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(54) **APPARATUS AND METHOD FOR ELECTROPOLISHING A SUBSTRATE IN AN ELECTROPLATING CELL**

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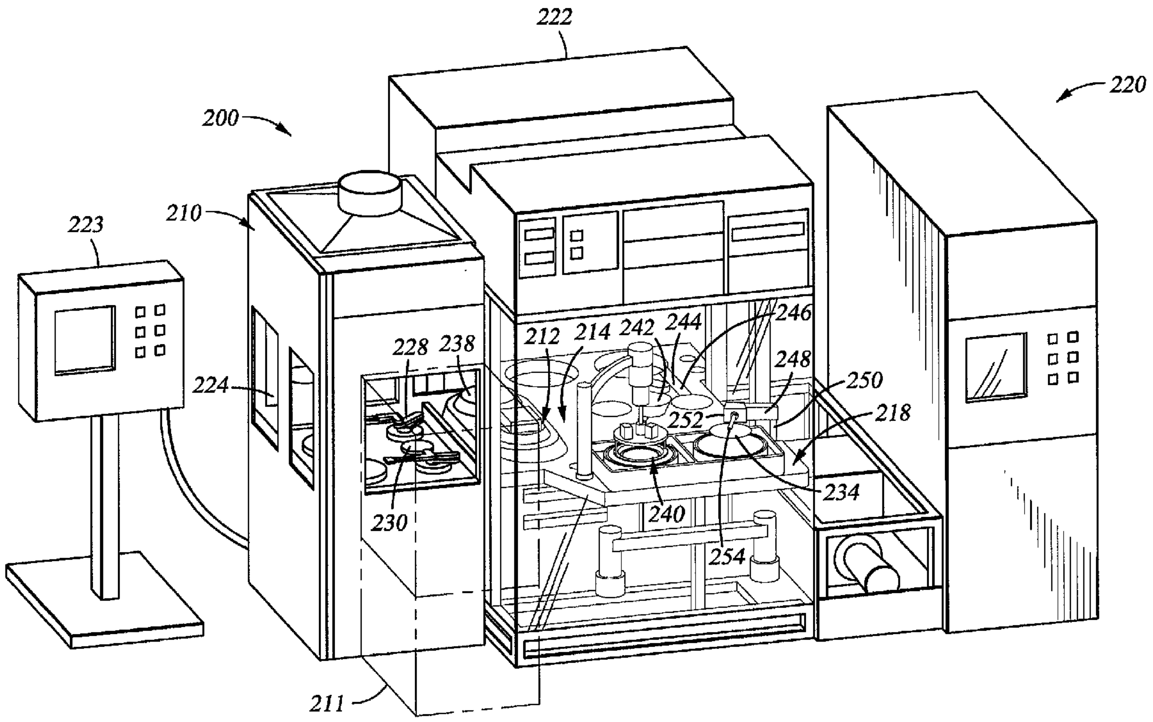
(57) **ABSTRACT**

An electrolyte cell receives a substrate for processing, a first electrode disposed in the electrolyte cell, the first electrode comprising at least a contact ring, a second electrode disposed within the electrolyte cell and spaced from the first electrode, and a porous membrane that is connected to the electrolyte cell and extends across at least a portion of the electrolyte cell, the membrane is positioned between a location for positioning a substrate when processing and surrounding electrolyte.



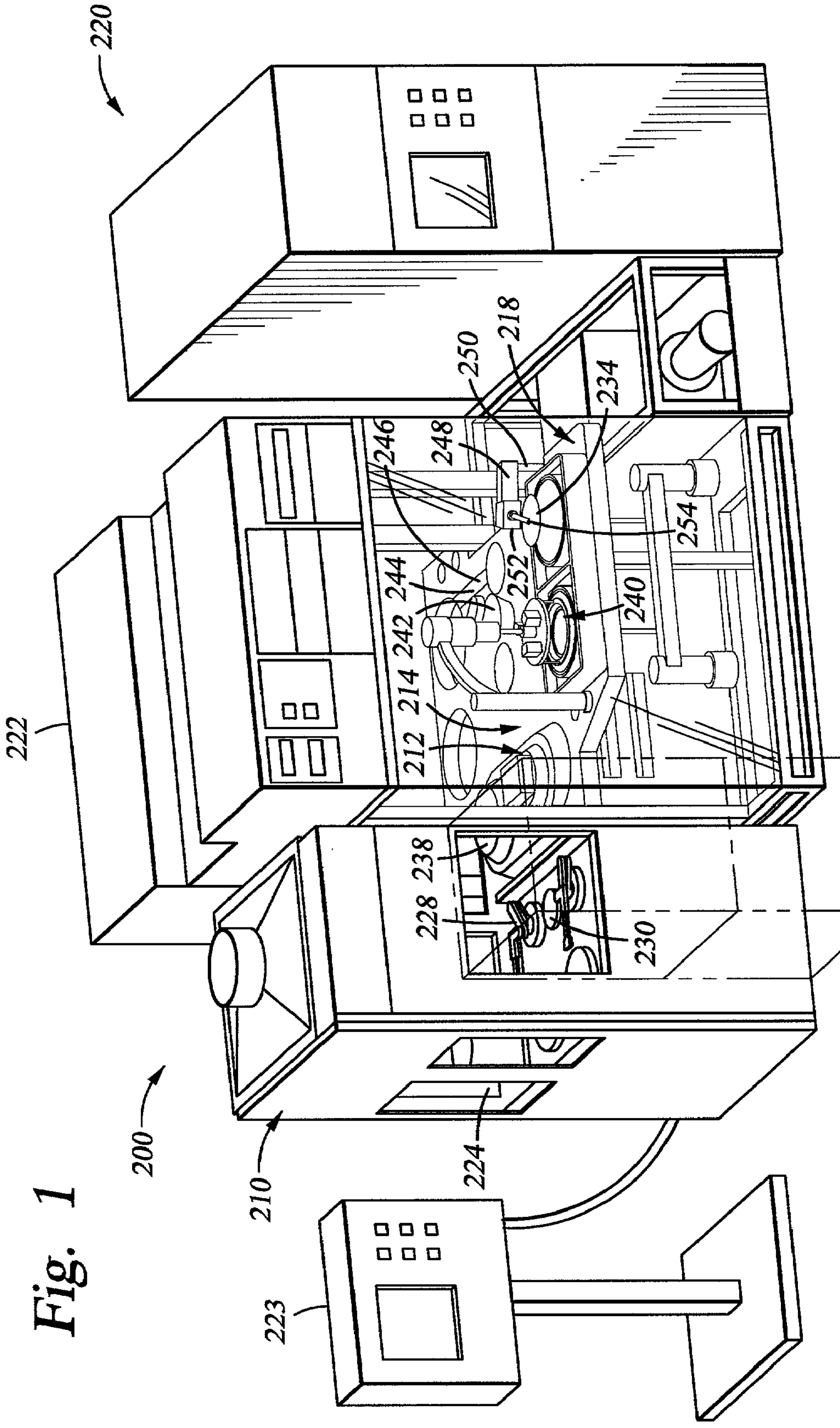

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Fig. 1

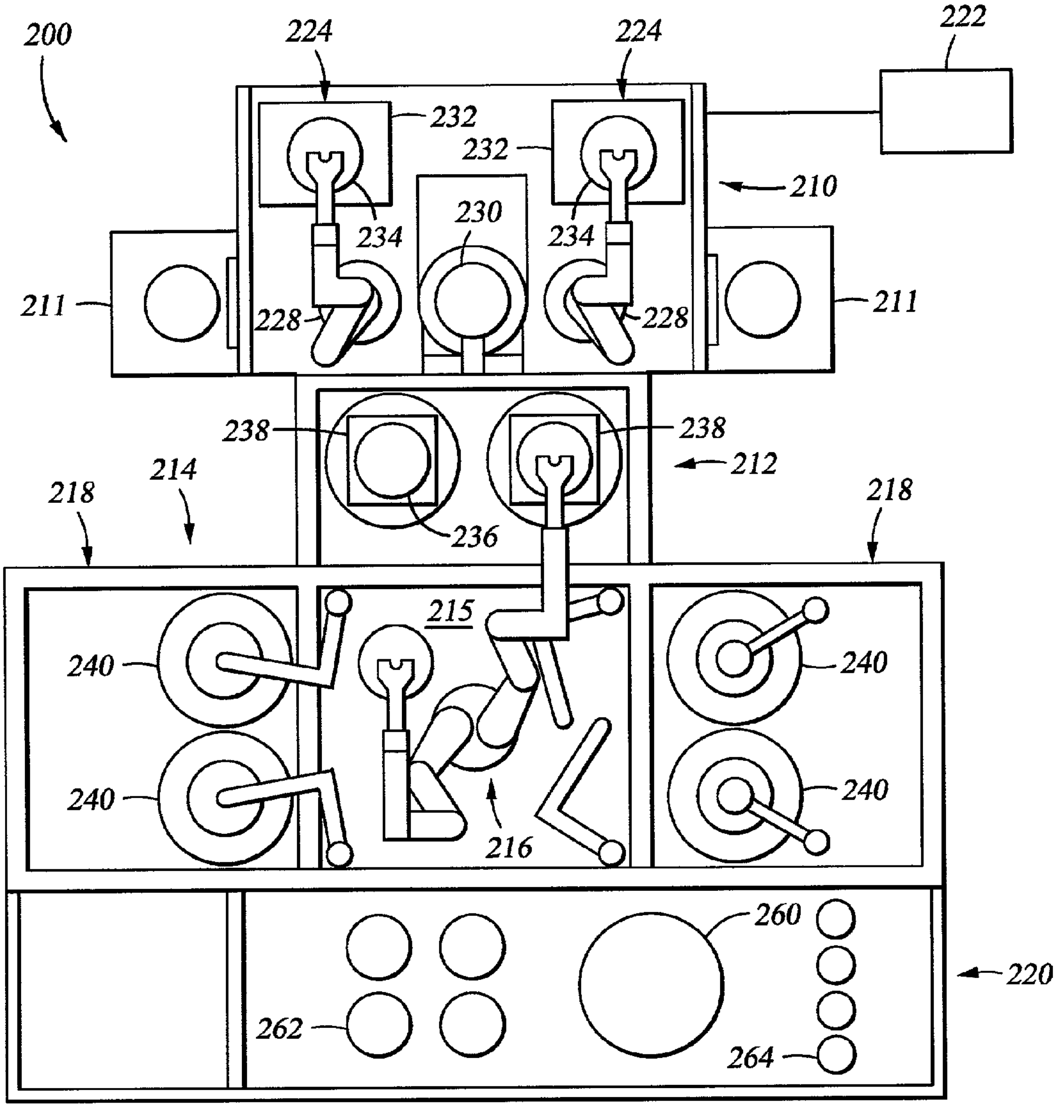
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Fig. 2

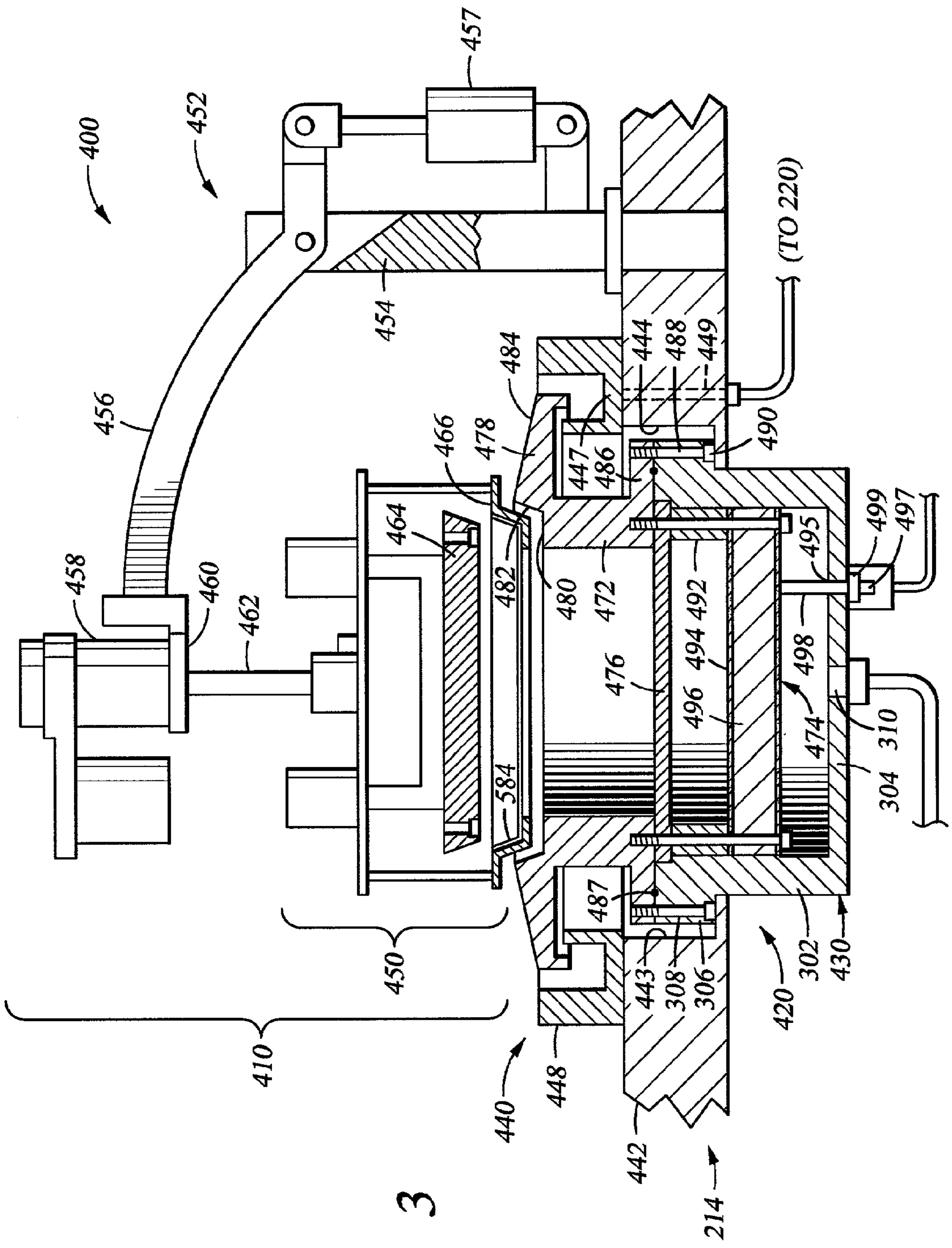
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Fig. 3

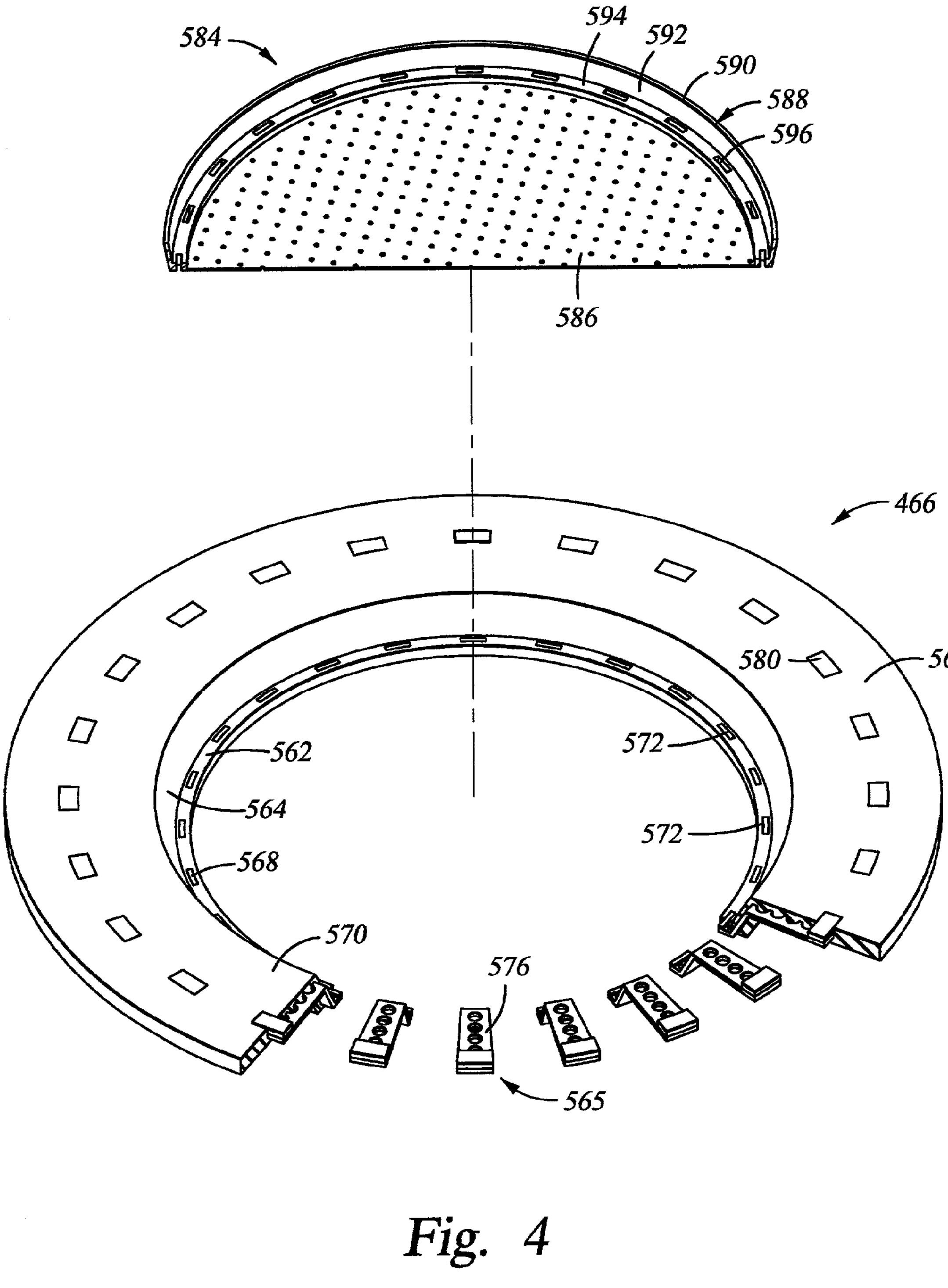
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Fig. 4

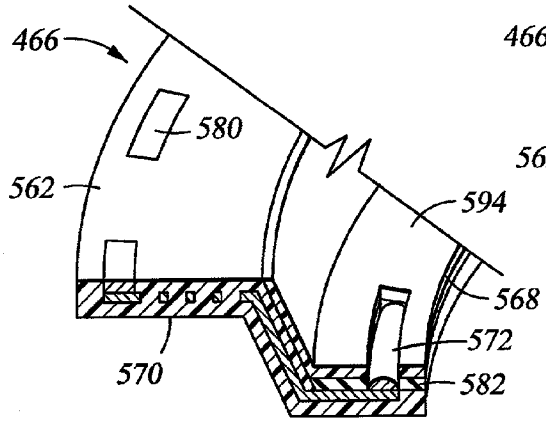


Fig. 5

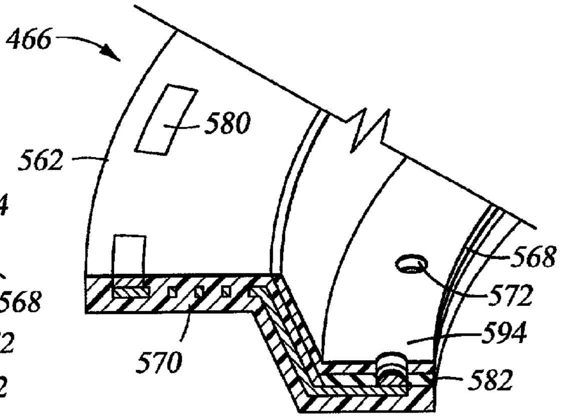


Fig. 6

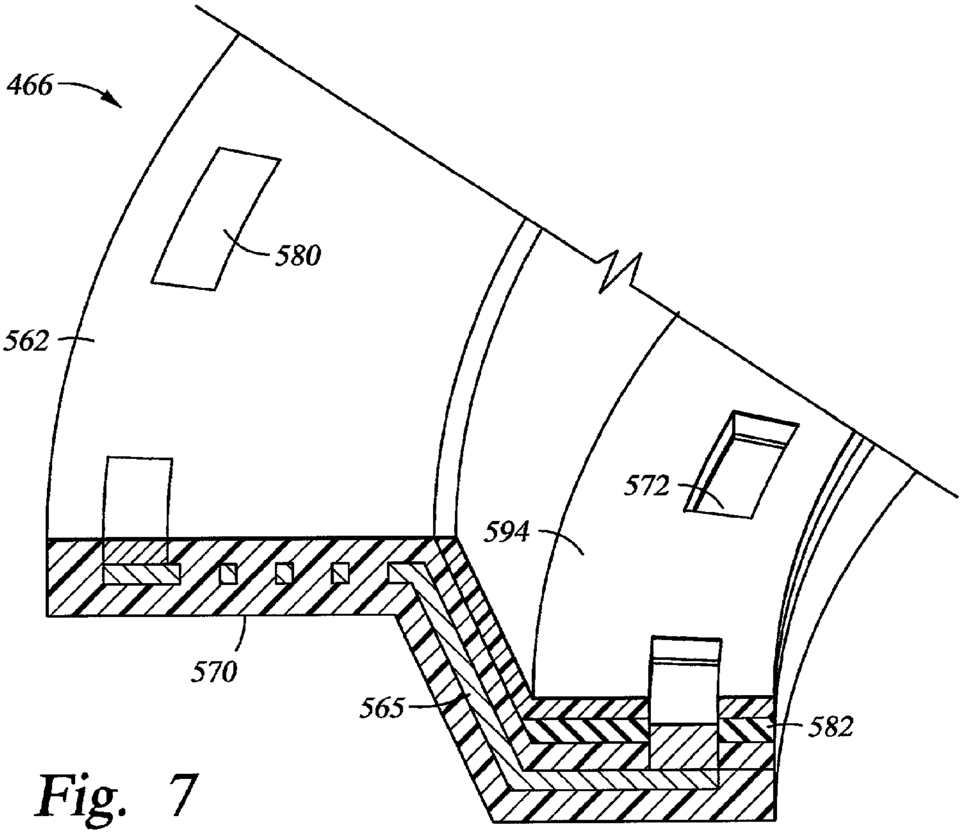
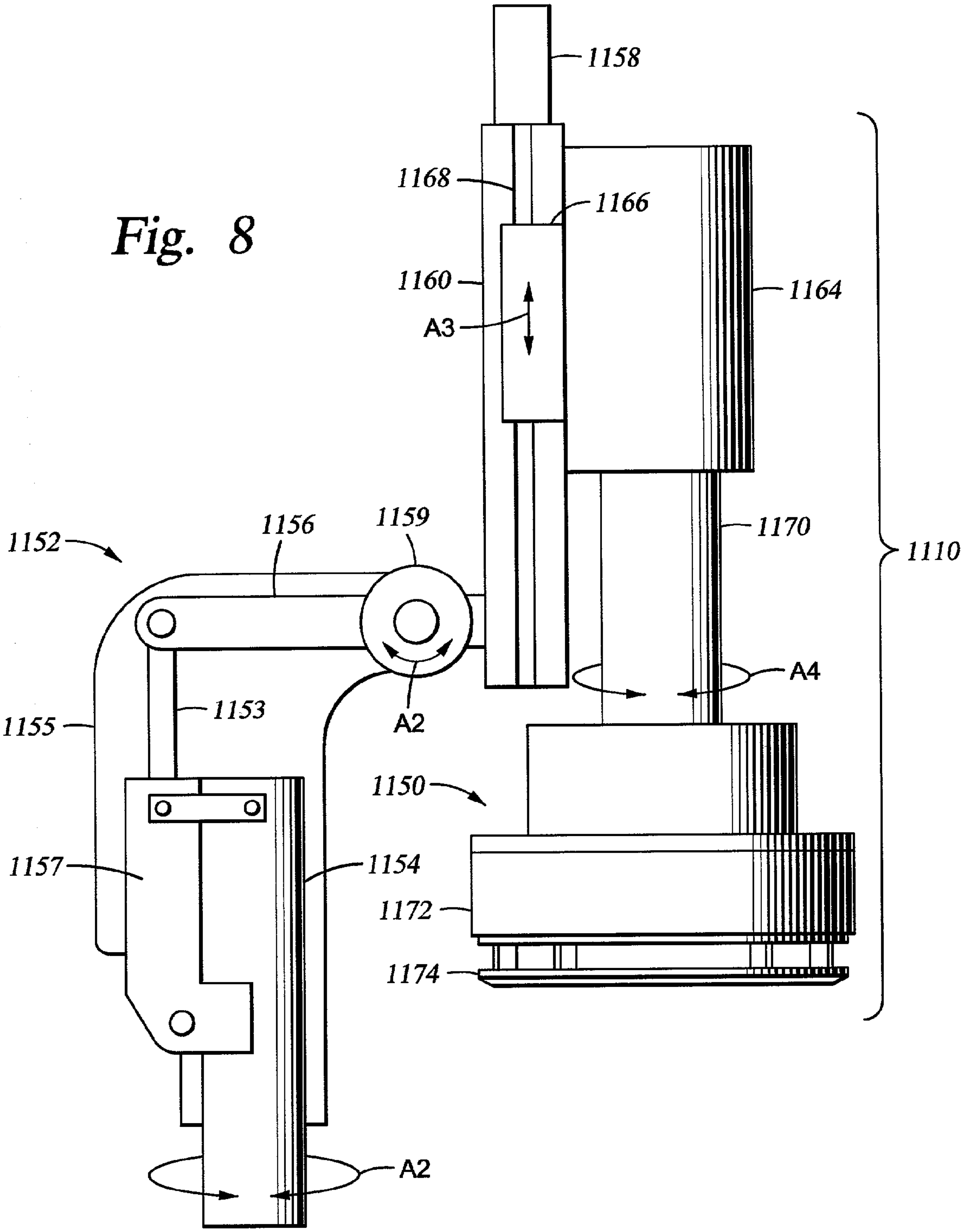


Fig. 7

Fig. 8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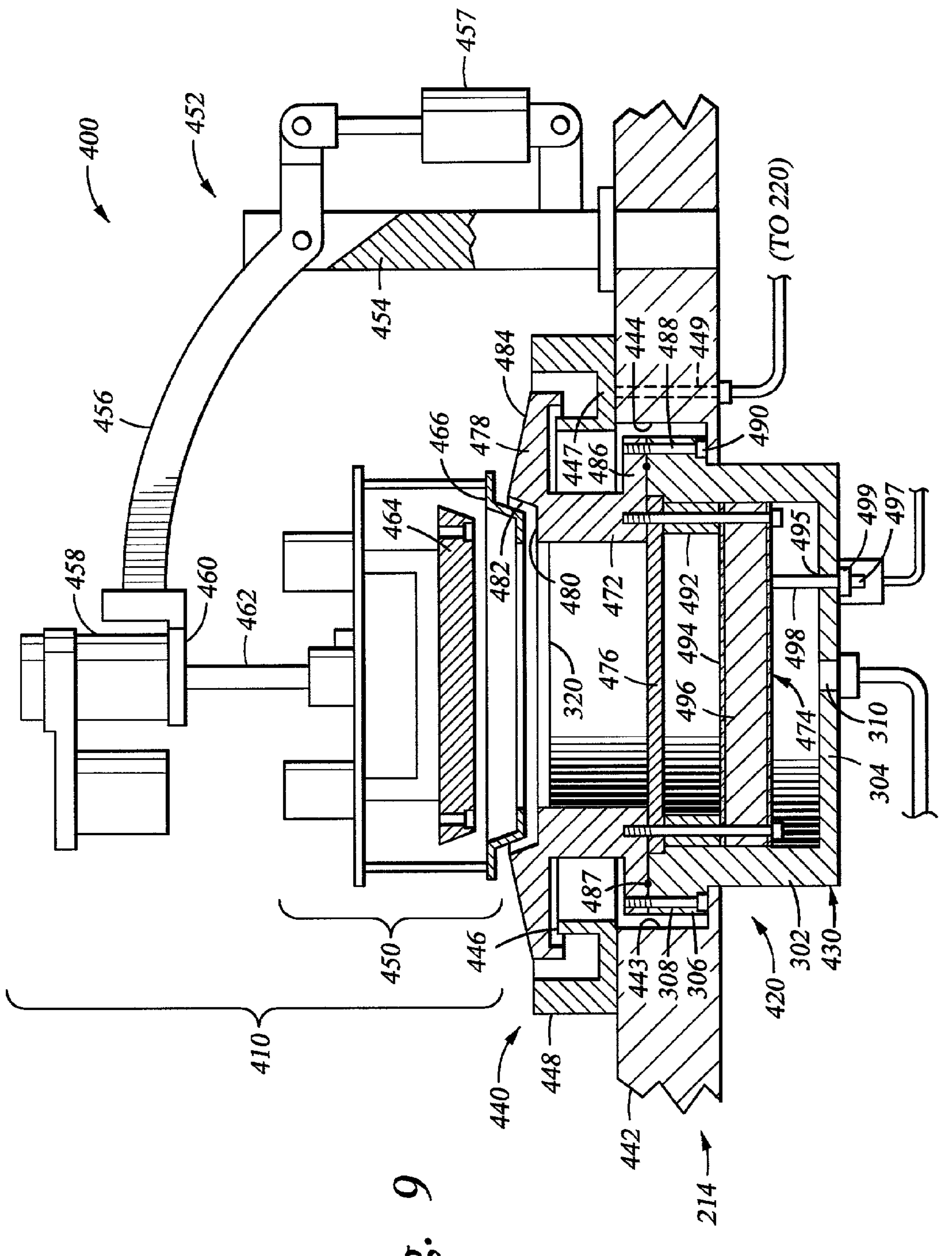
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Fig. 9

APPARATUS AND METHOD FOR ELECTROPOLISHING A SUBSTRATE IN AN ELECTROPLATING CELL

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention generally relates to electrochemical processing apparatus and methods used in semiconductor device fabrication and to an apparatus that minimizes substrate contamination during electrochemical deposition and electrochemical removal methods.

[0003] 2. Description of the Related Art

[0004] Sub-quarter micron, multi-level metallization is one of the key technologies for the next generation of ultra large-scale integration (ULSI). The multilevel interconnects that lie at the heart of this technology require planarization of interconnect features formed in high aspect ratio apertures, including contacts, vias, lines and other features. Reliable formation of these interconnect features is very important to the success of ULSI and to the continued effort to increase circuit density and quality on individual substrates and die.

[0005] As circuit densities increase, the widths of vias, contacts and other features, as well as the dielectric materials between them, decrease to less than 250 nanometers, whereas the thickness of the dielectric layers remains substantially constant, with the result that the aspect ratios for the features, i.e., their height divided by width, increases. Many traditional deposition processes, such as physical vapor deposition (PVD) and chemical vapor deposition (CVD), have difficulty filling structures where the aspect ratio exceeds 4:1, and particularly where it exceeds 10:1. Therefore, there is a great amount of ongoing effort being directed at the formation of void-free, nanometer-sized features having high aspect ratios wherein the ratio of feature height to feature width can be 4:1 or higher.

[0006] Electroplating, which was previously limited in integrated circuit design to the fabrication of lines on circuit boards, is now being used to deposit metal films, such as copper, on substrates to form features. Electroplating is performed by establishing a voltage/current level between the seed layer on the substrate and a separate anode to deposit metal ions from an electrolyte solution on the layer to form the deposited metal film. One feature filling embodiment that utilizes electroplating requires initially depositing a diffusion barrier layer on the substrate by a process such a physical vapor deposition (PVD) or chemical vapor deposition (CVD). A seed layer is deposited on the diffusion barrier layer by a process such as PVD or CVD to define a plating surface on the substrate. Metal ions are then deposited by electroplating on the substrate seed layer to form a metal film. Finally, the deposited metal film can be planarized, for example, by chemical mechanical polishing (CMP), to define a conductive interconnect feature.

[0007] In one example of an electroplating process, electrolyte solution is generally injected into an electrolyte cell from an inlet disposed below an anode, and the electrolyte solution follows a generally upward path to a substrate surface acting as a cathode for deposition of material thereon. The fluid flow pattern of the electrolyte solution flowing around the anode plate to the upper surface of the anode plate is typically non-linear considering the shape and contour of the anode and the irregular fluid flow path around the anode. Laminar fluid flow of electrolyte solution to the upper surface of the anode enhances the generation of metal ions in the electrolyte solution since laminar flow electrolyte solutions interact more uniformly and predictably with the anode than with a turbulent flow.

[0008] However, turbulence often occurs in the electrolyte solution flow adjacent the upper surface of the anode plate that may cause the formation of eddies in the flow near the upper surface of the anode plate. The formation of such eddies may obstruct the chemical reaction between the electrolyte solution and the anode. A turbulent flow adjacent the upper anode surface may limit the chemical reaction between the electrolyte solution and the anode, and thereby may reduce the quantity of metal ions released into the electrolyte solution and may limit the plating effectiveness of the electrolyte, process, and apparatus. Additionally, turbulence may result in particulate matter separation from the anode surface. This particulate matter may deposit on the substrate surface, which can detrimentally affect subsequent deposition processes and detrimentally affect device fabrication.

[0009] One technique to provide uniformity of flow across the width of the electrolyte cell involves extending a diffuser across the width of the electrolyte cell. The diffuser is configured to permit the electrolyte solution containing the metal ions to pass through. However, diffusers have been observed to perform as a virtual electrode. In considering the path of electric flux within the electrolyte cell from the anode to the seed layer, a flow diffuser can appear, to the substrate, to be generating the electric flux and act as the anode. The presence of this virtual anode may detrimentally affect deposition performance.

[0010] For example, the electrical resistance between a particular location on the flow diffuser and the substrate seed layer is generally a function of the distance between the flow diffuser to the seed layer. Thus, electrical current flowing from one part of the flow diffuser through the electrolyte solution to one point on the substrate may be greater than or less than the electric resistance through the electrolyte solution from other portions of the flow diffuser to other points on the substrate depending upon deformation or design of the diffuser.

[0011] Additionally, diffusers may be sufficiently spaced from the substrate surface so that fluid flow may become non-uniform between the diffuser and the substrate surface and exhibit variable electrical resistance therebetween. Varying electrical currents and electrical resistances may result in variable deposition rate of conductive materials on the substrate surface and the formation of an uneven topography, which may lead to voids in the feature upon plating.

[0012] Also, such varying currents across the face of the substrate may detrimentally affect an electrochemical removal process, such as electropolishing, as non-uniform currents across the substrate surface can result in non-uniform removal and a failure to achieve planarization during material removal. Additionally, as the feature widths decrease, the device current remains constant or increases, which results in an increased current density in the feature, which can lead to varying current in and around features.

[0013] Therefore, there remains a need for an electrochemical processing system that enhances the uniformity of electrical current density applied across the face of the substrate and limits contamination of the substrate surface.

SUMMARY OF THE INVENTION

[**0014**] Aspects of the invention generally provide apparatus and processes for diffusing fluid flow and providing uniform hydrodynamics for electrochemical processing, such as electroplating and electropolishing. In one aspect, an apparatus is provided including an electrolyte cell configured to receive a substrate for processing, a substrate support in the electrolyte cell, the substrate support comprising at least a substrate seating surface, a fixed electrode disposed within the electrolyte cell and spaced from the substrate support, and a porous membrane that is connected to the electrolyte cell and extends across at least a portion of the electrolyte cell, wherein the membrane is positioned between the substrate seating surface and a substrate.

[**0015**] In another aspect, an apparatus is provided for electrochemically processing a substrate including an electrolyte cell configured to receive a substrate to have a conductive material film deposited thereon or removed therefrom, a substrate support, a contact ring in electrical communication with the substrate support, wherein the contact ring comprises at least a portion of a first electrode, a second electrode disposed on a bottom portion of a electrolyte cell, a power source coupled to the contact ring and second electrode, a source of electrolyte in fluid communication with the electrolyte cell, and a porous membrane connected to the electrolyte cell and extends across at least a portion of the electrolyte cell, wherein the porous membrane is positioned between the first electrode and the second electrode.

[**0016**] In another aspect, an apparatus is provided for use in an electrolyte cell, the apparatus including a porous membrane that is connected to and extends across a portion of the electrolyte cell, wherein the porous membrane is positioned between a first electrode and a second electrode disposed in the electrolyte cell, and wherein the porous membrane is formed a ceramic material, a polymer, a polishing material, or combinations thereof, having pore sizes between about 0.25 μm and about 2 μm wide.

[**0017**] In another aspect, a method is provided for processing a substrate including extending a porous membrane across the electrolyte cell, positioning a substrate in the electrolyte cell and adjacent the porous membrane, supplying an electrolyte solution to the electrolyte cell through the porous membrane to a substrate surface, and delivering power to the substrate and an electrode disposed in the electrolyte cell to perform an electrochemical process.

[**0018**] In another aspect, a contact ring is provided for use in an apparatus for electroplating a metal onto a substrate having an electrically conductive portion, the contact ring comprising an annular insulative body defining a central opening, a plurality of conductive elements disposed through the insulative member, and a porous membrane assembly disposed on the annular insulative body, wherein the porous membrane assembly comprises a porous material disposed within the central opening.

BRIEF DESCRIPTION OF THE DRAWINGS

[**0019**] So that the manner in which the above recited features are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof, which are illustrated in the appended drawings.

[**0020**] 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.

[**0021**] **FIG. 1** is a perspective view of one embodiment of an electrochemical plating (ECP) system;

[**0022**] **FIG. 2** is a top schematic view of the ECP system of **FIG. 2**;

[**0023**] **FIG. 3** is a cross sectional view of one embodiment of a process cell used in ECP processing;

[**0024**] **FIG. 4** is a partial cross sectional perspective view of one embodiment of contact ring and porous membrane of **FIG. 3**;

[**0025**] **FIG. 5** is a cross sectional perspective view of an alternate embodiment of contact ring and porous membrane of **FIG. 3**;

[**0026**] **FIG. 6** is a cross sectional perspective view of the **FIG. 3** contact ring and porous membrane showing an alternative embodiment of the contacts and an isolation gasket;

[**0027**] **FIG. 7** is a cross sectional perspective view of the **FIG. 3** contact ring and porous membrane showing an embodiment of isolation gasket;

[**0028**] **FIG. 8** is an alternative embodiment of a substrate holder system having a rotatable head assembly; and

[**0029**] **FIG. 9** is a cross sectional view of another embodiment of a process cell used in ECP processing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[**0030**] Aspects of the invention generally provide an apparatus for electrochemically processing a substrate in an electroplating cell by providing a porous membrane positioned between a substrate seating surface and an element. The porous membrane may be used to diffuse electrolyte flow and provide uniform hydrodynamics for electrochemical processes including electroplating and electropolishing.

[**0031**] The words and phrases used herein should be given their ordinary and customary meaning in the art by one skilled in the art unless otherwise further defined. Electropolishing should be broadly construed and includes, but is not limited to, planarizing a substrate by the application of electrochemical activity, such as by anodic dissolution.

[**0032**] **FIG. 1** is a perspective view of an electrochemical deposition system including a substrate holder having a flexible seal. **FIG. 2** is a schematic view of an electrochemical deposition system including a substrate holder having a flexible seal of the invention. Referring to both **FIGS. 1 and 2**, the electrochemical deposition system **200** generally includes a loading station **210**, a thermal anneal chamber **211**, a spin-rinse-dry (SRD) station **212**, a mainframe **214**, and an electrolyte replenishing system **220**. The electrochemical deposition system **200** may be enclosed in a clean environment using panels such as Plexiglas panels. The mainframe **214** generally includes a mainframe transfer station **215** and a plurality of processing stations **218**. Each processing station **218** includes one or more processing cells **240**. An electrolyte replenishing system **220** is positioned adjacent the electrochemical deposition system **200** and connected to the process cells **240** individually to circulate electrolyte used for the electroplating process. The electrochemical deposition system **200** also includes a control system **222**, typically comprising a programmable microprocessor.

[**0033**] The loading station **210** may includes one or more substrate cassette receiving areas **224**, one or more loading station transfer robots **228** and at least one substrate orientor **230**. The number of substrate cassette receiving areas, loading station transfer robots **228** and substrate orientor included in the loading station **210** can be configured according to the desired throughput of the system. As shown for one embodiment in **FIGS. 1 and 2**, the loading station **210** includes two substrate cassette receiving areas **224**, two loading station transfer robots **228** and one substrate orientor **230**. A substrate cassette **232** containing substrates **234** is loaded onto the substrate cassette receiving area **224** to introduce substrates **234** into the electrochemical deposition system **200**. The loading station transfer robot **228** transfers substrates **234** between the substrate cassette **232** and the substrate orientor **230**. The loading station transfer robot **228** includes a typical transfer robot commonly known in the art. The substrate orientor **230** positions each substrate **234** in a desired orientation to ensure that the substrate is properly processed. The loading station transfer robot **228** also transfers substrates **234** between the loading station **210** and the SRD station **212** and between the loading station **210** and the thermal anneal chamber **211**.

[**0034**] The SRD station **212** includes one or more SRD modules **236** and one or more substrate pass-through cassettes **238**. The SRD station **212** may include two SRD modules **236** corresponding to the number of loading station transfer robots **228**, and a substrate pass-through cassette **238** is positioned above each SRD module **236**. The substrate pass-through cassette **238** facilitates substrate transfer between the loading station **210** and the mainframe **214**. The substrate pass-through cassette **238** provides access to and from both the loading station transfer robot **228** and a robot **216** in the mainframe transfer station **215**.

[**0035**] The electrolyte replenishing system **220** provides the electrolyte to the electroplating process cells **240** for the electroplating and/or anodic dissolution process. The electrolyte replenishing system **220** generally includes a main electrolyte tank **260**, a plurality of source tanks **262**, and a plurality of filter tanks **264**. One or more controllers control the composition of the electrolyte in the main tank **260** and the operation of the electrolyte replenishing system **220**. The controllers are typically independently operable but integrated with the control system **222** of the system **200**.

[**0036**] **FIG. 3** is a cross sectional view of an electroplating process cell **400** according to the invention. The electroplating process cell **400** as shown in **FIG. 3** is the same as the electroplating process cell **240** as shown in **FIGS. 1 and 2**. The processing cell **400** generally includes a head assembly **410**, a process kit **420** and an electrolyte collector **440**. The electrolyte collector **440** is secured onto the body **442** of the mainframe **214** over an opening **443** that defines the location for placement of the process kit **420**. The electrolyte collector **440** includes an inner wall **446**, an outer wall **448** and a bottom **447** connecting the walls. An electrolyte outlet **449** is disposed through the bottom **447** of the electrolyte collector **440** and connected to the electrolyte replenishing system **220** (shown in **FIG. 1**) through tubes, hoses, pipes or other fluid transfer connectors.

[**0037**] The head assembly **410** is mounted onto a head assembly frame **452**. The head assembly frame **452** includes a mounting post **454** and a cantilever arm **456**. The mounting post **454** is mounted onto the body **442** of the mainframe **214**, and the cantilever arm **456** extends laterally from an upper portion of the mounting post **454**. The mounting post **454** may provide rotational movement with respect to a vertical axis along the mounting post to allow rotation of the head assembly **410**.

[**0038**] The head assembly **410** is attached to a mounting plate **460** disposed at the distal end of the cantilever arm **456**. The lower end of the cantilever arm **456** is connected to a cantilever arm actuator **457**, such as a pneumatic cylinder, mounted on the mounting post **454**. The cantilever arm actuator **457** provides pivotal movement of the cantilever arm **456** with respect to the joint between the cantilever arm **456** and the mounting post **454**. When the cantilever arm actuator **457** is retracted, the cantilever arm **456** moves the head assembly **410** away from the process kit **420** to provide the spacing required to remove and/or replace the process kit **420** from the electroplating process cell **400**. When the cantilever arm actuator **457** is extended, the cantilever arm **456** moves the head assembly **410** toward the process kit **420** to position the substrate in the head assembly **410** in a processing position.

[**0039**] The head assembly **410** generally includes a substrate holder assembly **450** and a substrate assembly actuator **458**. The substrate assembly actuator **458** is mounted onto the mounting plate **460**, and includes a head assembly shaft **462** extending downwardly through the mounting plate **460**. The lower end of the head assembly shaft **462** is connected to the substrate holder assembly **450** to position the substrate holder assembly **450** in a processing position and in a substrate loading position.

[**0040**] The substrate holder assembly **450** generally includes a substrate holder **464** and a contact ring **466**. **FIG. 4** is a cross sectional view of one embodiment of a contact ring **466** of the present invention. In general, the contact ring **466** includes an annular body having a plurality of conducting members disposed thereon. The annular body is constructed of an insulating material to electrically isolate the plurality of conducting members. Together the body and conducting members form a diametrically interior substrate seating surface which, during processing, supports a substrate and provides a current thereto.

[**0041**] Referring now to **FIG. 4** in detail, the contact ring **466** generally includes a plurality of conducting members **565** at least partially disposed within an annular insulative body **570**. The insulative body **570** is shown having a flange **562** and a downward sloping shoulder portion **564** leading to a substrate seating surface **568** located below the flange **562** such that the flange **562** and the substrate seating surface **568** lie in offset and substantially parallel planes. Thus, the flange **562** may be understood to define a first plane while the substrate seating surface **568** may define a second plane parallel to the first plane, and the shoulder **564** is disposed between the two planes. However, contact ring design shown in **FIG. 4** is intended to be merely illustrative, and is therefore, not limiting on the scope of the invention.

[**0042**] In another embodiment, the shoulder portion **564** may be of a steeper angle including a substantially vertical angle so as to be substantially normal to both the flange **562** and the substrate seating surface **568**. Alternatively, the contact ring **466** may be substantially planar thereby eliminating the shoulder portion **564**. However, a preferred embodiment includes the shoulder portion **564** shown in **FIG. 4** or some variation thereof.

[**0043**] The conducting members **565** are defined by a plurality of outer electrical contact pads **580** annularly disposed on the flange **562**, a plurality of inner electrical contact pads **572** disposed on a portion of the substrate seating surface **568**, and a plurality of embedded conducting connectors **576**, which link the pads **572, 580** to one another. The conducting members, including the contact pads **572**, may be modified to extend above the substrate seating surface when a porous membrane assembly **584** is disposed thereon so as to contact the substrate surface when a porous membrane is disposed between the substrate and the contact ring **466**.

[**0044**] The conducting members **565** are isolated from one another by the insulative body **570** which may be made of a plastic such as polyvinylidenefluoride (PVDF), perfluoroalkoxy resin (PFA), Teflon™, and Tefzel™, or any other insulating material such as Alumina (Al_2O_3) or other ceramics. The outer contact pads **580** are coupled to a power supply (not shown) to deliver current and voltage to the inner contact pads **572** via the connectors **576** during processing. The inner contact pads **572** supply the current and voltage to a substrate by maintaining contact around a peripheral portion of the substrate. Thus, in operation the conducting members **565** act as discrete current paths electrically connected to a substrate.

[**0045**] Low resistivity, and conversely high conductivity, are directly related to good plating. To ensure low resistivity, the conducting members **565** may be made from copper (Cu), platinum (Pt), tantalum (Ta), titanium (Ti), gold (Au), silver (Ag), stainless steel or other conducting materials. Low resistivity and low contact resistance may also be achieved by coating the conducting members **565** with a conducting material. Thus, the conducting members **565** may, for example, be made of copper (resistivity for copper is approximately 2×10^{-8} Ωm) and be coated with platinum (resistivity for platinum is approximately 10.6×10^{-8} Ωm). Coatings such as tantalum nitride (TaN), titanium nitride (TiN), rhodium (Rh), Au, Cu, or Ag on a conductive base materials such as stainless steel, molybdenum (Mo), Cu, and Ti are also possible.

[**0046**] Further, since the contact pads **572, 580** are typically separate units bonded to the conducting connectors **576**, the contact pads **572, 580** may be manufactured from one material, such as Cu, and the conducting members **565** another, such as stainless steel. Either or both of the pads **572, 780** and conducting connectors **576** may be coated with a conducting material. Additionally, because plating repeatability may be adversely affected by oxidation, which acts as an insulator, the inner contact pads **572** may be manufactured from include a material resistant to oxidation such as Platinum (Pt), silver (Ag), or gold (Au).

[**0047**] In addition to being a function of the contact material, the total resistance of each circuit is dependent on the geometry, or shape, of the inner contact pads **572** and the force supplied by the contact ring **466**. These factors define a constriction resistance, R_{CR}, at the interface of the inner contact pads **572** and the substrate seating surface **568** due to asperities between the two surfaces. Generally, as the applied force is increased the apparent area is also increased. The apparent area is, in turn, inversely related to R_{CR} so that an increase in the apparent area results in a decreased R_{CR}. Thus, to minimize overall resistance, force may be maximized.

[**0048**] The maximum force applied in operation is limited by the yield strength of a substrate that may be damaged under excessive force and resulting pressure. However, because pressure is related to both force and area, the maximum sustainable force is also dependent on the geometry of the inner contact pads **572**. Thus, while the contact pads **572** may have a flat upper surface as in **FIG. 4**, other shapes may be used to advantage. For example, two preferred shapes are shown in **FIGS. 5 and 6**.

[**0049**] **FIG. 5** shows a knife-edge contact pad and **FIG. 6** shows a hemispherical contact pad. A person skilled in the art will readily recognize other shapes that may be used to advantage. A more complete discussion of the relation between contact geometry, force, and resistance is given in Ney Contact Manual, by Kenneth E. Pitney, The J. M. Ney Company, 1973, which is hereby incorporated by reference in its entirety.

[**0050**] The number of connectors **576** may be varied depending on the particular number of contact pads **572** (shown in **FIG. 4**) desired. In one aspect, at least twenty-four connectors **576** are spaced equally over 360° for a 200 mm substrate. Since the dimensions of the present invention are readily altered to suit a particular application (for example, a 300 mm substrate), the optimal number may easily be determined for varying scales and embodiments.

[**0051**] As shown in **FIG. 7**, the substrate seating surface **568** includes an isolation gasket **582** disposed on the insulative body **570** and extending diametrically interior to the inner contact pads **572** to define the inner diameter of the contact ring **466**. The isolation gasket **582** may extend slightly above the inner contact pads **572** (e.g., a few mils) and may include an elastomer such as Viton™, Teflon™, buna rubber and the like. Where the insulative body **570** also includes an elastomer the isolation gasket **582** may be of the same material. In the latter embodiment, the isolation gasket **582** and the insulative body **570** may be monolithic, i.e., formed as a single piece. However, the isolation gasket **582** may be separate from the insulative body **570** so that it may be easily removed for replacement or cleaning.

[**0052**] While **FIG. 7** shows a preferred embodiment of the isolation gasket **582** wherein the isolation gasket is seated entirely on the insulative body **570**, **FIGS. 5 and 6** show an alternative embodiment. In the latter embodiment, the insulative body **570** is partially machined away to expose the upper surface of the connecting member **576** and the isolation gasket **582** is disposed thereon. Thus, the isolation gasket **582** contacts a portion of the connecting member **576**. This design requires less material to be used for the inner contact pads **572** that may be advantageous where material costs are significant such as when the inner contact pads **572** include gold. Persons skilled in the art will recognize other embodiments that do not depart from the scope of the present invention.

[**0053**] During processing, the isolation gasket **582** maintains contact with a peripheral portion of the substrate plating surface and is compressed to provide a seal between the remaining contact ring **466** and the substrate. The seal minimizes or prevents the electrolyte from contacting the edge and backside of the substrate.

[**0054**] Referring to **FIG. 4**, in one embodiment, a porous membrane assembly **584** may be disposed in the substrate holder assembly **450** is positioned on the contact ring **466**. The porous membrane assembly **584** generally includes a field or membrane of porous material **586** circumferentially connected to an annular body **588**. The annular body **588**, in the embodiment shown in **FIG. 4**, has a flange **590** and a downward sloping shoulder portion **592** leading to a seating surface **594** located below the flange **590** such that the flange **590** and the seating surface **594** lie in offset and substantially parallel planes. The form of the flange **590** and the seating surface **594** are generally designed to be match the circumferential shape of the contact ring and mate with the flange **562** and the substrate seating surface **568** of the contact ring **466**.

[**0055**] The field of porous material **586** is disposed within the annular portion defined by the annular body **588** and is coupled to the vertical portions of the seating surface **594**. Alternatively, the field of porous material **586** may be coupled to the on the top surface of the seating surface **594** for contact with any substrate disposed thereon or may be coupled to the bottom surface of the seating surface **594** in a planar spaced relationship with any substrate disposed thereon. The invention contemplates varying the design of the porous membrane assembly **584** to reflect the underlying shape of the contact ring **466** and the extent of contact, if any, with a substrate disposed on or adjacent thereto. The contact ring **466** and the porous membrane assembly **584** shown in **FIG. 4** are intended to be merely illustrative.

[**0056**] Orifices **596** extend through the substrate-seating surface **594** to allow contact pads **572** therethrough and access to contact any substrate disposed thereon. The thickness of the substrate shoulder **596** and porous membrane field **586** may be designed with regard to the design of the contact pads **572** to provide a separation between the porous membrane field **586** and a substrate surface. The porous membrane field **586** may be disposed at about 2000 Å or less from the substrate surface.

[**0057**] Generally, in embodiments where the substrate surface does not contact the field **586**, a separation distance of between about 1000 Å and about 2000 Å is used between the substrate surface and field **586**. The thickness of the substrate shoulder **596** and porous membrane field **586** may be designed with regard to the contact pads **572** to provide effective contact between the contact pads **572** and a substrate surface through the substrate shoulder and to minimize any damage to substrate surface material such as seed layer.

[**0058**] The porous membrane assembly **584** may be adapted to be coupled with contact rings having different configurations. For example, if electrical contact is established by a backside contact to the substrate rather than front side contact with the substrate as described herein, the annular body **588** described herein adapted to be coupled between the substrate and backside contact pins while having the field of porous material **586** disposed on or adjacent the immediate substrate surface having materials electroplated thereon to fill apertures and other surface features. Additionally, the invention contemplated adapting the porous membrane assembly **584** configuration to be coupled to the lateral sides or edge of a contact ring of any configuration rather than on a front surface contacting an electrolyte and/or substrate or a back surface with the field of porous material **586** disposed on or adjacent the immediate substrate surface having materials electroplated thereon.

[**0059**] The annular body **588** is typically composed of an insulative material including, but not limited to polyvinylidenefluoride (PVDF), perfluoroalkoxy resin (PFA), Teflon™, and Tefzel™, or any other insulating material such as Alumina (Al203) or other ceramics.

[**0060**] The porous membrane field **586** may be composed of an insulative material, such as polyvinylidenefluoride (PVDF), perfluoroalkoxy resin (PFA), Teflon™ polymer, Tefzel™ polymer, or a ceramic, such as Alumina (Al_2O_3). The porous membrane may also include a conventional membrane material, such as polyvinyllidene fluoride. Membranes as described herein may be produced by a variety of companies such as Millapore Corporation, located in Bedford, Mass. The material of the annular body **588** and the porous membrane field **586** may be the same material or a different material.

[**0061**] The porous membrane field **586** may also include a chemical mechanical polishing material, such as polyurethane. Examples of polishing materials which can be used include, but are not limited to, the materials comprising an IC 1000, an IC 1010, a Suba series pad, a Politex series pad, or a MH S series pad from Rodel, Inc., of Phoenix, Ariz. The porous membrane field **586** may also include a conductive chemical mechanical polishing material, such as conductive polymers including such as polyacetylene, polyethylenedioxythiophene (PEDT), which is commercially available under the trade name Baytron™, polyaniline, polypyrrole, and combinations thereof. Conductive polishing materials are further described in U.S. patent application Ser. No. 10/033,732, filed Dec. 27, 2001, which is incorporated by reference herein to the extent not inconsistent with the description and claims disclosed herein.

[**0062**] The porous membrane field **586** has porosity between about 60% and about 80%; for example a porosity of about 70% may be used. Porosity is broadly described herein as the area or volume of porous membrane field **586** the pores include the diameter or size of the perforations, of the surface or body of the field **586** when pores are formed therein. The pore width or diameter is generally between about 0.025 μm and about 2 μm. A pore width or diameter between about 0.1 μm and about 0.2 μm may be used in the field **586**. The membrane may have a thickness equivalent to the width of the pores, for example, having a 1:1 aspect ratio between the diameter of the pore and the thickness of the membrane. However, the thickness of the membrane may be of any desired thickness used in the processes described herein.

[**0063**] In operation, the porous membrane assembly **584** provides a membrane to limit the amount of material exposed to the substrate surface. A small gap is formed between the membrane and the substrate surface with a minimal amount of electrolyte, for example, between about 0.1 ml and about 100 ml depending upon component spacing, available to contact the substrate surface. The electrolyte in the small gap between the substrate and the membrane is generally free of impurities, such as particles, electrolyte "sludge", and chemical by-products in the electrolyte solution which may interfere with the electroplating process, while retaining sufficient permeability for the flow of desired electrolyte components, such as copper ions and additives that may improve electroplating deposition, such as suppressors or brighteners among others. Impurities may enter the electrolyte when the electrolyte is flowing between the electrodes and across the face of the substrate. Additionally, it is believed that the limited electrolyte flow rate allows plating or polishing from a limited amount of electrolyte disposed adjacent the substrate surface, which allows for plating of material with limited amount of contaminants and reduced void formation.

[0064] The porous membrane also believed to diffuse material flowing therethrough to provide improved or uniform hydrodynamic flow, and reduce or eliminate the virtual anode effect on the substrate surface from diffusers used in the prior art. The improved or uniform hydrodynamic flow is believed to result in reduction or minimization of turbulent flow, enhances the generation of metal ions, and improves the chemical reaction between the electrolyte solution and the anode, and improves the uniformity of electrical resistance of the electrolyte at the surface of the substrate.

[0065] The porous membrane is also believed to reduce or minimize variation of electric flux within the electrolyte cell from the anode to the substrate surface, and thus, the electrical resistance between the electrolytic cell and the substrate surface. Reducing or minimizing variation of electric flux is believed to result in more uniform electrical currents at the substrate surface and more uniform deposition or polishing rates of conductive materials on the substrate surface. A more uniform polishing rate will allow for more uniform planarization during material removal. Additionally, the invention contemplates the use of the membrane with a diffuser (not shown) that may be affixed across the surface of the electrolytic cell. The porous membrane may then be used to correct or reduce any electrical flux produced by the diffuser as described herein.

[0066] Referring back to **FIG. 3, a** cross sectional view of an electroplating process cell **400**, the substrate holder assembly **450** is positioned above the process kit **420**. The process kit **420** generally includes a bowl **430**, a container body **472**, an electrode assembly **474** and a filter **476**. The electrode assembly **474** may be disposed below the container body **472** and attached to a lower portion of the container body **472**, and the filter **476** is disposed between the electrode assembly **474** and the container body **472**. The electrode assembly **474** may be an anode or cathode depending upon the positive bias (anode) or negative bias (cathode) applied between the electrode **204** and the contact ring **466**.

[0067] For example, depositing material from an electrolyte on the substrate surface, the electrode assembly **474** acts as an anode and the substrate surface and/or contact ring **466** acts as a cathode. When removing material from a substrate surface, such as by electropolishing or dissolution from an applied bias, the electrode assembly **474** functions as a cathode and the substrate surface and/or contact ring **466** may act as an anode for the electropolishing process.

[0068] The container body **472** can be a cylindrical body composed of an electrically insulative material, such as ceramics, plastics, Plexiglas (acrylic), Lexane, PVC, CPVC, and PVDF. Alternatively, the container body **472** can be made from a metal, such as stainless steel, nickel and titanium, which is coated with an insulating layer, such as Teflon™, PVDF, plastic, rubber and other combinations of materials that do not dissolve in the electrolyte and can be electrically insulated from the electrodes (i.e., the anode and cathode of the electroplating system).

[0069] The container body **472** can be sized and adapted to conform to the substrate plating surface and the shape of the substrate being processed through the system, typically circular or rectangular in shape. One preferred embodiment of the container body **472** includes a cylindrical ceramic tube having an inner diameter that has about the same dimension as or slightly larger than the substrate diameter. The inventors have discovered that the rotational movement typically required in typical electroplating systems is not required to achieve uniform plating results when the size of the container body conforms to about the size of the substrate plating surface.

[0070] An upper portion of the container body **472** extends radially outwardly to form an annular weir **478**. The weir **478** extends over the inner wall **446** of the electrolyte collector **440** and allows the electrolyte to flow into the electrolyte collector **440**. The upper surface of the weir **478** may match the lower surface of the contact ring **466**. The upper surface of the weir **478** may include an inner annular flat portion **480**, a middle inclined portion **482** and an outer declined portion **484**. When a substrate is positioned in the processing position, the substrate plating surface is positioned above the cylindrical opening of the container body **472**, and a gap for electrolyte flow is formed between the lower surface of the contact ring **466** and the upper surface of the weir **478**. The lower surface of the contact ring **466** is disposed above the inner flat portion **480** and the middle inclined portion of the weir **478**. The outer declined portion **484** is sloped downwardly to facilitate flow of the electrolyte into the electrolyte collector **440**.

[0071] A lower portion of the container body **472** extends radially outwardly to form a lower annular flange **486** for securing the container body **472** to the bowl **430**. The outer dimension (i.e., circumference) of the annular flange **486** is smaller than the dimensions of the opening **444** and the inner circumference of the electrolyte collector **440** to allow removal and replacement of the process kit **420** from the electroplating process cell **400**. A plurality of bolts **488** may be fixedly disposed on the annular flange **486** and extend downwardly through matching bolt holes on the bowl **430**. A plurality of removable fastener nuts **490** secure the process kit **420** onto the bowl **430**. A seal **487**, such as an elastomer O-ring, is disposed between container body **472** and the bowl **430** radially inwardly from the bolts **488** to prevent leaks from the process kit **420**. The nuts/bolts combination facilitates fast and easy removal and replacement of the components of the process kit **420** during maintenance.

[**0072**] The filter **476** may be attached to and completely covers the lower opening of the container body **472**, and the electrode assembly **474** is disposed below the filter **476**. A spacer **492** is disposed between the filter **476** and the electrode assembly **474**. The filter **476**, the spacer **492**, and the electrode assembly **474** may be fastened to a lower surface of the container body **472** using removable fasteners, such as screws and/or bolts. Alternatively, the filter **476**, the spacer **492**, and the electrode assembly **474** are removably secured to the bowl **430**.

[**0073**] The electrode assembly **474** may includes a consumable electrode or non-consumable electrode. For example the electrode assembly may include a consumable anode that serves as a metal source in the electrolyte. Alternatively, the electrode assembly **474** includes a non-consumable anode, and the metal to be electroplated is supplied within the electrolyte from the electrolyte replenishing system **220**. Generally for electropolishing processes, a non-consumable electrode is used as a cathode. The follow description contemplates the use of a consumable anode for deposition of a material on a substrate surface by an electroplating process.

[**0074**] As shown in **FIG. 3**, the electrode assembly **474** is a self-enclosed module having a porous electrode enclosure **494**, which made of the same metal as the metal to be electroplated, such as copper. Alternatively, the electrode enclosure **494** is made of porous materials, such as ceramics or polymeric membranes. For a consumable anode, a soluble metal **496**, such as pure copper, or nearly pure copper, for electrochemical deposition of copper, is disposed within the electrode enclosure **494**. The soluble metal **496** may be a perforated sheet. The porous electrode enclosure **494** also acts as a filter that keeps the particulates generated by the dissolving metal within the electrode enclosure **494**. As compared to a non-consumable anode, the consumable (i.e., soluble) anode provides gas-generation-free electrolyte and minimizes the need to constantly replenish the metal in the electrolyte.

[**0075**] An electrode contact **498** is inserted through the electrode enclosure **494** to provide electrical connection to the soluble metal **496** from a power supply. The electrode contact **498** may be made from a conductive material that is insoluble in the electrolyte, such as titanium, platinum, and platinum-coated stainless steel. The electrode contact **498** extends through the bowl **430** and is connected to an electrical power supply. The electrical contact **498** may include a threaded portion **497** for a fastener nut **499** to secure the electrical contact **498** to the bowl **430**, and a seal **495**, such as a elastomer washer, is disposed between the fastener nut **499** and the bowl **430** to prevent leaks from the process kit **420**.

[**0076**] The bowl **430** generally includes a cylindrical portion **302** and a bottom portion **304**. An upper annular flange **306** extends radially outwardly from the top of the cylindrical portion **302**. The upper annular flange **306** includes a plurality of holes **308** that matches the number of bolts **488** from the lower annular flange **486** of the container body **472**. To secure the upper annular flange **306** of the bowl **430** and the lower annular flange **486** of the container body **472**, the bolts **488** are inserted through the holes **308**, and the fastener nuts **490** are fastened onto the bolts **488**. The outer dimension (i.e., circumference) of the upper annular flange **306** may be about the same as the outer dimension (i.e., circumference) of the lower annular flange **486**. The lower surface of the upper annular flange **306** of the bowl **430** can rest on a support flange of the mainframe **214** when the process kit **420** is positioned on the mainframe **214**.

[**0077**] The inner circumference of the cylindrical portion **302** accommodates the electrode assembly **474** and the filter **476**. The outer dimensions of the filter **476** and the electrode assembly **474** may be slightly smaller than the inner dimension of the cylindrical portion **302** to force a substantial portion of the electrolyte to flow through the electrode assembly **474** first before flowing through the filter **476**. The bottom portion **304** of the bowl **430** includes an electrolyte inlet **310** that connects to an electrolyte supply line from the electrolyte replenishing system **220**. The electrode assembly **474** may be disposed about a middle portion of the cylindrical portion **302** of the bowl **430** to provide a gap for electrolyte flow between the electrode assembly **474** and the electrolyte inlet **310** on the bottom portion **304**.

[**0078**] The electrolyte inlet **310** and the electrolyte supply line may be connected by a releasable connector that facilitates easy removal and replacement of the process kit **420**. When the process kit **420** needs maintenance, the electrolyte is drained from the process kit **420**, and the electrolyte flow in the electrolyte supply line is discontinued and drained. The connector for the electrolyte supply line is released from the electrolyte inlet **310**, and the electrical connection to the electrode assembly **474** is also disconnected. The head assembly **410** is raised or rotated to provide clearance for removal of the process kit **420**. The process kit **420** is then removed from the mainframe **214**, and a new or reconditioned process kit is replaced into the mainframe **214**.

[**0079**] Alternatively, the bowl **430** can be secured onto the support flange of the mainframe **214**, and the container body **472** along with the electrode and the filter are removed for maintenance. In this case, the nuts securing the electrode assembly **474** and the container body **472** to the bowl **430** are removed to facilitate removal of the electrode assembly **474** and the container body **472**. New or reconditioned electrode assembly **474** and container body **472** are then replaced into the mainframe **214** and secured to the bowl **430**.

[**0080**] **FIG. 8** is an alternative embodiment of the process head assembly having a rotatable head assembly **1110**. A rotational actuator may be disposed on the cantilevered arm and attached to the head assembly to rotate the head assembly during substrate processing. The rotatable head assembly **1110** is mounted onto a head assembly frame **1152**. The alternative head assembly frame **1152** and the rotatable head assembly **1110** are mounted onto the mainframe similarly to the head assembly frame **452** and head assembly **410** as shown in **FIG. 3** and described above. The head assembly frame **1152** includes a mounting post **1154**, a post cover **1155**, and a cantilever arm **1156**. The mounting post **1154** is mounted onto the body of the mainframe **214**, and the post cover **1155** covers a top portion of the mounting post **1154**. The mounting post **454** can provide rotational movement (as indicated by arrow A1) with respect to a vertical axis along the mounting post to allow rotation of the head assembly frame **1152**. The cantilever arm **1156** extends laterally from an upper portion of the mounting post **1154** and is pivotally connected to the post cover **1155** at the pivot joint **1159**. The rotatable head assembly **1110** is attached to a mounting slide **1160** disposed at the distal end of the cantilever arm **1156**. The mounting slide **1160** guides the vertical motion of the head assembly **1110**. A head lift actuator **1158** is disposed on top of the mounting slide **1160** to provide vertical displacement of the head assembly **1110**.

[**0081**] The lower end of the cantilever arm **1156** is connected to the shaft **1153** of a cantilever arm actuator **1157**, such as a pneumatic cylinder or a lead-screw actuator, mounted on the mounting post **1154**. The cantilever arm actuator **1157** provides pivotal movement (as indicated by arrow A2) of the cantilever arm **1156** with respect to the joint **1159** between the cantilever arm **1156** and the post cover **1154**. When the cantilever arm actuator **1157** is retracted, the cantilever arm **1156** moves the head assembly **1110** away from the process kit **420** to provide the spacing required to remove and/or replace the process kit **420** from the electroplating process cell **110**. When the cantilever arm actuator **1157** is extended, the cantilever arm **1156** moves the head assembly **1110** toward the process kit **420** to position the substrate in the head assembly **1110** in a processing position.

[**0082**] The rotatable head assembly **1110** includes a rotating actuator **1164** slideably connected to the mounting slide **1160**. The shaft **1168** of the head lift actuator **1158** is inserted through a lift guide **1166** attached to the body of the rotating actuator **1164**. The shaft **1168** may be a lead-screw type shaft that moves the lift guide (as indicated by arrows A3) between various vertical position. The rotating actuator **1164** is connected to the substrate holder assembly **1150** through the shaft **1170** and rotates the substrate holder assembly **1150** (as indicated by arrows A4). The substrate holder assembly **1150** includes a contact ring and permeable membrane, such as the embodiments described above with respect to FIGS. **4**-**7** and.

[**0083**] The rotation of the substrate during the electroplating process generally enhances the deposition results. The head assembly may be rotated between about 2 rpm and about 20 rpm during the electroplating process. However, the invention contemplates that the head assembly may be rotated at speeds between about 0 rpms and about 200 rpms. The head assembly can also be rotated as the head assembly is lowered to position the substrate in contact with the electrolyte in the process cell as well as when the head assembly is raised to remove the substrate from the electrolyte in the process cell. The head assembly may be rotated at a high speed (i.e., >20 rpm) after the head assembly is lifted from the process cell to enhance removal of residual electrolyte on the head assembly.

[**0084**] In an alternative embodiment, a porous membrane, such as porous membrane **320** shown in **FIG. 9**, may attached inside the body of the electrolyte cell, e.g., being supported by a support ring that extends around, and being attached to, the inner periphery of the bowl **430**. The porous membrane is typically disposed between a substrate and an electrode, such as an electrode assembly **494** disposed at the bottom of the bowl **430**. The porous membrane **320** may be removable from the bowl **430** to facilitate easy maintenance. The membrane **320** is generally located in the upper container body **472** near the substrate surface. The membrane **320** may be spaced at about 10,000 Å or less from the contact ring **466**. The membrane may be disposed between about 1,000 Å and about 2,000 Å from the contact ring or substrate disposed in the contact ring. However, the membrane may also be located at any location in the process cell **420** between the electrode and the substrate.

[**0085**] The porous membrane **320** may also comprise a polishing material. The polishing material may be a conventional polishing material or a conductive polishing material. Examples of conductive polishing materials are more fully described in co-pending U.S. patent application Ser. No. 10/033,732, filed on Dec. 27, 2001, which is incorporated by reference herein to the extent not inconsistent with the claims and description herein. The porous membrane **320** of polishing material may be adapted to contact the substrate surface when the substrate and contact ring **466** are in processing position. Such a porous membrane may be used in conjunction with the rotatable head assembly **1110** as shown in **FIG. 8** to provide sufficient rotation to the substrate to enact mechanical polishing during electrochemical deposition or electrochemical removal of material disposed thereon. Alternatively, the porous membrane **320** may also be disposed on or in place of the filter material **476**.

[**0086**] In a further embodiment, a chemical mechanical polishing material (not shown) is disposed between the porous membrane **320** and the contact ring **466** to enact conventional polishing on the substrate disposed in the rotatable head assembly **1110**. The membrane **320** may be spaced from the polishing material while providing sufficient uniform hydrodynamic flow and filtration of sludge from the electrode or substrate surface. The membrane may be integrated with the polishing material forming a two-part structure of a first portion including the polishing material for contacting the substrate surface and a second portion to regulate fluid flow therethrough. The polishing material generally has pores corresponding to pores formed in the porous membrane as described herein. The pores of the polishing material and the porous membrane may be aligned for effective fluid flow therethrough and to achieve the benefits believed to be achieved by the porous membrane.

[**0087**] The rotatable head assembly **1110** and process may be adapted to provide polishing between the substrate surface and the polishing article during an electroplating or electropolishing process. A process illustrating the use of polishing pads during electrochemical processes is described in co-pending U.S. patent application Ser. No. 09/739,139, filed on Dec. 18, 2000, which is incorporated by reference herein to the extent not inconsistent with the claims and description herein.

[**0088**] The following is one example of a substrate electroplating process sequence through the electroplating system platform **200** as shown in **FIG. 1**-**7**. A substrate cassette containing a plurality of substrates is loaded into the substrate cassette receiving areas **224** in the loading station **210** of the electroplating system platform **200**. A loading station transfer robot **228** picks up a substrate from a substrate slot in the substrate cassette and places the substrate in the substrate orientor **230**. The substrate orientor **230** determines and orients the substrate to a desired orientation for processing through the system.

[**0089**] The loading station transfer robot **228** then transfers the oriented substrate from the substrate orientor **230** and positions the substrate in one of the substrate slots in the substrate pass-through cassette **238** in the SRD station **212**. The mainframe transfer robot **242** picks up the substrate from the substrate pass-through cassette **238** and positions the substrate for transfer by the flipper robot **248**. The flipper robot **248** rotates its robot blade below the substrate and picks up substrate from mainframe transfer robot blade. The vacuum suction gripper on the flipper robot blade secures the substrate on the flipper robot blade, and the flipper robot flips the substrate from a face up position to a face down position. The flipper robot **248** rotates and positions the substrate face down in the substrate holder assembly **450**.

[**0090**] The substrate is positioned below the substrate holder **464** but above the contact ring **466** and porous membrane assembly **584**. The flipper robot **248** then releases the substrate to position the substrate into the contact ring **466** and on the porous membrane assembly **584**. The substrate holder **464** moves toward the substrate and the vacuum chuck secures the substrate on the substrate holder **464**. The flexible seal assembly on the substrate holder assembly **450** exerts pressure against the substrate backside to ensure electrical contact between the substrate plating surface and the contact ring **466**.

[**0091**] The head assembly **452** is lowered to a processing position above the process kit **420**. At this position the substrate is below the upper plane of the weir **478** and contacts the electrolyte contained in the process kit **420**. The power supply is activated to supply electrical power (i.e., voltage and current) to the cathode and the anode to enable the electroplating process. The electrolyte is typically continually pumped into the process kit during the electroplating or electropolishing process. The electrolyte flows around the electrode disposed in the chamber and to the substrate surface through the porous membrane **586** to contact the substrate surface and deposit material on the substrate surface or remove material thereform. The electrical power supplied to the cathode and the anode and the flow of the electrolyte are controlled by the control system **222** to achieve the desired electroplating or electropolishing results. The head assembly may be rotated as the head assembly is lowered and also during the electroplating or electropolishing process.

[**0092**] After the electroplating process is completed, the head assembly **410** raises the substrate holder assembly and removes the substrate from the electrolyte. The head assembly may be rotated for a period of time to enhance removal of residual electrolyte from the substrate holder assembly. The vacuum chuck and the flexible seal assembly of the substrate holder then release the substrate from the substrate holder, and the substrate holder is raised to allow the flipper robot blade to pick up the processed substrate from the contact ring. The flipper robot rotates the flipper robot blade above the backside of the processed substrate in the contact ring and picks up the substrate using the vacuum suction gripper on the flipper robot blade. The flipper robot rotates the flipper robot blade with the substrate out of the substrate holder assembly, flips the substrate from a face-down position to a face-up position, and positions the substrate on the mainframe transfer robot blade. The mainframe transfer robot then transfers and positions the processed substrate above the SRD module **236**.

[**0093**] The SRD substrate support lifts the substrate, and the mainframe transfer robot blade retracts away from the SRD module **236**. The substrate is cleaned in the SRD module using deionized water or a combination of deionized water and a cleaning fluid as described in detail above. The substrate is then positioned for transfer out of the SRD module. The loading station transfer robot **228** picks up the substrate from the SRD module **236** and transfers the processed substrate into the RTA chamber **211** for an anneal treatment process to enhance the properties of the deposited materials. The annealed substrate is then transferred out of the RTA chamber for further processing.

[**0094**] 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. An apparatus for electrochemically processing a substrate, comprising:

an electrolyte cell configured to receive a substrate for processing;

a substrate support in the electrolyte cell, the substrate support comprising at least a substrate seating surface;

a fixed electrode disposed within the electrolyte cell and spaced from the substrate support; and

a porous membrane that is connected to the electrolyte cell and extends across at least a portion of the electrolyte cell, wherein the membrane is positioned between the substrate seating surface and a substrate.

2. The apparatus of claim 1, wherein the substrate support comprises at least a portion of the first electrode and the fixed electrode disposed within the electrolyte cell comprises a second electrode.

3. The apparatus of claim 1, wherein the porous membrane comprises a material selected from the group of a ceramic material, a polymeric material, a polishing material, or combinations thereof.

4. The apparatus of claim 1, wherein the porous membrane comprises a conductive polishing media and comprises at least a portion of the first electrode.

5. The apparatus of claim 1, wherein the porous membrane has pore sizes between about 0.25 μm and about 2 μm wide.

6. The apparatus of claim 1, wherein the substrate support further comprises a contact ring with the substrate seating surface disposed thereon.

7. The apparatus of claim 2, wherein the porous membrane is disposed between a substrate surface and the second electrode.

8. The apparatus of claim 6, wherein the porous membrane is disposed between a contact ring and a substrate surface.

9. The apparatus of claim 1, wherein the porous membrane is disposed about 2000 Å or less from a substrate surface.

10. The apparatus of claim 1, wherein the porous membrane is positioned in contact with at least a portion of a substrate surface.

11. The apparatus of claim 1, further comprising a power source coupled to the first electrode and the second electrode, wherein the power source may provide a positive or negative bias between the first electrode and the second electrode.

12. The apparatus of claim 1, further comprising an electrolyte supply coupled to the electrolyte cell.

13. The apparatus of claim 1, further comprising a rotatable substrate support, the contact ring coupled to the rotatable substrate support, and adapted to move a substrate within the electrolyte cell.

14. The apparatus of claim 1, further comprising a polishing article disposed in the electrolytic cell.

15. An apparatus for electrochemically processing a substrate, comprising:

an electrolyte cell configured to receive a substrate to have a conductive material film deposited thereon or removed therefrom;

a substrate support;

a contact ring in electrical communication with the substrate support, wherein the contact ring comprises at least a portion of a first electrode;

a second electrode disposed on a bottom portion of a electrolyte cell;

a power source coupled to the contact ring and second electrode;

a source of electrolyte in fluid communication with the electrolyte cell; and

a porous membrane connected to the electrolyte cell and extends across at least a portion of the electrolyte cell, wherein the porous membrane is positioned between the first electrode and the second electrode.

16. The apparatus of claim 15, wherein the porous membrane comprises a material selected from the group of a ceramic material, a polymeric material, a polishing material, or combinations thereof.

17. The apparatus of claim 15, wherein the porous membrane comprises a conductive polishing material.

18. The apparatus of claim 15, wherein the porous membrane has pore sizes between about 0.25 μm and about 2 μm wide.

19. The apparatus of claim 15, further comprising a substrate in electrical communication with the contact ring and comprising at least a portion of the first electrode.

20. The apparatus of claim 15, wherein the porous membrane is disposed between a substrate surface comprising a portion of the first electrode and the second electrode.

21. The apparatus of claim 20, wherein the porous membrane is disposed between a contact ring and a substrate surface.

22. The apparatus of claim 15, wherein the porous membrane is disposed about 2000 Å or less from a substrate surface.

23. The apparatus of claim 15, wherein the porous membrane is positioned in contact with at least a portion of a substrate surface.

24. The apparatus of claim 15, further comprising a power source coupled to the first electrode and the second electrode, wherein the power source may provide a positive or negative bias between the first electrode and the second electrode.

25. The apparatus of claim 15, further comprising an electrolyte supply coupled to the electrolyte cell.

26. The apparatus of claim 15, further comprising a rotatable substrate support, the contact ring coupled to the rotatable substrate support, and adapted to move a substrate within the electrolyte cell.

27. The apparatus of claim 15, further comprising polishing media disposed in the electrolytic cell between the first electrode and the second electrode.

28. An apparatus for use in an electrolyte cell, the apparatus comprising:

a porous membrane that is connected to and extends across a portion of the electrolyte cell, wherein the porous membrane is positioned between a first electrode and a second electrode disposed in the electrolyte cell, and wherein the porous membrane is formed a ceramic material, a polymer, a polishing material, or combinations thereof, having pore sizes between about 0.25 μm and about 2 μm wide.

29. A method for processing a substrate, comprising:

positioning a substrate in the electrolyte cell adjacent a porous membrane;

supplying an electrolyte solution to the electrolyte cell and through the porous membrane to a substrate surface; and

delivering power to the substrate and an electrode disposed in the electrolyte cell to perform an electrochemical process.

30. The method of claim 29, wherein a positive bias is applied to the second electrode and an electroplating process is performed on the substrate.

31. The method of claim 29, wherein a positive bias is applied to the first electrode and an electropolishing process is performed on the substrate.

32. The method of claim 29 wherein an alternative bias is applied to the first electrode and the second electrode and alternating electroplating and electropolishing processes are performed on the substrate.

33. The method of claim 29, further comprising chemical polishing the substrate by contacting and rotating the substrate against the porous membrane or polishing media.

34. A contact ring for use in an apparatus for electroplating a metal onto a substrate having an electrically conductive portion, the contact ring comprising:

an annular insulative body defining a central opening;

a plurality of conductive elements disposed through the insulative member; and

a porous membrane assembly disposed on the annular insulative body, wherein the porous membrane assembly comprises a porous material disposed within the central opening.

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