PLATING EQUIPMENT

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001]

The present invention relates to a plating equipment in which an insoluble anode is used.

DESCRIPTION OF THE RELATED ART

[0002]

Conventionally, various plating processes have been performed on object to be platies such as a semiconductor wafer and a printed wiring board. A so-called jet type plating equipment is known as an equipment that is used in the case of performing a plating process on such an object to be plated.

[0003]

Generally, this jet type plating equipment includes: an opening part in which an object to be plated can be placed; a solution supply piping that supplies a plating solution toward the object to be plated; and an anode that is arranged so as to be opposed to the object to be plated. This jet type plating equipment performs a plating process while supplying the plating solution from the solution supply piping toward the object to be plated. The jet type plating equipment can perform a uniform plating process on a surface to be plated of the object to be plated, and can perform the plating process while sequentially replacing object to be platies arranged in the opening part. Hence, the jet type plating equipment is widely utilized as an equipment suitable for small-lot production and plating process automation.

[0004]

Although this jet type plating equipment has such advantages as described above, in the case where a soluble anode is used, a coating film formed on the anode surface, for example, a black film or the like, comes off to become an impurity in the solution, the impurity flows together with the plating solution supplied toward the object to be plated, and this exerts a harmful effect on the plating process in some cases. Moreover, air mixed in the solution and air bubbles generated from the anode reach the surface to be plated, and hinder a favorable plating process in other cases. Therefore, for this jet type plating equipment, a method of arranging, in a plating tank, a diaphragm for to separate the object to be plated and the anode from each other is known (see Patent Literature 1 and Patent Literature 2).

Citation List

Patent Literature

[0005]

[Patent Literature 1] Japanese Patent Application Laid-Open No. 2000-273693 (9860P)

[Patent Literature 2] Japanese Patent Application Laid-Open No. 2007-~~139773~~ 169773 (EJ0137-P)

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0006]

If an insoluble anode is used, the jet type plating equipment including the diaphragm has various merits compared with the case where the soluble anode is used. For example, the consumption amounts of additives in the plating solution can be decreased. Moreover, maintenance such as anode replacement, which is required in the case where the soluble anode is used, is not required, and hence the productivity can be improved.

[0007]

Although the jet type plating equipment in which the insoluble anode is used has various merits as described above compared with the case where the soluble anode is used, under present circumstances in the plating field, the utilization of this jet type plating equipment has made little progress, except for precious metal plating and copper plating.

[0008]

If the diaphragm is arranged in the plating tank in the jet type plating equipment, an upper **catholyte chamber** is formed on the upper side of the diaphragm by the object to be plated placed in the opening part and the diaphragm, and a lower anolyte chamber is formed on the lower side of the diaphragm by the plating tank and the diaphragm. Then, because the insoluble anode is arranged in the lower anolyte chamber, many air bubbles are generated on the lower side of the diaphragm by gas generation due to electrolysis of water in plating. Therefore, it is necessary to efficiently discharge the air bubbles generated on the lower side of the diaphragm. Moreover, in order to obtain the merits in the case where the insoluble anode is used, different types of solutions are separately supplied to the upper catholyte chamber and the lower anolyte chamber, and it is necessary to prevent the different types of solutions supplied to the upper catholyte chamber and the lower anolyte chamber from mixing with each other, by means of the diaphragm arranged in the plating tank.

[0009]

In Patent Literature 1 of the related art, because a pressure loss at the time of the solution supply to the lower anolyte chamber is large, the supply flow rate to the lower anolyte chamber cannot be more a lot, and there is a tendency that ~~the~~ a lot of air bubbles generated from the insoluble anode cannot be sufficiently discharged. Moreover, in Patent Literature 2, although

the air bubbles can be efficiently discharged in the lower anolyte chamber, the solution supplied to the upper catholyte chamber and the lower anolyte chamber cannot be separated, and hence the merits of the insoluble anode cannot be sufficiently realized.

[0010]

The present invention has been made under the above-mentioned circumstances, and has an object to provide a jet type plating equipment in which an insoluble anode is used and merits of the insoluble anode can be sufficiently enjoyed.

Means for Solving the Problems

[0011]

In order to solve the above-mentioned problem, the present invention provides a plating equipment having a plating tank including: an opening part in which an object to be plated is placed; a solution supply piping that supplies a plating solution toward the object to be plated; an insoluble anode that is arranged so as to be opposed to the object to be plated; and an diaphragm for to separate the object to be plated and the insoluble anode from each other, an diaphragm outer peripheral end being fixed to a plating tank inner wall, a through-hole being provided in an diaphragm center, a hole peripheral end of the through-hole being fixed to the solution supply piping, the diaphragm being thus arranged so as to be inclined upward in an outer circumferential direction from the solution supply piping, in which: a silicon ring is firmly fixed to each of the outer peripheral end of the diaphragm and a hole edge of the through-hole of the diaphragm; the solution supply piping supplies the plating solution to an upper catholyte chamber in the plating tank, the upper catholyte chamber being formed by the diaphragm and the placed object to be plated; and an annular flow passage including a solution

ejection hole in an upper part thereof is provided in an outer circumference of the solution supply piping, a lower anolyte chamber solution is supplied from the solution ejection hole to a lower anolyte chamber in the plating tank, the lower anolyte chamber being formed below the diaphragm, and a flow that moves from around the through-hole of the diaphragm toward the outer circumferential direction of the diaphragm is thus formed in the lower anolyte chamber solution.

[0012]

According to the plating equipment of the present invention, the different solutions respectively supplied to the lower anolyte chamber and the upper catholyte chamber do not directly mix with each other. To realize this, the silicon ring be firmly fixed to each of the outer peripheral end of the diaphragm and the hole edge of the through-hole of the diaphragm. Then, the annular flow passage including the solution ejection hole in the upper part thereof is provided in the outer circumference of the solution supply piping, and the lower anolyte chamber solution is supplied from the solution ejection hole to the lower anolyte chamber in the plating tank, the flow that moves from around the through-hole of the diaphragm toward the outer circumferential direction of the diaphragm is formed in the lower anolyte chamber solution. In this way, gas (air bubbles) generated from the insoluble anode can be efficiently discharged from the lower anolyte chamber.

[0013]

In the case where the silicon ring is firmly fixed to the diaphragm in the plating equipment of the present invention, it is preferable to use a process called simultaneous casting of the silicon ring. The simultaneous casting of the silicon ring is performed in the following manner. The diaphragm is fixed to a mold frame that can press from above and below the outer peripheral end of the diaphragm having the through-hole provided in the center thereof

and the hole edge of the through-hole. An adhesive (primer) is applied to the outer peripheral end portion and the hole edge portion to each of which the silicon ring is to be firmly fixed. Silicon is injected into the portions to which the adhesive has been applied. Then, the mold frame is pressurized. After the silicon is cured, when the mold frame is removed, the silicon ring is firmly fixed to each of the outer peripheral end of the diaphragm and the hole edge of the through-hole of the diaphragm. With the use of the diaphragm to which such a silicon ring as described above is firmly fixed, it is possible to reliably prevent solution leakage from: the portion of the diaphragm outer peripheral end fixed to the plating tank inner wall; and the portion of the hole peripheral end of the through-hole in the diaphragm center, the portion of the hole peripheral end being fixed to the solution supply piping. The material of the diaphragm is not particularly limited, and may be selected in consideration of solution permeability and resistance to the plating solution. It is preferable to use a diaphragm whose diaphragm base material is a polyethylene terephthalate resin and whose diaphragm material is a polyvinylidene fluoride resin-based material. Moreover, it is preferable that the water permeability be equal to or less than 0.1 mL/min/cm^2.

[0014]

It is preferable that, in the plating equipment of the present invention, the lower anolyte chamber solution be supplied toward a circumferential direction of the annular flow passage provided in the outer circumference of the solution supply piping. The lower anolyte chamber solution is caused to flow in the lower anolyte chamber while rotating and flowing. Accordingly, a pressure loss at the time of the solution supply can be decreased, the supply amount can be increased, and gas (air bubbles) generated from the insoluble anode can be highly efficiently discharged from the lower anolyte chamber.

[0015]

It is preferable that the plating equipment of the present invention include a flow rate controller that controls a supply flow rate of the lower anolyte chamber solution supplied to the lower anolyte chamber. When the plating process is ended, if the object to be plated is removed from the opening part, the upper side of the diaphragm is opened. Hence, the solution pressure of the lower anolyte chamber solution supplied to the lower anolyte chamber is applied from the lower side of the diaphragm. If such a pressure from one side is continuously applied to the diaphragm, the diaphragm is likely to deform. Hence, when the object to be plated is removed from the opening part, it is preferable that the supply flow rate of the lower anolyte chamber solution be controlled by the flow rate controller and an excessive solution pressure be prevented from being applied to the diaphragm.

Advantageous Effect of Invention

[0016]

The present invention allows a jet type plating equipment to perform a plating treatment that sufficiently has advantages of an insoluble anode enjoyed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a cross-sectional view of a plating equipment of a present embodiment;

Fig. 2 is a plan view of the plating equipment of the present embodiment;

Fig. 3 is a cross-sectional view of the plating equipment taken along A-A';

Fig. 4 is a plan view of a diaphragm;

Fig. 5 illustrates a simultaneous casting process; ~~and~~and

Fig. 6 is a line graph obtained as a result of examining a concentration change in each additive.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018]

An embodiment of the present invention is described with reference to the drawings. Fig. 1 is a cross-sectional view of a plating equipment of the present embodiment, and Fig. 2 is a plan view of the plating equipment.

[0019]

In the plating equipment of the present embodiment, a torus-shape diaphragm 2 having a through-hole in the center thereof is set in a plating tank 1. This diaphragm 2 has a diaphragm outer peripheral end fixed to a plating tank inner wall, and a hole edge of the through-hole is fixed to a leading end of a solution supply piping 3, whereby the diaphragm 2 is inclined upward in the outer circumferential direction from the solution supply piping 3 (in the plan view of Fig. 2, illustration of the diaphragm is omitted). An annular flow passage 4 is provided in an outer circumference of the solution supply piping 3. Moreover, a mesh-like insoluble anode 5 is arranged in a bottom part of the plating tank 1 (in the plan view of Fig. 2, illustration of the insoluble anode is omitted).

[0020]

When a wafer W as was an object to be plated is placed in an opening part of the plating tank 1, an upper catholyte chamber U and a lower anolyte chamber D are formed in the plating tank 1. A plating solution is supplied to the upper **catholyte chamber** U from the solution supply piping 3. Then, a lower anolyte chamber solution is supplied to the lower anolyte chamber D

from a solution ejection hole 6 provided to an upper part of the annular flow passage 4.

[0021]

Fig. 3 is a cross-sectional view taken along a line A-A' in Fig. 2. The solution supply to the annular flow passage 4 is performed by a lower anolyte chamber solution supply piping 7 provided to the plating tank bottom part, and this lower anolyte chamber solution supply piping 7 is configured to enable the solution supply toward the circumferential direction of the annular flow passage 4. The lower anolyte chamber solution that has been supplied from the lower anolyte chamber solution supply piping 7 rotates and flows in the annular flow passage 4 to flow in the lower anolyte chamber D from the solution ejection hole 6. The lower anolyte chamber solution that has flowed in the lower anolyte chamber D forms a flow that spreads in an outer circumference of the diaphragm 2 along a lower surface of the diaphragm 2.

[0022]

The plating solution that has been supplied to the upper catholyte chamber ~~D~~ U is guided to and discharged from a solution discharge outlet 8 provided to the plating tank 1, and the lower anolyte chamber solution that has been supplied to the lower anolyte chamber D is guided to and discharged from a solution discharge outlet 9 provided to the plating tank 1.

[0023]

Fig. 4 is a plan view of the diaphragm 2. A silicon ring 10 is firmly fixed to each of an outer peripheral end 2' of the diaphragm 2 and a hole edge of a through-hole 2". This silicon ring 10 is firmly fixed through a simultaneous casting process of the silicon ring. As an example, description is given here of the case where the silicon ring is firmly fixed to the outer peripheral end of the diaphragm, and Fig. 5 is a cross-sectional view concerning the

simultaneous casting process in this case. An upper mold 21 and a lower mold 22 are arranged in the outer peripheral end of the diaphragm 2, and the upper mold 21 and the lower mold 22 are configured to be capable of sandwiching therebetween an end part of the outer peripheral end of the diaphragm 2 along the outer peripheral end thereof, whereby the diaphragm 2 is fixed. The upper mold 21 and the lower mold 22 are processed such that a ring formation space 23 is formed in the outer peripheral end of the diaphragm 2 when the upper mold 21 and the lower mold 22 sandwich the diaphragm 2 therebetween. An injection passage 24 for injecting silicon resin into the ring formation space 23 is formed in the upper mold 21. The diaphragm to which the silicon ring was firmly fixed as illustrated in Fig. 4 was manufactured with the use of such a mold frame as described above.

[0024]

Next, description is given of test results obtained as a result of~~:~~ performing a copper plating process with a copper sulfate plating solution by the plating equipment of the present embodiment~~;~~ and examining an additive concentration change in the plating solution.

[0025]

This test was carried out in the following manner: a copper sulfate plating solution containing three types of additives (commercial products) called an accelerator (promotor), a suppressor (inhibitor), and a leveler (smoother) was supplied to the upper catholyte chamber corresponding to a cathode side~~;~~ and a copper sulfate plating solution containing no additive was supplied to the lower anolyte chamber corresponding to an anode side. The solution compositions are shown below.

[0026]

*Upper catholyte chamber Supply Solution:

· Copper sulfate plating solution (commercial product ~~MicroFab~~ Microfab Cu525 / produced by Electroplating Engineers of Japan Ltd.)

Copper concentration ··· 60 g/L

Sulfuric acid concentration ··· 30 g/L

· Accelerator (promotor) ··· 3 mL/L

· Suppressor (inhibitor) ··· 10 mL/L

· Leveler (smoother) ··· 10 mL/L

· Solution temperature 22 to 23°C

· Solution volume 40 L

· Supply flow rate 25 L/min

* Lower anolyte chamber Supply Solution:

· Copper sulfate plating solution (commercial product Microfab Cu525 / produced by Electroplating Engineers of Japan Ltd., which is the same solution as that for the upper catholyte chamber)

· Solution temperature 22 to 25°C

· Solution volume 20 L

· Supply flow rate 5 L/min

[0027]

In the plating equipment, a mesh-like insoluble anode made of Pt-Ti was used, and a commercial product (film material: a fluorine-based resin, thickness: 0.12 mm, water permeability: 0.08 mL/min/cm^2 25°C) was used as the diaphragm. An 8-inch wafer made of PCB was used as the object to be plated. This wafer made of PCB is a object to be plated that is a glass epoxy base material to which copper foil is attached and which is processed into a wafer-like circular shape.

[0028]

A testing method included: performing a 3A and 7-hour copper plating process on the wafer made of PCB as the object to be plated; collecting the

upper catholyte chamber supply solution and the lower anolyte chamber supply solution immediately after the plating~~,~~ and analyzing the concentrations of copper, sulfuric acid, additives, and the like. The upper catholyte chamber supply solution was collected after the upper catholyte chamber supply solution immediately after the plating was replenished with the same amount of copper as that of copper consumed in the copper plating process. After the plating process, a process pause was taken for a predetermined period of time (16 hours). This process pause for the predetermined period of time and the copper plating process were repeated 5 times, and concentration changes in copper, sulfuric acid, the additives, and the like were examined. Moreover, in order to examine time degradation in the solution, after the fifth plating process, a process pause was taken for 48 hours. Then, without the plating process, concentration changes in copper, sulfuric acid, the additives, and the like were examined (sixth time). The obtained results are illustrated in Fig. 6. Note that, during each process pause, the supply amount of the ~~upper~~ lower catholyte chamber supply solution was 8 to 10 L/min, and the supply amount of the upper catholyte chamber supply solution was 1 to 2 L/min.

[0029]

Fig. 6 illustrates a concentration change in each additive in each of the upper catholyte chamber supply solution and the lower anolyte chamber supply solution, and Fig. 6 illustrates the concentration change in the order of the accelerator (promotor), the suppressor (inhibitor), and the leveler from the top by means of line graphs. In each line graph, the vertical axis represents an additive concentration (mL/L), the horizontal axis represents a concentration measurement period, data points represented by squares represent the concentration of the upper catholyte chamber supply solution,

and data points represented by circles represent the concentration of the lower anolyte chamber supply solution.

[0030]

As illustrated in Fig. 6, for the lower anolyte chamber supply solution containing no additive, additive components were not detected even after a lapse of the process pause period. For the upper catholyte chamber supply solution, there was a tendency that each additive gradually decreased with the increasing number of times of the plating processes. Particularly, the decrease in the concentration of the leveler was large, but the rate of decrease in this result was significantly smaller than the rate of decrease in the case where a soluble anode was used. Moreover, for the copper concentration and the sulfuric acid concentration, almost no concentration change was found in both the upper catholyte chamber supply solution and the lower anolyte chamber supply solution.

[0031]

These test results proved that, in the plating equipment of the present embodiment, the upper catholyte chamber supply solution and the lower anolyte chamber supply solution were controlled in the state where the two supply solutions were completely separated from each other by the diaphragm. These test results proved that the additives could be easily managed in the upper catholyte chamber supply solution, and also proved that the consumption amount of such an additive as the leveler whose consumption amount was large could be decreased in the case where a soluble anode was used. Further, because the solution supply amount during the process pause was controlled, deformation of the arranged diaphragm was not seen.

Reference Signs List

[0032]

1 plating tank

2 diaphragm

3 solution supply piping

4 annular flow passage

5 insoluble anode

6 solution ejection hole

7 lower anolyte chamber solution supply piping

8 solution discharge outlet

9 solution discharge outlet

10 silicon ring

21 upper mold

22 lower mold

23 ring formation space

24 injection passage"

U upper catholyte chamber

D lower anolyte chamber

W wafer

~~AMENDED CLAIMES~~

~~[Received by International Bureau on March 11, 2022]~~

WHAT IS CLAIMED IS:

1. ~~(Amended)~~ A plating equipment comprising a plating tank including: an opening part in which an object to be plated is placed; a solution supply piping that supplies a plating solution toward the object to be plated; an insoluble anode that is arranged so as to be opposed to the object to be plated; and a diaphragm for to separate the object to be plated and the insoluble anode from each other,

a diaphragm outer peripheral end being fixed to a plating tank inner wall, a through-hole being provided in a diaphragm center, a hole peripheral end of the through-hole being fixed to the solution supply piping, the diaphragm being thus arranged so as to be inclined upward in an outer circumferential direction from the solution supply piping, wherein

a silicon ring is firmly fixed to each of the outer peripheral end of the diaphragm and a hole edge of the through-hole of the diaphragm,

the solution supply piping supplies the plating solution to an upper catholyte chamber in the plating tank, the upper catholyte chamber being formed by the diaphragm and the placed object to be plated, and

an annular flow passage including a solution ejection hole in an upper part thereof is provided in an outer circumference of the solution supply piping, a lower anolyte chamber solution is supplied toward a circumferential direction of the annular flow passage to a lower anolyte chamber in the plating tank, the lower anolyte chamber being formed below the diaphragm, causing the lower anolyte chamber solution to rotate and flow to thereby allow the lower anolyte chamber solution from around the through-hole of the diaphragm toward the outer circumferential direction of the diaphragm to rotate and flow.

~~2. (Canceled)~~

~~3.~~2. The plating equipment according to claim 1 or claim 2, comprising a flow rate controller that controls a supply flow rate of the lower anolyte chamber solution supplied to the lower anolyte chamber.