate.

17. The method of claim 12, wherein the second period of time is an amount of time it takes to circulate the plating solution between the plating membrane and the substrate.

18. A method plating a metal on a substrate, comprising:

positioning the substrate in a plating position;

supplying a plating solution to a plating surface of the substrate using a plating membrane;

applying a plating bias to plate the metal on the plating surface;

removing the plating solution from the plating surface using fluid draining channels in the plating membrane; and

repeating the applying the plating bias and removing the plating solution.

19. The method of claim 18, wherein removing the plating solution from the plating surface comprises increasing the distance between the plating surface and the plating membrane.

20. The method of claim 18, further comprising rotating the substrate during the applying the plating bias.

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