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METAL FINISHING APPARATUS AND METAL FINISHING METHOD USING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a metal finishing apparatus, and more particularly, to a metal finishing apparatus having a membrane for separating a positive electrode and a negative electrode from each other, installed in an electrolytic bath, for prevent foreign matter from being electro-deposited on the electrodes, and a metal finishing method using the same.

2. Description of the Related Art

In general, semiconductor lead frames have a variety of shapes according to high-density and high integration of semiconductor chips and mounting methods thereof. The semiconductor lead frames are made of copper or iron group alloys, and various kinds of impurities are adhered to the raw material surface thereof.

Accordingly, in order to obtain a desired shape of a semiconductor lead frame, it is subjected to etching or stamping and then electro-polishing for enhancing the leveling effect by removing oxide from the raw material surface is necessary. Also, wire-bonding is necessarily performed in order to electrically connect a semiconductor lead frame having a particular shape with a semiconductor chip. Here, electro-plating is necessary for the purpose of improving bonding capacity, corrosion resistance and mounting efficiency.

FIG. 1 shows an electro-polishing apparatus 10 of a conventional metal finishing apparatus.

Referring to FIG. 1, the electro-polishing apparatus 10 includes an electrolytic bath 11 having a positive electrode 12, a negative electrode 13 and an electrolyte 14 between the positive electrode 12 and the negative electrode 13. The positive electrode 12 is a semiconductor lead frame made of a copper or iron group alloy, and the negative electrode 13 is a stainless steel (SUS) or platinum (Pt) grid. Also, the electrolyte 14 is an aqueous solution containing $60 \pm 5\%$ H_3PO_3 .

A reservoir 16 having a pump 15 is installed in the lower portion of the electrolytic bath 11. The reservoir 16 is connected to the electrolytic bath 11 via a supply path 17 and a recovery path 18. A nozzle 19 capable of jetting the electrolyte 14 supplied from the reservoir 16 via the supply path 17, is installed
5 on the bottom of the electrolytic bath 11.

The conventional electro-polishing apparatus 10 having the aforementioned configuration has the following reaction mechanism.

An oxidation reaction in which copper atoms lose electrons to be dissolved as copper ions, takes place at the positive electrode 12, and a
10 reduction reaction in which copper ions accept electrons to be reduced into copper atoms, takes place at the negative electrode 13.

However, the conventional metal finishing apparatus has the following disadvantages.

First, sludge is formed in the electrolytic bath and the sludge is electro-
15 deposited on the surface of the positive electrode 12 along the flow of the electrolyte 14. The sludge, which is a solid matter coagulated by the reaction between metal ions dissolved from the positive electrode 12 and the electrolyte 14 on the surface of the negative electrode 13, is impurity containing a large amount of H_2O . Also, the sludge is not completely removed even by a
20 cleaning process of products used as the positive electrode 12, resulting in inferiority of products.

Second, the amount of the sludge electro-deposited on the surface of the negative electrode 13 may increase until the negative electrode 13 is entirely covered by the sludge. Accordingly, the current efficiency sharply drops, which
25 lowers the electro-polishing speed. Thus, in order to remove the sludge, the metal finishing apparatus must be repeatedly cleaned at appropriate intervals while temporarily stopping driving the metal finishing apparatus. In particular, an in-line equipment such as a semiconductor lead frame must be wholly stopped.

Third, the electrolyte 14 is deteriorated by the sludge, by which the
30 concentration is reduced. Thus, the solution must be refilled at all times.

Fourth, reaction byproducts generated at the positive electrode are electro-deposited on the surface of the negative electrode at which a plating layer is formed, during metal plating, thereby adversely affecting the plating layer, resulting in reduction in the life span of the electrolyte.

SUMMARY OF THE INVENTION

To solve the above problems, it is an objective of the present invention to provide improvement of a metal finishing apparatus configured to have a membrane for selectively permeating particular ions between a positive
5 electrode and a negative electrode, installed in an electrolytic bath, for suppressing the reaction of generating foreign matter and preventing electro-deposition of foreign matter on electrodes, and a metal finishing method using the same.

It is another objective of the present invention to provide a metal finishing
10 apparatus which maintains a change in the concentration of an electrolytic bath by collecting particular ions of an electrolyte, and a metal finishing method using the same.

Accordingly, to achieve the first objective, there is provided a metal finishing apparatus including an electrolytic bath, an electrolyte contained in the
15 electrolytic bath, a positive electrode dipped into the electrolyte, a negative electrode dipped into the electrolyte, and a membrane installed between the positive electrode and the negative electrode, and having fine pores to selectively permeate particular ions dissolved in the electrolyte during an electrode reaction from one electrode to another electrode.

20 Also, the positive electrode is a polished structure and the negative electrode is a metal plate. Here, metal ions are dissolved from the positive electrode by electro-polishing to level the surface of the positive electrode, the metal ions not being permeated to the negative electrode by the membrane to prevent generation of metal sludge on the surface of the negative electrode.

25 Further, the positive electrode is a metal plate and the negative electrode is a plated structure. Here, metal ions are dissolved from the positive electrode to then be plated on the surface of the negative electrode by electro-plating and the reaction byproducts of the positive electrode do not permeate to the negative electrode by the membrane.

30 The metal finishing apparatus may further include an ion collecting portion capable of collecting metal ions or reaction byproducts recovered from the electrolyte at one side of the electrolytic bath.

According to another aspect of the present invention, there is provided a metal finishing method including the steps of preparing an electrolytic bath
35 having a positive electrode and a negative electrode, both dipped into the electrolyte, and a membrane separating the positive electrode and the negative

electrode from each other and having fine pores to selectively permeate particular ions from one electrode to another electrode, applying current to the electrolytic bath to cause an electrode reaction while particular ions dissolved from one electrode are prevented from being permeated to another electrode, and collecting the particular ions generated during the electrode reaction by an ion collecting portion connected to one side of the electrolytic bath to maintain the concentration of the electrolyte at a constant level.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The above objectives and advantages of the present invention will become more apparent by describing in detail a preferred embodiment thereof with reference to the attached drawings in which:

FIG. 1 is a schematic diagram illustrating a conventional metal finishing apparatus;

15 FIG. 2 is a schematic diagram illustrating a metal finishing apparatus according to a preferred embodiment of the present invention;

FIG. 3 is a graph illustrating a change in the concentration of copper ions over time, in the metal finishing apparatus shown in FIG. 2;

20 FIG. 4 is a graph illustrating a change in the concentration of phosphoric acid over time, in the metal finishing apparatus shown in FIG. 2;

FIG. 5 is a graph illustrating changes in the concentrations of copper ions in an electrolytic bath and a reservoir over time, in the metal finishing apparatus shown in FIG. 2; and

25 FIG. 6 is a graph illustrating contamination values over time, in the metal finishing apparatus shown in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 2 is a schematic diagram illustrating an electro-polishing apparatus 20 of a metal finishing apparatus according to a preferred embodiment of the present invention.

30 Referring to FIG. 2, the electro-polishing apparatus 20 includes an electrolytic bath 21 having a positive electrode 22, a negative electrode 23 and an electrolyte 24 between the positive electrode 22 and the negative electrode 23. The positive electrode 22 is a semiconductor lead frame which is a polished material made of a copper or iron group alloy, and the negative electrode 23 is an SUS or Pt grid. Also, the electrolyte 24 is an acidic solution to which a high

current is applied, and is preferably an aqueous solution containing $60\pm 5\%$ H_3PO_3 .

Here, a membrane 200 is installed in the electrolytic bath 21 in order to prevent the sludge generated by the reaction between copper ions dissolved from the positive electrode 22 and the electrolyte 24 on the surface of the negative electrode 23, from being electro-deposited on the positive electrode 22.

The membrane 200 is installed at a position where the positive electrode 22 and the negative electrode 23 are separated from each other. The membrane 200 is a thin film such as filter paper or celluloid and has numerous pores to serve to selectively permeate only particular ions. Here, the membrane 200 prevents copper ions dissolved from the positive electrode 22 from being electro-deposited on the negative electrode 23 and selectively permeates only H^+ ions.

A first reservoir 26 having a first pump 25 is installed in the lower portion of the electrolytic bath 21. The first reservoir 26 includes a first supply path 27 and a first recovery path 28 connected to a positive electrode cell 30, for supplying and recovering the electrolyte 24 to the positive electrode cell 30 separated from a negative electrode cell 40 by a membrane 200. The electrolyte 24 supplied through the first supply path 27 can be jetted through a nozzle 29 installed on the bottom of the electrolytic bath 21.

Also, the first reservoir 26 is connected to an ion collecting portion 220 having a third pump 260 through a third supply path 270 and a third recovery path 280. The ion collecting portion 220 supplies electrons to copper ions existing in the electrolytic bath 24 during electro-polishing to be reduced into copper, thereby preventing the concentration of copper ions from increasing.

A second reservoir 210 having a second pump 230 and connected with a second supply path 240 and a second recovery path 250 for supplying and recovering the electrolyte 24 from the negative cell 40, is installed in the lower portion of the electrolytic bath 21. An electrolyte having the same components as the electrolyte 24 supplied to the positive electrode cell 30 or a conductive polishing solution is contained in the second reservoir 210.

The aforementioned electro-polishing apparatus 20 according to the present invention has the following reaction mechanism.

If predetermined power is applied to the positive electrode 22 and the negative electrode 23, an oxidation reaction in which copper atoms lose electrons to be dissolved as copper ions, takes place at the positive electrode 22. Here, since the membrane 200 is installed between the positive electrode 22 and the negative electrode 23, particular ions cannot move the negative electrode cell 40 due to the membrane 200.

In other words, the copper ions dissolved from the positive electrode 22 cannot permeate but exist at the positive electrode cell 30 in an ion state. Only the H^+ ions can move to the negative electrode cell 40 through fine pores of the membrane 200. Accordingly, since the copper ions ionized from the positive electrode 22 do not move, the reaction of producing foreign matter due to the copper ions can be suppressed on the surface of the negative electrode 23. Thus, generation of copper sludge in the electrolytic bath 21 and electro-deposition of sludge on the surfaces of the electrodes can be prevented.

Also, the electrolyte 24 containing copper ions flows from the positive electrode cell 30 toward the ion collecting portion 220 via the first recovery path 28, the first reservoir 26 and the third recovery path 280, to collect the copper ions. Accordingly, an increase in the concentration of copper ions in the electrolyte 24 can be prevented.

The same is applied to the case of performing electro-plating by using an appropriate metal as a positive electrode and using a plated structure such as a semiconductor lead frame as a negative electrode. In other words, even if byproducts of a positive electrode reaction are generated during plating, since the plating solution can be independently controlled for each of the positive and negative electrode cells and by installing a membrane between the positive electrode and the negative electrode in an electrolytic bath, plating byproducts generated at the positive electrode cell do not affect the negative electrode cell.

The result of the experiment carried out by the present applicant using the electro-polishing apparatus 20 is summarized as follows.

Table 1 shows the change in the concentration of the electrolyte in each cell and generation of copper sludge over time.

Table 1

Time (hr)	Negative electrode cell		Positive electrode cell		Electro-deposition of sludge on negative electrode
	Phosphoric acid (%)	Copper (g/l)	Phosphoric acid (%)	Copper (g/l)	
??	64.3	None	64.2	0.75	None
2	64.3	None	62.3	1.23	None
4	64.6	None	59.7	1.71	None
6	62.9	None	58.7	2.36	None

Referring to Table 1, the positive electrode 22 is a semiconductor lead frame and the negative electrode 23 is an SUS or Pt grid. Also, the electrolyte 24 contains phosphoric acid. The current applied to the electrolytic bath 21 is 60 A/dm² and the polishing time interval was 2 hours. Here, the membrane 200 for preventing particular ions, e.g., copper ions, from being permeated is installed between the positive electrode 22 and the negative electrode 23 in the electrolytic bath 21.

According to the experimental result, when polishing was performed at 2 hour intervals, the concentration of phosphoric acid in the positive electrode cell 30 was changed from 64.2% to 62.3, 59.7 and to 58.7%. Then, the concentration of copper ions was changed from 0.75 g/l to 1.23, 1.71 and to 2.36 g/l. In other words, as the time elapsed, the concentration of phosphoric acid gradually decreased and the concentration of copper ions gradually increased, in the positive electrode cell 30. This is because the copper ions dissolved from the positive electrode 22 cannot permeate the membrane 200 and remains on the positive electrode cell 30.

On the other hand, in the negative electrode cell 40, the concentration of phosphoric acid was changed from 64.3% to 64.3, 64.6 and to 62.9%, that is, there was a very slight change in the concentration of phosphoric acid, and no copper ion was detected. This implies that copper ions could not move from the positive electrode cell 30 to the negative electrode cell 40 due to the membrane 200. As a result, copper sludge was not electro-deposited on the surface of the negative electrode 23.

FIG. 3 is a graph showing the change in the concentration of copper ions over time, in which the X-axis indicates the time and the Y-axis indicates the concentration of copper ions. The plot A indicates the change in the concentration of copper ions in the positive electrode cell 30, and the plot B indicates the change in the concentration of copper ions in the negative electrode cell 40.

Referring to the graph, as the time elapsed, the concentration of copper ions gradually increased in the positive electrode cell 30, as shown in Table 1. On the other hand, there was no change in the concentration of copper ions in the negative electrode cell 40. In other words, since the copper ions dissolved from the positive electrode 22 could not move to the negative electrode 23, copper sludge was not formed on the surface of the negative electrode 23 due to the reaction between the copper ions and the electrolyte.

FIG. 4 is a graph showing the change in the concentration of phosphoric acid over time, in which the X-axis indicates the time and the Y-axis indicates the concentration of phosphoric acid. The plot A indicates the change in the concentration of phosphoric acid in the positive electrode cell 30, and the plot B indicates the change in the concentration of phosphoric acid in the negative electrode cell 40.

Referring to the graph, as the time elapsed, while the concentration of phosphoric acid gradually decreased in the positive electrode cell 30, there was no change in the concentration of phosphoric acid in the negative electrode cell 40. In other words, in the positive electrode 22, as the concentration of copper ions increased, the concentration of phosphoric acid decreased.

FIG. 5 shows the change in the concentration of copper ions in the electrolytic bath 21 and the reservoir 26, over time, in which the X-axis indicates the time and the Y-axis indicates the concentration of copper ions. The plot C indicates the change in the concentration of copper ions in the electrolytic bath 21, and the plot D indicates the change in the concentration of copper ions in the reservoir 26.

Referring to the graph, in the electrolytic bath 21, as the time elapsed, the concentration of copper ions gradually increased. On the other hand, in the reservoir 26, the concentration of copper ions gradually decreased. The reason of copper ions in the reservoir 26 decreasing is that the copper ions were collected on the ion collecting portion 220.

FIG. 6 is a graph showing the contamination value over time in the reservoir 26, in which the X-axis indicates the time and the Y-axis indicates the contamination value. The plot E shows the change in the contamination value over time. Here, the current density was 3 A/dm².

5 Referring to the graph, in the reservoir 26, the contamination value had a tendency of decreasing according to the passage of time, which is because the collection ratio of the copper ions dissolved from the positive electrode 21 relatively increased in the ion collecting portion 220.

As described above, according to the metal finishing apparatus of the
10 present invention and the metal finishing method using the same have the following advantages by installing a membrane between a positive electrode and a negative electrode and collecting particular ions.

First, the ions dissolved from the positive electrode cannot move to the negative electrode, thereby preventing the ions from reacting with the electrolyte
15 on the surface of the negative electrode, so that sludge is not formed. Accordingly, the electro-deposition of the sludge on the positive electrode can be prevented, thereby noticeably reducing the defect ratio of products.

Second, since the sludge is not electro-deposited on the surface of the negative electrode, the reduction of current efficiency over time can be
20 prevented. As a result, the polishing speed can be maintained at a constant level. Also, since the periodic cleaning steps can be reduced, the productivity can be increased.

Third, since deterioration of the electrolyte due to sludge is reduced, the replacement period of the electrolyte can be extended.

25 Fourth, since the byproducts of a positive electrode reaction occurring at the positive electrode cannot move to the negative electrode during electro-plating, the plating solution can be efficiently controlled.

Although the invention has been shown and described with respect to a certain preferred embodiment, it is obvious that equivalent alterations and
30 modifications will occur to others skilled in the art upon the reading and understanding of the specification. The present invention includes all such equivalent alterations and modifications and is limited only by the scope of the claims.

What is claimed is:

- 1 1. A metal finishing apparatus comprising:
2 an electrolytic bath;
3 an electrolyte contained in the electrolytic bath;
4 a positive electrode dipped into the electrolyte;
5 a negative electrode dipped into the electrolyte; and
6 a membrane installed between the positive electrode and the negative
7 electrode, and having fine pores to selectively permeate particular ions
8 dissolved in the electrolyte during an electrode reaction from one electrode to
9 another electrode.

- 1 2. The metal finishing apparatus according to claim 1, wherein the
2 positive electrode is a polished structure and the negative electrode is a metal
3 plate, and wherein metal ions are dissolved from the positive electrode by
4 electro-polishing to level the surface of the positive electrode, the metal ions not
5 being permeated to the negative electrode by the membrane to prevent
6 generation of metal sludge on the surface of the negative electrode.

- 1 3. The metal finishing apparatus according to claim 2, wherein the
2 positive electrode is a lead frame.

- 1 4. The metal finishing apparatus according to claim 2, wherein the
2 electrolyte is an aqueous solution having phosphoric acid as a main component.

- 1 5. The metal finishing apparatus according to claim 1, wherein the
2 positive electrode is a metal plate and the negative electrode is a plated
3 structure, and wherein metal ions are dissolved from the positive electrode to
4 then be plated on the surface of the negative electrode by electro-plating and
5 the reaction byproducts of the positive electrode do not permeate to the
6 negative electrode by the membrane.

- 1 6. The metal finishing apparatus according to claim 2, further
2 comprising an ion collecting portion capable of collecting metal ions or reaction
3 byproducts recovered from the electrolyte at one side of the electrolytic bath.

1 7. The metal finishing apparatus according to claim 5, further
2 comprising an ion collecting portion capable of collecting metal ions or reaction
3 byproducts recovered from the electrolyte at one side of the electrolytic bath.

1 8. The metal finishing apparatus according to claim 6, wherein the ion
2 collecting portion is connected to a first reservoir connected to the electrolytic
3 bath, for supplying and recovering the electrolyte from a positive electrode cell
4 separated from a negative electrode cell by the membrane.

1 9. The metal finishing apparatus according to claim 7, wherein the ion
2 collecting portion is connected to a first reservoir connected to the electrolytic
3 bath, for supplying and recovering the electrolyte from a positive electrode cell
4 separated from a negative electrode cell by the membrane.

1 10. The metal finishing apparatus according to claim 8, wherein a
2 second reservoir is connected to the other side of the electrolytic bath, for
3 supplying and recovering the electrolyte from the negative electrode cell
4 separated from the positive electrode cell by the membrane.

1 11. The metal finishing apparatus according to claim 9, wherein a
2 second reservoir is connected to the other side of the electrolytic bath, for
3 supplying and recovering the electrolyte from the negative electrode cell
4 separated from the positive electrode cell by the membrane.

1 12. A metal finishing method comprising the steps of:
2 preparing an electrolytic bath having a positive electrode and a negative
3 electrode, both dipped into the electrolyte, and a membrane separating the
4 positive electrode and the negative electrode from each other and having fine
5 pores to selectively permeate particular ions from one electrode to another
6 electrode;
7 applying current to the electrolytic bath to cause an electrode reaction
8 while particular ions dissolved from one electrode are prevented from being
9 permeated to another electrode; and
10 collecting the particular ions generated during the electrode reaction by an
11 ion collecting portion connected to one side of the electrolytic bath to maintain the
12 concentration of the electrolyte at a constant level.