

ELECTROPLATING APPARATUS AND ELECTROPLATING METHOD

FOR NON-CIRCULAR SUBSTRATE

FIELD OF THE INVENTION

The present invention relates to the field of semiconductor manufacturing equipment, and in particular, to an electroplating process in semiconductor manufacturing technology.

BACKGROUND

Traditional substrates are mostly circular, while chips are mostly square. Forming square chips on circular substrates leads to the waste of the area at the corners and edges of the substrates due to shape mismatch, resulting in a low area utilization efficiency for producing square chips on circular substrates and affecting the production efficiency of chips to a certain extent.

With the gradual popularization of panel-level packaging and the change of substrate materials, the application of square substrates is increasing day by day. Square substrates exhibit better shape compatibility with chips, enabling a greater number of chips to be accommodated on substrates of identical surface area compared to circular substrates. Additionally, chip placement can extend to the edge regions of square substrates. Therefore, the area utilization efficiency of square substrates is improved, and chip production efficiency is enhanced accordingly.

When square substrates are electroplated, vertical electroplating is generally employed. In existing vertical electroplating, a substrate is typically clamped onto a dedicated fixture, and both the substrate and fixture are sequentially immersed in multiple different plating tanks. During electroplating, the current is output to the fixture and then conducted to the substrate surface through the fixture's metal contact points, enabling copper ions in the chemical solution to deposit onto the substrate surface and complete the electroplating process. However, square substrates processed with this vertical electroplating method cannot achieve the same results as circular substrates, such as poor surface flatness and more noticeable crystalline originated particle (COP) defects. Furthermore, during the vertical electroplating process, the

substrate and fixture are transferred between different plating tanks, making cross-contamination of electroplating solutions unavoidable, which also affects the stability of the chemical solutions and deposited layers. Additionally, vertical electroplating fails to effectively adjust the top-to-bottom variation in electroplating results for square substrates.

Moreover, directly using an existing electroplating apparatus for horizontal electroplating of square substrates will lead to the problem of excessive edge thickness. As shown in FIGS. 1A to 1B and 2A to 2B, an electrode 1 of the existing electroplating apparatus is mostly circular or annular. When an electroplating process is performed on a square substrate or a rectangular substrate, the substrate cannot cover all electrode regions due to the shape mismatch with the electrode. During the rotation of a square substrate w , a central region 101 of the electrode 1 is always covered by the substrate w . However, only a part of the edge region of the electrode 1 is covered by the substrate w at the same time, thus forming a situation where the electric field is cut at the edge of the substrate w , which will cause uneven electroplating and a significant increase in the copper pillar height at the edge of the substrate.

SUMMARY

The objective of the present invention is to provide an electroplating apparatus and an electroplating method for a non-circular substrate.

To achieve the above objective and other relevant objectives, the present invention provides an electroplating apparatus for a non-circular substrate, comprising:

a central electrode region, circular in shape, sized to be the inscribed circle of the non-circular substrate, a central electrode being arranged in the central electrode region, and the central electrode fully filling the central electrode region;

a peripheral electrode region, arranged around the central electrode region, with an outer periphery of the peripheral electrode region sized to be the circumscribed circle of the non-circular substrate, a peripheral electrode being arranged in the peripheral electrode region, and the peripheral electrode including a plurality of block electrodes that fully fill the peripheral electrode region;

a power supply module, including a plurality of power supplies for supplying power to the central electrode and the peripheral electrode;

a control module, configured to detect the rotational position of the substrate, calculate the current magnitude required by each block electrode at present, and notify the power supply module to adjust the current magnitude.

Preferably, the current magnitude required by the block electrode is $I' = \frac{S'}{S} \times I$, where S' is the area of the block electrode covered by the substrate, S is the area of the block electrode, and I is the current supplied by the power supply module to the central electrode region.

Preferably, a plurality of peripheral electrode regions are provided, and the plurality of peripheral electrode regions are concentric annular regions.

Preferably, the block electrodes are obtained by equally dividing the peripheral electrode into N parts, where N is a multiple of 4.

Preferably, the control module includes an angle sensor and a projection simulator, the angle sensor is used for tracking the rotation angle of the substrate, and the projection simulator simulates the current position of each vertex of the substrate according to the rotation angle of the substrate to determine the projection area of the substrate in the peripheral electrode region, and further calculates the area of each block electrode covered by the substrate.

Preferably, the control module includes an angle sensor and a controller, the angle sensor is used for tracking the rotation of the substrate to identify the rotation angle of the substrate, the controller presets the current magnitude to be adjusted for each block electrode at angular intervals of substrate rotation, and when the angle sensor identifies each angular interval of substrate rotation, the controller feeds the preset current magnitude back to the power supply module according to the preset current magnitude to adjust the corresponding current.

Preferably, each block electrode is supplied with power by a corresponding one of the plurality of power supplies.

Preferably, the non-circular substrate is a rectangular substrate.

Preferably, every two centrosymmetric block electrodes form a group to obtain a plurality of electrode groups, and each electrode group is supplied with power by one power supply.

Preferably, the non-circular substrate is a square substrate.

Preferably, the number of power supplies arranged in each peripheral electrode region is the maximum number of block electrodes that any corner of the substrate can cover in each peripheral electrode region.

The present invention also provides an electroplating method for a non-circular substrate, comprising:

dividing an electrode region, including dividing the electrode region into a central electrode region and a peripheral electrode region, the central electrode region being circular in shape and sized to be the inscribed circle of the non-circular substrate, a central electrode being arranged in the central electrode region, the central electrode fully filling the central electrode region, the peripheral electrode region being arranged around the central electrode region, with an outer periphery of the peripheral electrode region sized to be the circumscribed circle of the non-circular substrate, a peripheral electrode being arranged in the peripheral electrode region, and the peripheral electrode including a plurality of block electrodes that fully fill the peripheral electrode region;

tracking the rotational position of the substrate;

calculating the current required by each block electrode according to the effective area of each block electrode covered by the substrate;

adjusting the current required by each block electrode and supplying the adjusted current to the corresponding block electrode.

The present invention also provides another electroplating method for a non-circular substrate, comprising:

dividing an electrode region, including dividing the electrode region into a central electrode region and a peripheral electrode region, the central electrode region being circular in shape and sized to be the inscribed circle of the non-circular substrate, a central electrode being arranged in the central electrode region, the central electrode fully filling the central electrode region, the peripheral electrode region being arranged around the central electrode region, with an outer periphery of the peripheral electrode region sized to be the circumscribed circle of the non-circular substrate, a peripheral electrode being arranged in the peripheral electrode region, and the peripheral electrode including a plurality of block electrodes that fully fill the peripheral electrode region;

presetting the current parameter required by each block electrode corresponding to each angular interval of substrate rotation;

tracking the rotational position of the substrate;

when the substrate rotates through each angular interval, adjusting the current according to the preset power supply parameter and supplying the adjusted current to the corresponding block electrode.

As mentioned above, the electroplating apparatus and electroplating method provided by the present invention divide the electrode into a central electrode region and a peripheral electrode region, and arrange a plurality of small electrode blocks in the peripheral electrode region to fully fill the peripheral electrode region. By obtaining the change in the area of each small electrode block covered by the substrate during substrate rotation, the current supplied to each small electrode block is adjusted, which can solve the problems of uneven electroplating and excessive copper pillar height at the edge of the non-circular substrate when using the existing electroplating apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a schematic diagram of an electroplating process for a square substrate by an existing electroplating apparatus;

FIG. 1B is a schematic diagram of a square substrate after rotating by a certain angle on an existing electroplating apparatus;

FIG. 2A is a schematic diagram of an electroplating process for a rectangular substrate by an existing electroplating apparatus;

FIG. 2B is a schematic diagram of a rectangular substrate after rotating by a certain angle on an existing electroplating apparatus;

FIG. 3A is a schematic diagram illustrating a peripheral electrode of an electroplating apparatus for a non-circular substrate divided into four equal parts according to an embodiment of the present invention;

FIG. 3B is a schematic diagram illustrating a peripheral electrode of an electroplating apparatus for a non-circular substrate divided into eight equal parts according to an embodiment of the present invention;

FIG. 3C is a schematic diagram illustrating a peripheral electrode of an electroplating apparatus for a non-circular substrate divided into sixteen equal parts according to an embodiment of the present invention;

FIG. 4 is a schematic diagram of a power supply control for an electroplating apparatus for a non-circular substrate according to an embodiment of the present invention;

FIG. 5A is a schematic diagram of the area change of a square substrate w covering peripheral electrode regions during rotation;

FIG. 5B is a schematic diagram of the area change of a rectangular substrate w covering peripheral electrode regions during rotation;

FIG. 6A is a schematic diagram of a power supply control for an electroplating apparatus for a rectangular substrate according to an embodiment of the present invention;

FIG. 6B is a schematic diagram of a power supply control for an electroplating apparatus for a square substrate according to an embodiment of the present invention;

FIGS. 7A to 7E are schematic diagrams illustrating area changes of an

electroplating apparatus for a square substrate according to an embodiment of the present invention, covering peripheral electrodes divided into eight, twelve, sixteen, twenty, and twenty-four equal parts, respectively;

FIG. 8 is a table of the minimum number of power supplies corresponding to different division numbers of peripheral electrodes for a square substrate;

FIG. 9 is a schematic table of the current magnitude required by each block electrode corresponding to different division numbers of peripheral electrodes for a square substrate;

FIG. 10 is a flowchart of an electroplating method for a non-circular substrate according to an embodiment of the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

The following illustrates embodiments of the present invention through specific examples. Those skilled in the art may readily understand other advantages and effects of the present invention from the content disclosed in this specification. The present invention may also be implemented or applied through other specific embodiments. Various details in this specification may be modified or changed based on different viewpoints and applications without departing from the spirit of the present invention.

It should be noted that the drawings provided in the embodiments are merely schematic illustrations for explaining the basic concept of the present invention. Although the drawings only show components related to the present invention rather than being drawn according to the actual number, shape, and size of components during actual implementation, the form, quantity, and proportion of each component during actual implementation may be arbitrarily changed, and the layout configuration of the components may also be more complex. In addition, the same reference numerals shown in multiple accompanying drawings indicate identical or equivalent parts or components.

FIGS. 3A to 3C provide schematic diagrams of various specific embodiments of an electroplating apparatus for a non-circular substrate according to an embodiment of the present invention. The non-circular substrate in the present invention may be

regular figures such as rectangular, triangle, rhombus, and the like. The mainstream non-circular substrates at present are rectangular substrates, i.e., square substrates and rectangular substrates. Therefore, the present invention focuses on the rectangular substrate as an example. The electroplating apparatus for a non-circular substrate comprises a central electrode region 101 and peripheral electrode regions 102. The central electrode region 101 is circular, and the size of the central electrode region 101 corresponds to the inscribed circle of the non-circular substrate w. A central electrode is arranged in the central electrode region 101 that fully fills the central electrode region 101. Since the central electrode fully fills the entire central electrode region, the reference numeral 101 represents both the central electrode region and the central electrode in this specification and the accompanying drawings. The central electrode can be a single circular electrode that fully fills the central electrode region 101. The central electrode can also be a combination of a plurality of small electrodes that fully fill the central electrode region 101.

The peripheral electrode regions 102 are arranged around the central electrode region 101, and the outer periphery size of the peripheral electrode regions 102 corresponds to the circumscribed circle of the non-circular substrate. Peripheral electrodes are arranged in the peripheral electrode regions 102 that fully fill the peripheral electrode regions 102. A plurality of peripheral electrode regions are provided, and the plurality of peripheral electrode regions are concentric annular regions and are arranged sequentially outward from the central electrode region 101, wherein the size of the outermost peripheral electrode region corresponds to the circumscribed circle of the non-circular substrate. Since the peripheral electrodes fully fill the entire peripheral electrode region, the reference numeral 102 represents both the peripheral electrode regions and the peripheral electrodes in this specification and the accompanying drawings. As shown in FIGS. 3A to 3C, two peripheral electrode regions, a first peripheral electrode region 121 and a second peripheral electrode region 122, are sequentially arranged around the central electrode region 101. In the illustrated embodiment, the two peripheral electrode regions have the same width, while in other embodiments, the widths of the plurality of peripheral electrode regions can be different.

The peripheral electrode includes a plurality of block electrodes 1021 that fully

fill the peripheral electrode regions 102. The plurality of block electrodes 1021 can be obtained by equally dividing the peripheral electrode of the peripheral electrode regions 102 into N parts, where N is a multiple of 4, such as four equal parts, eight equal parts, and sixteen equal parts, corresponding to FIGS. 3A, 3B, and 3C, respectively. The electrode bisectors of the plurality of peripheral electrode regions 102 can overlap, as shown in FIGS. 3A and 3B, and the electrode bisectors of the plurality of electrode regions 102 can also be staggered, as shown in FIG. 3C. The block electrodes 1021 are preferably obtained by equally dividing the peripheral electrode into eight or sixteen equal parts, which facilitates the precise control of each block electrode, meanwhile, the computing power required for controlling each block electrode individually will not be excessive.

The electroplating apparatus for the non-circular substrate provided in this embodiment further comprises a power supply module 103 and a control module 104. The power supply module 103 includes a plurality of independent power supplies, such as 103a, 103b, ..., 103n in FIG. 4. Each block electrode 1021 is provided with a one-to-one corresponding power supply to provide power. When the control module 104 calculates the current I' required by each block electrode 1021 and provides the current I' to the power supply module 103, the corresponding power supply module 103 adjusts the current magnitude and supplies the adjusted current to the block electrode 1021.

FIGS. 5A and 5B are schematic diagrams of the change of the coverage area when a square substrate and a rectangular substrate rotate on the electroplating apparatus of the present invention, respectively. The substrate at the first position is shown by the dashed line in the figure, and the area of the peripheral electrode regions covered by the substrate w at this time can be seen. The substrate w reaching the second position after rotating by a certain angle is shown by the solid line in the figure, and the hatched portion represents the area of the peripheral electrode regions covered by the substrate w at the second position. Since the central electrode 101 is the inscribed circle of the square substrate w, the central electrode 101 is always covered by the substrate w and does not change with the rotation of the substrate w. The peripheral electrode regions 102 are only partially covered by the four corners of the substrate w. It can be seen that the area of the same block electrode 1021 covered by the substrate w is different at different times due to the rotation of the substrate w. Therefore, it is necessary to

determine the area S' of each block electrode 1021 covered by the substrate w and adjust the current supplied to each block substrate 1021.

Returning to FIG. 4, to realize the above process, the control module 104 includes an angle sensor 141 and a projection simulator 142. Taking any corner of the substrate w as a reference vertex, and taking the initial position of the reference vertex as 0° , the angle differences between the other three vertices and the reference vertex are 90° , 180° , and 270° . The angle sensor 141 is arranged in an electroplating chamber and is used for tracking the rotation angle of the reference vertex of the substrate w . According to the rotation angle of the substrate w determined by the angle sensor 141, the angle of the reference vertex of the substrate w can be determined, and the angles of the other three vertices can be calculated accordingly. The projection simulator 142 obtains the rotation angle of the substrate w from the angle sensor 141, determines the positions of all vertices according to the rotation angle of the substrate w , and after determining the positions of all vertices, connects all vertices in a line to simulate the projection area covered by the substrate in the peripheral electrode regions, and further obtains the area of each block electrode 1021 covered by the substrate. In one embodiment, the projection simulator 142 is embedded software implemented in hardware such as processors and controllers. The control module 104 calculates the current required by each block electrode 1021 according to the area of each block electrode 1021 covered by the substrate, and feeds the current back to the power supply module 103 for adjustment. Specifically, since the central electrode 101 is always covered by the substrate w during the process, the current supplied by the power supply module 103 to the central electrode 101 is constant during the entire process, denoted as I . After the control module 104 calculates the area S' of each block electrode 1021 covered by the substrate w , the current required by each block electrode 1021 at present can be calculated as $I' = \frac{S'}{S} \times I$, where S is the total area of the block electrode. The power supply corresponding to each block electrode 1021 adjusts the current magnitude according to the calculated required current. The control module 104 can monitor the rotation angle of the substrate w in real time to adjust the current magnitude required by each block electrode in real time, or can be set to calculate and adjust the current magnitude required by each block electrode through the above steps each time the substrate w rotates by one angular interval.

FIG. 6A is a schematic diagram of a second configuration mode of the power supply module of the electroplating apparatus when the substrate is of rectangular shape. In the second configuration mode, the non-circular substrate w is of rectangular shape. According to FIG. 5B, when the substrate w is of rectangular shape, the area of every two centrosymmetric block electrodes 1021 in the same peripheral electrode region 102 covered by the substrate w is the same. Therefore, every two centrosymmetric block electrodes 1021 in the same peripheral electrode region 102 form an electrode group, and the block electrodes 1021 in each electrode group require the same current magnitude, which can be controlled by one power supply, as shown in FIG. 6A. Therefore, the number of power supplies can be reduced by half compared to the first configuration mode of the power supply module. When the substrate w is of square shape, as the requirement that every two axially symmetric block electrodes 1021 in the same peripheral electrode region 102 are covered by the substrate w with identical areas is also satisfied, this configuration mode of the power supply module is likewise applicable.

FIG. 6B is a schematic diagram of a third configuration mode of the power supply module of the electroplating apparatus when the substrate is of a square shape. In the third configuration mode, when the non-circular substrate w is of a square shape, to save the number of power supplies used by the power supply module 103, the block electrodes 1021 are first grouped according to the number of peripheral electrode regions. As shown in FIG. 6B, the peripheral electrode regions are two in number, including a first peripheral electrode region group and a second peripheral electrode region group. The minimum number of power supplies set for each group can be determined according to the maximum number of block electrodes 1021 that any corner of the substrate w can cover in each peripheral electrode region 102. FIG. 8 shows the minimum number of power supplies that can be set for the first peripheral electrode region 121 and the second peripheral electrode region 122, respectively, when the peripheral electrode regions 102 are under various common equal-division configurations. FIGS. 7A to 7E are schematic diagrams illustrating the number of block electrodes covered by a square substrate on peripheral electrode regions divided into eight, twelve, sixteen, twenty, and twenty-four equal parts, respectively. Taking FIG. 7B as an example, each peripheral electrode region is divided into twelve equal parts to obtain twelve block electrodes of the first peripheral electrode region 121 and twelve

block electrodes of the second peripheral electrode region 122. The maximum number of block electrodes covered by any corner of the substrate w in the first peripheral electrode region 121 is two, and the maximum number of block electrodes covered in the second peripheral electrode region 122 is three. Therefore, the power supply module 103 with the peripheral electrode region divided into twelve equal parts can use a minimum of five power supplies, two power supplies for the first peripheral electrode region 121 and three power supplies for the second peripheral electrode region 122, which is the same as the number in the table shown in FIG. 8.

The electroplating apparatus for the non-circular substrate of the present invention can also be set to perform non-real-time control of the current magnitude; instead, the current is adjusted each time the substrate rotates by a certain angle α . An interval angle α is set, and in the range where the substrate w rotates by 0° to 90° , the area of each block electrode covered by the substrate w when the substrate w rotates by $\alpha, 2\alpha, \dots, n\alpha, \dots, 90^\circ$ is calculated, the current magnitude required by each block electrode is calculated according to the area of each block electrode covered by the substrate, and recorded in the table in FIG. 9. In this embodiment, the control module 104 includes the angle sensor 141 and the controller. The data in FIG. 9 is preset in the controller, and the controller is configured such that the power supply module adjusts the current magnitude of the power supply corresponding to each block electrode each time the substrate w rotates by one interval angle α . During the process, the angle sensor 141 monitors the rotation angle of the substrate w in real time, and when the substrate w rotates by $0, \alpha, 2\alpha, \dots, n\alpha, \dots, 90^\circ$, the angle sensor 141 feeds the angle back to the controller, and the controller transmits a signal to the power supply module according to the preset current magnitude to control the power supply module to adjust the current to the corresponding value. When the substrate w rotates to 90° , the angle is cleared to zero, and the rotation angle of the substrate w is calculated cyclically, and the corresponding current is adjusted.

The present invention also provides an electroplating method for a non-circular substrate, which can also be understood as the working process of the above electroplating apparatus for the non-circular substrate w. FIG. 10 is a flowchart of an electroplating method for a non-circular substrate according to an embodiment of the present invention, and the electroplating method for the non-circular substrate

comprises the following steps:

S1: Dividing an electrode region.

The electrode region is divided into a central electrode region and a peripheral electrode region, the central electrode region is circular in shape and sized to be the inscribed circle of the non-circular substrate, a central electrode is arranged in the central electrode region, and the central electrode fully fills the central electrode region. The peripheral electrode region is arranged around the central electrode region, with an outer periphery of the peripheral electrode region sized to be the circumscribed circle of the non-circular substrate, the peripheral electrode region is an annular region and includes a plurality of block electrodes equally divided along the ring.

S2: Tracking the rotational position of the substrate.

S3: Calculating the current required by each block electrode according to the effective area of the block electrode covered by the substrate.

Since the magnitude of the current I supplied to the central electrode is constant, the area S' of each block electrode covered by the substrate is calculated according to the rotational position of the substrate, and the current I' required by each block electrode is further obtained as $I' = \frac{S'}{S} \times I$, where S' is the current area of the block electrode covered by the substrate, S is the total area of the block electrode, and I is the current supplied to the central electrode.

S4: Adjusting the current supplied by the power supply to the block electrode according to the calculated current magnitude required by the block electrode.

In this method, the current required by each block electrode can be calculated in real time, and the current can be adjusted in real time, or an angular interval can be preset such that Steps S3 and S4 are performed each time Step S2 tracks that the substrate rotates by one angular interval.

The present invention also provides another electroplating method for the non-circular substrate, comprising:

S1: Dividing an electrode region;

S2: Presetting the current parameter required by each block electrode corresponding to each angular interval of substrate rotation;

S3: Tracking the rotational position of the substrate;

S4: When the substrate rotates through each angular interval, adjusting the current according to the preset power supply parameter and supplying the adjusted current to the corresponding block electrode.

It should be noted that, provided the technical solutions are logically accurate, the above-described multiple embodiments may be combined with one another to form new solutions. That is, certain features, structures, or characteristics of one or more embodiments of the present application may be appropriately combined. Further elaboration on such new solutions is omitted herein.

Through the above embodiments and related drawings, the present invention has specifically and thoroughly disclosed the relevant technologies, enabling those skilled in the art to implement the same. The above-described embodiments are merely illustrative of the present invention and are not intended to limit the present invention. The scope of the present invention shall be defined by the appended claims. Changes in the number of elements described herein or substitution of equivalent elements shall all fall within the scope of the present invention.

Meanwhile, specific terms are used in the present invention to describe embodiments of the present invention. Terms such as "one embodiment," "an embodiment," and/or "some embodiments" mean a certain feature, structure, or characteristic related to at least one embodiment of the present invention. Therefore, it should be emphasized and noted that "an embodiment" or "one embodiment" or "an alternative embodiment" mentioned two or more times at different locations in the present specification do not necessarily refer to the same embodiment.

Similarly, it should be noted that, in order to simplify the description of the disclosure of the present invention and thereby facilitate understanding of one or more embodiments of the invention, the foregoing description of the embodiments of the

present invention sometimes consolidates multiple features into one embodiment, accompanying drawing, or description thereof. However, this disclosure method does not imply that the subject of the present invention requires more features than the features mentioned in the claims. In fact, the features of an embodiment are fewer than all the features of the single embodiment disclosed above.

What is claimed is:

1. An electroplating apparatus for a non-circular substrate, comprising:

a central electrode region, circular in shape, sized to be the inscribed circle of the non-circular substrate, a central electrode being arranged in the central electrode region, and the central electrode fully filling the central electrode region;

a peripheral electrode region, arranged around the central electrode region, with an outer periphery of the peripheral electrode region sized to be the circumscribed circle of the non-circular substrate, a peripheral electrode being arranged in the peripheral electrode region, and the peripheral electrode including a plurality of block electrodes that fully fill the peripheral electrode region;

a power supply module, including a plurality of power supplies for supplying power to the central electrode and the peripheral electrode;

a control module, configured to detect the rotational position of the substrate, calculate the current magnitude required by each block electrode at present, and notify the power supply module to adjust the current magnitude.

2. The electroplating apparatus for the non-circular substrate according to claim 1, wherein the current magnitude required by the block electrode is $I' = \frac{S'}{S} \times I$, where S' is the area of the block electrode covered by the substrate, S is the area of the block electrode, and I is the current supplied by the power supply module to the central electrode region.

3. The electroplating apparatus for the non-circular substrate according to claim 2, wherein a plurality of peripheral electrode regions are provided, and the plurality of peripheral electrode regions are concentric annular regions.

4. The electroplating apparatus for the non-circular substrate according to claim 3, wherein the block electrodes are obtained by equally dividing the peripheral electrode into N parts, where N is a multiple of 4.

5. The electroplating apparatus for the non-circular substrate according to claim

2, wherein the control module includes an angle sensor and a projection simulator, the angle sensor is used for tracking the rotation angle of the substrate, and the projection simulator simulates the current position of each vertex of the substrate according to the rotation angle of the substrate to determine the projection area of the substrate in the peripheral electrode region, and further calculates the area of each block electrode covered by the substrate.

6. The electroplating apparatus for the non-circular substrate according to claim 2, wherein the control module includes an angle sensor and a controller, the angle sensor is used for tracking the rotation of the substrate to identify the rotation angle of the substrate, the controller presets the current magnitude to be adjusted for each block electrode corresponding to angular interval of substrate rotation, and when the angle sensor identifies that the substrate rotates by one angular interval each time, the controller feeds the preset current magnitude back to the power supply module according to the preset current magnitude to adjust the corresponding current.

7. The electroplating apparatus for the non-circular substrate according to claim 4, wherein each block electrode is supplied with power by a corresponding one of the plurality of power supplies.

8. The electroplating apparatus for the non-circular substrate according to claim 4, wherein the non-circular substrate is a rectangular substrate.

9. The electroplating apparatus for the non-circular substrate according to claim 8, wherein every two centrosymmetric block electrodes form a group to obtain a plurality of electrode groups, and each electrode group is supplied with power by one power supply.

10. The electroplating apparatus for the non-circular substrate according to claim 4, wherein the non-circular substrate is a square substrate.

11. The electroplating apparatus for the non-circular substrate according to claim 10, wherein the number of power supplies arranged in each peripheral electrode region is the maximum number of block electrodes that any corner of the substrate can cover in each peripheral electrode region.

12. An electroplating method for a non-circular substrate, comprising:

dividing an electrode region, including dividing the electrode region into a central electrode region and a peripheral electrode region, the central electrode region being circular in shape and sized to be the inscribed circle of the non-circular substrate, a central electrode being arranged in the central electrode region, the central electrode fully filling the central electrode region, the peripheral electrode region being arranged around the central electrode region, with an outer periphery of the peripheral electrode region sized to be the circumscribed circle of the non-circular substrate, a peripheral electrode being arranged in the peripheral electrode region, and the peripheral electrode including a plurality of block electrodes that fully fill the peripheral electrode region;

tracking the rotational position of the substrate;

calculating the current required by each block electrode according to the effective area of each block electrode covered by the substrate;

adjusting the current required by each block electrode and supplying the adjusted current to the corresponding block electrode.

13. An electroplating method for a non-circular substrate, comprising:

dividing an electrode region, including dividing the electrode region into a central electrode region and a peripheral electrode region, the central electrode region being circular in shape and sized to be the inscribed circle of the non-circular substrate, a central electrode being arranged in the central electrode region, the central electrode fully filling the central electrode region, the peripheral electrode region being arranged around the central electrode region, with an outer periphery of the peripheral electrode region sized to be the circumscribed circle of the non-circular substrate, a peripheral electrode being arranged in the peripheral electrode region, and the peripheral electrode including a plurality of block electrodes that fully fill the peripheral electrode region;

presetting the current parameter required by each block electrode corresponding to each angular interval of substrate rotation;

tracking the rotational position of the substrate;

when the substrate rotates through each angular interval, adjusting the current according to the preset power supply parameter and supplying the adjusted current to the corresponding block electrode.