

ELECTROPLATING APPARATUS AND ELECTROPLATING METHOD

FIELD OF THE INVENTION

[0001] The present invention relates to the field of semiconductor devices, and in particular, to an electroplating apparatus and an electroplating method.

5

BACKGROUND

[0002] Electroplating is the primary process for completing copper interconnections. Currently, there are two types of electroplating apparatus on the market: horizontal jet cup plating and vertical rack plating. Vertical rack plating is to immerse substrates vertically in the plating solution, and one plating tank can perform multiple substrates plating at the same time. Cup plating is to cover a substrate in a cup-shaped plating tank, and plating is performed one cup per substrate. Compared with rack plating, the process of cup plating is more controllable and can meet more complex and diverse product requirements.

[0003] With the development of technology, the chip area increases, and the number of bumps in the chip increases sharply. There may even be tens of thousands or even more than 100,000 bumps inside a single chip. The electroplating process requires higher electroplating rate and output, and in the field of advanced packaging, higher uniformity inside the chip is also required. However, it is difficult to achieve uniformity inside the chip, that is, the coplanarity of the bumps, in the case of weak stirring. At the same time, for the advanced packaging technology of interconnections between chips, the height of copper pillars can reach 250 um, which puts higher requirements on the mass transfer during the electroplating process. Ordinary stirring has weak mass transfer and cannot meet the requirements of production capacity and quality.

[0004] To enhance the stirring of electroplating solution, a paddle assembly can be installed in the electroplating apparatus, which includes multiple paddles parallel to the substrate surface. The paddles reciprocate to stir the electroplating solution, fully supplying metal ions and electroplating additives to the substrate surface. However, in practice, during the stirring process of ordinary paddles, there is no control over the time while the surface of the substrate is blocked by the paddles. As a result, quantity of electricity received by each point on the surface of the substrate is uneven, and there still exists the problem of uneven electroplating height.

SUMMARY

[0005] The present invention aims to provide an electroplating apparatus and an electroplating method in view of the above technical problems, so as to improve the consistency of electroplating height on the substrate.

5 [0006] To achieve the objective, an embodiment of the present invention proposes an electroplating apparatus comprising multiple parallel paddles, the paddles being arranged in parallel to the substrate to stir the electroplating solution. The electroplating apparatus further comprises a controller and a driving mechanism. The driving mechanism is connected to the controller and the paddles respectively, and the controller controls the driving mechanism to make
10 the paddles move periodically so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

[0007] Taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

[0008] moving right from the coordinate origin to coordinate Δ ;

15 [0009] moving left to coordinate c ;

[0010] moving right to coordinate $\Delta+c$;

[0011] moving left to coordinate $2c$;

[0012] ...

[0013] moving right to coordinate $\Delta+(N-1)*c$;

20 [0014] moving left to coordinate $N*c$;

[0015] moving right to coordinate $\Delta+N*c$;

[0016] moving left back to the coordinate origin;

[0017] Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $b=N*a$ or $a=N*b$, N is an integer.

25 [0018] Another embodiment of the present invention proposes an electroplating apparatus

comprising multiple parallel paddles, the paddles being arranged in parallel to the substrate to stir the electroplating solution. The electroplating apparatus further comprises a controller and a driving mechanism. The driving mechanism is connected to the controller and the paddles respectively, and the controller controls the driving mechanism to make the paddles move periodically so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

[0019] Taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

[0020] moving left to coordinate c ;

10 [0021] moving right to coordinate $\Delta+c$;

[0022] moving left to coordinate $2c$;

[0023] ...

[0024] moving right to coordinate $\Delta+(N-1) *c$;

[0025] moving left to coordinate $N*c$;

15 [0026] moving right to coordinate $\Delta+N*c$;

[0027] moving left to coordinate $N*c$;

[0028] moving right to coordinate $\Delta+(N-1) *c$;

[0029] ...

[0030] moving left to coordinate $2c$;

20 [0031] moving right to coordinate $\Delta+c$

[0032] moving left to coordinate c ;

[0033] moving right to coordinate Δ ;

[0034] moving left back to the origin;

[0035] moving right to coordinate $\Delta+N*c$;

[0036] moving left back to the origin;

[0037] Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $b=N*a$ or $a=N*b$, N is an integer.

5 [0038] Another embodiment of the present invention proposes an electroplating apparatus comprising multiple parallel paddles, the paddles being arranged in parallel to the substrate to stir the electroplating solution. The electroplating apparatus further comprises a controller and a driving mechanism. The driving mechanism is connected to the controller and the paddles respectively, and the controller controls the driving mechanism to make the paddles move periodically so that each corresponding point on the substrate accumulated time blocked by the
10 paddles is equal;

[0039] Taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

[0040] moving right from the origin to coordinate Δ ;

[0041] moving left to coordinate c ;

15 [0042] moving right to coordinate $\Delta+c$;

[0043] moving left to coordinate $2c$;

[0044] ...

[0045] moving right to coordinate $\Delta+(y-2)*c$;

[0046] moving left to coordinate $(y-1)*c$;

20 [0047] moving right to coordinate $\Delta+(y-1)*c$;

[0048] moving left back to the origin;

[0049] Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $y=x*(N+1)$, $b=N*a$ or $a=N*b$, N is a non-integer greater than 1, and x is a value that makes $x*N$ be an integer.

[0050] Another embodiment of the present invention proposes an electroplating apparatus comprising multiple parallel paddles, the paddles being arranged in parallel to the substrate to stir the electroplating solution. The electroplating apparatus further comprises a controller and a driving mechanism. The driving mechanism is connected to the controller and the paddles respectively, and the controller controls the driving mechanism to make the paddles move periodically so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

[0051] Taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

10 [0052] moving right from the origin to coordinate Δ ;

[0053] moving left to coordinate c ;

[0054] moving right to coordinate $\Delta+c$;

[0055] moving left to coordinate $2c$;

[0056] ...

15 [0057] moving right to coordinate $\Delta+(y-2) * c$;

[0058] moving left to coordinate $(y-1) * c$;

[0059] moving right to coordinate $\Delta+(y-1) * c$;

[0060] moving left to coordinate $(y-1) * c$;

[0061] moving right to coordinate $\Delta+(y-2) * c$;

20 [0062] ...

[0063] moving left to coordinate $2c$;

[0064] moving right to coordinate $\Delta+c$;

[0065] moving left to coordinate c ;

[0066] moving right to coordinate Δ ;

[0067] moving left back to the origin;

[0068] moving right to coordinate $\Delta+(y-1)*c$;

[0069] moving left back to the origin;

5 [0070] Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $y=x*(N+1)$, $b=N*a$ or $a=N*b$, N is a non-integer greater than 1, and x is a value that makes $x*N$ be an integer.

10 [0071] One embodiment of the present invention proposes an electroplating method comprising setting multiple parallel paddles, the paddles being arranged parallel to the substrate and moving to stir the electroplating solution, and controlling the paddles movement so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

[0072] Taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

[0073] moving right from the coordinate origin to coordinate Δ ;

[0074] moving left to coordinate c ;

15 [0075] moving right to coordinate $\Delta+c$;

[0076] moving left to coordinate $2c$;

[0077] ...

[0078] moving right to coordinate $\Delta+(N-1)*c$;

[0079] moving left to coordinate $N*c$;

20 [0080] moving right to coordinate $\Delta+N*c$;

[0081] moving left back to the coordinate origin;

[0082] Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $b=N*a$ or $a=N*b$, N is an integer.

[0083] Another embodiment of the present invention proposes an electroplating method comprising setting multiple parallel paddles, the paddles being arranged parallel to the substrate and moving to stir the electroplating solution, and controlling the paddles movement so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

5 [0084] Taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

[0085] moving left to coordinate c ;

[0086] moving right to coordinate $\Delta+c$;

[0087] moving left to coordinate $2c$;

10 [0088] ...

[0089] moving right to coordinate $\Delta+(N-1) *c$;

[0090] moving left to coordinate $N*c$;

[0091] moving right to coordinate $\Delta+N*c$;

[0092] moving left to coordinate $N*c$;

15 [0093] moving right to coordinate $\Delta+(N-1) *c$;

[0094] ...

[0095] moving left to coordinate $2c$;

[0096] moving right to coordinate $\Delta+c$

[0097] moving left to coordinate c ;

20 [0098] moving right to coordinate Δ ;

[0099] moving left back to the origin;

[00100] moving right to coordinate $\Delta+N*c$;

[00101] moving left back to the origin;

[0100] Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $b=N*a$ or $a=N*b$, N is an integer.

[0101] Another embodiment of the present invention proposes an electroplating method comprising setting multiple parallel paddles, the paddles being arranged parallel to the substrate and moving to stir the electroplating solution, and controlling the paddles movement so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

[0101] Taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

[0102] moving right from the origin to coordinate Δ ;

[0103] moving left to coordinate c ;

[0104] moving right to coordinate $\Delta+c$;

[0105] moving left to coordinate $2c$;

[0106] ...

[0107] moving right to coordinate $\Delta+(y-2)*c$;

[0108] moving left to coordinate $(y-1)*c$;

[0109] moving right to coordinate $\Delta+(y-1)*c$;

[0110] moving left back to the origin;

[0100] Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $y=x*(N+1)$, $b=N*a$ or $a=N*b$, N is a non-integer greater than

1, and x is a value that makes $x*N$ be an integer.

[0101] Another embodiment of the present invention proposes an electroplating method comprising setting multiple parallel paddles, the paddles being arranged parallel to the substrate and moving to stir the electroplating solution, and controlling the paddles movement so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

[0102] Taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

[0111] moving right from the origin to coordinate Δ ;

[0112] moving left to coordinate c ;

5 [0113] moving right to coordinate $\Delta+c$;

[0114] moving left to coordinate $2c$;

[0115] ...

[0116] moving right to coordinate $\Delta+(y-2) *c$;

[0117] moving left to coordinate $(y-1) *c$;

10 [0118] moving right to coordinate $\Delta+(y-1) *c$;

[0119] moving left to coordinate $(y-1) *c$;

[0120] moving right to coordinate $\Delta+(y-2) *c$;

[0121] ...

[0122] moving left to coordinate $2c$;

15 [0123] moving right to coordinate $\Delta+c$;

[0124] moving left to coordinate c ;

[0125] moving right to coordinate Δ ;

[0126] moving left back to the origin;

[0127] moving right to coordinate $\Delta+(y-1) *c$;

20 [0128] moving left back to the origin;

[0129] Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $y=x*(N+1)$, $b=N*a$ or $a=N*b$, N is a non-integer greater than

1, and x is a value that makes $x*N$ be an integer.

[0130] The present invention improves the consistency of electroplating height by designing the movement mode of the paddle, which blocks each corresponding point on the substrate for an equal amount of time and receives an equal amount of quantity of electricity.

5

BRIEF DESCRIPTION OF DRAWINGS

[0131] FIG. 1 illustrates a schematic diagram of an electroplating apparatus according to a **first embodiment** of the present invention;

[0132] FIG. 2 shows a top view of a paddle board according to a **first embodiment** of the present invention;

10 [0133] FIG. 3A illustrates a sectional view of a paddle board according to a **first embodiment** of the present invention;

[0134] FIG. 3B is an enlarged view of part D in FIG.3A;

[0135] FIG. 4 shows the dimensions of a paddle according to a **first embodiment** of the present invention;

15 [0136] FIG. 5 illustrates the position changes of a paddle within one cycle according to a **first embodiment** of the present invention;

[0137] FIG. 6 shows the dimensions of a paddle according to a **first embodiment** of the present invention;

20 [0138] FIG. 7 illustrates the position changes of a paddle within one cycle according to a **second embodiment** of the present invention;

[0139] FIG. 8 shows the dimensions of a paddle according to a **third embodiment** of the present invention;

[0140] FIG. 9 illustrates the position changes of a paddle within one cycle according to a **third embodiment** of the present invention;

25 [0141] FIG. 10 illustrates one way of the position changes of a paddle within one cycle according to a **fourth embodiment** of the present invention;

[0142] FIG. 11 shows the dimensions of a paddle according to a **fifth embodiment** of the

present invention;

[0143] FIG. 12 illustrates the position changes of a paddle within one cycle according to a **fifth embodiment** of the present invention;

5 [0144] FIG. 13 illustrates a schematic diagram of an electroplating apparatus in the according to a **seventh embodiment** of the present invention;

[0145] FIG. 14 shows a comparison of an electroplating result curves between an electroplating apparatus with a diffusion plate and an electroplating apparatus without a diffusion plate according to a **seventh embodiment** of the present invention;

10 [0146] FIG. 15 illustrates a coordinate position diagram of a paddle according to an **eighth embodiment** of the present invention;

[0147] FIG. 16 illustrates a connection structure diagram of a paddle board and the guide rail according to a **ninth embodiment** of the present invention;

[0148] FIG. 17 illustrates a nitrogen protection box used to surround an eccentric bearing and a guide rail according to a **ninth embodiment** of the present invention

15 [0149] FIG. 18 illustrates a schematic diagram of a paddle board according to a **tenth embodiment** of the present invention;

[0150] FIG. 19A shows an electroplating effect diagram using an existing electroplating apparatus;

20 [0151] FIG. 19B shows an electroplating effect diagram using an electroplating apparatus of the present invention;

[0152] FIG. 19C shows a comparison of electroplating height data of test points on the substrate using an existing electroplating apparatus and an electroplating apparatus of the present invention.

DETAILED DESCRIPTION

25 [0153] To provide a detailed description of the technical content, structural features, achieved objectives and effects of the present invention, the following will be described in detail with reference to embodiments and accompanying diagrams.

[0154] In an electroplating apparatus, in order to enhance the agitation of the electroplating solution, a paddle can be installed in a position opposite to the substrate. During electroplating,

the paddle reciprocates along a direction parallel to the substrate to enhance the agitation of the electroplating solution. As the paddle itself blocks the electric field, only the gap between the paddles allows the electric field to pass through. Therefore, the area on the substrate facing the paddle will have a "shadow", where the received quantity of electricity is less than that of the "non-shadow" area. If the degree of "shadowing" varies at different points on the substrate, the received quantity of electricity will be uneven, resulting in uneven plating height on the entire substrate.

[0155] During electroplating, the substrate rotates, and the result of the "shadowing" appears as concentric rings on the surface of the substrate, that is, significant fluctuations in the electroplating height along the radial direction of the substrate, as shown in FIG. 19A. The present invention aims to eliminate the "shadowing" effect and ensure consistent electroplating height at all points on the substrate.

First embodiment

[0156] As shown in FIG. 1, the present embodiment discloses an electroplating apparatus comprising an electroplating tank 101, a substrate holder 102, and a plurality of paddles 103 arranged in parallel. The substrate holder 102 is used to clamp the substrate 104, and the paddles 103 are located between the substrate 104 and the electrode, parallel to the substrate 104. During electroplating, the substrate 104 and the paddles 103 are immersed in the electroplating solution in the electroplating tank 101. The paddles 103 reciprocate along a direction parallel to the substrate 104 under the drive of a driving mechanism 105, which can be a motor, to agitate the electroplating solution. The movement direction of the paddles 103 can be further limited by the guide rail 109 connected to them. The driving mechanism 105 is connected to a controller 106, which controls the movement of the paddles 103 by programming the driving mechanism 105.

[0157] As shown in FIG.2, the paddles 103 are formed by rectangular through-holes in a paddle board 108. The material of the paddle board 108 is an insulator, such as PVC, PC, CPVC, PPS, PEEK, PTFE and other plastic materials. Specifically, parallel rectangular through-holes are processed in the circular area in the middle of the paddle board 108, through which the liquid and electric field can pass. The solid part between adjacent through-holes forms the paddles 103. The size of the circular area matches the size of the substrate 104.

[0158] As shown in FIG. 3A and FIG. 3B, the cross-section of the paddles 103 can be roughly trapezoidal, with the bases of each trapezoid located on the same line, which is the direction of the arrangement of the paddles 103. The two legs of the trapezoid have slight curvature.

[0159] The cross-section of the paddles 103 can also be triangular or rectangular. Compared the paddle board with rectangular paddles, the opening area of the paddle board with triangular

or trapezoidal paddles is larger, so that the side of the paddle board **108** with a larger opening area faces the substrate **104**, and the electroplating solution is stirred more fully on this side, thereby further improving the consistency of the plating height. On the other hand, since bubbles are easily generated on the side of the paddle **103** during high-speed stirring, the bubbles will adhere to the side of the paddle **103**. If the side of the paddle **103** is designed as an inclined surface, the bubbles are more easily discharged from the paddle board **108**.

[0160] As shown in FIG. 4, taking the shape of an isosceles triangle as an example, the width of the paddle **103** is a . In other words, the width of the projection of the paddle **103** on the coordinate axis in the direction of the arrangement of the paddles **103** is a , which is the size of the base of the isosceles triangle. The narrowest width of the gap between adjacent paddles **103** is b . In other words, the distance between the two closest points on adjacent paddles **103** is b , which is the distance between the adjacent vertices of two adjacent isosceles triangles.

[0161] In this embodiment, $a=b$, that is, the opening rate of the opening area of the paddle board **108** at the bottom is 50%.

[0162] As shown by the arrow in FIG.4, the movement direction of the paddles **103** is the same as the arrangement direction of the paddles **103**, and is also perpendicular to the length direction of the paddles **103**. Due to the obstruction of the electric field between the electrode and the substrate **104** caused by the paddles **103** itself, the area on the substrate **104** corresponding to the paddle **103** cannot receive electricity. However, the area on the substrate **104** corresponding to the gap between adjacent paddles **103** can receive electricity because there is no obstruction to the electric field between them. In the electroplating process, if each point on the substrate **104** can receive the same amount of electricity, the electroplating height at each point on the substrate **104** can be consistent. The applicant found that this requires optimization design of the size and the movement mode of the paddles **103**.

[0163] As shown in FIG. 5, the triangle represents the cross-section of the paddle **103**. For ease of understanding, one of the paddles **103** is drawn as a black triangle. Since the relative positions of the paddles **103** do not change, the movement of all the paddles **103** is consistent with that of the selected black triangle paddle **103**. Taking the arrangement direction of the paddles **103** as the direction of a one-dimensional coordinate axis, and taking the starting point of the selected black triangle paddle **103** as the origin of the coordinate system, specifically, taking the left endpoint of the selected black triangle paddle **103** as the origin of the coordinate system, the paddle **103** reciprocates along the coordinate axis at the following four coordinate points: Δ , a , $\Delta+a$, 0.

[0164] In order to facilitate the observation of the coordinate position of the paddle **103**, multiple dashed lines perpendicular to the coordinate axis are drawn in FIG. 5, and ellipses indicate several paddles **103** that are not drawn. The arrow with a border indicates the

displacement of the paddle **103**. As can be seen from FIG. **5**, the movement of the paddles **103** within one cycle is divided into the following four steps:

[0165] Step **501**, moving right from the origin to the coordinate Δ ;

[0166] Step **502**, moving left to the coordinate a ;

5 [0167] Step **503**, moving right to the coordinate $\Delta+a$;

[0168] Step **504**, moving left back to the origin.

[0169] Within one cycle, the paddle **103** moves alternately from side to side. Since each point on the substrate **104** corresponding to the paddle **103** is blocked by the paddle **103** for an equal amount of time, when the electric field is evenly distributed, each point on the substrate **104** corresponding to the paddle **103** receives the same amount of quantity of electricity, and thus the electroplating height at each point is the same.

[0170] Within one cycle, to ensure that the coordinate ranges covered by the paddle **103** at each turning point do not overlap, it is required that $\Delta \geq a+b$, that is, $\Delta \geq 2a$, so that the stirring degree at each point during electroplating is more balanced. The width a of the paddle **103** can range from 5 mm to 15 mm, and can be set according to the size of the substrate **104** and the size of the parts of the electroplating apparatus. Taking $a=5\text{mm}$ and $\Delta=15\text{mm}$ as an example, the paddle **103** reverses at the following four coordinate points: 15 mm, 5 mm, 20 mm, 0 mm.

[0171] In the electroplating process, after completing one cycle of movement, the paddle **103** immediately enters the next cycle of movement.

20 Second embodiment

[0172] The present embodiment discloses an electroplating apparatus, which includes all the structures of the electroplating apparatus in **First embodiment**, as shown in FIG. **1**. It will not be repeated here.

[0173] Unlike **First embodiment**, as shown in FIG. **6**, $b=2a$, where a is the width of the paddle **103** and b is the narrowest width of the gap between adjacent paddles **103**. The opening area at the bottom of the paddle plate **108** in this embodiment has a larger opening ratio, approximately 66.7%, compared to the 50% opening ratio. The paddle **103** itself will block the electric field less. Therefore, the movement of the paddle **103** is different. Within one cycle, the paddle **103** reverses at the following six coordinate points: Δ , a , $\Delta+a$, $2a$, $\Delta+2a$, 0, as shown in FIG. **7**. The movement of the paddle **103** consists of the following six steps:

[0174] Step 701: moving right from the origin to coordinate Δ ;

[0175] Step 702: moving left to coordinate a

[0176] Step 703: moving right to coordinate $\Delta+a$;

[0177] Step 704: moving left to coordinate $2a$;

5 [0178] Step 705: moving right to coordinate $\Delta+2a$;

[0179] Step 706: moving left back to the origin.

10 [0180] Within one cycle, the paddle 103 moves alternately from side to side. Since each point on the substrate 104 corresponding to the paddle 103 is blocked by the paddle 103 for an equal amount of time, when the electric field is evenly distributed, each point on the substrate 104 corresponding to the paddle 103 receives the same amount of quantity of electricity, and thus the electroplating height at each point is the same.

15 [0181] Within one cycle, to ensure that the coordinate ranges covered by the paddle 103 at each reversal position do not overlap, it is required that $\Delta \geq a+b$, that is, $\Delta \geq 3a$. Taking $a=6$ mm and $\Delta=20$ mm as an example, the paddle 103 reverses at the following six coordinate points: 20 mm, 6 mm, 26 mm, 12 mm, 32 mm, 0 mm.

Third embodiment

[0182] The present embodiment discloses an electroplating apparatus, which includes all the structures of the electroplating apparatus in **First embodiment**, as shown in FIG. 1. It will not be repeated here.

20 [0183] Unlike **First embodiment**, as shown in FIG. 8, $a=2b$, where a is the width of the paddle 103 and b is the narrowest width of the gap between adjacent paddles 103. The opening area at the bottom of the paddle plate 108 in this embodiment has a smaller opening ratio, approximately 33.3%. This size design can be considered as swapping the size of the paddle 103 in **Second embodiment** with the size of the gap between adjacent paddles 103. Therefore, the movement of
25 the paddle 103 can be similar to that described in **Second embodiment**, where the paddle 103 reverses at the following six coordinate points: Δ , b , $\Delta+b$, $2b$, $\Delta+2b$, 0.

[0184] As shown in FIG. 9, the movement of the paddle 103 within one cycle consists of the following six steps:

[0185] Step 901: moving right from the origin to coordinate Δ .

[0186] Step 902: moving left to coordinate b .

[0187] Step 903: moving right to coordinate $\Delta+b$.

[0188] Step 904: moving left to coordinate $2b$.

[0189] Step 905: moving right to coordinate $\Delta+2b$.

5 [0190] Step 906: moving left back to the origin by moving.

[0191] Within one cycle, the paddle 103 moves alternately from side to side. Since each point on the substrate 104 corresponding to the paddle 103 is blocked by the paddle 103 for an equal amount of time, when the electric field is evenly distributed, each point on the substrate 104 corresponding to the paddle 103 receives the same amount of quantity of electricity, and thus the electroplating height at each point is the same.

[0192] Similarly, within one cycle, to make the coordinates at which the paddle 103 reverses as dispersed as possible, $\Delta \geq a+b$ is required, that is, $\Delta \geq 3b$. Taking $b=10$ mm and $\Delta=35$ mm as an example, the coordinates at which the paddle 103 pauses are: 35 mm, 10 mm, 45 mm, 20 mm, 55 mm, 0 mm.

15 Fourth embodiment

[0193] In First embodiment to Third embodiment, the multiple between the width a of the paddle 103 and the narrowest width b of the gap between adjacent paddles 103 is an integer. For an electroplating apparatus where the multiple between the width a of the paddle 103 and the narrowest width b of the gap between adjacent paddles 103 is an integer, the present embodiment discloses the following electroplating method:

[0194] Execute the program in the controller to move the paddle 103 as follows: within one cycle, the movement steps of the paddle 103 are:

[0195] moving from the origin to coordinate Δ in the direction of the arrangement of the paddle 103;

25 [0196] moving to coordinate c in the opposite direction;

[0197] moving to coordinate $\Delta+c$ in the direction of the arrangement of the paddle 103;

[0198] moving to coordinate $2c$ in the opposite direction;

[0199] ...

[0200] moving to coordinate $\Delta + (N-1) * c$ in the direction of the arrangement of the paddle **103**;

[0201] moving to coordinate $N * c$ in the opposite direction;

[0202] moving to coordinate $\Delta + N * c$ in the direction of the arrangement of the paddle **103**;

5 [0203] moving back to the origin in the opposite direction.

[0204] Wherein, $\Delta \geq a + b$, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $b = N * a$ or $a = N * b$, N is an integer.

[0205] On the one hand, the alternating movement of the paddle **103** can make the distribution of metal ions and electroplating additives in the electroplating solution uniform. On the other hand, each point on the substrate **104** corresponding to the paddle **103** is blocked by the paddle
10 **103** for an equal amount of time, which can make the electroplating height of each point on the substrate **104** corresponding to the paddle **103** the same.

[0206] Alternatively, within one cycle, the paddle **103** can move as follows:

[0207] moving from the origin to coordinate Δ in the direction of the arrangement of the paddle **103**;

15 [0208] moving to coordinate c in the opposite direction;

[0209] moving to coordinate $\Delta + c$ in the direction of the arrangement of the paddle **103**;

[0210] moving to coordinate $2c$ in the opposite direction;

[0211] ...

[0212] moving to coordinate $\Delta + (N-1) * c$ in the direction of the arrangement of the paddle **103**;

20 [0213] moving to coordinate $N * c$ in the opposite direction;

[0214] moving to coordinate $\Delta + N * c$ in the direction of the arrangement of the paddle **103**;

[0215] moving to coordinate $N * c$ in the opposite direction;

[0216] moving to coordinate $\Delta + (N-1) * c$ in the direction of the arrangement of the paddle **103**;

- [0217] ...
- [0218] moving to coordinate $2c$ in the opposite direction;
- [0219] moving to coordinate $\angle + c$ in the direction of the arrangement of the paddle **103**;
- [0220] moving to coordinate c in the opposite direction;
- 5 [0221] moving to coordinate $\angle$ in the direction of the arrangement of the paddle **103**;
- [0222] moving back to the origin in the opposite direction;
- [0223] moving to coordinate $\angle + N * c$ in the direction of the arrangement of the paddle **103**;
- [0224] moving back to the origin in the opposite direction.
- [0225] To display the position of the paddle **103** at each turning point more intuitively, taking
 10 $b = 2a$ as an example, the movement of the paddle **103** within one cycle is divided into the following 12 steps, as shown in FIG. **10**:
- [0226] Step **1001**, moving from the origin to coordinate $\angle$ in the direction of the arrangement of the paddle **103**;
- [0227] Step **1002**, moving to coordinate a in the opposite direction;
- 15 [0228] Step **1003**, moving to coordinate $\angle + a$ in the direction of the arrangement of the paddle **103**;
- [0229] Step **1004**, moving to coordinate $2a$ in the opposite direction;
- [0230] Step **1005**, moving to coordinate $\angle + 2a$ in the direction of the arrangement of the paddle **103**;
- 20 [0231] Step **1006**, moving to coordinate $2a$ in the opposite direction;
- [0232] Step **1007**, moving to coordinate $\angle + a$ in the direction of the arrangement of the paddle **103**;
- [0233] Step **1008**, moving to coordinate a in the opposite direction;
- [0234] Step **1009**, moving to coordinate $\angle$ in the direction of the arrangement of the paddle **103**;

[0235] Step 1010, moving back to the origin in the opposite direction;

[0236] Step 1011, moving to coordinate $\Delta+2a$ in the direction of the arrangement of the paddle 103;

[0237] Step 1012, moving back to the origin in the opposite direction.

5 [0238] Similarly, the time that each point on the substrate 104 corresponding to the paddle 103 is blocked is equal, so the received quantity of electricity is equal and the electroplating height is consistent.

Fifth embodiment

10 [0239] The present embodiment discloses an electroplating apparatus, which includes all the structures of the electroplating apparatus in **First embodiment**, as shown in FIG. 1. It will not be repeated here.

[0240] Unlike **First embodiment**, as shown in FIG. 11, $b=1.5a$, where the width of the paddle 103 is a and the narrowest width of the gap between adjacent paddles 103 is b .

[0241] As shown in FIG. 12, the paddle 103 reverses at the following 10 coordinate points:

15 [0242] $\Delta, a, \Delta+a, 2a, \Delta+2a, 3a, \Delta+3a, 4a, \Delta+4a, 0$.

[0243] Within one cycle, the movement of the paddle 103 includes the following 10 steps:

[0244] Step 1201, moving from the origin to coordinate Δ in the direction of the arrangement of the paddle 103;

[0245] Step 1202, moving to coordinate a in the opposite direction;

20 [0246] Step 1203, moving to coordinate $\Delta+a$ in the direction of the arrangement of the paddle 103;

[0247] Step 1204, moving to coordinate $2a$ in the opposite direction;

[0248] Step 1205, moving to coordinate $\Delta+2a$ in the direction of the arrangement of the paddle 103;

25 [0249] Step 1206, moving to coordinate $3a$ in the opposite direction;

[0250] Step 1207, moving to coordinate $\Delta+3a$ in the direction of the arrangement of the paddle 103;

[0251] Step 1208, moving to coordinate $4a$ in the opposite direction;

5 [0252] Step 1209, moving to coordinate $\Delta+4a$ in the direction of the arrangement of the paddle 103;

[0253] Step 1210, moving back to the origin in the opposite direction.

10 [0254] Within one cycle, the time that each point on the substrate 104 corresponding to the paddle 103 is blocked is equal. When the electric field is uniformly distributed, each point on the substrate 104 corresponding to the paddle 103 receives an equal amount of quantity of electricity, so the electroplating height of each point is the same.

Sixth embodiment

15 [0255] In **Fifth embodiment**, the multiple between the width a of the paddle 103 and the narrowest gap b between adjacent paddles 103 is a non-integer greater than 1. For the electroplating apparatus with a non-integer multiple between a and b greater than 1, the following electroplating method is disclosed in this example:

[0256] Execute the program in the controller to move the paddle 103 as follows: Within one cycle, the movement steps of the paddle are:

[0257] moving right from the origin to coordinate Δ ;

[0258] moving left to coordinate c

20 [0259] moving right to coordinate $\Delta+c$;

[0260] moving left to coordinate $2c$ to the left;

[0261] ...

[0262] moving right to coordinate $\Delta+(y-2) * c$ to the right;

[0263] moving left to coordinate $(y-1) * c$ to the left;

25 [0264] moving right to coordinate $\Delta+(y-1) * c$ to the right;

[0265] moving left to the origin to the left;

[0266] Wherein $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest gap between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $y=x*(N+1)$, $b=N*a$ or $a=N*b$, N is a non-integer greater than 1, and x is a value that makes $x*N$ be an integer.

5 [0267] To understand this method, imagine that c is the smaller value between a and b , and use several small grids with a width of c to fill a large grid with a width of $x*(a+b)$, where x is an integer. Each small grid is arranged along the width direction, the covered positions do not overlap, and the large grid is filled without leaving any gaps. By selecting a suitable value of x , $x*(a+b)$ can be a multiple of c , which satisfies the requirement. $x*(a+b)$ being a multiple of c is equivalent
10 to $x*(N+1)$ being an integer, that is, $x*N$ is an integer.

[0268] The small grids with a width of c are regarded as the paddle **103** with a width of c , $x*(N+1)$ is regarded as the number of return points in a group, and the large grid with a width of $x*(a+b)$ is regarded as the coordinate range covered by the paddle **103** at the return points in the group. The description of filling the large grid with small grids can be regarded as achieving the
15 effect of “the time that each point on the substrate **104** corresponding to the paddle **103** is blocked is equal” mentioned in **Fifth embodiment**. Since there are two groups of return points within one cycle, the number of return points within one cycle is $2x*(N+1)$. To simplify the expression, let $y = x*(N+1)$, then the coordinates of the first group of return points are $0, c, 2c, \dots, (y-2)*c, (y-1)*c$, and the coordinates of the second group of return points are $\Delta, \Delta+c, \Delta+2c, \dots, \Delta+(y-2)*c$,
20 $\Delta+(y-1)*c$.

[0269] Within one cycle, the movement steps of the paddle **103** can also be:

[0270] moving right from the origin to coordinate Δ

[0271] moving left to coordinate c ;

[0272] moving right to coordinate $\Delta+c$;

25 [0273] moving left to coordinate $2c$;

[0274] ...

[0275] moving right to coordinate $\Delta+(y-2)*c$ to the right;

[0276] moving left to coordinate $(y-1)*c$;

[0277] moving right to coordinate $\Delta + (y-1) * c$;

[0278] moving left to coordinate $(y-1) * c$;

[0279] moving right to coordinate $\Delta + (y-2) * c$;

[0280] ...

5 [0281] moving left to coordinate $2c$;

[0282] moving right to coordinate $\Delta + c$;

[0283] moving left to coordinate c ;

[0284] moving right to coordinate Δ ;

[0285] moving left to the origin;

10 [0286] moving right to coordinate $\Delta + (y-1) * c$;

[0287] moving left to the origin.

[0288] Similarly, each point on the substrate **104** corresponding to the paddle **103** is covered for an equal amount of time, and the received quantity of electricity is equal, resulting in a consistent electroplating height.

15 **Seventh embodiment**

[0289] This example discloses an electroplating apparatus that includes all the structures of the electroplating apparatus in **First embodiment**, which will not be repeated here.

20 [0290] In addition, as shown in FIG. **13**, the electroplating apparatus in this example further includes a diffusion plate **107** set between the paddle **103** and the substrate **104**. The diffusion plate **107** has multiple through-holes, and by setting the density and aperture of the through-holes, the consistency of the electroplating height at each point on the substrate can be further improved.

25 [0291] To compare the electroplating results of an electroplating apparatus without the diffusion plate **107** and an electroplating apparatus with the diffusion plate **107** of the present invention, FIG. **14** shows the electroplating result curves of the two electroplating apparatus. The horizontal axis represents the distance between the test point and the center point of the substrate, and the vertical axis represents the electroplating height of the test point. It can be seen that the

electroplating apparatus with the diffusion plate can achieve a more consistent electroplating height.

Eighth embodiment

[0292] The present embodiment discloses an electroplating apparatus, which includes all the structures of the electroplating apparatus in **First embodiment**, as shown in FIG. 1. It will not be repeated here.

[0293] Unlike **First embodiment**, the paddle **103** has an angle α with the coordinate axis in the direction of the paddle arrangement, where α is less than 90° . Therefore, the coordinate of the paddle **103** is the projection of the actual position of the paddle **103** on the coordinate axis. As shown in FIG. 15, if the actual position of a point on the paddle **103** is point A, the coordinate position of the point is the projection point B of point A on the coordinate axis. This can be understood as follows: since only the component of the paddle **103**'s movement in the direction of the coordinate axis will cause a change in the amount of electricity received by the corresponding area on the substrate **104**, only the coordinate change of the paddle **103** on the coordinate axis is considered.

[0294] Obviously, due to the existence of the angle α , the actual distance the paddle **103** moves are greater, so the size of the angle α can be set according to the actual situation.

Ninth embodiment

[0295] The present embodiment discloses an electroplating apparatus, which includes all the structures of the electroplating apparatus in **First embodiment**, as shown in FIG. 1. It will not be repeated here.

[0296] Furthermore, as shown in FIG. 16, one side of the paddle plate **108** is connected to the eccentric bearing **1010** through a connecting member **1011**, and the eccentric bearing **1010** is slidably connected to the guide rail **109**. The paddle plate **108** is driven by the driving mechanism **105** to move. Without the eccentric bearing **1010**, the movement of the paddle plate **108** should be along the direction of the guide rail **109**. If the driving mechanism causes the paddle plate **108** to move in other directions, the paddle plate **108** will be stuck by the guide rail **109**. The function of the eccentric bearing **1010** is to allow for slight deviations between the movement direction of the paddle plate **108** and the direction of the guide rail, preventing the movement of the paddle plate **108** from being obstructed due to installation errors.

[0297] To prevent corrosive gases from corroding precision components, the driving mechanism **105**, eccentric bearing **1010**, and guide rail **109** are surrounded by a nitrogen

protection box **1012**. FIG. **17** shows the eccentric bearing **1010** and guide rail **109** surrounded by the nitrogen protection box **1012**, which has a nitrogen inlet and a nitrogen outlet. The nitrogen protection box **1012** is kept filled with nitrogen, and external gases cannot enter the nitrogen protection box **1012** to corrode the internal precision components. Similarly, the driving mechanism **105** can also be surrounded by another nitrogen protection box.

Tenth embodiment

[0298] The present embodiment discloses an electroplating apparatus, which includes all the structures of the electroplating apparatus in **First embodiment**, as shown in FIG. **1**. It will not be repeated here.

[0299] Unlike **First embodiment**, as shown in FIG. **18**, the shape of the paddle plate **108** is square, suitable for electroplating square substrates. Correspondingly, the paddle **103** is formed by opening a strip through-hole in the square area in the middle of the paddle plate **108**.

[0300] It should be noted that the limitation of the coordinate of the paddle **103** in each embodiment of the present invention is to reflect the translation distance of the paddle **103**. In an electroplating process, the origin position of the coordinate axis can be arbitrarily specified.

[0301] To demonstrate the effect achieved by the present invention, FIG. **19A**, FIG. **19B**, and FIG. **19C** respectively show the electroplating effect of the substrate using an existing electroplating apparatus, the electroplating effect of the substrate using the electroplating apparatus of the present invention, and the electroplating height data of the test points on the substrate. Compared with FIG. **19B**, the concentric circles on the substrate in FIG. **19A** are more obvious, and the electroplating height is uneven. In FIG. **19C**, the horizontal axis represents the distance between the test point and the center point of the substrate, and the vertical axis represents the electroplating height of the test point. It can be seen from FIG. **19C** that using the existing electroplating apparatus, there is a large fluctuation in the electroplating height along the radial direction of the substrate, which is more obvious in the area near the center of the substrate. Using the electroplating apparatus of the present invention, the electroplating height of each point of the substrate is more consistent, and the small differences in electroplating height between different points are related to other factors and are within an acceptable range.

[0302] In summary, the present invention has been specifically and comprehensively disclosed through the above embodiments and related diagrams, enabling those skilled in the art to implement the invention. The above embodiments are only used to illustrate the present invention and are not intended to limit the scope of the present invention. The scope of the present invention should be defined by the claims of the present invention. Changes in the number of components or the substitution of equivalent components as described in this document should also be within

the scope of the present invention.

What is claimed is:

1. An electroplating apparatus, comprising: multiple parallel paddles, the paddles being arranged parallel to a substrate and moving to stir electroplating solution, wherein the electroplating apparatus further comprises a controller and a driving mechanism, the driving mechanism being connected to the controller and the paddles respectively, and the controller controls the driving mechanism to make the paddles move periodically so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

moving right from the coordinate origin to coordinate Δ ;

moving left to coordinate c ;

moving right to coordinate $\Delta+c$;

moving left to coordinate $2c$;

...

moving right to coordinate $\Delta+(N-1)*c$;

moving left to coordinate $N*c$;

moving right to coordinate $\Delta+N*c$;

moving left back to the coordinate origin;

wherein $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width of the gap between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $b=N*a$ or $a=N*b$, and N is an integer.

2. The electroplating apparatus according to claim 1, wherein a diffusion plate is provided between the paddles and the substrate, and the diffusion plate has multiple through-holes.
3. The electroplating apparatus according to claim 1, wherein the electroplating apparatus is provided with a guide rail, and the paddles are formed by opening strip-shaped through-holes on a paddle plate, one side of which is connected to a driving mechanism and the other side is slidably connected to the guide rail via an eccentric bearing.

4. The electroplating apparatus according to claim 3, wherein the driving mechanism, eccentric bearing, and guide rail are surrounded by a nitrogen protection box, and the nitrogen protection box is provided with a nitrogen inlet and a nitrogen outlet.
5. An electroplating apparatus, comprising: multiple parallel paddles, the paddles being arranged parallel to a substrate and moving to stir electroplating solution, wherein the electroplating apparatus further comprises a controller and a driving mechanism, the driving mechanism being connected to the controller and the paddles respectively, and the controller controls the driving mechanism to make the paddles move periodically so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;
 - 10 taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:
 - moving left to coordinate c ;
 - moving right to coordinate $\Delta+c$;
 - moving left to coordinate $2c$;
 - 15 ...
 - moving right to coordinate $\Delta+(N-1) *c$;
 - moving left to coordinate $N*c$;
 - moving right to coordinate $\Delta+N*c$;
 - moving left to coordinate $N*c$;
 - 20 moving right to coordinate $\Delta+(N-1) *c$;
 - ...
 - moving left to coordinate $2c$;
 - moving right to coordinate $\Delta+c$
 - moving left to coordinate c ;
 - 25 moving right to coordinate Δ ;

moving left back to the origin;

moving right to coordinate $\Delta+N*c$;

moving left back to the origin;

Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width of the gap between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $b=N*a$ or $a=N*b$, N is an integer.

6. The electroplating apparatus according to claim 5, wherein a diffusion plate is provided between the paddles and the substrate, and the diffusion plate has multiple through-holes.

7. The electroplating apparatus according to claim 5, wherein the electroplating apparatus is provided with a guide rail, and the paddles are formed by opening strip-shaped through-holes on a paddle plate, one side of which is connected to a driving mechanism and the other side is slidably connected to the guide rail via an eccentric bearing.

8. The electroplating apparatus according to claim 7, wherein the driving mechanism, eccentric bearing, and guide rail are surrounded by a nitrogen protection box, and the nitrogen protection box is provided with a nitrogen inlet and a nitrogen outlet.

9. An electroplating apparatus, comprising: multiple parallel paddles, the paddles being arranged parallel to a substrate and moving to stir electroplating solution, wherein the electroplating apparatus further comprises a controller and a driving mechanism, the driving mechanism being connected to the controller and the paddles respectively, and the controller controls the driving mechanism to make the paddles move periodically so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

moving right from the origin to coordinate Δ ;

moving left to coordinate c ;

moving right to coordinate $\Delta+c$;

moving left to coordinate $2c$;

...

moving right to coordinate $\Delta+(y-2) * c$;

moving left to coordinate $(y-1) * c$;

moving right to coordinate $\Delta+(y-1) * c$;

moving left back to the origin;

5 Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width of the gap between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $y=x*(N+1)$, $b=N*a$ or $a=N*b$, N is a non-integer greater than 1, and x is a value that makes $x*N$ be an integer.

10. An electroplating apparatus, comprising: multiple parallel paddles, the paddles being arranged parallel to a substrate and moving to stir electroplating solution, wherein the electroplating apparatus further comprises a controller and a driving mechanism, the driving mechanism being connected to the controller and the paddles respectively, and the controller controls the driving mechanism to make the paddles move periodically so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

15 taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

moving right from the origin to coordinate Δ ;

moving left to coordinate c ;

moving right to coordinate $\Delta+c$;

moving left to coordinate $2c$;

20 ...

moving right to coordinate $\Delta+(y-2) * c$;

moving left to coordinate $(y-1) * c$;

moving right to coordinate $\Delta+(y-1) * c$;

moving left to coordinate $(y-1) * c$;

25 moving right to coordinate $\Delta+(y-2) * c$;

...

moving left to coordinate $2c$;

moving right to coordinate $\Delta+c$;

moving left to coordinate c ;

5 moving right to coordinate Δ ;

moving left back to the origin;

moving right to coordinate $\Delta+(y-1) * c$;

moving left back to the origin;

10 wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width of the gap between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $y=x*(N+1)$, $b=N*a$ or $a=N*b$, N is a non-integer greater than 1, and x is a value that makes $x*N$ be an integer.

11. An electroplating method, comprising: setting multiple parallel paddles, the paddles being arranged parallel to a substrate and moving to stir electroplating solution, and controlling the paddles movement so that each corresponding point on the substrate accumulated time
15 blocked by the paddles is equal;

taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

moving right from the coordinate origin to coordinate Δ ;

moving left to coordinate c ;

20 moving right to coordinate $\Delta+c$;

moving left to coordinate $2c$;

...

moving right to coordinate $\Delta+(N-1) * c$;

moving left to coordinate $N*c$;

moving right to coordinate $\Delta + N * c$;

moving left back to the coordinate origin;

wherein $\Delta \geq a + b$, a is the width of the paddle, b is the narrowest width of the gap between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $b = N * a$ or $a = N * b$, and N is an integer.

- 5 12. An electroplating method, comprising: setting multiple parallel paddles, the paddles being arranged parallel to a substrate and moving to stir electroplating solution, and controlling the paddles movement so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

10 taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

moving left to coordinate c ;

moving right to coordinate $\Delta + c$;

moving left to coordinate $2c$;

...

15 moving right to coordinate $\Delta + (N - 1) * c$;

moving left to coordinate $N * c$;

moving right to coordinate $\Delta + N * c$;

moving left to coordinate $N * c$;

moving right to coordinate $\Delta + (N - 1) * c$;

20 ...

moving left to coordinate $2c$;

moving right to coordinate $\Delta + c$

moving left to coordinate c ;

moving right to coordinate Δ ;

moving left back to the origin;

moving right to coordinate $\Delta+N*c$;

moving left back to the origin;

5 Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width of the gap between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $b=N*a$ or $a=N*b$, N is an integer.

10 13. An electroplating method, comprising: setting multiple parallel paddles, the paddles being arranged parallel to a substrate and moving to stir electroplating solution, and controlling the paddles movement so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

moving right from the origin to coordinate Δ ;

moving left to coordinate c ;

15 moving right to coordinate $\Delta+c$;

moving left to coordinate $2c$;

...

moving right to coordinate $\Delta+(y-2)*c$;

moving left to coordinate $(y-1)*c$;

20 moving right to coordinate $\Delta+(y-1)*c$;

moving left back to the origin;

Wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width of the gap between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $y=x*(N+1)$, $b=N*a$ or $a=N*b$, N is a non-integer greater than 1, and x is a value that makes $x*N$ be an integer.

14. An electroplating method, comprising: setting multiple parallel paddles, the paddles being arranged parallel to a substrate and moving to stir electroplating solution, and controlling the paddles movement so that each corresponding point on the substrate accumulated time blocked by the paddles is equal;

5 taking the arrangement direction of the paddles as the coordinate axis direction, the movement steps of the paddles within one cycle comprising:

moving right from the origin to coordinate Δ ;

moving left to coordinate c ;

moving right to coordinate $\Delta+c$;

10 moving left to coordinate $2c$;

...

moving right to coordinate $\Delta+(y-2) * c$;

moving left to coordinate $(y-1) * c$;

moving right to coordinate $\Delta+(y-1) * c$;

15 moving left to coordinate $(y-1) * c$;

moving right to coordinate $\Delta+(y-2) * c$;

...

moving left to coordinate $2c$;

moving right to coordinate $\Delta+c$;

20 moving left to coordinate c ;

moving right to coordinate Δ ;

moving left back to the origin;

moving right to coordinate $\Delta+(y-1) * c$;

moving left back to the origin;

wherein, $\Delta \geq a+b$, a is the width of the paddle, b is the narrowest width of the gap between adjacent paddles, $c = \begin{cases} a, & a < b \\ b, & a \geq b \end{cases}$, $y=x*(N+1)$, $b=N*a$ or $a=N*b$, N is a non-integer greater than 1, and x is a value that makes $x*N$ be an integer.