

ELECTROPLATING APPARATUS AND ELECTROPLATING SYSTEM

FIELD OF THE INVENTION

The present invention relates to the field of semiconductor electroplating equipment, and in particular to an electroplating apparatus and an electroplating system.

BACKGROUND

Substrate electroplating process refers to a process where metal ions in electroplating solution are electroplated onto the surface of a substrate to form metal interconnects during chip manufacturing.

Electroplating equipment for performing the substrate electroplating process generally has a soluble anode. The soluble anode can replenish metal ions consumed in the electroplating solution through the dissolution of the soluble anode, thereby maintaining the concentration of the metal ions in the electroplating solution. However, the soluble anode also has inherent drawbacks.

Taking a soluble copper anode used in a copper electroplating process for a substrate as an example, the following drawbacks are encountered in practical applications during the substrate electroplating:

1. As the copper anode is consumed, the distance between the copper anode and the substrate serving as the cathode changes, easily leading to non-uniform deposition of copper. FIGS. 1 and 2 are schematic diagrams showing the state of the copper anode 215 before and after the electroplating, respectively. As shown in FIGS. 1 and 2, during the electroplating, the continuous consumption of the copper anode 215 causes the distance between the copper anode 215 and the substrate 100 as the cathode to increase continuously, that is, the distance between the copper anode 215 and the substrate 100 changes from d_1 before the electroplating to d_2 after the electroplating. Additionally, the surface shape of the copper anode 215 changes constantly. The increasing distance between the copper anode 215 and the substrate 100 as well as the changing shape of the surface of the copper anode 215 results in a non-uniform electric field distribution between the substrate 100 and the copper

anode 215, thereby causing non-uniform deposition of copper on the surface of the substrate 100.

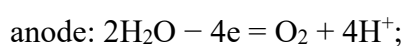
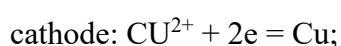
2. A phosphorus-containing copper anode is generally used in a copper electroplating process. However, when the phosphorus-containing copper anode is consumed, a layer of black anode slime (mainly composed of copper phosphide Cu_3P_2) is formed on the surface of the copper anode. The generated anode slime requires regular maintenance, as excessive anode slime can clog pipelines and ion-exchange membranes.

3. Regular production halts are required to replenish or replace the consumed anode.

In view of the above drawbacks of using a soluble anode for electroplating, the prior art has proposed a technical solution using an insoluble anode to replace the soluble anode.

During the substrate electroplating, an insoluble anode is not consumed during the electroplating reaction, so the surface shape of the insoluble anode remains unchanged, and the distance between the insoluble anode and the substrate remains unchanged. Therefore, using an insoluble anode can ensure a uniform electric field distribution between the anode and the cathode, thereby achieving a high electroplating uniformity.

However, during the substrate electroplating using an insoluble anode, a reduction reaction occurs on the surface of the substrate as the cathode, reducing the metal ions in the electroplating solution to solid metal; an oxidation reaction occurs on the surface of the insoluble anode, electrolyzing water in the electroplating solution to generate oxygen and thereby generating bubbles on the surface of the insoluble anode. Taking copper electroplating as an example, the following reactions occur when an insoluble anode is used:



overall reaction: $2\text{CuSO}_4 + 2\text{H}_2\text{O} = 2\text{Cu} + \text{O}_2 + 2\text{H}_2\text{SO}_4$.

In practical applications, if the bubbles generated on the surface of the insoluble anode adhere to the surface of the substrate, recesses will be formed on the electroplated layer, affecting the substrate quality. Therefore, the application of the insoluble anode is hindered to a certain extent in the field of substrate electroplating.

In summary, overcoming the impact of the bubbles generated by an insoluble anode on the substrate quality during the substrate electroplating is an urgent technical problem to be solved by those skilled in the art.

SUMMARY

To address the above technical problem, the object of the present invention is to overcome the problem where an insoluble anode generates a large number of bubbles during the substrate electroplating, and thereby affecting the substrate quality. To achieve the objective, the present invention provides an electroplating apparatus and an electroplating system.

In some embodiments, the electroplating apparatus is used to electroplate metal onto a substrate, comprising: an electroplating tank, for containing electroplating solution and the substrate; an insoluble anode, disposed inside the electroplating tank and located below the substrate; an anode solution inlet, for supplying the electroplating solution into the electroplating tank; an anode solution outlet, for discharging the electroplating solution from the electroplating tank; wherein, the anode solution inlet is higher than the insoluble anode and the anode solution outlet, so that during the electroplating, the electroplating solution flows along a first direction between the anode solution inlet and the anode solution outlet, away from the substrate. In addition, the flow rate of the electroplating solution in the electroplating tank is configured to make the electroplating solution exert a force on bubbles generated on the surface of the insoluble anode toward the first direction, and the force is greater than the buoyant force of the bubbles, thereby driving the bubbles away from the substrate.

Further, the bottom of the electroplating tank is conical or hemispherical, and

the anode solution outlet is located at the center of the bottom of the electroplating tank.

Further, a flow-guiding plate assembly is also included, disposed between the insoluble anode and the anode solution outlet.

Further, the flow-guiding plate assembly includes a plurality of flow-guiding plates arranged at intervals, and the spacing between at least two of the adjacent flow-guiding plates gradually decreases along the first direction to form channels for the electroplating solution to flow.

Further, an ion-exchange membrane is also included, disposed inside the electroplating tank. The ion-exchange membrane divides the interior of the electroplating tank into a cathode region and an anode region along the vertical direction. Both the anode solution inlet and the anode solution outlet are located in the anode region, and the substrate is located in the cathode region.

Further, a plurality of the anode solution inlets are provided on the side wall of the electroplating tank, and the plurality of anode solution inlets are distributed at intervals at the same horizontal height of the electroplating tank.

Further, the electroplating apparatus further comprises: an electroplating solution supply line, an electroplating solution discharge line, and a liquid pump. The electroplating solution supply line is connected to the anode solution inlet for supplying the electroplating solution into the electroplating tank through the anode solution inlet; the electroplating solution discharge line is connected to the anode solution outlet for discharging the electroplating solution through the anode solution outlet; the liquid pump is arranged on the electroplating solution supply line and/or the electroplating solution discharge line for adjusting the flow rate of the electroplating solution in the electroplating tank.

Further, the electroplating apparatus further comprises a power supply for supplying power to the insoluble anode and the substrate.

Further, the electroplating apparatus further comprises a liquid supply device for supplying the electroplating solution to the electroplating apparatus.

In some embodiments, the electroplating system includes the above electroplating apparatus and further comprises a liquid supply device for supplying the electroplating solution to the electroplating apparatus.

Further, the liquid supply device in the electroplating system further comprises: a dissolution tank, for supplying the electroplating solution to the electroplating tank; a powder metering and adding device, for supplying metal powder to the dissolution tank; a current metering device, for detecting the output electric charge of the power supply; a controller, configured to control the powder metering and adding device to add a predetermined amount of the metal powder each time the current metering device detects that the output electric charge of the power supply increases by a preset ampere-hour value.

Further, the electroplating system further comprises a buffer tank disposed between the electroplating tank and the dissolution tank for temporarily storing and mixing the electroplating solution circulating between the dissolution tank and the electroplating tank.

Further, the dissolution tank includes a stirring device and/or a temperature control device.

Compared with the prior art, the present invention has the following beneficial effects:

1. A downward flow direction of the electroplating solution is created above the insoluble anode, so that the electroplating solution exerts a force on the bubbles to drive the bubbles away from the substrate. In this way, it is difficult for the bubbles to approach or adhere to the surface of the substrate, avoiding the formation of recesses on the electroplated layer of the substrate.

2. With a plurality of anode solution inlets provided, and the anode solution outlet arranged below the insoluble anode, together with the flow-guiding plates and the conical or spherical bottom of the electroplating tank, the electroplating solution can flow across the surface of the insoluble anode at a substantially uniform rate. This ensures that the rate of the reaction between the entire surface of the insoluble

anode and the electroplating solution is basically consistent, and the force exerted by the electroplating solution on the bubbles on the entire surface of the insoluble anode is also basically consistent.

3. The interior of the electroplating tank is divided into an anode region and a cathode region by the ion-exchange membrane. For one thing, such a division can prevent additives in the cathode region from entering the anode region and being oxidatively decomposed during the electroplating. For another, such a division can prevent solid particles smaller than 1 micrometer (μm) input through the anode solution inlet into the anode region from entering the cathode region and adhering to the surface of the substrate, which can affect the yield.

4. By using an insoluble anode, the anode is not consumed during the substrate electroplating, and the shape and position of the anode can remain unchanged, providing a stable and uniform electric field distribution. This ensures the electroplating uniformity. Compared with phosphorus-containing copper anodes, the insoluble anode does not undergo anode passivation on the surface of the insoluble anode, allowing higher anode current density and providing lower maintenance costs.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and performance of the present invention are further described by the following embodiments and the accompanying drawings.

FIG. 1 shows a schematic view of the initial state of a copper anode in a substrate electroplating process;

FIG. 2 shows a schematic view of the state of a copper anode after a period of electroplating in a substrate electroplating process;

FIG. 3 shows a schematic view of an embodiment of an electroplating apparatus in the present invention;

FIG. 4 shows a perspective structural view of a flow-guiding plate assembly in an electroplating apparatus in an embodiment of the present invention; and

FIG. 5 shows a schematic view of an embodiment of an electroplating system in the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

To more clearly illustrate technical solutions of the embodiments of the present application or the prior art, specific embodiments of the present invention will be introduced according to the accompanying drawings in the following text. Obviously, the drawings in the following description are only some embodiments of the present invention. For those of ordinary skill in the art, other accompanying drawings and embodiments can be obtained based on the accompanying drawings without creative efforts.

To simplify the drawings, only parts related to the invention are schematically shown in each figure, and the parts do not represent the actual structures of the products. In addition, to simplify the drawings for easy understanding, in some figures, for components with the same structure or function, only one of the components is schematically shown or marked. In this document, "one" not only means "only one," but also can mean "more than one."

In this document, it should be noted that unless otherwise clearly specified and limited, the terms "install," "interconnect," and "connect" should be understood in a broad sense. For example, the connection can be a fixed connection, a detachable connection, or an integral connection; the connection can be a mechanical connection or an electrical connection; the connection can be a direct connection, an indirect connection through an intermediate medium, or internal communication between two components. For those of ordinary skill in the art, the specific meanings of the above terms in the present invention can be understood according to specific situations.

In addition, in the description of the present application, the terms "first," "second," and the like are only used for distinguishing description and cannot be understood as indicating or implying relative importance.

As shown in FIG. 3, the embodiment discloses an electroplating apparatus 21, and the electroplating apparatus 21 is used in a substrate electroplating process, that

is, to electroplate metal onto a substrate 100.

As shown in FIG. 3, the electroplating apparatus 21 is configured to electroplate the substrate 100, and the electroplating apparatus 21 has an electroplating tank 210 for containing electroplating solution and the substrate 100. An insoluble anode 213 is disposed inside the electroplating tank 210, and the substrate 100 to be plated can be fixed above the insoluble anode 213. The dashed lines in FIG. 3 indicate the liquid level of the electroplating solution. An anode solution inlet 216 is used to supply the electroplating solution into the electroplating tank 210; an anode solution outlet 217 is used to discharge the electroplating solution from the electroplating tank 210. The electroplating apparatus 21 is also configured with a power supply 260 (as shown in FIG. 5) for supplying power to the insoluble anode 213 and the substrate 100 to be plated. It should be noted that in this application, metal ions refer to the ions of the metal to be electroplated onto the substrate.

Wherein, the insoluble anode 213 has a mesh or plate-shaped structure. If an insoluble anode 213 of a plate-shaped structure is used, a plurality of vertical fluid-through holes can be provided on the surface of the insoluble anode 213, or a predetermined gap can be provided between the edge of the insoluble anode 213 and the inner wall of the electroplating tank 210, so that the electroplating solution can flow from the above vertical fluid-through holes or gap to the anode solution outlet 217 below the insoluble anode 213. In addition, titanium can be used as the base material of the insoluble anode 213, with a coating of precious metals such as iridium, tantalum, or platinum coated on the surface of the insoluble anode 213. Materials such as lead, carbon, platinum, graphite, nickel, stainless steel, lead alloys, and cast magnetic iron oxide can also be used.

In this embodiment, to solve the problem that a large number of bubbles are generated from water electrolysis in the electroplating solution on the surface of the insoluble anode 213 during the substrate electroplating using the insoluble anode 213 in the electroplating apparatus 21, which affects the substrate quality, the anode solution inlet 216 is configured to be higher than the insoluble anode 213 and the anode solution outlet 217. In the example shown in FIG. 3, the anode solution inlet 216 is provided on the side wall of the electroplating tank 210 and is higher than the insoluble anode 213; the anode solution outlet 217 is provided at the bottom of the

electroplating tank 210 and is located below the insoluble anode 213. Since the anode solution inlet 216 is located above the anode solution outlet 217 and the insoluble anode 213, during the electroplating, the electroplating solution flows along a first direction d between the anode solution inlet 216 and the anode solution outlet 217, away from the substrate 100, which can prevent the bubbles generated on the surface of the insoluble anode 213 from floating upward through the flow direction of the electroplating solution. In addition, the flow rate of the electroplating solution in the electroplating tank 210 is configured to make the electroplating solution exert a force on the bubbles toward the first direction d , and the above force is greater than the buoyant force of the above bubbles, so that the above bubbles are driven away from the substrate 100, thereby preventing the bubbles from floating upward and adhering to the surface of the substrate 100, which can cause recesses on the electroplated layer and affect the substrate quality.

In a specific example, the electroplating apparatus 21 further includes an electroplating solution supply pipeline 2160 and an electroplating solution discharge pipeline 2170. As shown in FIG. 3, the electroplating solution supply pipeline 2160 is connected to the anode solution inlet 216 for supplying the electroplating solution into the electroplating tank 210; the electroplating solution discharge pipeline 2170 is connected to the anode solution outlet 217 for discharging the electroplating solution from the electroplating tank 210. At least one of the electroplating solution supply pipeline 2160 and the electroplating solution discharge pipeline 2170 is configured with a liquid pump 219 for adjusting the flow rate of the electroplating solution in the electroplating tank 210. In the example shown in FIG. 3, the liquid pump 219 is arranged on the electroplating solution supply pipeline 2160.

By way of example, where the cross-sectional diameter of the anode solution outlet 217 along the flow direction of the electroplating solution is 300 mm, the flow rate of the electroplating solution at the anode solution outlet 217 can be configured to 0.01 m/s to 0.02 m/s via the liquid pump 219, ensuring that the force exerted by the electroplating solution on the bubbles to move away from the substrate 100 is greater than the upward buoyant force of the bubbles.

Additionally, to even out the flow rate of the electroplating solution flowing across the surface of the insoluble anode 213, the bottom of the electroplating tank

210 can be designed to be conical or hemispherical, with the anode solution outlet 217 positioned at the center of the bottom of the electroplating tank 210 and on the centerline of the insoluble anode 213. Alternatively, a flow-guiding plate assembly 218 can be disposed between the insoluble anode 213 and the anode solution outlet 217. Additionally, a plurality of anode solution inlets 216 can be uniformly arranged at the same horizontal height on the side wall of the electroplating tank 210. A plurality of electroplating solution supply pipelines 2160 are connected to the plurality of anode solution inlets 216 in a one-to-one relationship. Alternatively, an electroplating solution supply pipeline 2160 is divided into a plurality of branches, and the branches are connected to the plurality of anode solution inlets 216 in a one-to-one relationship, enabling the simultaneous supply of the electroplating solution to the plurality of anode solution inlets 216. In this way, the uniformity of the flow rate of the electroplating solution across the surface of the insoluble anode 213 is improved, promoting a consistent reaction rate of the electroplating solution across the entire surface of the insoluble anode 213, providing a high electroplating uniformity for the substrate 100 to be plated, and enabling a uniform force distribution of the electroplating solution on the bubbles across the entire surface of the insoluble anode 213, thereby better suppressing bubble ascent and avoiding the impact of the bubbles on the substrate quality.

As shown in FIGS. 3 and 4, the flow-guiding plate assembly 218 can consist of a plurality of flow-guiding plates 2180 disposed between the insoluble anode 213 and the anode solution outlet 217. The flow-guiding plates 2180 are spaced apart and arranged in parallel, and both ends of each flow-guiding plate are fixed to the side wall of the electroplating tank 210, with the spacing between at least two adjacent flow-guiding plates 2180 gradually decreasing along the first direction d. Channels are formed for the electroplating solution to flow between adjacent flow-guiding plates 2180, regulating the flow rate of the electroplating solution near the side wall and the centerline of the electroplating tank 210 to prevent non-uniform distribution — where the flow rate of the electroplating solution is slow near the side wall of the electroplating tank 210 and fast near the centerline of the electroplating tank 210. Therefore, the uniformity of the flow rate of the electroplating solution is improved across the surface of the insoluble anode 213. Alternatively, the flow-guiding plate assembly 218 can be a plate with a plurality of vertical fluid-through holes provided

on the surface of the plate, and the axial direction of each vertical fluid-through hole can be oriented toward the anode solution outlet 217, forming channels for the electroplating solution to flow and regulating the flow rate of the electroplating solution near the side wall and the centerline of the electroplating tank 210.

In addition, in this embodiment, as shown in FIG. 3, an ion-exchange membrane 214 can also be configured in the electroplating tank 210, and the ion-exchange membrane 214 is preferably horizontally arranged, with minor angular deviations permitted, that is, the ion-exchange membrane 214 can be inclined at a shallow angle relative to the horizontal plane. The ion-exchange membrane 214 divides the interior of the electroplating tank 210 into a cathode region 211 and an anode region 212 along the vertical direction. The substrate 100 is located in the cathode region 211, while both the anode solution inlet 216 and the anode solution outlet 217 are situated in the anode region 212. Consequently, as shown in FIG. 5, during the circulation of the electroplating solution between the electroplating tank 210 and a dissolution tank 220 within the anode region 212, the ion-exchange membrane 214 prevents particles in the electroplating solution, for example, solid particles with a diameter greater than 1 μm , from entering the cathode region 211 and adhering to the surface of the substrate 100, which affects the substrate yield.

As shown in FIG. 5, some embodiments disclose an electroplating system 200 comprising the aforementioned electroplating apparatus 21 and a liquid supply device 22 for supplying the electroplating solution to the electroplating apparatus 21.

During the electroplating of the substrate 100, metal ions in the electroplating solution are reduced on the surface of the substrate 100 to form an electroplated metal layer, reducing the concentration of the metal ions in the electroplating solution in the electroplating tank 210.

To address the above technical problem, the liquid supply device 22 in the embodiment of FIG. 5 comprises a dissolution tank 220, a delivery pipeline 230, a powder metering and adding device 240, a current metering device 270, and a controller 290. As shown in FIG. 5, the dissolution tank 220 is connected to the electroplating tank 210 via the delivery pipeline 230 to supply the electroplating solution. The powder metering and adding device 240 is connected to the dissolution

tank 220 to replenish metal ions in the electroplating solution by supplying metal powder into the dissolution tank 220. The current metering device 270 is connected to a power supply 260 of the electroplating apparatus 21 to detect the output electric charge of the power supply 260. For example, the current metering device 270 can be an ampere-hour meter, and the ampere-hour meter measures electric charge based on the principle of integrating the instantaneous current over time. The controller 290 is electrically connected to the current metering device 270 and the powder metering and adding device 240 respectively, and the controller 290 is used to control the powder metering and adding device 240 to add a predetermined amount of metal powder into the dissolution tank 220 based on the output electric charge detected by the current metering device 270.

Since the consumption of metal ions is directly proportional to ampere-hours, the predetermined amount of metal powder that needs to be introduced by the powder metering and adding device 240 corresponding to the preset ampere-hours delivered by the power supply 260 can be calculated. Accordingly, in the present application, the controller 290 replenish metal ions in the electroplating solution to maintain a stable concentration of the metal ions in the electroplating solution by controlling the powder metering and adding device 240 to add a predetermined amount of metal powder for each preset ampere-hour increment of the output electric charge delivered by the power supply 260, as measured by the current metering device 270.

Wherein, the metal powder can be copper oxide powder, and the electroplating solution in the dissolution tank 220 may contain components such as sulfuric acid, hydrochloric acid, copper sulfate, and water. In addition, the copper oxide powder can react with sulfuric acid or hydrochloric acid to dissolve in the dissolution tank 220, forming copper ions.

Specifically, in this embodiment, the powder metering and adding device 240 includes a hopper 241 for storing metal powder, and the hopper 241 has an inlet 242 for introducing the metal powder into the hopper and an outlet 243 for the metered discharge of the metal powder. The outlet 243 is disposed above the dissolution tank 220, and the outlet 243 is configured with an electrically-driven control assembly (not shown in the figures), such as a motor-driven screw feeder shaft.

Specifically, in this embodiment, the power supply 260 is connected to the substrate 100 to be plated via a cathode line 261 and is connected to the insoluble anode 213 via an anode line 262 to supply power to the insoluble anode 213 and the substrate 100 to be plated.

It should be noted that the electroplating tank 210 and dissolution tank 220 may be connected bidirectionally via the delivery pipeline 230. One branch of the delivery pipeline 230 delivers the electroplating solution in the dissolution tank 220 to the electroplating tank 210, while another branch of the delivery pipeline 230 delivers the electroplating solution in the electroplating tank 210 back to the dissolution tank 220. After metal ions are replenished, the electroplating solution is re-delivered into the electroplating tank 210, achieving the bidirectional circulation of the electroplating solution. In addition, the electroplating tank 210 can be connected to the dissolution tank 220 through the delivery pipeline 230 in a unidirectional manner. One branch of the delivery pipeline 230 delivers the electroplating solution in the dissolution tank 220 to the electroplating tank 210, and another branch of the delivery pipeline 230 discharges the electroplating solution in the electroplating tank 210 to another recovery device except the dissolution tank 220. The electroplating solution in the dissolution tank 220 is also replenished by another device for the unidirectional flow of the electroplating solution.

Preferably, in this embodiment, the liquid supply device further comprises a buffer tank 250, and the buffer tank 250 is disposed between the electroplating tank 210 and the dissolution tank 220 and is used to temporarily store and mix the electroplating solution that circulates between the dissolution tank 220 and the electroplating tank 210.

According to FIG. 5, in this embodiment, the delivery pipeline 230 is used to make the electroplating solution to circulate among the electroplating tank 210, the buffer tank 250, and the dissolution tank 220 in the directions indicated by arrows in FIG. 5. Specifically, the delivery pipeline 230 comprises a first inlet pipeline 231, a first outlet pipeline 232, a second inlet pipeline 233, and a second outlet pipeline 234. The first inlet pipeline 231 and the first outlet pipeline 232 are disposed between the dissolution tank 220 and the buffer tank 250, and a liquid pump 235 is arranged on the first inlet pipeline 231. The second inlet pipeline 233 and the second outlet

pipeline 234 are disposed between the buffer tank 250 and the electroplating tank 210, and a fluid pump 238 is arranged on the second inlet pipeline 233. Wherein, the first inlet pipeline 231 is used to deliver the electroplating solution in the dissolution tank 220 to the buffer tank 250; the first outlet pipeline 232 is used to deliver the electroplating solution in the buffer tank 250 back into the dissolution tank 220; the second inlet pipeline 233 is used to deliver the electroplating solution in the buffer tank 250 to the electroplating tank 210; the second outlet pipeline 234 is used to deliver the electroplating solution in the electroplating tank 210 back to the buffer tank 250. It should be noted that the second inlet pipeline 233 corresponds to the electroplating solution supply pipeline 2160 in the embodiment shown in FIG. 3, the second outlet pipeline 234 corresponds to the electroplating solution discharge pipeline 2170 in the embodiment shown in FIG. 3, and the fluid pump 238 corresponds to the liquid pump 219 in the embodiment shown in FIG. 3.

In order to prevent impurities such as undissolved metal powder in the dissolution tank 220 from being delivered to the interior of the electroplating tank 210, a multi-stage filtration device 2360 can be arranged on the first inlet pipeline 231.

Preferably, the electroplating system 200 further comprises a concentration analyzer 280 configured to monitor the concentration of the metal ions in the electroplating solution. As shown in FIG. 5, the concentration analyzer 280 can be disposed in the buffer tank 250. It can be understood that in other embodiments, the concentration analyzer 280 can be disposed in other tanks, for example, in the electroplating tank 210 or the dissolution tank 220; the concentration analyzer 280 can also be arranged on the delivery pipeline 230, for example, on the second inlet pipeline 233 or the second outlet pipeline 234.

In addition, in order to ensure full dissolution of the metal powder, a stirring device 221 can be additionally disposed in the dissolution tank 220. To monitor the temperature of the electroplating solution, a temperature control device 222 can be additionally disposed in the dissolution tank 220.

When the electroplating system 200 performs electroplating operations, the electroplating system 200 can make the bubbles generated on the surface of the

insoluble anode 213 be driven away from the substrate 100 to prevent the bubbles from flowing upward and adhering to the surface of the substrate 100, thereby avoiding the formation of recesses on the electroplated layer, which can affect the substrate quality. The electroplating system 200 can also use the ion-exchange membrane 214 to isolate impurity particles in the electroplating solution, thereby preventing the impurity particles from entering the cathode region 211 and adhering to the surface of the substrate 100, which can affect the substrate yield. Alternatively, the electroplating system 200 can also precisely regulate the concentration of the metal ions in the electroplating solution in the electroplating tank 210, thereby improving the controllability of the electroplating efficiency for the substrate 100.

It should be noted that all of the above embodiments can be freely combined as required. The above embodiments are merely preferred embodiments of the present invention. For those of ordinary skill in the art, a plurality of improvements and modifications can be made without departing from the principles of the present invention, and such improvements and modifications shall also be deemed to fall within the scope of protection of the present invention.

What is claimed is:

1. An electroplating apparatus, for electroplating metal onto a substrate, comprising:

an electroplating tank, for containing electroplating solution and the substrate;

an insoluble anode, disposed inside the electroplating tank and located below the substrate;

an anode solution inlet, for supplying the electroplating solution into the electroplating tank;

an anode solution outlet, for discharging the electroplating solution from the electroplating tank;

wherein, the anode solution inlet is higher than the insoluble anode and the anode solution outlet, so that during the electroplating, the electroplating solution flows along a first direction between the anode solution inlet and the anode solution outlet, away from the substrate, in addition, the flow rate of the electroplating solution in the electroplating tank is configured to make the electroplating solution exert a force on bubbles generated on the surface of the insoluble anode toward the first direction, and the force is greater than the buoyant force of the bubbles, thereby driving the bubbles away from the substrate.

2. The electroplating apparatus according to claim 1, wherein,

the bottom of the electroplating tank is conical or hemispherical, and the anode solution outlet is located at the center of the bottom.

3. The electroplating apparatus according to claim 1, further comprising a flow-guiding plate assembly, disposed between the insoluble anode and the anode solution outlet.

4. The electroplating apparatus according to claim 3, wherein,

the flow-guiding plate assembly includes a plurality of flow-guiding plates

arranged at intervals, and the spacing between at least two of the adjacent flow-guiding plates gradually decreases along the first direction to form channels for the electroplating solution to flow.

5. The electroplating apparatus according to claim 1, further comprising an ion-exchange membrane disposed inside the electroplating tank, wherein the ion-exchange membrane divides the interior of the electroplating tank into a cathode region and an anode region along the vertical direction, both the anode solution inlet and the anode solution outlet are located in the anode region, and the substrate is located in the cathode region.

6. The electroplating apparatus according to claim 1, wherein,

a plurality of the anode solution inlets are provided on the side wall of the electroplating tank, and the plurality of anode solution inlets are distributed at intervals at the same horizontal height of the electroplating tank.

7. The electroplating apparatus according to claim 1, further comprising:

an electroplating solution supply line, an electroplating solution discharge line, and a liquid pump, the electroplating solution supply line being connected to the anode solution inlet, for supplying the electroplating solution into the electroplating tank through the anode solution inlet; the electroplating solution discharge line being connected to the anode solution outlet, for discharging the electroplating solution through the anode solution outlet; the liquid pump being arranged on the electroplating solution supply line and/or the electroplating solution discharge line, for adjusting the flow rate of the electroplating solution in the electroplating tank.

8. The electroplating apparatus according to claim 1, further comprising:

a power supply, for supplying power to the insoluble anode and the substrate.

9. An electroplating system, comprising the electroplating apparatus according to any one of claims 1 to 8, further comprising:

a liquid supply device, for supplying the electroplating solution to the

electroplating apparatus.

10. The electroplating system according to claim 9, wherein, the liquid supply device comprises:

a dissolution tank, for supplying the electroplating solution to the electroplating tank;

a powder metering and adding device, for supplying metal powder to the dissolution tank;

a current metering device, for detecting the output electric charge of the power supply;

a controller, configured to control the powder metering and adding device to add a predetermined amount of the metal powder each time the current metering device detects that the output electric charge of the power supply increases by a preset ampere-hour value.

11. The electroplating system according to claim 10, further comprising:

a buffer tank, disposed between the electroplating tank and the dissolution tank, for temporarily storing and mixing the electroplating solution circulating between the dissolution tank and the electroplating tank.

12. The electroplating system according to claim 10, wherein the dissolution tank includes a stirring device and/or a temperature control device.