

STIRRING MECHANISM FOR ELECTROPLATING APPARATUS, **ELECTROPLATING APPARATUS, AND ELECTROPLATING METHOD**

FIELD OF THE INVENTION

The present invention relates to the technical field of semiconductor manufacturing, and in particular to a stirring mechanism for an electroplating apparatus, an electroplating apparatus, and an electroplating method.

BACKGROUND

With the popularization of wafer-level packaging technology, the process requirements for electroplating on wafers containing non-electroplated regions have been established. A typical non-electroplated region is in the wafer notch region. In some requirements, dies on a wafer may be arranged in an asymmetrical manner, and irregularly shaped non-electroplated regions may also be formed. Taking the more common wafer notch as the non-electroplated region as an example, in the electroplated region where a chip is arranged, there will be many openings on the photoresist, and metals will be deposited in the openings. These metal-deposited openings act as wires during electroplating. Since no chip is arranged within the wafer notch (the non-electroplated region), there is no opening on the photoresist, and no metal deposition occurs. For the electroplated region and the non-electroplated region, when under a uniform electric field, no current can be generated in the non-electroplated region because of the lack of wires, which will cause a larger current to be generated in the wires in the peripheral region of the non-electroplated region. Hence, the region around the non-electroplated region is exposed to a higher density of metal ions, so the electroplating rate of the region around the non-electroplated region is higher, and the final result is that the electroplating height is higher than other regions. For the wafer-level packaging process, the overall height control is very strict, and the excessively high electroplating height around the wafer notch can easily lead to reduced product yield and yield loss.

SUMMARY

The object of the present invention is to provide a stirring mechanism for an

electroplating apparatus, an electroplating apparatus, and an electroplating method in order to improve the uniformity of the electroplating height.

In a first aspect, the present invention provides a stirring mechanism for an electroplating apparatus, the stirring mechanism comprises a shielding region and a stirring region, the shielding region is used to weaken the flow field in the region, and the stirring region comprises a plurality of first paddles disposed in parallel. Wherein, during the wafer electroplating process, when the wafer notch is located in the shielding region, the rotational speed of the wafer is a first rotational speed, when the wafer notch is located in the stirring region, the rotational speed of the wafer is a second rotational speed, and the first rotational speed is less than the second rotational speed. The shielding region is used to reduce the rotational speed of the wafer, so that the total amount of metal ions received by the wafer notch in the shielding region is reduced.

According to a specific implementation of the embodiment of the present application, the shielding region comprises a region enclosed by a plurality of sequentially connected straight edges and the edge line of the stirring mechanism.

According to a specific implementation of the embodiment of the present application, the shielding region comprises a region enclosed by a curved edge and the edge line of the stirring mechanism.

According to a specific implementation of the embodiment of the present application, the shielding region is a closed block structure, and the height of the upper end surface of the shielding region is higher than the height of the upper end surface of the first paddle.

According to a specific implementation of the embodiment of the present application, a stirring unit is disposed in the shielding region, and the stirring force of the stirring unit is weaker than the stirring force of the first paddles.

According to a specific implementation of the embodiment of the present application, the stirring unit comprises a plurality of second paddles disposed in parallel, and the stirring force of the second paddles in the shielding region is weaker than the stirring force of the first paddles in the stirring region.

According to a specific implementation of the embodiment of the present application, the width of the upper end surface of the second paddle in the shielding region is larger than the width of the lower end surface of the second paddle.

According to a specific implementation of the embodiment of the present application, the height of the upper end surface of the second paddle in the shielding region is higher than or equal to the height of the upper end surface of the first paddle in the stirring region.

According to a specific implementation of the embodiment of the present application, the shielding region is a hollow frame structure.

According to a specific implementation of the embodiment of the present application, the upper end surface of the frame of the shielding region is higher than the upper end surface of the stirring region.

In a second aspect, the present application proposes an electroplating apparatus for performing electroplating on the surface of a wafer, the electroplating apparatus comprises the aforementioned stirring mechanism, and the electroplating apparatus is configured to control the stirring mechanism to move parallel to the wafer to stir the electroplating solution during the electroplating process.

According to a specific implementation of the embodiment of the present application, the electroplating apparatus further comprises a rotatable wafer holding device, the wafer holding device has a clamp for fixing the wafer on the wafer holding device to rotate with the clamp, and the relative position of the wafer notch and the clamp is fixed.

In a third aspect, the present application proposes an electroplating method, comprising: providing a stirring mechanism including a shielding region and a stirring region in an electroplating apparatus, wherein the shielding region is used to weaken the flow field in the region, the stirring region comprises a plurality of first paddles disposed in parallel; the surface of a wafer is electroplated by using the electroplating apparatus provided with the stirring mechanism, the stirring mechanism is controlled to move parallel to the wafer to stirring the electroplating solution; the shielding region

is used to weaken the flow field in the region; and the stirring region comprises a plurality of paddles disposed in parallel. When the wafer notch is located in the shielding region, the rotational speed of the wafer is a first rotational speed, when the wafer notch is located in the stirring region, the rotational speed of the wafer is a second rotational speed, and the first rotational speed is less than the second rotational speed. The shielding region is used to reduce the total amount of metal ions received by the wafer notch in the shielding region, when the wafer notch is located in the shielding region, the rotational speed of the wafer is reduced to reduce the total amount of metal ions received by the wafer notch in the shielding region.

According to a specific implementation of the embodiment of the present application, a rotatable wafer holding device is disposed in the electroplating apparatus, and the rotational speed of the wafer is controlled by regulating the rotational speed of the wafer holding device.

The stirring mechanism for the electroplating apparatus, the electroplating apparatus, and the electroplating method of the present invention provide a shielding region on the stirring mechanism to reduce the flow rate of the electroplating solution in the shielding region. At the same time, in combination with the process, the rotational speed of the wafer is appropriately controlled to be reduced to increase the time of the wafer notch in the shielding region, so that the total amount of metal ions received by the wafer notch in the shielding region is reduced, and the phenomenon that the excessively high electroplating height in the peripheral region of the wafer notch during the electroplating process is avoided. Other features and advantages of the present invention will be set forth in the following specification, and will become apparent in part from the specification, or will be learned by practicing the present invention. The object and other advantages of the present invention can be achieved and obtained by the structures pointed out in the specification and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and performance of the present invention are further described by the following embodiments and the accompanying drawings of the embodiments.

FIG. 1 shows a schematic structural view of an electroplating apparatus according to an embodiment of the present invention;

FIG. 2 shows another schematic structural view of an electroplating apparatus according to an embodiment of the present invention;

FIG. 3 shows a schematic structural view showing the region enclosed by one straight edge of the shielding region of the stirring mechanism and the edge line of the stirring mechanism according to embodiment 1 of the present invention;

FIG. 4 shows a schematic structural view showing the region enclosed by two straight edges of the shielding region of the stirring mechanism and the edge line of the stirring mechanism according to embodiment 1 of the present invention;

FIG. 5 shows a schematic structural view showing the region enclosed by three straight edges of the shielding region of the stirring mechanism and the edge line of the stirring mechanism according to embodiment 1 of the present invention;

FIG. 6 shows a schematic structural view showing the region enclosed by the curved edge of the shielding region of the stirring mechanism and the edge line of the stirring mechanism according to embodiment 1 of the present invention;

FIG. 7 shows a schematic perspective view of the stirring mechanism according to embodiment 2 of the present invention;

FIG. 8 shows a schematic perspective view of the stirring mechanism according to embodiment 3 of the present invention;

FIG. 9 shows a schematic structural view of a stirring mechanism in the prior art;

FIG. 10 shows a schematic view showing the electron density detection result on different regions of a wafer corresponding to a stirring mechanism in the prior art and the stirring mechanism of the present invention;

FIG. 11a shows a schematic view of the position of a detection region *a* corresponding to a prior-art stirring mechanism;

FIG. 11b shows a view showing the change in the flow rate of the electroplating solution in the X and Z directions in region *a* during the electroplating process using a prior-art stirring mechanism;

FIG. 11c shows a schematic view of the change in the electric field intensity in region *a* during the electroplating process using a prior-art stirring mechanism;

FIG. 12a shows a schematic view of the position of the detection region *b* corresponding to the shielding region of the stirring mechanism in FIG. 4;

FIG. 12b shows a view showing the change in the flow rate of the electroplating solution in the X and Z directions in region *b* during the electroplating process using the stirring mechanism in FIG. 4; and

FIG. 12c shows a schematic view of the change in the electric field intensity in region *b* during the electroplating process using the stirring mechanism in FIG. 4.

PREFERRED EMBODIMENTS OF THE INVENTION

In order to further clarify the object, technical solutions and advantages of the embodiments of the present invention, the technical solutions in the embodiments of the present invention will be clearly and completely described below with reference to the drawings in the embodiments of the present invention, and it is obvious that the described embodiments are part of the embodiments of the present invention, not all the embodiments. Based on the embodiments in the present invention, all other embodiments obtained by those of ordinary skill in the art without making creative efforts fall within the scope of protection of the present invention.

Through actual observation and summary of the electroplating process and result, the inventor found that in order to adapt to the situation that different regions of a wafer need to correspond to the fluidity of different electroplating solutions in the same electroplating chamber, the present invention proposes a structural design for a stirring mechanism in an electroplating apparatus, aiming to precisely regulate the total amount of metal ions in the electroplating solutions that different regions of the wafer need to receive. In combination with the controlled rotational speed of the wafer, this approach achieves a better control effect.

According to FIGS. 1 and 2, FIGS. 1 and 2 show schematic structural views of an electroplating apparatus according to an embodiment of the present invention at different angles respectively. The electroplating apparatus according to the embodiment of the present invention comprises an electroplating chamber 100 and a stirring mechanism 200, and the stirring mechanism 200 is disposed in the electroplating chamber 100. The electroplating chamber 100 is used to accommodate the electroplating solution. During the process, a wafer 300 is positioned directly above the stirring mechanism 200, and the stirring mechanism 200 moves parallel to the wafer 300 to stir the electroplating solution. In the embodiment of the present invention, the stirring mechanism 200 is made of an insulating material, such as plastic materials including Polyvinyl Chloride (PVC), Polycarbonate (PC), Chlorinated Polyvinyl Chloride (CPVC), Polyphenylene Sulfide (PPS), Polyether Ether Ketone (PEEK), Polytetrafluoroethylene (PTFE), and the like. The stirring mechanism 200 comprises a shielding region 201 and a stirring region 202, and the shielding region 201 is used for shielding the flow field, weakening the stirring force of the electroplating solution in the region, reducing the fluidity of the electroplating solution in the region, and reducing the metal-ion density of the electroplating solution in the region corresponding to the shielding region 201. The stirring region 202 comprises a plurality of first paddles 203 disposed in parallel, and gaps between adjacent first paddles 203 allow liquid and an electric field to pass through. During the wafer electroplating process, when the wafer notch 301 is located in the shielding region 201, the rotational speed of the wafer 300 is a first rotational speed, when the wafer notch 301 is located in the stirring region 202, the rotational speed of the wafer 300 is a second rotational speed, and the first rotational speed is less than the second rotational speed. The shielding region 201 is used to reduce the total amount of metal ions received by the wafer notch 301 in the shielding region 201. The first rotational speed is less than the second rotational speed, which can ensure that in one complete electroplating process, the duration of the wafer notch 301 in the shielding region 201 is prolonged, and the ion-exchange rate around the wafer notch 301 will be reduced, thereby avoiding the excessively high electroplating height around the wafer notch 301 and achieving the purpose of uniform electroplating.

Furthermore, when the shielding region 201 is designed, the area of the shielding region 201 is larger than the area of the wafer notch 301, so as to ensure that the wafer

notch 301 can be completely in the shielding region 201, and the shielding effect is better. Specifically, when the stirring mechanism 200 is actually disposed, the size and shape of the stirring mechanism 200 are matched and designed according to the size and shape of the wafer 300, so that the electroplating solution and the electric field in the stirring region 202 can better pass through the gaps between adjacent first paddles 203. The shielding region 201 is designed according to the position and size of the wafer notch 301, so that the area of the shielding region 201 is larger than the area of the wafer notch 301 to ensure that the wafer notch 301 can be completely in the shielding region 201. For example, as shown in FIG. 2, when the wafer notch 301 is disposed at the edge of the wafer 300, the shielding region 201 is disposed at the edge of the stirring mechanism 200 correspondingly, and the area of the shielding region 201 is larger than the area of the wafer notch 301.

According to FIG. 1, the electroplating apparatus according to the embodiment of the present invention further comprises a wafer holding device 400, and the wafer 300 is fixed by the wafer holding device 400. The wafer holding device 400 is rotatable, and the wafer 300 is fixed to the wafer holding device 400 to rotate with the wafer holding device 400. Since the relative position of the wafer notch 301 on the wafer 300 and the wafer holding device 400 is fixed, the position of the wafer notch 301 can be known from the rotational position of the wafer holding device 400. During the electroplating process, the wafer holding device 400 drives the wafer 300 to rotate. The rotational speed can be from 0.1 rpm to 500 rpm, and can be specifically determined according to the actual situation. The position of the wafer notch 301 is tracked according to the rotational speed of the wafer holding device 400, when the wafer notch 301 is located in the stirring region 202, the rotational speed of the wafer 300 is controlled to be the second rotational speed, when the wafer notch 301 starts to enter the shielding region 201, the rotational speed of the wafer 300 is reduced to the first rotational speed. The decrease in the rotational speed of the wafer 300 reduces the total amount of metal ions received by the wafer notch 301 in the shielding region 201, and avoids the occurrence of the phenomenon that a larger metal-ion density is generated in the peripheral region of the wafer notch 301, resulting in excessively high electroplating height in the peripheral region of the wafer notch 301.

In order to achieve the above object, the embodiments of the present invention

make a series of optimizations on the specific structure of the stirring mechanism 200, which will be described in detail hereinafter.

Embodiment 1

In the present embodiment, the shielding region 201 is a closed block structure, specifically, the shielding region 201 can include a region enclosed by a plurality of sequentially connected straight edges and the edge line of the stirring mechanism, and the meaning of "a plurality of" in the embodiment of the present invention refers to an integer greater than or equal to 1. The shielding region 201 can also be a region enclosed by a curved edge and the edge line of the stirring mechanism.

As an example, according to FIG. 3, FIG. 3 illustrates the shielding region 201 formed by a region enclosed by a plurality of sequentially connected straight edges and the edge line of the stirring mechanism, wherein the number of straight edges is 1. As can be seen from FIG. 3, both ends of the straight edge 3011 are directly connected to the edge line 3012 of the stirring mechanism to form a closed enclosed region, that is, the shielding region 201, and in this embodiment, the shielding region 201 is a closed block structure. According to FIG. 4, the shielding region 201 enclosed when the number of the straight edges is 2 is illustrated as an example. As can be seen from FIG. 4, the straight edge 4011a and the straight edge 4011b are sequentially connected, the free end of the straight edge 4011a is connected to the edge line 4012 of the stirring mechanism, and the free end of the straight edge 4011b is connected to the edge line 4012 of the stirring mechanism. The closed region enclosed by the straight edge 4011a, the straight edge 4011b, and the edge line 4012 of the stirring mechanism is the shielding region 201, and the shielding region 201 is a closed block structure. Wherein, the term "free end" refers to the outer ends of the straight edge 4011a and the straight edge 4011b, respectively. It is understandable that, although lines or edges are used in the description, both the stirring mechanism and the shielding region 201 are structures with a certain thickness, therefore, the edge line of the stirring mechanism indicates the cross section of the stirring mechanism is the vertical curved surface or planar surface of the edge line, and the straight edge indicates the vertical planar surface in the shielding region with the cross section being a straight line.

According to FIG. 5, the shielding region 201 formed when the number of straight

edges is 3 is illustrated as an example. As can be seen from FIG. 5, one end of the straight edge 5011a is connected to the edge line 5012 of the stirring mechanism, the other end of the straight edge 5011a is connected to one end of the straight edge 5011b, the other end of the straight edge 5011b is connected to one end of the straight edge 5011c, and the other end of the straight edge 5011c is connected to the edge line 5012 of the stirring mechanism. The straight edge 5011a, the straight edge 5011b, and the straight edge 5011c, together with the edge line 5012 of the stirring mechanism, enclose a closed region (the shielding region 201), and the region is a closed block structure.

In other embodiments, the shielding region 201 is a region enclosed by a curved edge and the edge line of the stirring mechanism.

According to FIG. 6, the shielding region 201 enclosed by a curved edge 6011 and the edge line 6012 of the stirring mechanism is illustrated as an example. As can be seen from FIG. 6, both ends of the curved edge 6011 are directly connected to the edge line 6012 of the stirring mechanism to form a closed enclosed region (the shielding region 201). In this embodiment, the shielding region 201 is a closed block structure. It should be understood that the above is merely an example for description, and the number of straight edges is not limited in the embodiment of the present invention. When the number of straight edges is greater than or equal to 2, the included angle formed by the two connected straight edges is not limited in the embodiment of the present invention, and the specific shape of the curved edge is not limited. The curved edge may be an arc or a corrugated curve.

Furthermore, the height of the upper end surface of the shielding region 201 is higher than the height of the upper end surface of the first paddle 203 in the stirring region 202, that is, the upper end surface of the shielding region 201 is closer to the wafer 300 than the upper end surface of the first paddle 203 during the process. If the distance between the shielding region 201 and the wafer 300 is less than the distance between each first paddle 203 and the wafer 300, during the stirring of the electroplating solution by the stirring mechanism 200, the space between the shielding region 201 and the wafer 300 is relatively small, and a limited amount of electroplating solution can be accommodated. At the same time, because the fluidity of the electroplating solution within the region corresponding to the shielding region 201 is

less than the fluidity of the electroplating solution within the region corresponding to the stirring region 202, the metal-ion exchange rate in the electroplating solution within the region corresponding to the shielding region 201 will be lower than the metal-ion exchange rate in the electroplating solution within the region corresponding to the stirring region 202. When the wafer notch 301 rotates into the shielding region 201, the wafer 300 is controlled to decelerate so that the wafer notch 301 is located in the shielding region 201 for a longer time, the total amount of metal ions received by the peripheral region of the wafer notch 301 is reduced, and the electroplating height around the wafer notch 301 is further reduced, so that the overall electroplating height of the wafer 300 is kept uniform. At the same time, the shielding region 201 is a closed block structure made of an insulating material, which will prevent the electric field below the shielding region 201 from being transmitted above the shielding region 201 to act on the wafer 300, so that the current density in the shielding region 201 is also small, and the electroplating layer plated on the region corresponding to the wafer 300 in the shielding region 201 is also correspondingly reduced during electroplating. When the wafer notch 301 is in the shielding region 201 for a long time, the effect of suppressing the electroplating height around the wafer notch 301 is more obvious than the effect in the non-notched region, thereby ensuring that the overall electroplating height of the wafer 300 remains uniform. It should be understood that in other embodiments, the relative height of the upper end surface of the shielding region 201 and the upper end surface of the first paddle 203 of the stirring region 202 can be set according to actual needs.

During the electroplating process, when the wafer notch 301 is located in the shielding region 201, the shielding region 201 plays a role in shielding the electric field, and the current density in the shielding region 201 is relatively low. At this time, the rotational speed of the wafer 300 is reduced, and the duration of the wafer notch 301 in the shielding region 201 becomes longer. Relatively speaking, the electroplating layer plated on the region corresponding to the wafer 300 shielded by the shielding region 201 becomes less, so that the electroplating height of the peripheral region of the wafer notch 301 can be controlled. Because the block structure has a closed characteristic, the electric field in the electroplating chamber 100 is obstructed when the electric field passes through the shielding region 201 being a closed block structure, especially when the stirring mechanism in the embodiments of the present invention

adopts an insulating material, the electric field cannot pass through the shielding region 201, so that the total amount of the electric power received by the peripheral region of the wafer notch 301 in the shielding region 201 is reduced, thereby forming an effect of suppressing the electroplating height of the peripheral region of the wafer notch 301. At the same time, when the shielding region 201 is a closed block structure, the effect of stirring the electroplating solution is weak, so that the fluidity of the electroplating solution in the shielding region 201 is weaker than the fluidity of the electroplating solution in the stirring region 202, the total amount of metal ions received by the wafer notch 301 in the shielding region 201 is reduced, and the electroplating height of the peripheral region of the wafer notch 301 is further suppressed.

Embodiment 2

The structure of the stirring mechanism in embodiment 2 is slightly different from the structure of the stirring mechanism in embodiment 1. A stirring unit is disposed in the shielding region, and the stirring force of the stirring unit is weaker than the stirring force of the paddles in the stirring region. For example, the stirring unit is a structure composed of a plurality of parallel paddles, and the paddles in the shielding region may be perpendicular to the paddles in the stirring region or may be parallel to the paddles in the stirring region, as shown in FIG. 7. The present embodiment is described in an example in which the stirring unit is composed of a plurality of parallel paddles, and the second paddles 204 in the shielding region 201 are parallel to the first paddles 203 in the stirring region 202. In order to make the stirring force of the second paddles 204 weaker than the stirring force of the first paddles 203, the design may be based on various factors, including but not limited to the cross-sectional shape of the second paddles 204, the gaps between adjacent second paddles 204, and the like. Furthermore, the width of the upper end surface of the second paddle 204 is larger than the width of the lower end surface of the second paddle 204, so as to reduce the flow field and shield the electric field at the same time. For example, the cross-sectional shape of the second paddles 204 includes, but is not limited to, an inverted trapezoid, an inverted "T" shape, an inverted triangle, etc. The distance between adjacent second paddles 204 may be selected to be less than the distance between adjacent first paddles 203, or may be selected to be greater than or equal to the distance between adjacent first paddles 203. In the present embodiment, no specific limitation is imposed on any factor that

influences the stirring force of the stirring unit, any arrangement in which the second paddles 204 located inside the shielding region 201 generate a weaker stirring force than the stirring force of the first paddles 203 inside the stirring region 202 falls within the scope of protection of the present invention. In the actual processing and manufacturing process, the first paddles 203 and the second paddles 204 may be processed and manufactured in a manner in which the same paddle is designed in sections and integrally molded, or may be processed and manufactured in sections and then installed and fixed.

Furthermore, the height of the upper end surface of the second paddle 204 is higher than or equal to the height of the upper end surface of the first paddle 203.

In some embodiments, when the upper end surface of the second paddle 204 lie in the same horizontal plane as the upper end surface of the first paddle 203, the stirring force achieved by the cross-sectional shape of the second paddles 204, the gaps between adjacent second paddles 204, or the combination of both and the stirring force achieved by the cross-sectional shape of the first paddles 203, the gaps between adjacent first paddles 203, or the combination of both can be adjusted and designed to achieve the purpose that the stirring force of the second paddles 204 is weaker than the stirring force of the first paddles 203.

In other embodiments, the upper end surface of the second paddle 204 is higher than the upper end surface of the first paddle 203, that is, the upper end surface of the second paddle 204 is closer to the wafer 300 than the upper end surface of the first paddle 203 during the process. The distance between each second paddle 204 and the wafer 300 is less than the distance between each first paddle 203 and the wafer 300, so that in the process of stirring the electroplating solution by the stirring mechanism 200, the fluidity of the electroplating solution in the shielding region 201 is less than the fluidity of the electroplating solution in the stirring region 202, and the purpose of making the metal-ion exchange rate in the electroplating solution in the shielding region 201 is lower than the metal-ion exchange rate in the electroplating solution in the stirring region 202 is further achieved. When the wafer notch 301 rotates into the shielding region 201, the wafer 300 is controlled to decelerate to the first rotational speed, so that the duration of the wafer notch 301 to be located in the shielding region 201 is prolonged, the metal-ion mass transfer rate is reduced, and the electroplating

height of the peripheral region of the wafer notch 301 is further reduced, so that the overall electroplating height of the wafer 300 is kept uniform. It should be understood that when the upper end surface of the second paddle 204 is higher than the upper end surface of the first paddle 203, factors such as the cross-sectional shapes of the second paddles 204 and the first paddles 203, the gaps between adjacent paddles, or a combination of the two may also be taken into account to adjust the stirring force of the shielding region 201 and the stirring region 202, so as to better achieve the purpose that the stirring force of the second paddles 204 is weaker than the stirring force of the first paddles 203.

The height of the upper end surface of the second paddle 204 can be set according to actual needs.

Embodiment 3

The structure of the stirring mechanism in embodiment 3 is slightly different from the structure in embodiment 1, and the shielding region 201 in embodiment 1 is a solid structure. In this embodiment, the shielding region 201 is a hollow frame structure, and no structure is disposed in the shielding region 201 of the hollow frame structure design. In this embodiment, the shielding region 201 is only enclosed by the edge line of the stirring mechanism and a curved edge or a plurality of sequentially connected straight edges. The shape of the enclosed shielding region 201 is as shown in FIGS. 3 to 6 in embodiment 1, and will not be repeated herein. If no paddle-like structure is disposed in the shielding region 201, the stirring force inside the shielding region 201 is weaker than the stirring force inside the stirring region 202, and the fluidity of the electroplating solution in the shielding region 201 is also weaker than the fluidity of the electroplating solution in the stirring region 202, thereby making the mass transfer rate of metal ions in the electroplating solution in the shielding region 201 lower than the mass transfer rate in the stirring region 202. In combination with the control method of controlling the deceleration of the wafer 300 when the wafer notch 301 rotates into the shielding region 201, the duration of the wafer notch 301 to be located in the shielding region 201 is prolonged, the metal-ion mass transfer rate is reduced, and the electroplating height of the peripheral region of the wafer notch 301 is further reduced, so that the overall electroplating height of the wafer 300 is maintained uniformly.

Furthermore, according to FIG. 8, the upper end surface of the edge frame of the shielding region 201 is higher than the upper end surface of the paddle in the stirring region 202 to prevent the rapid exchange of the electroplating solution in the stirring region 202 and the electroplating solution in the shielding region 201. It should be understood that the height of the upper end face of the edge frame of the shielding region 201 may also be selected to be equal to the height of the upper end face of the paddles within the stirring region 202.

When specifically arranged, the position and shape of the shielding region 201 are referred to in embodiment 1, and will not be repeated herein.

The present application also provides an electroplating method for electroplating using an electroplating apparatus, comprising:

Step S1: Providing a stirring mechanism including a shielding region and a stirring region in the electroplating apparatus, wherein the shielding region is used for weakening the flow field in the region, and the stirring region includes a plurality of first paddles disposed in parallel;

Step S2: Performing electroplating on the surface of a wafer by using the electroplating apparatus, controlling the stirring mechanism to move parallel to the wafer to stir the electroplating solution; wherein, when the wafer notch is located in the shielding region, the rotational speed of the wafer is a first rotational speed, when the wafer notch is located in the stirring region, the rotational speed of the wafer is a second rotational speed, the first rotational speed is less than the second rotational speed; the shielding region is used to reduce the total amount of metal ions received by the wafer notch within the shielding region.

The setting of the rotational speed of the wafer in the above steps can be controlled by a controller in the electroplating apparatus.

Furthermore, a rotatable wafer holding device is disposed in the electroplating apparatus, and the rotational speed of the wafer is controlled by regulating the rotational speed of the wafer holding device. Specifically, the rotational speed of the wafer holding device can be regulated by the controller of the electroplating apparatus.

In order to reflect the effect achieved by the present invention, taking the shielding region 201 of the stirring mechanism 200 being a closed block structure as an example, according to FIGS. 9 and 4, FIG. 9 shows a schematic structural view of a stirring mechanism in the prior art.

Under the same electroplating process condition, the stirring mechanisms of FIG. 9 and FIG. 4 are disposed in the electroplating chamber, respectively, so as to detect the charge density in the electroplating solution below the wafer, respectively. For a specific result, as shown in FIG. 10, FIG. 10 shows a schematic view of the charge density detection result on different regions of the wafer corresponding to a stirring mechanism in the prior art and the stirring mechanism of the present invention. In FIG. 10, the horizontal coordinate is the coordinate of the wafer 300 extending from one edge to the other side along the diameter direction, and it can be seen that the size of the wafer 300 in the present embodiment is 300 mm. The vertical coordinate of FIG. 10 indicates the charge density value of the lower surface of the wafer 300. The line *a* indicates the measurement result of the charge density of the wafer corresponding to different positions during the electroplating process by using a stirring mechanism in the prior art; and the line *b* indicates the measurement result of the charge density of the wafer corresponding to different positions during the electroplating process by using the stirring mechanism of the present invention. As shown in FIG. 10, when one edge of the wafer 300 extends to the other side along the diameter direction, the line *a* and the line *b* have an intersection point, and the region between a first intersection point A and a second intersection point B is the shielding region 201 corresponding to the wafer notch 301. The charge density of line *b* in the shielding region 201 is significantly less than the charge density of line *a*, which indicates that the charge density of the stirring mechanism 200 in the shielding region 201 can be significantly reduced after the shielding region 201 is disposed. During the electroplating process, when the wafer notch 301 enters the shielding region 201, the total amount of the electric power received will be reduced, thereby reducing the electroplating height of the peripheral region of the wafer notch 301.

Furthermore, the flow rate of the electroplating solution in the same region of the stirring mechanism 200 in which the shielding region is disposed, and the stirring mechanism 600 in which no shielding region is disposed, is detected. Specifically,

when the wafer 300 is placed in the wafer holding device 400, a region having the same area as the shielding region 201 is defined as a detection region using the central axis of the wafer notch 301 as the center. For the detection region corresponding to the stirring mechanism in the prior art, according to FIG. 11a, the region *a* is the detection region; for the detection region corresponding to the stirring mechanism of the present invention, according to FIG. 12a, the region *b* is the detection region. The flow rate in the X direction, and the flow rate in the Z direction in region *a* and region *b* are detected, and the flow rate result in the X direction in region *a* is shown in FIG. 11b. The horizontal coordinate in FIG. 11b is the position coordinate when the end point of X located on the edge of the wafer 300 extends along the X direction to the other end point in the X direction, and the vertical coordinate indicates the flow rate of the electroplating solution on the surface of the wafer 300. It can be seen from the figure that the average flow rate in the X direction in region *a* is 0.0035 m/s. FIG. 11c shows the flow rate result in the Z direction in region *a*, the horizontal coordinate in FIG. 11c is the position coordinate when the lower end point of Z located on the edge of the wafer 300 extends along the Z direction to the other end point in the Z direction, and the vertical coordinate indicates the flow rate of the electroplating solution on the surface of the wafer 300. It can be seen from the figure that the average flow rate in the Z direction in region *a* is 0.0031 m/s. For the flow rate result in the X direction in region *b*, according to FIG. 12b, the horizontal coordinate in FIG. 12b is the position coordinate when the end point of X located on the edge of the wafer 300 extends along the X direction to the other end point in the X direction, and the vertical coordinate indicates the flow rate of the electroplating solution on the surface of the wafer 300. It can be seen from the figure that the average flow rate in the X direction in region *b* is 0.0014 m/s. For the flow rate result in the Z direction in region *b*, according to FIG. 12c, the horizontal coordinate in FIG. 12c is the position coordinate when the lower end point of Z located on the edge of the wafer 300 extends along the Z direction to the other end point in the Z direction, and the vertical coordinate indicates the flow rate of the electroplating solution on the surface of the wafer 300. It can be seen from the figure that the average flow rate in the Z direction in region *b* is 0.0021 m/s.

According to the experimental data, when the stirring mechanism 600 in the prior art is used to stir the electroplating solution, the flow rate of the electroplating solution and the electric field intensity of the region corresponding to the wafer notch are

relatively high, and the periphery of the wafer notch is prone to excessively high electroplating height. However, the stirring mechanism 200 of the present invention can significantly reduce the flow rate of the electroplating solution and the electric field intensity of the region corresponding to the wafer notch, thereby suppressing the electroplating height around the wafer notch, and making the electroplating height on the wafer surface more uniform. Taking a certain re-distribution layer (RDL) product as an example, the actual required electroplating height is 4 μm . When the electroplating solution is stirred by a stirring mechanism in the prior art, the final electroplating result is that the electroplating height around the wafer notch can reach 8 μm high. After adopting the stirring mechanism designed by the present invention, when the wafer notch rotates into the shielding region, the rotational speed of the wafer is controlled to be decelerated to 5% of the original speed, and the final electroplating result is that the electroplating height around the wafer notch can be reduced by 50%, which meets the requirement (the electroplating height is 4 μm).

Although the present invention has been described in detail with reference to the aforementioned embodiments, those of ordinary skill in the art should understand that the technical solutions described in the aforementioned embodiments can be modified, or some technical features can be equivalently replaced. However, these modifications or replacements do not make the essence of the corresponding technical solutions deviate from the spirit and scope of the technical solutions of each embodiment of the present invention.

What is claimed is:

1. A stirring mechanism for an electroplating apparatus, comprising:

a shielding region, used to weaken the flow field in the region;

a stirring region, including a plurality of first paddles disposed in parallel;

wherein, during the wafer electroplating process, when a wafer notch is located in the shielding region, the rotational speed of the wafer is a first rotational speed, when the wafer notch is located in the stirring region, the rotational speed of the wafer is a second rotational speed, the first rotational speed is less than the second rotational speed; the shielding region is used to reduce the total amount of metal ions received by the wafer notch in the shielding region.

2. The stirring mechanism according to claim 1, wherein the shielding region includes a region enclosed by a plurality of sequentially connected straight edges and the edge line of the stirring mechanism.

3. The stirring mechanism according to claim 1, wherein the shielding region includes a region enclosed by a curved edge and the edge line of the stirring mechanism.

4. The stirring mechanism according to claim 2 or 3, wherein the shielding region is a closed block structure, and the height of the upper end surface of the shielding region is higher than the height of the upper end surface of the first paddle.

5. The stirring mechanism according to claim 1, wherein a stirring unit is disposed in the shielding region, and the stirring force of the stirring unit is weaker than the stirring force of the first paddles.

6. The stirring mechanism according to claim 5, wherein the stirring unit includes a plurality of second paddles disposed in parallel, and the stirring force of the second paddles is weaker than the stirring force of the first paddles.

7. The stirring mechanism according to claim 6, wherein the width of the upper end surface of the second paddle is larger than the width of the lower end surface of

the second paddle.

8. The stirring mechanism according to claim 7, wherein the height of the upper end surface of the second paddle is higher than or equal to the height of the upper end surface of the first paddle.

9. The stirring mechanism according to claim 2 or 3, wherein the shielding region is a hollow frame structure.

10. The stirring mechanism according to claim 9, wherein the upper end surface of the frame of the shielding region is higher than the upper end surface of the stirring region.

11. An electroplating apparatus for performing electroplating on the surface of a wafer, comprising the stirring mechanism according to any one of claims 1 to 10, configured to control the stirring mechanism to move parallel to the wafer to stir the electroplating solution during the electroplating process.

12. The electroplating apparatus according to claim 11, wherein the electroplating apparatus further comprises a rotatable wafer holding device, the wafer holding device has a clamp for fixing the wafer, and the relative position of the wafer notch and the clamp is fixed.

13. An electroplating method, comprising:

providing a stirring mechanism including a shielding region and a stirring region in an electroplating apparatus, the shielding region being used to weaken the flow field in the region, and the stirring region including a plurality of first paddles disposed in parallel;

using the electroplating apparatus to perform electroplating on the surface of a wafer, controlling the stirring mechanism to move parallel to the wafer to stir the electroplating solution;

when the wafer notch is located in the shielding region, the rotational speed of the wafer is a first rotational speed, when the wafer notch is located in the stirring region,

the rotational speed of the wafer is a second rotational speed, the first rotational speed is less than the second rotational speed; and the shielding region is used to reduce the total amount of metal ions received by the wafer notch in the shielding region.

14. The electroplating method according to claim 13, wherein a rotatable wafer holding device is disposed in the electroplating apparatus, and the rotational speed of the wafer is controlled by regulating the rotational speed of the wafer holding device.