



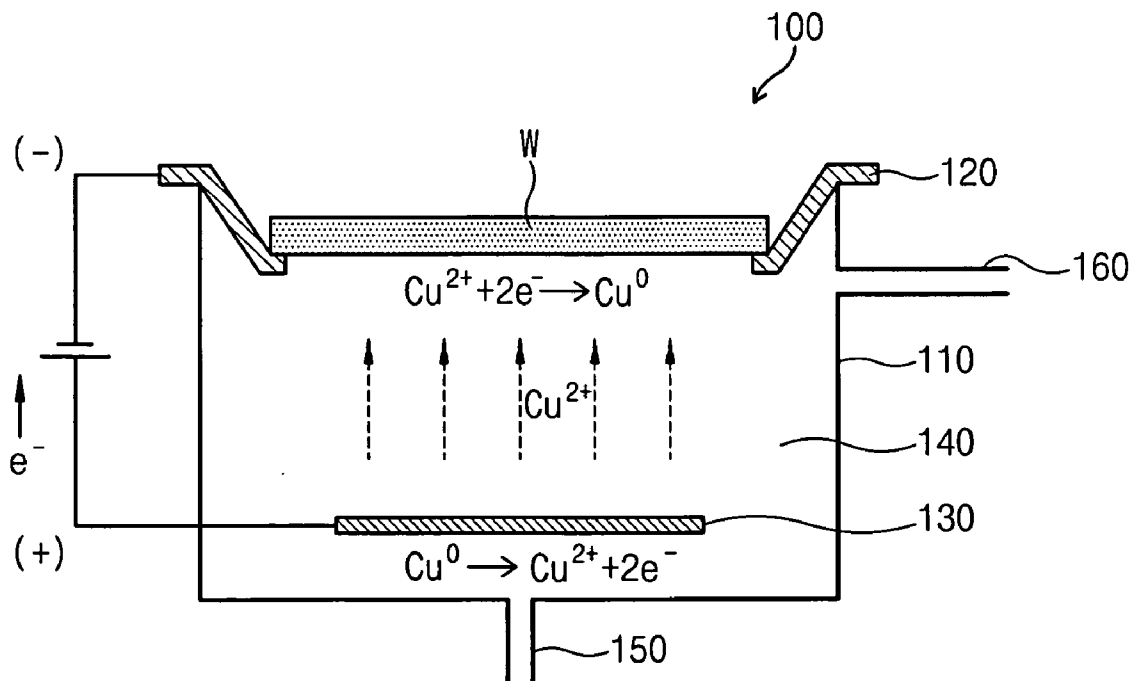
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(19) **United States**(12) **Patent Application Publication**  
**Jeon**(10) **Pub. No.: US 2006/0137977 A1**(43) **Pub. Date: Jun. 29, 2006**(54) **WAFER ELECTROPLATING APPARATUS  
FOR IMPROVING PROCESS UNIFORMITY****Publication Classification**(75) Inventor: **Chang-Seon Jeon**, Yongin-si (KR)(51) **Int. Cl.**  
**C25D 17/12** (2006.01)(52) **U.S. Cl.** ..... **204/289**Correspondence Address:  
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**WOODBURY, NY 11797 (US)**(57) **ABSTRACT**

Disclosed is a wafer electroplating apparatus, which includes an electroplating bath comprising an anode in the electroplating bath, an electroplating solution, and a cathode located on the top of the electroplating bath and on to which a wafer is mounted. The cathode comprises a first portion electrically connected to an edge of the wafer, and a second portion extending from the first portion and electrically connected to a side of the wafer. The direct contact of the cathode with the side and front edges of the wafer ensures uniform distribution of the electrical field on the wafer during the electroplating process. Consequently, a uniform thickness of metal film deposition is achieved.

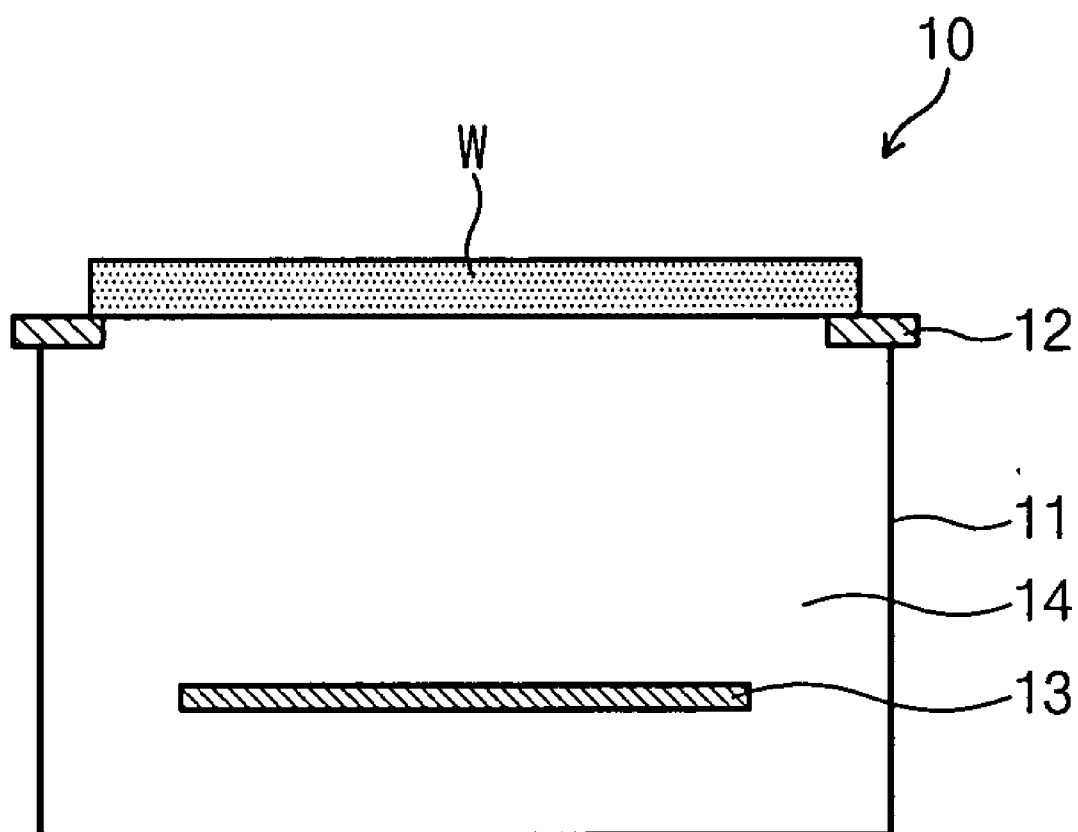
(73) Assignee: **Samsung Electronics Co., Ltd.**(21) Appl. No.: **11/283,039**(22) Filed: **Nov. 18, 2005**(30) **Foreign Application Priority Data**

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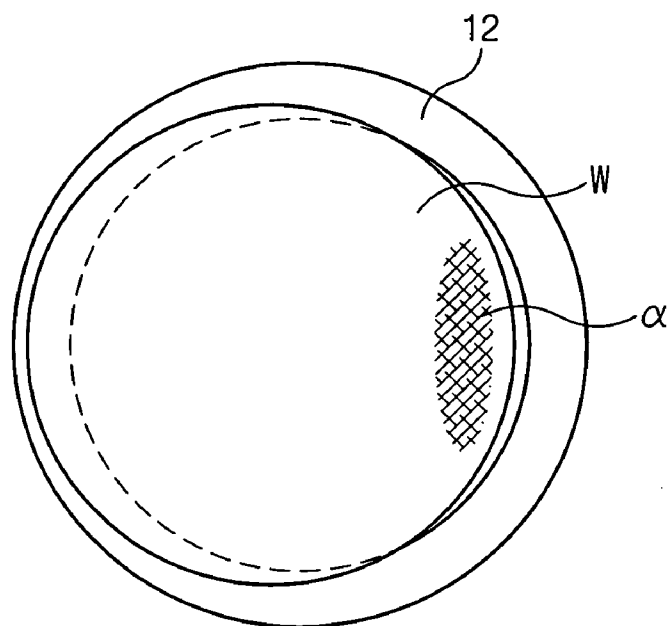
# Fig. 1

(Prior Art)



# Fig. 2A

(Prior Art)



# Fig. 2B

(Prior Art)

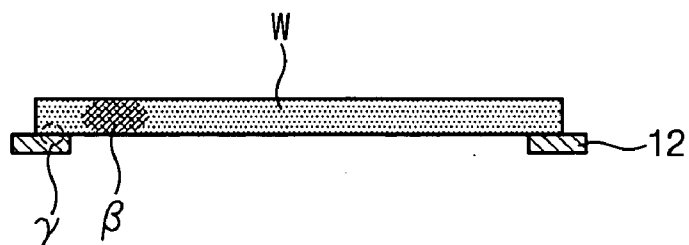


Fig. 3

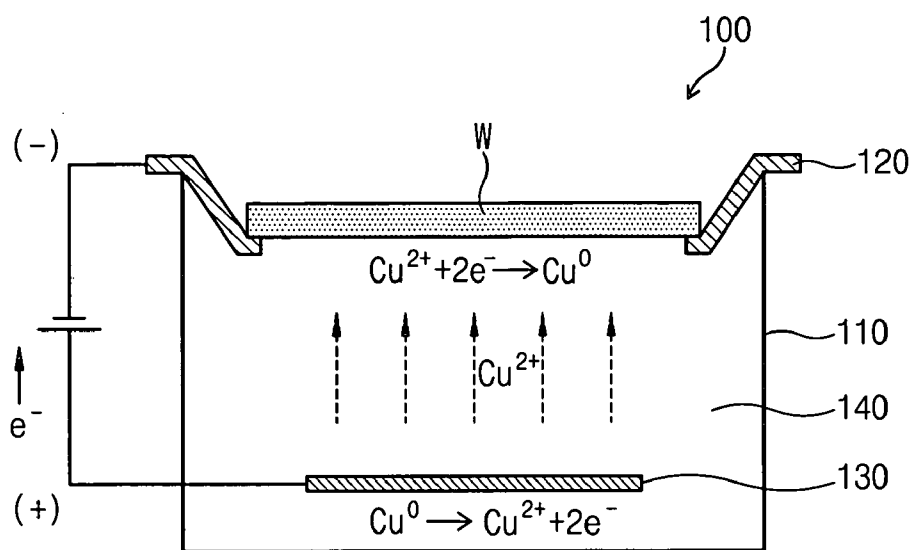


Fig. 4

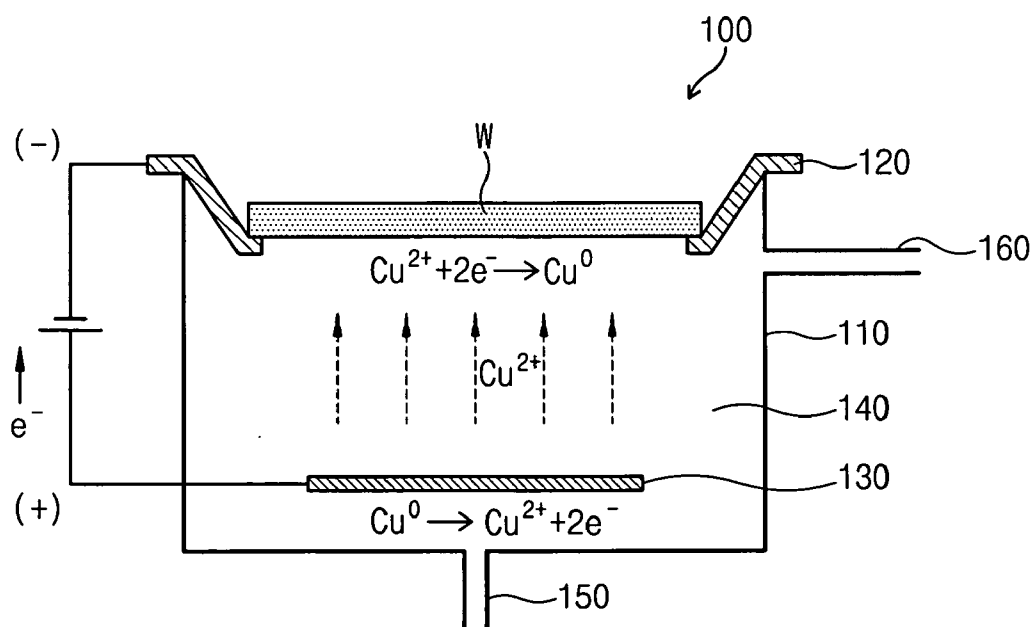


Fig. 5

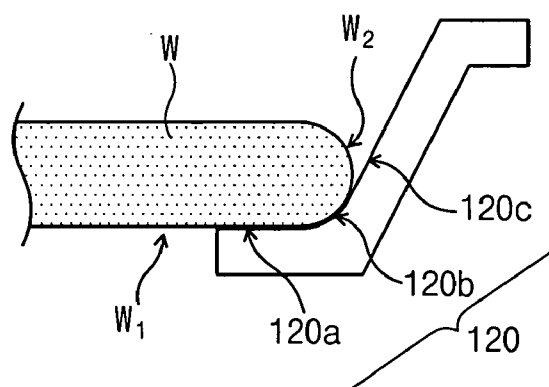
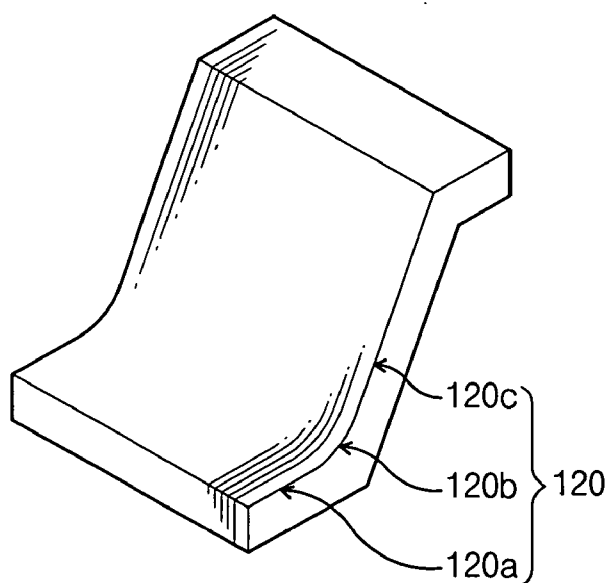


Fig. 6



# **WAFER ELECTROPLATING APPARATUS FOR IMPROVING PROCESS UNIFORMITY**

## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This U.S. non-provisional patent application claims priority under 35 U.S.C. §119 to Korean Patent Application 2004-115407 filed on Dec. 29, 2004, the entire contents of which is incorporated by reference herein.

## BACKGROUND

[0002] The invention relates to wafer electroplating apparatuses; more specifically, a wafer electroplating apparatus for enhancing the uniformity of metal film deposition of the wafer electroplating process, and a method thereof. There are numerous electroplating methods used for depositing metal films on wafers; such as chemical vapor deposition, physical vapor deposition and electrochemical reactions. However, electroplating methods using electrochemical reactions are currently more prevalent since these methods produce better quality of metal deposition on the wafers than the other techniques.

[0003] **FIG. 1** shows a sectional view of a conventional wafer electroplating apparatus. The wafer electroplating apparatus **10** includes an electroplating bath **11** containing a plating solution **14**, an anode **13** located inside the bottom portion of the electroplating bath **11**, and a ring-shaped cathode **12** on which a wafer **W** is directly mounted. A power source is directly connected between and applied to anode **13** and the cathode **12**. In this conventional electroplating arrangement, the metal (for example, copper) is electrochemically reduced and deposited as a film on to the wafer surface.

[0004] **FIG. 2A** shows the top view of a conventional planar ring type cathode **12**. This shape has disadvantages because of probable misalignment of the wafer **W** supported atop the cathode leading to insufficient contact of the wafer with the cathode; including contamination with possible impurities on the wafer. These instances can lead to both inefficient and insufficient metal film deposition on the wafer.

[0005] Similarly, in **FIG. 2B**, the sites  $\alpha$  (area on wafer not in contact with cathode) and  $\beta$  (area on the wafer with less metal film deposit) may occur as a result of the instances stated above.

[0006] These problems exist in the prior art which lead to irregularities in metal film deposition on the wafers.

## SUMMARY OF THE INVENTION

[0007] In an embodiment of the invention, a wafer electroplating apparatus is configured wherein an electrode is in direct contact with both the face and front edges of the wafer.

[0008] According to an embodiment of the invention, a wafer electroplating apparatus comprises an electroplating bath, an electroplating solution, an anode located inside the base portion of the electroplating bath, and a cathode, which is installed on top of the electroplating bath, atop of which a wafer is mounted. The cathode further comprises: a first portion electrically connected to an edge of the wafer; and

a second portion extending from the first portion and electrically connected to a side of the wafer.

[0009] In an embodiment of the invention, the second portion of the cathode structurally matches the side of the wafer.

[0010] In an embodiment of the invention, the second portion of the cathode is concave shaped to match the convex edge of the wafer.

[0011] In an embodiment of the invention, the cathode further comprises a third portion for aligning the wafer, wherein said third portion extends in a planar direction from the second portion.

[0012] In an embodiment of the invention, the third portion of the cathode slants upwards and outwards of the top edge of the electroplating bath.

[0013] In another embodiment of the invention, the cathode is ring shaped and electrically connected to the entire edge of the wafer. The cathode is preferably an electroconductive material.

[0014] According to still another embodiment of the invention, a wafer electroplating apparatus comprises: an electroplating bath containing an electroplating solution; an anode located inside the base portion of the electroplating bath; and a cathode installed at the top of the electroplating bath, wherein the cathode is in direct contact with a wafer. Preferably, the cathode includes: a plane portion in contact with a side of the wafer; a concave portion extending from the plane portion which structurally matches the convex edge of the wafer; and a slanting portion which extends from the concave portion and inclined upwards and outwards of the top edge of the electroplating bath.

[0015] In another embodiment of the invention, the electroplating bath comprises: an inlet through which the electrolyte solution is supplied into the electroplating bath; and an outlet from which the spent electrolyte drains out of the electroplating bath.

[0016] In an embodiment of the invention, the cathode is of any shape, but most preferably structurally shaped to be in contact with both the side and edges of the wafer; thus allowing a uniform distribution of an electrical current on the wafer; thereby, allowing equivalent areas of attraction for a metal to deposit. Consequently, a metal film depositing on to the wafer is of uniform thickness.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings show illustrative embodiments of the present invention and, together with the description, serve to explain principles of the present invention. In the drawings:

[0018] **FIG. 1** is a sectional view showing the structure of a conventional wafer electroplating apparatus;

[0019] **FIG. 2A** and **FIG. 2B** are top and sectional views illustrating the conventional wafer electroplating apparatus;

[0020] **FIG. 3** is a sectional view illustrating a wafer electroplating apparatus in accordance with an embodiment of the invention;

[0021] FIG. 4 is a sectional view further illustrating the wafer electroplating apparatus in accordance with an embodiment of the invention;

[0022] FIG. 5 is a sectional view illustrating the enlargement of a cathode in the wafer electroplating apparatus according to an embodiment of the invention; and,

[0023] FIG. 6 is a perspective sectional view illustrating the partial enlargement of the cathode in the wafer electroplating apparatus according to an embodiment of the invention.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0024] Preferred embodiments of the present invention are described below with reference to the accompanying drawings. The present invention may, however, be embodied in different forms and should not be constructed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will fully convey the scope of the invention to those skilled in the art. Like numerals refer to like elements throughout the specification.

[0025] FIG. 3 is a sectional view illustrating a wafer electroplating apparatus in accordance with an embodiment of the invention. FIG. 3 shows a wafer electroplating apparatus 100. FIG. 3 shows the principle of electroplating via electrolysis in a wafer electroplating apparatus, where a metal ion is reduced to an elemental metal and deposited as a film on a wafer. The wafer electroplating apparatus 100 comprises an electroplating bath 110, which contains an electroplating solution 140, an electrode 130 located inside the electroplating bath 110, and an electrode 120 on which a wafer W is mounted.

[0026] The plating solution 140 contained in the electroplating bath 110 is an electrolytic solution, which consists of an aqueous solution of metallic salts. For example, an aqueous copper sulfate ( $\text{CuSO}_4$ ) solution may be used for electroplating a copper film on to the surface of the wafer W.

[0027] In another embodiment of the invention shown in FIG. 4, the electroplating bath 110 may further comprise an inlet 150 for supplying the electrolytic solution and an outlet 160 to drain out the used electrolytic solution.

[0028] As shown in FIG. 3, the electrode 130 is located inside the base portion of the electroplating bath 110, and acts as the anode or the positive electrode where electrochemical oxidation occurs. While electrode 120 acts as the cathode or negative electrode, is located at the top of the electroplating bath 110 where reduction occurs.

[0029] The anode 130 is preferably a metal or material similar thereto. As illustrated in FIG. 3, the anode 130 is made out of copper. Similarly, the cathode 120 is preferably made of an electroconductive material.

[0030] When electrical current is applied, the current is carried by the movement of electrons from the anode 130 to the cathode 120 and in the solution 140 by the movement of ions. The movement of positively charged cations in the solution towards the direction of the cathode 120 is equivalent electrically to the movement of negatively charged electrons in the opposite direction from the anode 130 to the cathode 120. The positively charged ions in the solution 140 migrate to electrode 120, where they are reduced and

deposited as elemental metal. Consequently, a metal film is deposited on to the surface of the electrically-charged wafer W, since the wafer is directly mounted on the cathode 120.

[0031] Simultaneously, at the electrode 130, with the passage of electrical current, the metal, for example, copper, in the anode 130 is oxidized to copper ions with the release of two electrons for each atom of copper. Ideally, the anode 130 loses mass and the cathode 120 gains an equal mass, as copper is transferred from the anode into solution 140 and from solution 140 to the cathode 120.

[0032] The cathode 120, can be of any shape; but is preferably shaped in a ring pattern and is configured to support the circular wafer W while contacting to an outer circle of the wafer W. The direct contact of cathode 120 with wafer W ensures the electrical conduction of the wafer W. The cathode 120 may be formed of any metal; but most preferably a metal containing a stainless steel (SUS). The wafer W is mounted on the cathode 120 where the outer circle face of the front face W1 (see FIG. 5) thereof is laid on the cathode 120; and the front face W1 is in direct contact with the cathode 120.

[0033] FIG. 5 is a sectional view illustrating the enlargement of a cathode in the wafer electroplating apparatus according to an embodiment of the invention, and FIG. 6 is a perspective sectional view illustrating the partial enlargement of the cathode in the wafer electroplating apparatus according to an embodiment of the invention.

[0034] Referring to FIG. 5 and FIG. 6, the cathode 120 is constructed to include a plane portion 120a to contact with the flattened edge of the front face W1 of the wafer W, and concave portion 120b to contact with the convex side face W2 of the wafer W. When electrical power is applied to the electrodes, current flows evenly through both the front face W1, and through the side face W2 of the wafer W. Consequently, the application of current in the side face W2 ensures that the wafer is still electrically charged; even when front face W1 has impurities. Subsequently, the metal film will still be deposited uniformly on the surface of the wafer.

[0035] In another embodiment of the invention, the cathode 120 may be installed to have any elastic force distributed uniformly toward the wafer W; but most preferably, an elastic force, which maintains the aligned position of the wafer W relative to the cathode 120.

[0036] Furthermore, in another embodiment of the invention, the cathode 120 comprises a slanted portion 120c inclined upwards and outwards to the top of the electroplating bath 110. The slanted portion 120c enables the wafer W to be properly mounted on and aligned with the cathode 120 for an efficacious electroplating process.

[0037] In an embodiment of this invention, the cathode 120 acts as the negative electrode. The cathode 120, further, provides a uniform electrical conduction state of the wafer, since portion 120a is in direct contact with the side face W1 and slanted portion 120b is in direct contact with edge W2. However, the shape of cathode 120 can be modified according to the shape of the edge or side face W2 of the wafer W.

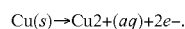
[0038] The description that follows is the operation of the wafer electroplating apparatus 100 with the aforementioned elements. An illustrative example is shown in FIG. 4, where

an aqueous copper sulfate ( $\text{CuSO}_4$ ) solution is the electrolyte **140** used in plating a copper film on the front face **W1** of the wafer **W**.

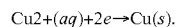
[0039] The wafer **W** is mounted on the cathode **120** and properly positioned to allow the edge of the front face **W1** to be in direct contact with the cathode **120**. In this holding position, the side face or edge **W2** is also allowed to be in direct contact with cathode **120**. Next, the power is applied to the electrodes **120** and **130**, consequently rendering the wafer **W** to be electrically conductive.

[0040] In solution, the copper sulfate ionizes into copper ions  $\text{Cu}^{2+}$ , sulfate ions  $\text{SO}_4^{2-}$ , hydrogen ions  $\text{H}^+$ , hydroxyl ions  $\text{OH}^-$  and hydronium ions  $\text{H}_3^+$ .

[0041] Simultaneously, at the positive electrode **130**, the oxidation reaction generates electrons  $e^-$ , according to the half-reaction:



[0042] Copper ions in the solution migrate to the negative electrode **120**, where they are reduced and deposited as elemental copper, according to the half-reaction:



[0043] Since side face or edge **W2**, and front face **W1** of wafer **W** are in direct contact with cathode **120** by the plane portion **120a**, curved portion **120b** and slanted portion **120c**, the conduction state with an electrical field is uniformly distributed on wafer **W**. Hence, this configuration, which is an embodiment of the invention, alleviates irregular coverage during the electroplating process.

[0044] Although the present invention has been described in connection with the embodiment of the present invention, and illustrated in the accompanying drawings, it is not limited thereto. It will be apparent to those skilled in the art that various substitutions, modifications and changes may be made thereto, without departing from the scope and spirit of the invention.

What is claimed is:

1. A wafer electroplating apparatus comprising:

an electroplating bath;

an anode disposed at a lower portion of the electroplating bath;

an electroplating solution; and

a cathode disposed on the top of the electroplating bath and on to which a wafer is mounted, wherein the cathode comprises a first portion electrically connected to an edge of the wafer, and a second portion extending from the first portion and electrically connected to a side of the wafer.

2. The wafer electroplating apparatus as set forth in claim 1, wherein the second portion of the cathode is sized and shaped to be in contact with side edges of the wafer.

3. The wafer electroplating apparatus as set forth in claim 2, wherein the second portion of the cathode is concave shaped to substantially conform with a convex side edge of the wafer.

4. The wafer electroplating apparatus as set forth in claim 1, wherein the cathode further comprises a third portion, extending from the second portion, provided for aligning the wafer.

5. The wafer electroplating apparatus as set forth in claim 4, wherein the third portion of the cathode is shaped in a slanted pattern inclined outwards and upwards at the top of the electroplating bath.

6. The wafer electroplating apparatus as set forth in claim 1, wherein the cathode is ring shaped and is electrically connected to the entire edge of the wafer.

7. A wafer electroplating apparatus comprising:

an electroplating bath containing a plating solution;

an anode disposed at a lower portion of the electroplating bath; and, a cathode disposed on the top of the electroplating bath, on to which a wafer is mounted;

wherein the cathode comprises:

a plane portion in direct contact with the side of the wafer;

a concave portion extending from the plane portion and substantially mating with a convex side of the wafer; and

a slanted portion extending from the concave portion and inclined upwards and outwards at the top of the electroplating bath.

8. The wafer electroplating apparatus as set forth in claim 7, wherein the electroplating bath comprises:

an inlet through which the electrolyte is supplied into the electroplating bath; and

an outlet through which the spent electrolyte is drained out of the electroplating bath.

9. The wafer electroplating apparatus of claim 7, wherein the electroplating solution comprises an aqueous copper sulfate, and the anode comprises a metal.

10. The wafer electroplating apparatus of claim 7, wherein the cathode is stainless steel.

11. The wafer electroplating apparatus as set forth in claim 7, wherein the cathode is ring shaped and is electrically connected to the entire edge of the wafer.

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