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(54) **CUP-SHAPED CHUCK OF SUBSTRATE HOLDING DEVICE, AND SUBSTRATE HOLDING DEVICE**

(57) Disclosed is a cup-shaped chuck of a substrate holding device. The cup-shaped chuck comprises an inner pressing ring, a middle frame, a sealing element, an outer pressing ring and a contact ring. The inner pressing ring is locked on the inner peripheral surface of the middle frame. The sealing element has an outer end part, a bottom part and an inner end part. The outer end part of the sealing element wraps the outer peripheral surface of at least part of the middle frame. The bottom part of the sealing element wraps the bottom of the middle frame, and is exposed to the outside of the cup-shaped chuck. The inner end part of the sealing element wraps the inner peripheral surface of at least part of the middle frame and is pressed between the inner pressing ring and the middle frame by the inner pressing ring. The outer pressing ring is made of an insulating material and is locked on the outer peripheral surface of the middle frame, and the outer end part of the sealing element is pressed between the outer pressing ring and the middle frame by the outer pressing ring. The contact ring is located above the sealing element and is pressed between the inner pressing ring and the middle frame, and a sealing ring is provided between the inner pressing ring and the contact ring.

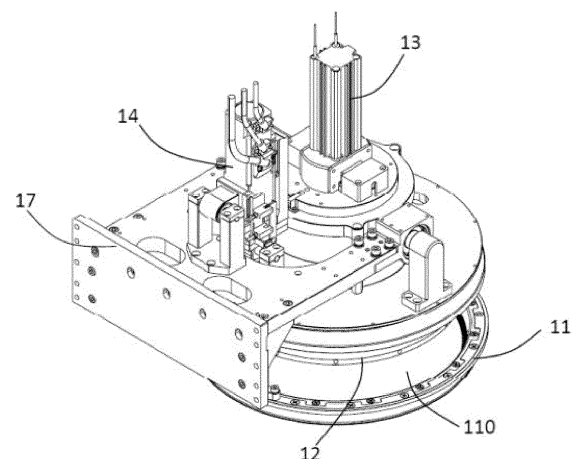


FIG. 1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to the technical field of semiconductor electroplating, and more particularly, to a cup-shaped chuck for holding a substrate during electroplating and a substrate holding device.

2. The Related Art

[0002] An electroplating chuck that holds a substrate is an important part of a semiconductor electroplating equipment. The electroplating chuck is usually equipped with a contact ring and a sealing element, and the sealing element is used to isolate the electroplating solution from the contact ring, so as to avoid the uneven electroplating film caused by poor contact between the contact ring and the seed layer. Therefore, the performance of the sealing element is a key factor in ensuring the normal operation of the electroplating process.

[0003] At present, there are still many problems in the long-term use of the sealing element in the electroplating chuck. For example: 1) As shown in Fig. 18, the electroplating chuck adopts all-wrapped type sealing element 23, and the exposed area of the sealing element 23 is too large, so the outer side 231 and the bottom surface 233 of the sealing element 23 are easily damaged, and especially the bottom bending part 232 is easily damaged. Once the sealing element 23 is damaged, the penetration of the electroplating solution through the sealing element 23 and the contact with the internal metal base 22 will result in partial loss of current, so that the thickness of the electroplating layer on the substrate is lower than the predetermined target value, which affects the product yield. 2) The sealing element 23 wraps a relatively hard metal base 22. The bottom of the metal base 22 is bent upward to form a support part 221, and the thickness of the support part 221 is only 1mm, which is very sharp. The sealing element 23 wraps the support part 221 to form a sealing lip part 234. During the electroplating process, the sealing lip part 234 is in close contact with the substrate through pressure to achieve sealing at the edge and the back of the substrate. However, prolonged stress on the sealing lip part 234 can easily cause the sealing lip part 234 to age and crack. 3) When the electroplating chuck is maintained, the contact ring 25 and the sealing element 23 need to be cleaned. However, the inner pressure ring 24 and the contact ring 25 of the existing electroplating chuck are directly conductive, and there is no seal between the outer metal base 22. When using an online spray cleaning or immersion cleaning, the cleaning solution or electroplating solution will penetrate into the inner layer of the electroplating chuck along the arrow shown in Fig. 18, which cannot achieve the purpose of rapid cleaning and maintenance. It needs to be disas-

sembled separately for maintenance.

SUMMARY

5 **[0004]** One purpose of the present invention is to provide a cup-shaped chuck of a substrate holding device, which can effectively reduce the risk of damage of the sealing element by reducing the exposed area of the sealing element, and in addition, by improving the installation
10 sealing performance of the contact ring, online cleaning of the contact ring and the sealing element can be achieved.

[0005] In order to achieve the above purpose, the cup-shaped chuck of the substrate holding device provided
15 by the present invention includes a cup-shaped chuck for holding a substrate, and the cup-shaped chuck includes:

an inner pressure ring;

20 a middle frame, the inner pressure ring being locked on the inner peripheral surface of the middle frame;

25 a sealing element, the sealing element having an outer end part, a bottom part and an inner end part, the outer end part of the sealing element wrapping the outer peripheral surface of at least part of the middle frame, the bottom part of the sealing element wrapping the bottom of the middle frame and being
30 exposed to the outside of the cup-shaped chuck, the inner end part of the sealing element wrapping the inner peripheral surface of at least part of the middle frame, the inner end part of the sealing element being pressed between the inner pressure ring and the middle frame by the inner pressure ring;

35 an outer pressure ring, the outer pressure ring being made of insulating material and locked on the outer peripheral surface of the middle frame, the outer end part of the sealing element being pressed between the outer pressure ring and the middle frame through the outer pressure ring; and
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45 a contact ring, the contact ring being located above the sealing element and pressed between the inner pressure ring and the middle frame, and a sealing ring being disposed between the inner pressure ring and the contact ring.

50 **[0006]** By employing an insulating outer pressure ring, and is locked with the sealing element, and only the bottom part of the sealing element is exposed, which is beneficial to reduce the exposed area of the sealing element and the risk of damage. By setting the sealing ring between the inner pressure ring and the middle frame, which is beneficial to improve the overall sealing of the cup-shaped chuck, preventing the electroplating solution or cleaning solution from penetrating into the inner layer
55

of the cup-shaped chuck.

[0007] Preferably, in the cup-shaped chuck of the substrate holding device, the bottom of the middle frame forms a horizontal support part radially and horizontally inward, and the bottom part of the sealing element wraps the horizontal support part. The end of the horizontal support part protrudes upwards to form a sealing lip part, and the number of sealing lip parts is one or two or more, and the sealing lip part is configured for sealing contact with the edge of the substrate.

[0008] There is no hard material support inside the sealing lip part, so as to avoid the inner hard support damaging the sealing lip part when the sealing lip part is pressed, which can prolong the service life of the sealing element. At the same time, the radial width of sealing lip part can be designed to be less than 1mm to meet the subsequent narrower edge removal process requirements. When two or more sealing lip parts are provided, multi-stage sealings can be formed between the sealing element and the edge of the substrate, so as to achieve better sealing effect.

[0009] Preferably, in the cup-shaped chuck of a substrate holding device, when the number of sealing lip parts is two or more, the heights of the two or more sealing lip parts are the same.

[0010] Preferably, in the cup-shaped chuck of a substrate holding device, when the number of sealing lip parts is two or more, there is a height difference between at least two of the sealing lip parts.

[0011] Preferably, in the cup-shaped chuck of a substrate holding device, the height of the sealing lip parts gradually increases radially inward.

[0012] Preferably, in the cup-shaped chuck of a substrate holding device, the height of the sealing lip parts gradually decreases radially inward.

[0013] Preferably, in the cup-shaped chuck of a substrate holding device, the heights of the sealing lip parts are alternately arranged high and low in the radial direction.

[0014] Preferably, in the cup-shaped chuck of a substrate holding device, when there is one sealing lip part, the radial width of the one sealing lip part is not more than 1 mm, and when there are two or more sealing lip parts, the total radial width of the two or more sealing lip parts is not more than 1mm.

[0015] Preferably, in the cup-shaped chuck of a substrate holding device, when there is one sealing lip part, the radial width of the one sealing lip part is 0.4mm-0.8mm, and when the number of sealing lip parts is two or more, the total radial width of the two or more sealing lip parts is 0.4mm-0.8mm.

[0016] Preferably, in the cup-shaped chuck of a substrate holding device, the sealing element as a separate accessory is detachable from the middle frame.

[0017] Preferably, in the cup-shaped chuck of a substrate holding device, the sealing element is bonded to the middle frame by an adhesive.

[0018] Preferably, in the cup-shaped chuck of a sub-

strate holding device, several inner sealing protrusions are formed on the contact surface of the sealing element and the middle frame, and correspondingly, the surface of the middle frame has several sealing grooves that match the inner sealing protrusions.

[0019] The inner sealing protrusions can form multi-stage sealings between the sealing element and the middle frame. Once a certain part of the sealing elements damaged, the multi-stage sealings can reduce the diffusion of the electroplating solution into the inner layer of the cup-shaped chuck and reduce the impact of the electroplating solution on the device corrosion.

[0020] Preferably, in the cup-shaped chuck of a substrate holding device, several outer sealing protrusions are formed on the contact surface of the sealing element and the outer pressure ring.

[0021] The outer sealing protrusions can enhance the sealing between the outer pressure ring, the middle frame and the sealing element. In addition, the inner sealing protrusions and the outer sealing protrusions are also conducive to the positioning of the sealing element and the middle frame during assembly, making the assembly of the two components more precise.

[0022] Preferably, in the cup-shaped chuck of a substrate holding device, the sealing element has hydrophobicity properties.

[0023] The hydrophobic treatment of the sealing element can reduce the adhesion of liquid on its surface. The hydrophobic treatment of the sealing element can use hydrophobic materials, or doped hydrophobic materials, or surface coating or sputtering hydrophobic films, or reducing surface roughness. Preferably, the surface roughness Ra of the sealing element is less than 10nm.

[0024] Preferably, in the cup-shaped chuck of a substrate holding device, the outer surface of the outer pressure ring has a blocking part.

[0025] By forming the blocking part on the outer surface of the outer pressure ring, it can increase the resistance of the liquid to climb upward along the outer surface of the outer pressure ring, guide the liquid to change its flow direction and make the liquid be thrown obliquely downward into the liquid collection trough arranged in the electroplating chamber, thereby preventing the liquid from being thrown out of the electroplating chamber and polluting the process environment.

[0026] Preferably, in the cup-shaped chuck of a substrate holding device, the blocking part comprises at least an upper blocking part and/or a lower blocking part. The number of upper blocking parts is one or more, and the number of lower blocking parts is one or more. The upper blocking part is a downward annular protrusion formed on the top of the outer pressure ring, and the lower blocking part is an outward annular protrusion formed at the middle and lower part of the outer pressure ring.

[0027] Preferably, in the cup-shaped chuck of a substrate holding device, the surface of the outer pressure ring has hydrophobicity properties.

[0028] The hydrophobic treatment of the outer pres-

sure ring can reduce the adhesion of liquid on its surface. Specifically, the outer pressure ring can be made of hydrophobic materials, or doped hydrophobic materials, or a hydrophobic film is formed on the surface of the outer pressure ring, or the surface roughness Ra of the outer pressure ring is less than 10nm.

[0029] Preferably, in the cup-shaped chuck of a substrate holding device, several bumps are formed on the contact surface of the outer pressure ring and the sealing element, and several bumps are formed on the contact surface of the inner pressure ring and the sealing element.

[0030] The bumps on the contact surfaces of the outer pressure ring and the inner pressure ring and the sealing element can improve the sealing effect between the parts in contact with each other.

[0031] Preferably, in the cup-shaped chuck of a substrate holding device, the bottom of the outer pressure ring has several bumps.

[0032] Several bumps set at the bottom of the outer pressure ring can play a supporting role during the maintenance of the device, it can keep the sealing element and the worktable at a certain distance, and reduce the damage or contamination of the sealing element.

[0033] Preferably, in the cup-shaped chuck of a substrate holding device, the material of the inner pressure ring is a conductive and corrosion-resistant metal, and the contact ring is electrically connected to the electroplating power supply through the inner pressure ring.

[0034] Preferably, in the cup-shaped chuck of a substrate holding device, the inner pressure ring is made of insulating material, and the middle frame is made of conductive metal, and the contact ring is electrically connected to the electroplating power supply through the middle frame.

[0035] Employing the middle frame to electrically connect the contact ring and the electroplating power supply, the inner pressure ring does not need to meet both conductivity and corrosion resistance, but only needs to have corrosion resistance, that is, the inner pressure ring can be made of insulating materials (such as PVC, PTFE, PVDF, etc.), thus, the material selection range of the inner pressure ring is expanded, which is beneficial to reduce the cost and realize the on-line cleaning of the cup-shaped chuck.

[0036] In the present invention, a substrate holding device is also provided, comprising:

the cup-shaped chuck of any of the above, for holding a substrate;

a chuck plate, the chuck plate pressing against the backside of the substrate so that the substrate is in pressing contact with the sealing element of the cup-shaped chuck;

a chuck plate driving device configured for driving the chuck plate against or away from the backside

of the substrate;

an angle driving device configured for adjusting the angle of the substrate clamped by the cup-shaped chuck and the chuck plate;

a rotation driving device configured for driving the substrate clamped by the cup-shaped chuck and the chuck plate to rotate; and

a vertical driving device configured for driving the substrate clamped by the cup-shaped chuck and the chuck plate to ascend or descend.

[0037] Preferably, in the substrate holding device, the chuck plate comprises a base. The base has a lower surface in contact with the backside of the substrate. The lower surface has several exhaust grooves, and the periphery of the base has several exhaust holes communicating with the exhaust grooves.

[0038] The exhaust grooves and the exhaust holes on the chuck plate facilitate the separation of the chuck plate and the substrate when the substrate is unloaded.

[0039] Preferably, in the substrate holding device, the lower surface of the base has contact parts protruding toward the substrate, so as to reduce the contact area between the chuck plate and the substrate.

[0040] The cup-shaped chuck of a substrate holding device of the present invention adopts an insulating outer pressure ring, which is locked tightly with the middle frame wrapped by the sealing element, so that only the bottom part of the sealing element is exposed, which greatly reduces the exposed area of the sealing element in the electroplating solution, and thus reduces the risk of damage of the sealing element and improves the reliability of the operation of the device; besides, the sealing ring is disposed between the inner pressure ring and the contact ring, so that the upper and lower sides of the contact ring are reliably sealed. During the maintenance of the device, especially when cleaning the contact ring and the sealing element, it can effectively prevent process liquids from infiltrating the inner layer of the cup-shaped chuck, and it is not necessary to disassemble and then maintain each part one by one, which can realize online cleaning, improving the convenience and the efficiency of the device maintenance, and reducing maintenance costs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] The features and performance of the present invention are further described by the following embodiments and accompanying drawings.

Fig. 1 illustrates a perspective view of a substrate holding device of the present invention;

Fig. 2 illustrates another perspective view of the sub-

strate holding device of the present invention;

Fig. 3 illustrates a cross-sectional view of the substrate holding device of the present invention;

Fig. 4 illustrates another cross-sectional view of the substrate holding device of the present invention;

Fig. 5 illustrates a partial enlarged view of A portion in Fig. 4;

Fig. 6 illustrates an enlarged view of some of the components in Fig. 5;

Fig. 7 illustrates a perspective view of a cup-shaped chuck of the present invention;

Fig. 8 illustrates an exploded view of the cup-shaped chuck of the present invention;

Fig. 9 illustrates a partial cross-sectional view of a middle frame of the present invention;

Fig. 10 illustrates a partial cross-sectional view of a sealing element of the present invention;

Fig. 11 illustrates a perspective view of an outer pressure ring of the present invention;

Fig. 12 illustrates a perspective view of a chuck plate of the present invention;

Fig. 13 illustrates another perspective view of the chuck plate of the present invention;

Fig. 14 illustrates a cross-sectional view of the chuck plate of the present invention;

Fig. 15 illustrates a partial enlarged view of B portion in Fig. 14;

Figs. 16a to 16d illustrate schematic views of different forms of outer pressure rings;

Figs. 17a to 17c illustrate partial schematic views of different forms of sealing elements; and

Fig. 18 illustrates an enlarged view of some components of an existing electroplating chuck.

DETAILED DESCRIPTION OF EMBODIMENTS

[0042] In order to describe the technical content, structural features, objectives and effects of the present invention in detail, the following will be described in detail with reference to embodiments and drawings.

[0043] Figs. 1 and 2 illustrate a substrate holding device in an embodiment of the present invention. The sub-

strate holding device includes components such as a cup-shaped chuck 11, a chuck plate 12, a chuck plate driving device 13, an angle driving device 14, a rotation driving device 16, and a vertical driving device. An accommodating space 110 is formed at the center of the cup-shaped chuck 11, and the accommodating space 110 is used for accommodating a substrate 10. The chuck plate driving device 13 is connected to the chuck plate 12 through a universal shaft 15 to drive the chuck plate 12 to ascend and descend. Specifically, referring to Fig. 3, the chuck plate 12 is lifted to the substrate loading/unloading position away from the cup-shaped chuck 11 by the chuck plate driving device 13. After the substrate 10 is put into the accommodating space 110 by a transfer robot, referring to Figs. 4 and 5, the chuck plate 12 is driven downward by the chuck plate driving device 13 to abut against the backside of the substrate 10 to clamp the substrate 10 between the cup-shaped chuck 11 and the chuck plate 12. Generally, the substrate holding device is connected to the vertical driving device (not shown) through a support plate 17, and the vertical driving device drives the substrate 10 clamped by the cup-shaped chuck 11 and the chuck plate 12 to ascend or descend. The angle driving device 14 is used to adjust the angle of the substrate 10 clamped by the cup-shaped chuck 11 and the chuck plate 12 during the process of entering the electroplating solution, so as to reduce the influence of bubbles in the electroplating process. The rotation driving device 16 is used to drive the substrate 10 clamped by the cup-shaped chuck 11 and the chuck plate 12 to rotate during the electroplating process. It can be understood that when the chuck plate 12 is lifted away from the cup-shaped chuck 11 by the chuck plate driving device 13 to clean the cup-shaped chuck 11, the rotation driving device 16 can also drive the cup-shaped chuck 11 to rotate.

[0044] Referring to Fig. 5 and Fig. 6, the cup-shaped chuck 11 includes an inner pressure ring 111, a middle frame 112 and an outer pressure ring 113, wherein the inner pressure ring 111 is locked on the inner peripheral surface of the middle frame 112, and the outer pressure ring 113 is locked on the outer peripheral surface of the middle frame 112. The outer pressure ring 113 is made of insulating material, which can directly contact the electroplating solution during the electroplating process, and there is no leakage problem. In addition, the outer pressure ring 113 has a certain hardness so as to support other components. Specifically, the outer pressure ring 113 can be made of PEEK, PVC, PVDF, PFA, CPVC, PE or PC and other materials.

[0045] Fig. 9 shows a partial cross-sectional view of the middle frame. The middle frame 112 has a side wall 1121, and the upper end of the side wall 1121 extends radially outward to form a first mounting platform 1122. The lower end of the side wall 1121 extends radially inward to form a second mounting platform 1123. The end of the second mounting platform 1123 extends obliquely inwardly to form the bottom of the middle frame 112, and

the end of the bottom of the middle frame 112 extends radially and horizontally inward to form a horizontal support part 1124. Wherein the second mounting platform 1123, the bottom of the middle frame 112 and the horizontal support part 1124 serve as the head of the middle frame 112, and the surface of the head of the middle frame 112 is wrapped with a sealing element 114, which will be described in detail hereinafter. Referring to Figs. 5 and 6 again, a first step 1131 is formed on the upper part of the inner side wall of the outer pressure ring 113, and a second step 1132 is formed at the lower part of the inner side wall of the outer pressure ring 113. When the middle frame 112 is installed in the outer pressure ring 113, the first mounting platform 1122 of the middle frame 112 is pressed against the first step 1131 of the outer pressure ring 113, and the second mounting platform 1123 of the middle frame 112 is pressed against the second step 1132 of the outer pressure ring 113. As shown in Fig. 9, several first positioning grooves 1125 are spaced apart on the upper surface of the first mounting platform 1122 of the middle frame 112. The upper part of the inner pressure ring 111 has several first positioning blocks 1111 (as shown in Fig. 8). When the inner pressure ring 111 is installed in the middle frame 112, the first positioning blocks 1111 of the inner pressure ring 111 are pressed in the first positioning grooves 1125 of the middle frame 112, and the lower part of the inner pressure ring 111 is pressed against the second mounting platform 1123 of the middle frame 112.

[0046] The outer surface of the outer pressure ring 113 has a blocking part for preventing the process liquid, such as electroplating solution, from splashing upward along the outer surface of the outer pressure ring 113 while the cup-shaped chuck rotates. The blocking part includes at least an upper blocking part and/or a lower blocking part. The number of upper blocking parts is one or more than one, and the number of lower blocking parts is one or more than one. The upper blocking part is a downward annular protrusion formed on the top of the outer pressure ring 113, and the lower blocking part is an outward annular protrusion formed at the middle and lower part of the outer pressure ring 113.

[0047] The outer pressure ring 113 shown in Fig. 16 (a) has a lower blocking part 1133. The lower blocking part 1133 is an outward annular protrusion formed at the middle and lower part of the outer pressure ring 113. The cross-sectional profile of the lower blocking part 1133 can be in any shape such as circular arc, elliptical arc, parabola or rectangle, etc. which can prevent the liquid from climbing up along the outer surface of the outer pressure ring 113 or guiding the liquid to flow downward. In Fig. 16 (a), the lower blocking part 1133 is located at the lowest part of the outer pressure ring 113, that is, flush with the bottom surface of the outer pressure ring 113. Of course, it is understood that in other embodiments, the lower blocking part 1133 is higher than the bottom surface of the outer pressure ring 113, and the lower blocking part 1133 is located at the middle and lower part of the

outer pressure ring 113, as shown in Fig. 16 (b). When the cup-shaped chuck 11 rotates, the lower blocking part 1133 will increase the resistance of the liquid to climb upward along the outer side wall of the outer pressure ring 113. Specifically, when the liquid rotates along with the cup-shaped chuck 11, it will be thrown obliquely downward along the solid line arrow in Fig. 16 (a) into the liquid collection trough arranged in the electroplating chamber, instead of climbing upwards along the outer side wall of the outer pressure ring 113 and then throwing out the electroplating chamber obliquely upwards along the dotted line arrow in Fig. 16 (a), polluting the process environment.

[0048] In other embodiments, the outer pressure ring can have two or more lower blocking parts, which can more effectively prevent the liquid from being thrown out obliquely upward along the outer side wall of the outer pressure ring when the cup-shaped chuck rotates. Fig. 16 (c) shows that the lower part of the outer pressure ring 113 has two lower blocking parts 1133, and the two lower blocking parts 1133 are arranged up and down along the outer surface of the outer pressure ring 113. Of course, it can be understood that in other embodiments the number of the lower blocking parts 1133 can be determined according to specific process requirements, and the number of the lower blocking parts 1133 can also be set to three, four or more than four. The outwardly protruding widths of the two or more lower blocking parts 1133 may be the same or different. For example, the outwardly protruding widths of the two or more lower blocking parts 1133 may gradually increase from bottom to top, or may decrease from bottom to top.

[0049] Fig. 16 (d) shows a schematic view of another outer pressure ring. The outer pressure ring 113 has an upper blocking part 1134, which is a downward annular protrusion formed on the top of the outer pressure ring 113. The upper blocking part 1134 is used to change the flow direction of the liquid, so that when the liquid flowing obliquely upward along the outer side wall of the outer pressure ring 113 passes the upper blocking part 1134, the liquid flows obliquely downward along the downwardly protruding upper blocking part 1134. When the cup-shaped chuck 11 rotates, even if part of the liquid climbs over the lower blocking part 1133 to the top of the outer pressure ring 113, it will be intercepted by the upper blocking part 1134 formed at the top of the outer pressure ring 113, and under the action of centrifugal force, it will be thrown obliquely downward into the liquid collection trough set in the electroplating chamber, as shown the solid arrow in Fig. 16 (d), so as to avoid the liquid from splashing out of the electroplating chamber and polluting the process environment. In the embodiment, the included angle θ between the upper blocking part 1134 and the outer peripheral surface of the outer pressure ring 113 is between 80° and 120° , preferably 90° .

[0050] In another embodiment, the number of the upper blocking parts 1134 may also be two or more (not shown in the figure), such as two, three, or four, and the

two or more upper blocking parts 1134 are arranged radially from inside to outside. The downwardly protruding heights of the two or more upper blocking parts 1134 may be the same or different. For example, the downwardly protruding heights of the two or more upper blocking parts 1134 may gradually increase from the inside to the outside, or may gradually decrease from inside to outside.

[0051] In order to reduce the adhesion of the electroplating solution on the surface of the outer pressure ring 113, the surface of the outer pressure ring 113 is treated with hydrophobicity, such as reducing the surface roughness of the outer pressure ring 113. In the embodiment, the surface roughness Ra of the outer pressure ring 113 is less than 10nm. Preferably, the surface roughness Ra of the outer pressure ring 113 is less than 2nm; or coating or sputtering a hydrophobic film (such as PTFE coating) on the surface of the outer pressure ring 113; or the outer pressure ring 113 is made of a hydrophobic material, or is mixed with a hydrophobic material.

[0052] The substrate holding device further includes a sealing element 114 and a contact ring 115, wherein the contact ring 115 generally has a mounting part and a finger part, and the mounting part is pressed between the inner pressure ring 111 and the middle frame 112. The contact ring 115 is installed and fixed in the cup-shaped chuck 11. The end of the finger part is in contact with the edge seed layer of the substrate 10 during the electroplating process to conduct electricity to the substrate. As shown in Fig. 5 and Fig. 6, the sealing element 114 wraps the inner peripheral surface, the bottom and the outer peripheral surface of the middle frame 112, and the contact ring 115 and the sealing ring 116 are sequentially installed on the sealing element 114, and are pressed on the middle frame 112 by the inner pressure ring 111. The inner space of the cup-shaped chuck 11 is sealed by the sealing ring 116, and at the same time, seal is simultaneously formed on the upper and lower sides of the contact ring 115 by the sealing element 114 and the sealing ring 116, thereby effectively preventing the cleaning solution or soaking solution from infiltrating into the inside of the cup-shaped chuck 11 during online cleaning or soaking of the cup chuck 11 after electroplating, that is, preventing the cleaning solution or soaking solution from entering between the inner pressure ring 111 and the middle frame 112. Wherein, the sealing ring 116 can be an O-ring sealing ring.

[0053] In the embodiment, as an independent accessory, the sealing element 114 can be integrally formed by mold opening or injection molding, and can be detachably installed with the middle frame 112. Specifically, the sealing element 114 integrally wraps the head of the middle frame 112, and its two ends are locked and fixed on the middle frame 112 by the inner pressure ring 111 and the outer pressure ring 113. When the sealing element 114 has worn out and its sealing performance has decreased after multiple uses, the damaged sealing element can be removed by simply disassembling the cup-shaped chuck 11, and then the equipment can be put

back into use by replacing with a new sealing element, which can reduce the difficulty and cost of replacing the sealing element. In other embodiments, for ensuring the installation of the sealing element 114 and the middle frame 112 more firmly, the sealing element 114 may be bonded on the middle frame 112 by an adhesive.

[0054] The sealing element 114 can be made of fluorine rubber (such as perfluorinated or fluorine-containing rubber), silicon rubber, etc., and the hardness range can be between 50 and 90 as measured by a durometer. Specifically, the sealing element 114 can be made of different materials depending on the process application. For instance, when electroplating copper, semi-fluorinated rubber (such as Viton fluorine rubber) with good sealing performance and low hardness can be used, while in high-temperature electroplating processes like electroplating nickel or gold, perfluorinated rubber can be used. In other embodiments, the adhesion of the electroplated solution to the surface of sealing element 114 can be reduced by treating the sealing element 114 to make it hydrophobic. Different methods for hydrophobic treatment of the sealing element 114 can be employed, such as: 1) using a hydrophobic material (e.g. Teflon) to make the sealing element 114; 2) coating the surface of the sealing element 114 with a hydrophobic coating (e.g. Teflon coating); 3) doping hydrophobic materials (such as doping Teflon) into the sealing element 114; 4) reducing the surface roughness of the sealing element 114, for example, the surface roughness Ra of the sealing element is less than 10nm, preferably, less than 2nm.

[0055] Fig. 10 shows a partial cross-sectional view of the sealing element. The sealing element 114 has an inner end part 1141, an outer end part 1142 and a bottom part 1143. Referring to Fig. 6, the inner end part 1141 wraps the inner peripheral surface of the middle frame 112 and is pressed against the upper surface of the second mounting platform 1123 of the middle frame 112 by the inner pressure ring 111. The outer end part 1142 wraps the outer peripheral surface of the middle frame 112 and is locked on the lower surface of the second mounting platform 1123 of the middle frame 112 by the second step 1132 of the outer pressure ring 113. The bottom part 1143 of the sealing element 114 wraps the bottom of the middle frame 112, and bends upward to wrap the horizontal support part 1124 of the middle frame 112. Referring to Fig. 10, the sealing element 114 protrudes upward at the end of the horizontal support part 1124 to form a sealing lip part 1144. The thickness of the sealing lip part 1144 is larger than that of the other parts of the sealing element 114. After the substrate 10 is loaded into the cup-shaped chuck 11, the chuck plate 12 presses the backside of the substrate 10 to make the edge of the substrate 10 be tightly attached to the sealing lip part 1144 to seal the edge and the backside of the substrate 10. In the embodiment, there is no metal support inside the sealing lip part 1144 and the thickness of the sealing lip part 1144 is increased, which can effectively prolong the service life of the sealing element 114.

Besides, since there is no metal support inside the sealing lip part 1144, its radial width is only determined by the width of the sealing lip part 1144 itself, which can be designed to be 1mm or less than 1mm. Preferably, the radial width of the sealing lip part 1144 is 0.4mm-0.8mm, and more preferably, the radial width of the sealing lip part 1144 is 0.8mm. The sealing lip part 1144 has a radial width of 1 mm or less than 1 mm, which can reduce the edge pressing width when the sealing element 114 is in sealing contact with the substrate 10, and can meet the requirements of the subsequent narrower and narrower edge removal process.

[0056] In another embodiment, the sealing element has two or more sealing lip parts. The sealing lip part has a certain elasticity, and can be slightly deformed under the pressure of the chuck plate, so that two or more sealing lip parts of the sealing element are in sealing contact with the substrate at the same time to achieve multi-stage sealing between the cup-shaped chuck and the substrate and to achieve better edge sealing effect. Two or more sealing lip parts are distributed radially inward and outward, and the sealing lip parts have the same height, or at least two sealing lip parts have a height difference between them. Specifically, the height of the sealing lip parts gradually rises radially inward, or gradually decreases radially inward, or is alternately arranged high and low in the radial direction. In addition, the total radial width of the two or more sealing lip parts is not greater than 1 mm, and preferably, the total radial width of the two or more sealing lip parts is 0.4 mm-0.8 mm.

[0057] Figs. 17 (a) to 17 (c) show a partial schematic view of a sealing element with two sealing lip parts, which are distributed radially inward and outward, respectively, an inner sealing lip part 1144a and an outer sealing lip part 1144b. Referring to Fig. 17 (a), the heights of the inner sealing lip part 1144a and the outer sealing lip part 1144b are equal, and the height h is about 0.3mm-0.5mm. Referring to Fig. 17 (b), the height h_2 of the inner sealing lip part 1144a is greater than the height h_1 of the outer sealing lip part 1144b, for example, the height h_2 of the inner sealing lip part 1144a is 0.4mm, and the height h_1 of the outer sealing lip part 1144b is 0.35mm. Referring to Fig. 17 (c), the height h_2 of the inner sealing lip part 1144a is smaller than the height h_1 of the outer sealing lip part 1144b, for example, the height h_2 of the inner sealing lip part 1144a is 0.35mm, and the height h_1 of the outer sealing lip part 1144b is 0.4mm.

[0058] The sum of the radial widths of the inner sealing lip part 1144a and the outer sealing lip part 1144b in Fig. 17 (a) to Fig. 17 (c) is not greater than 1mm, that is, $a+b \leq 1$ mm. The radial width a of the inner sealing lip part 1144a and the radial width b of the outer sealing lip part 1144b may be the same or different, preferably, the radial width a of the inner sealing lip part 1144a is smaller than the radial width b of the outer sealing lip part 1144b. Specifically, as shown in Fig. 17(c), the radial width b of the outer sealing lip part 1144b is 0.6 mm, and the radial width a of the inner sealing lip part 1144a is 0.2mm.

[0059] In the embodiment, the outer pressure ring 113 is made of insulating material, specifically, the entire side wall and the bottom of the outer pressure ring 113 are made of insulating material, and the outer pressure ring 113 is locked and sealed with the sealing element 114 from the outside, so that the exposed area of the sealing element 114 has significantly decreased. Therefore, only the bottom part 1143 is exposed to the electroplating solution during the process, effectively reducing the risk of damage of the sealing element 114.

[0060] Referring to Fig. 10 again, the contact surface of the sealing element 114 contacting the outer pressure ring 113 forms several outer sealing protrusions 1146 for enhancing the sealing between the sealing element 114 and the outer pressure ring 113. The contact surface of the sealing element 114 contacting the middle frame 112 forms several inner sealing protrusions 1145. When the sealing element 114 is wrapped to the middle frame 112 and locked by the inner pressure ring 111 and the outer pressure ring 112, the inner sealing protrusions 1145 are embedded in sealing grooves 1128 disposed on the surface of the middle frame 112. On the one hand, the sealing element 114 and the middle frame 112 can be tightly assembled, and on the other hand, a multi-stage seal can be formed inside the sealing element 114 to strengthen sealing effect between the sealing element 114 and the middle frame 112. When the bottom part 1143 of the sealing element 114 is damaged, the multi-circle inner sealing protrusions 1145 can effectively prevent the infiltrated electroplating solution from diffusing inside the cup-shaped chuck 11, reducing the corrosion of the electroplating solution to the inside of the cup-shaped chuck 11. Therefore, the substrate holding device can resume normal operation by simply replacing the sealing element 114, which is beneficial to reduce the maintenance time and cost of the device.

[0061] Since it is difficult to achieve complete sealing by pressing two planes together, the pressing surfaces of the inner pressure ring 111 and the outer pressure ring 113 and the sealing element 114 are provided with several bumps (not shown in the figure). Due to the bumps, the inner pressure ring 111 and the outer pressure ring 113 can be completely attached to the contact surface of the sealing element 114 when locked, thereby improving the sealing performance between the components.

[0062] Referring to Fig. 11, the bottom of the outer pressure ring 113 has bumps 1137. When the cup-shaped chuck 11 needs to be repaired, the bumps 1137 at the bottom of the outer pressure ring 113 can play a supporting role, so that the sealing element 114 remains suspended and not in contact with the maintenance workbench, thereby avoiding damage to the sealing element 114 or contaminating the surface of the sealing element 114. In the embodiment, the height of the bump 1137 at the bottom of the outer pressure ring 113 is about 1mm.

[0063] In the embodiment, the inner pressure ring 111 is made of conductive material, usually conductive metal, and the contact ring 115 is electrically connected to the

electroplating power source through the inner pressure ring 111. In another embodiment, the inner pressure ring 111 and the middle frame 112 are both made of conductive materials, usually conductive metals, the electroplating power source is directly connected to the middle frame 112, and the middle frame 112 is electrically connected to the contact ring 115 through the inner pressure ring 111. Due to the need of maintain the cup-shaped chuck 11 after multiple process cycles, processing liquids such as sulfuric acid, nitric acid, tin-silver deplating solution and various surfactants, etc. are often used. At this time, the inner pressure ring 111 will inevitably contact with the processing liquids. Therefore, the inner pressure ring 111 not only needs to have electrical conductivity, but also needs to have corrosion resistance. The requirements for material selection of the inner pressure ring 111 are high, and conductive and corrosion-resistant metals, such as titanium, titanium alloy, stainless steel and other expensive metal materials, need to be used. This will increase manufacturing and maintenance costs.

[0064] Preferably, in other embodiments, the middle frame 112 is made of conductive material, generally conductive metals, and the contact ring 115 is electrically connected to the electroplating power source through the middle frame 112. Since the middle frame 112 is sealed by the sealing element 114 and the sealing ring 116, no matter in the electroplating process or the cleaning of the device, the middle frame 112 is not in contact with the process liquids, and there is no risk of being corroded by the process liquids. The material of the middle frame 112 only needs to meet the conductivity requirements. Compared with the inner pressure ring 111 as an electrical connection part, the requirements for material selection of the middle frame 112 are reduced, and ordinary conductive metals can be used, which can effectively reduce manufacturing and maintenance costs. And the inner pressure ring 111 only needs to be corrosion-resistant, and corrosion-resistant insulating materials can be used instead of being limited to corrosion-resistant conductive materials, thereby expanding the material selection range of the inner pressure ring 111 and beneficial for reducing costs and realizing the online cleaning of the cup-shaped chuck 11. In the embodiment, the inner pressure ring 111 can be made of PVC, PEEK, PTFE, PVDF, PP, etc.

[0065] Referring to Figs. 7 and 8, the assembly of the cup-shaped chuck 11 is as follows:

Step 1: Wrap the sealing element 114 on the head of the middle frame 112, that is, wrap the sealing element 114 on the second mounting platform 1123, the bottom and the horizontal support part 1124 of the middle frame 112.

Step 2: Assemble the middle frame 112 wrapped by the sealing element 114 into the outer pressure ring 113. The contact surface between the outer pressure ring 113 and the middle frame 112 can be disposed

with several positioning pieces. As shown in Fig. 8, the inner side wall of the outer pressure ring 113 has a second positioning groove 1135, and the outer side wall of the middle frame 112 has a second positioning block 1120 matching with the second positioning groove 1135.

Step 3: Install the contact ring 115 on the middle frame 112, and the finger part of the contact ring 115 is used to contact the seed layer on the edge of the substrate to conduct electricity. For ease of assembly, referring to Fig. 9, several positioning columns 1129 are provided on the second mounting platform 1123 of the middle frame 112 so that the contact ring 115 is mounted on the second mounting platform 1123 of the middle frame 112 along the positioning columns 1129 and is located on the sealing element 114.

Step 4: After the contact ring 115 is installed, install the inner pressure ring 111 on the middle frame 112 and press the contact ring 115. The first positioning block 1111 formed on the periphery of the inner pressure ring 111 is disposed in the first positioning groove 1125 at the top of the middle frame 112, and the sealing ring 116 is installed on the lower surface of the inner pressure ring 111. When the inner pressure ring 111 and the middle frame 112 are locked, the sealing ring 116 is fixed between the inner pressure ring 111 and the contact ring 115.

Step 5: Several screws 117 pass through the first screw holes 1112 on the inner pressure ring 111 and the second screw holes 1126 on the middle frame 112 to lock the inner pressure ring 111 on the inner peripheral surface of the middle frame 112, and make the bottom of the inner pressure ring 111 press the sealing ring 116, the contact ring 115 and the inner end part 1141 of the sealing element 114 on the second mounting platform 1123 of the middle frame 112 in sequence from top to bottom. Several screws 118 pass through the third screw hole 1127 on the middle frame 112 and the fourth screw hole 1136 on the outer pressure ring 113 to lock the outer pressure ring 113 on the outer peripheral surface of the middle frame 112, and press the outer end part 1142 of the sealing element 114 between the outer pressure ring 113 and the middle frame 112.

[0066] Fig. 12 and Fig. 13 show perspective views of the chuck plate in the embodiment. The chuck plate 12 includes a base 121, and the base 121 has a lower surface contacting the substrate 10. Several exhaust grooves 122 are formed on the lower surface of the base 121, and exhaust holes 125 communicating with the exhaust grooves 122 are opened on the periphery of the base 121. When the chuck plate 12 is pressed against the backside of the substrate 10, the pressure on the

backside of the substrate 10 is equal to the ambient pressure through the exhaust holes 125 provided on the periphery of the chuck plate 12, so as to facilitate the separation of the substrate 10 and the chuck plate 12 after the electroplating process is completed, avoiding a slight negative pressure between the chuck plate 12 and the substrate 10 to cause the substrate 10 being adsorbed on the chuck plate 12, and the unloading operation of the substrate 10 is affected.

[0067] Referring to Fig. 13 again, the lower surface of the base 121 is further provided with contact parts protruding toward the substrate 10. Specifically, the contact parts can be a plurality of contact bumps 123 protruding from the lower surface of the base 121, and a contact ring protrusion 124 formed on the lower edge of the base 121. As shown in Fig. 14 and Fig. 15, the protrusion heights of the contact bumps 123 and the contact ring protrusion 124 are the same. When the chuck plate 12 is in contact with the substrate 10, only the contact bumps 123 and the contact ring protrusion 124 are in contact with the backside of the substrate 10, and the rest of the lower surface of the base 121 is not in contact with the substrate 10. On the one hand, the contact area between the chuck plate 12 and the substrate 10 can be reduced, and the scratches and contamination on the backside of the substrate 10 can be reduced. On the other hand, the pressure on the backside of the substrate 10 is equal to the ambient pressure to facilitate the separation of the substrate 10 from the chuck plate 12 when unloading.

[0068] As described above, the present invention has been described in detail through the description of the above-mentioned embodiments and the related drawings, so that those skilled in the art can implement it accordingly. The above-mentioned embodiments are only used to illustrate the present invention, rather than to limit the present invention, and the scope of rights of the present invention should be defined by the claims of the present invention. Changes in the number of elements described herein or substitution of equivalent elements should still fall within the scope of the present invention.

Claims

1. A cup-shaped chuck of a substrate holding device for holding a substrate, comprising:

an inner pressure ring;
a middle frame, wherein the inner pressure ring is locked on an inner peripheral surface of the middle frame;
a sealing element, wherein the sealing element has an outer end part, a bottom part and an inner end part, wherein the outer end part of the sealing element wraps an outer peripheral surface of at least part of the middle frame, and the bottom part of the sealing element wraps the bottom of the middle frame and is exposed to the outside

of the cup-shaped chuck, and the inner end part of the sealing element wraps an inner peripheral surface of at least part of the middle frame, wherein the inner end part of the sealing element is pressed between the inner pressure ring and the middle frame by the inner pressure ring;
an outer pressure ring, wherein the outer pressure ring is made of insulating material and locked on the outer peripheral surface of the middle frame, wherein the outer end part of the sealing element is pressed between the outer pressure ring and the middle frame through the outer pressure ring; and
a contact ring, wherein the contact ring is located above the sealing element and pressed between the inner pressure ring and the middle frame, and a sealing ring is disposed between the inner pressure ring and the contact ring.

2. The cup-shaped chuck of a substrate holding device according to claim 1, wherein the bottom of the middle frame forms a horizontal support part radially and horizontally inward, and the bottom part of the sealing element wraps the horizontal support part, wherein the end of the horizontal support part protrudes upwards to form a sealing lip part, and the number of sealing lip part is one or two or more, and the sealing lip part is configured for sealing contact with the edge of the substrate.
3. The cup-shaped chuck of a substrate holding device according to claim 2, wherein when the number of sealing lip parts is two or more, the heights of the two or more sealing lip parts are the same.
4. The cup-shaped chuck of a substrate holding device according to claim 2, wherein when the number of sealing lip parts is two or more, there is a height difference between at least two of the sealing lip parts.
5. The cup-shaped chuck of a substrate holding device according to claim 4, wherein the height of the sealing lip parts gradually increases radially inward.
6. The cup-shaped chuck of a substrate holding device according to claim 4, wherein the height of the sealing lip parts gradually decreases radially inward.
7. The cup-shaped chuck of a substrate holding device according to claim 4, wherein the heights of the sealing lip parts are alternately arranged high and low in the radial direction.
8. The cup-shaped chuck of a substrate holding device according to claim 2, wherein when there is one sealing lip part, the radial width of the one sealing lip part is not more than 1 mm, and when there are two or

more sealing lip parts, the total radial width of the two or more sealing lip parts is not more than 1mm.

9. The cup-shaped chuck of a substrate holding device according to claim 8, wherein when there is one sealing lip part, the radial width of the one sealing lip part is 0.4mm-0.8mm, and when the number of sealing lip parts is two or more, the total radial width of the two or more sealing lip parts is 0.4mm-0.8mm.
10. The cup-shaped chuck of a substrate holding device according to claim 1, wherein the sealing element as a separate accessory is detachable from the middle frame.
11. The cup-shaped chuck of a substrate holding device according to claim 10, wherein the sealing element is bonded to the middle frame by an adhesive.
12. The cup-shaped chuck of a substrate holding device according to claim 1, wherein several inner sealing protrusions are formed on the contact surface of the sealing element and the middle frame, and correspondingly, the surface of the middle frame has several sealing grooves that match the inner sealing protrusions.
13. The cup-shaped chuck of a substrate holding device according to claim 12, wherein several outer sealing protrusions are formed on the contact surface of the sealing element and the outer pressure ring.
14. The cup-shaped chuck of a substrate holding device according to claim 1, wherein the sealing element has hydrophobicity properties.
15. The cup-shaped chuck of a substrate holding device according to claim 1, wherein the outer surface of the outer pressure ring has a blocking part.
16. The cup-shaped chuck of a substrate holding device according to claim 15, wherein the blocking part comprises at least an upper blocking part and/or a lower blocking part, wherein the number of upper blocking parts is one or more, and the number of lower blocking parts is one or more, wherein the upper blocking part is a downward annular protrusion formed on the top of the outer pressure ring, and the lower blocking part is an outward annular protrusion formed at the middle and lower part of the outer pressure ring.
17. The cup-shaped chuck of a substrate holding device according to claim 1, wherein the surface of the outer pressure ring has hydrophobicity properties.
18. The cup-shaped chuck of a substrate holding device according to claim 1, wherein several bumps are formed on the contact surface of the outer pressure

ring and the sealing element, and several bumps are formed on the contact surface of the inner pressure ring and the sealing element.

19. The cup-shaped chuck of a substrate holding device according to claim 1, wherein the bottom of the outer pressure ring has several bumps.
20. The cup-shaped chuck of a substrate holding device according to claim 1, wherein the material of the inner pressure ring is a conductive and corrosion-resistant metal, and the contact ring is electrically connected to an electroplating power supply through the inner pressure ring.
21. The cup-shaped chuck of a substrate holding device according to claim 1, wherein the inner pressure ring is made of insulating material, the middle frame is made of conductive metal, and the contact ring is electrically connected to an electroplating power supply through the middle frame.
22. A substrate holding device, comprising:
 - a cup-shaped chuck as claimed in anyone of claims 1 to 21 for holding a substrate;
 - a chuck plate, wherein the chuck plate presses against the backside of the substrate so that the substrate is in pressing contact with the sealing element of the cup-shaped chuck;
 - a chuck plate driving device configured for driving the chuck plate against or away from the backside of the substrate;
 - an angle driving device configured for adjusting the angle of the substrate clamped by the cup-shaped chuck and the chuck plate;
 - a rotation driving device configured for driving the substrate clamped by the cup-shaped chuck and the chuck plate to rotate; and
 - a vertical driving device configured for driving the substrate clamped by the cup-shaped chuck and the chuck plate to ascend or descend.
23. The substrate holding device according to claim 22, wherein the chuck plate comprises a base, the base has a lower surface contacting with the backside of the substrate, the lower surface of the base has several exhaust grooves, and the periphery of the base has several exhaust holes communicating with the exhaust grooves.
24. The substrate holding device according to claim 23, wherein the lower surface of the base has contact parts protruding toward the substrate, so as to reduce the contact area between the chuck plate and the substrate.

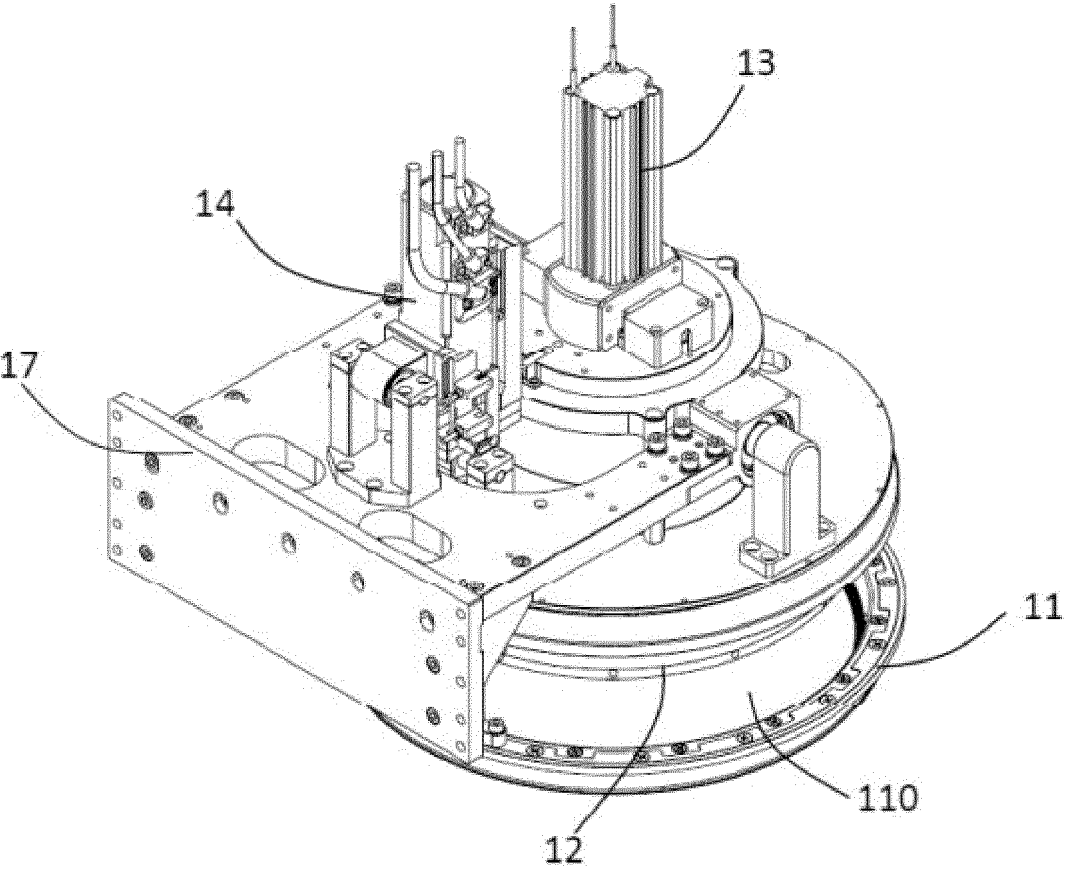


FIG. 1

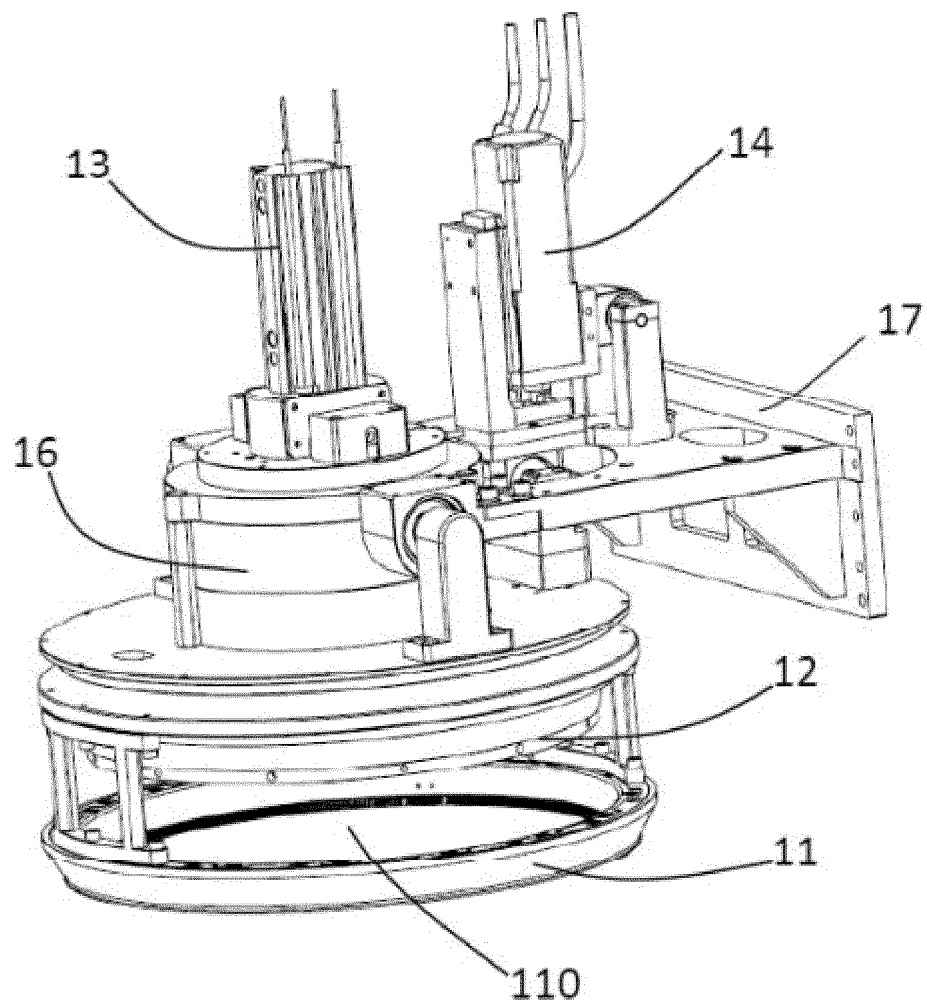


FIG. 2

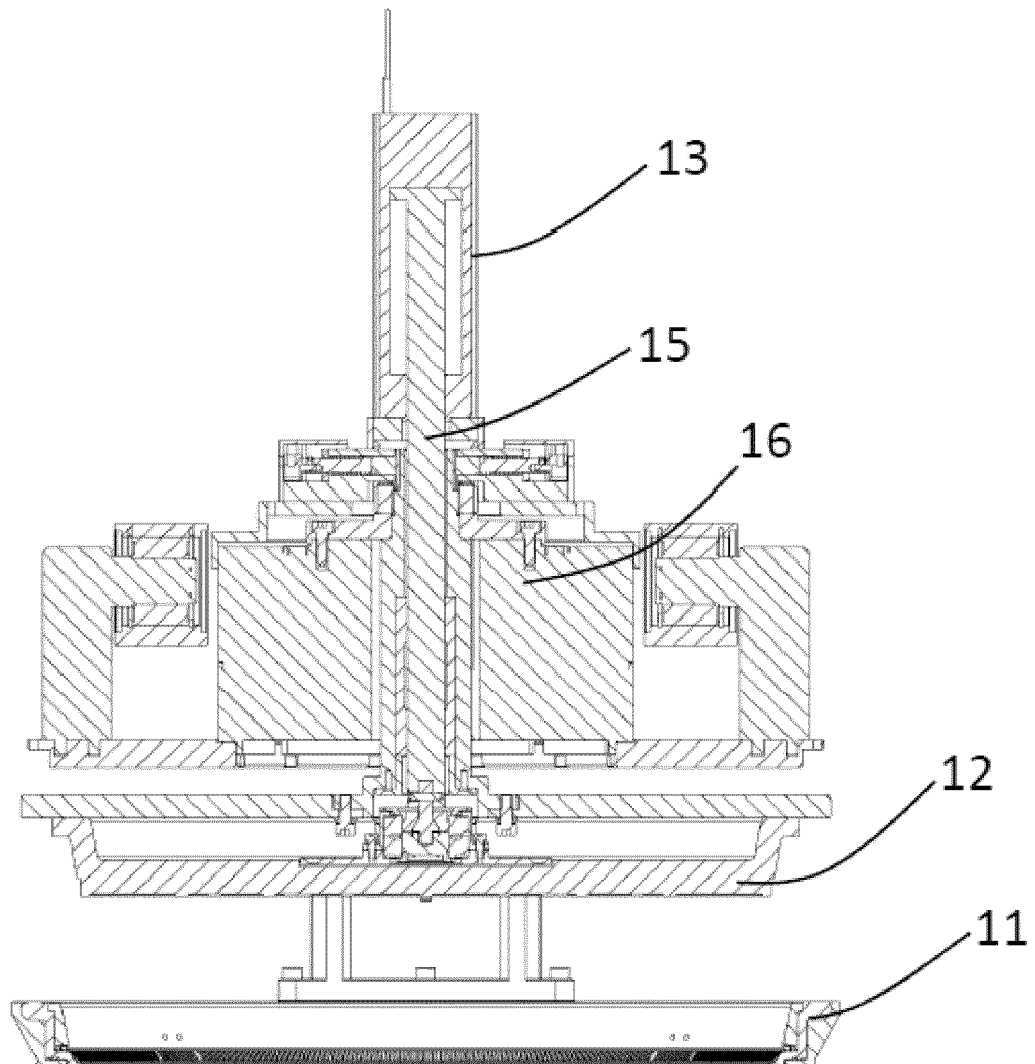


FIG. 3

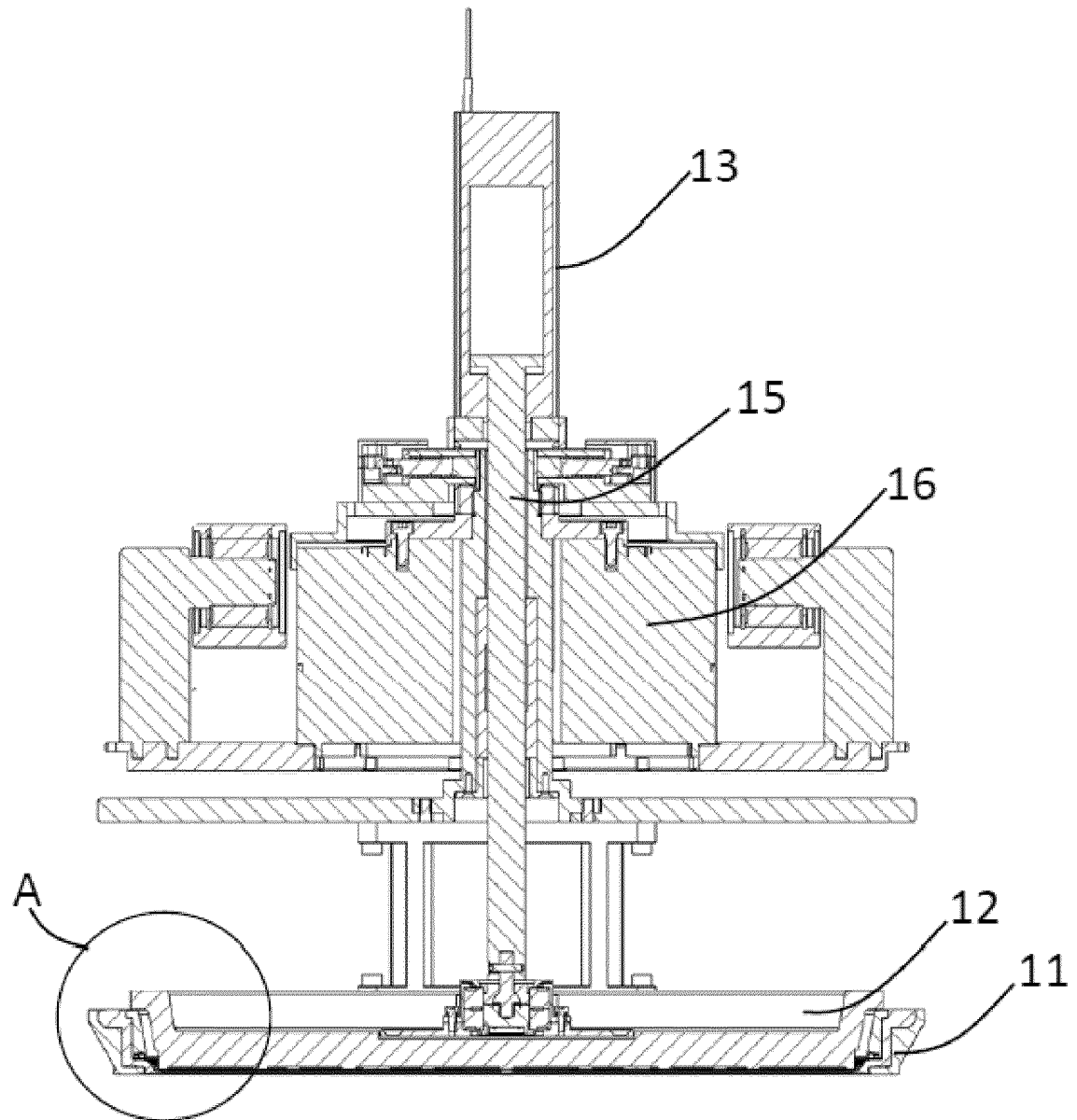


FIG. 4

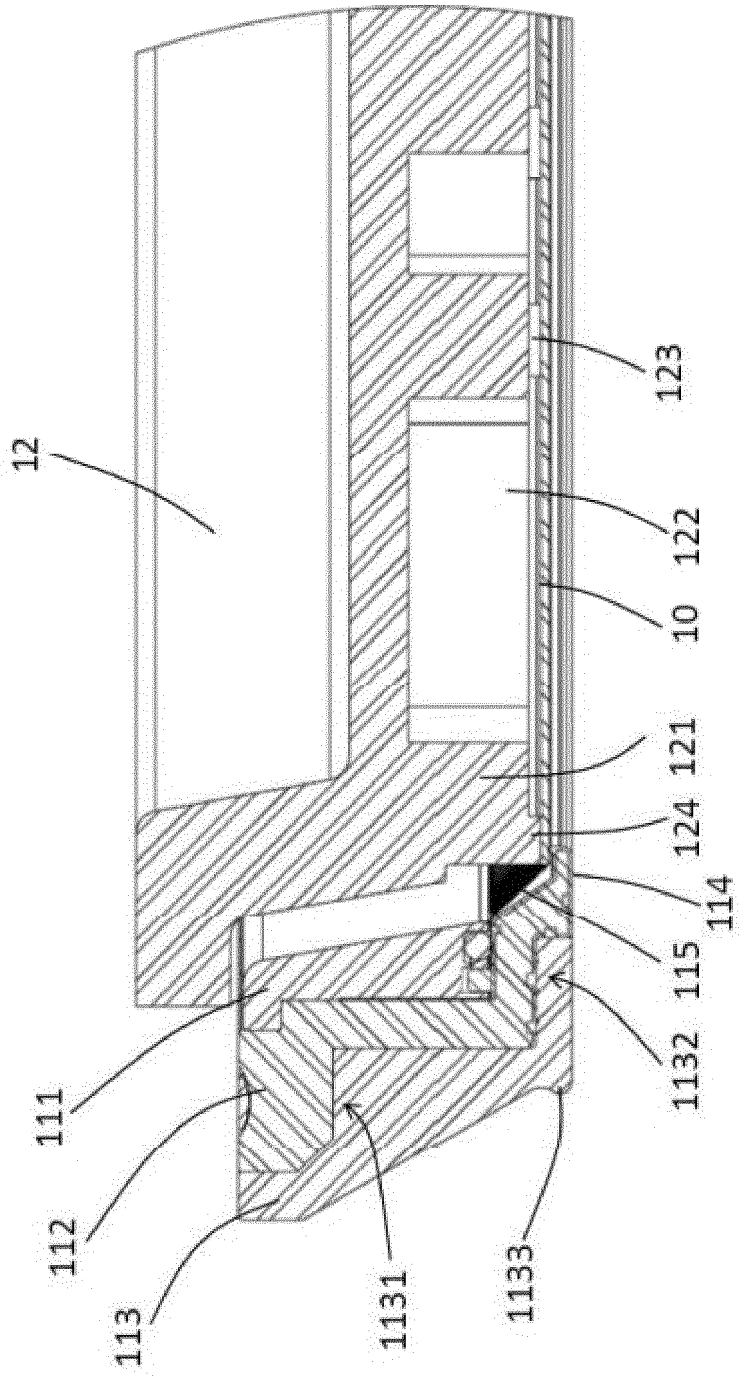


FIG. 5

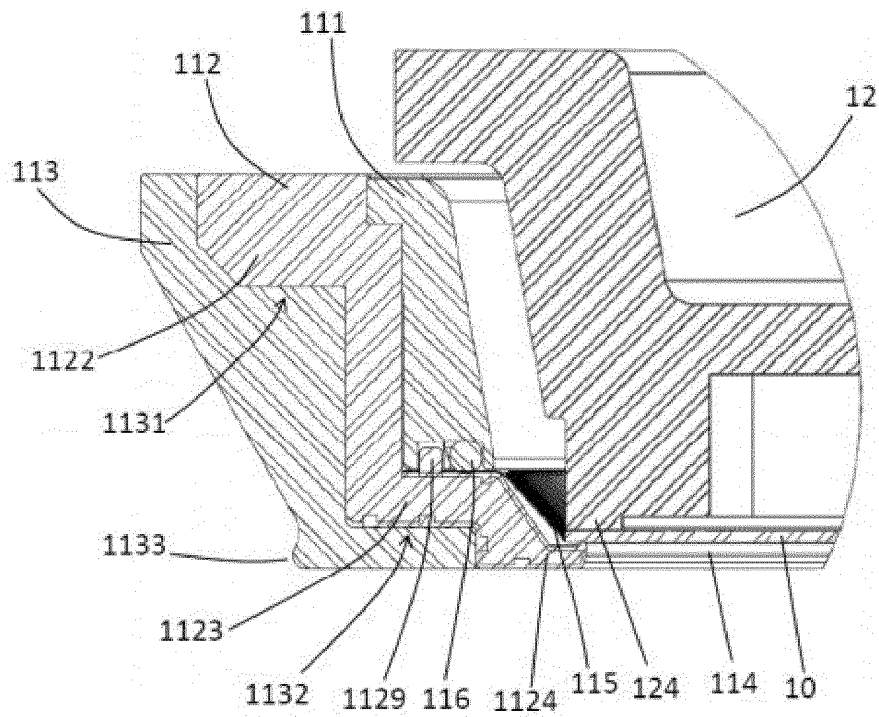


FIG. 6

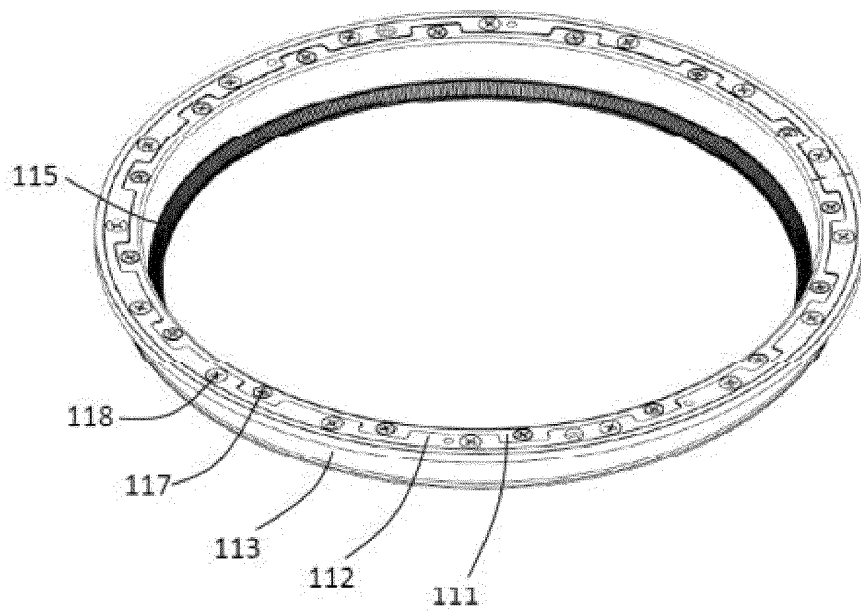


FIG. 7

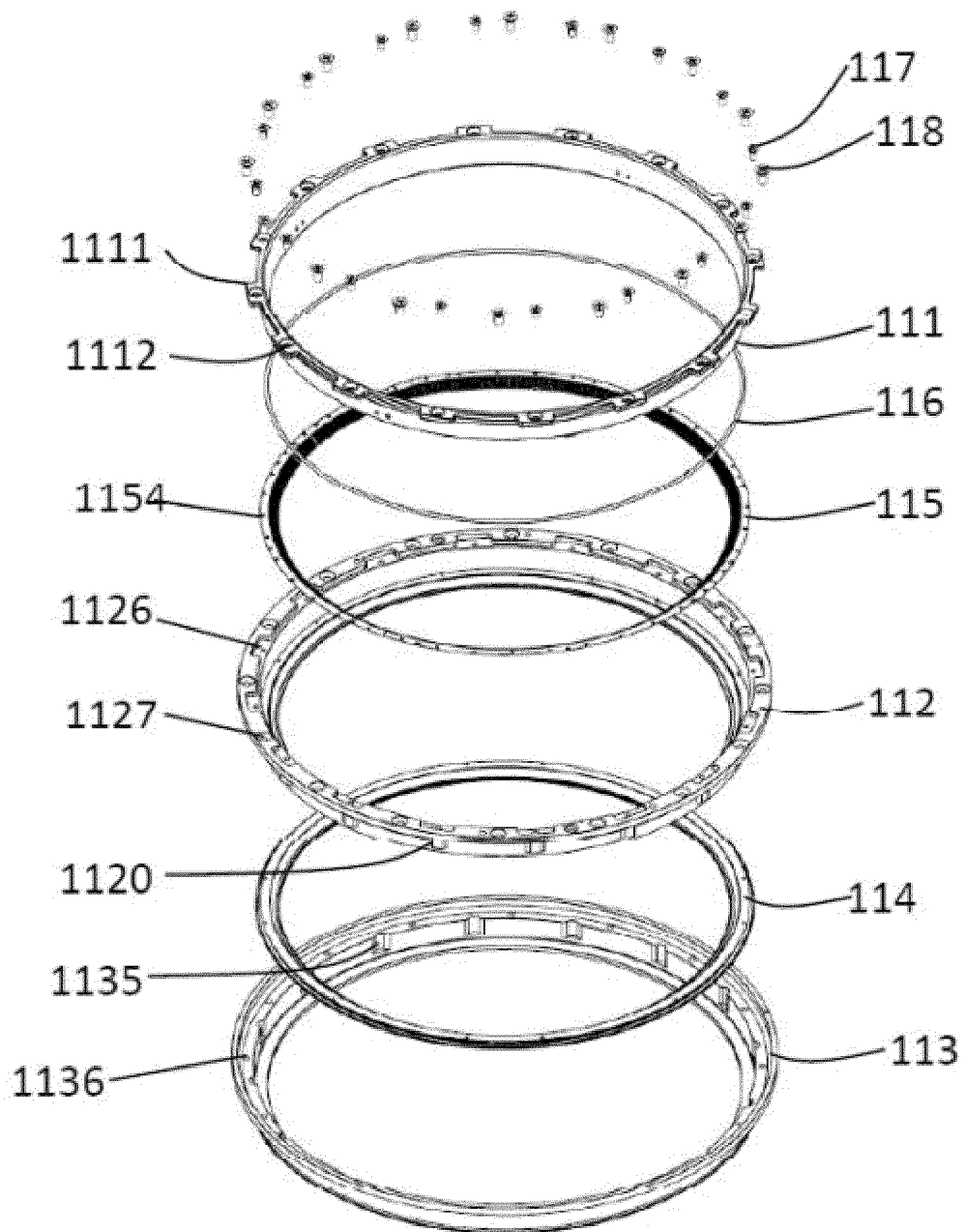


FIG. 8

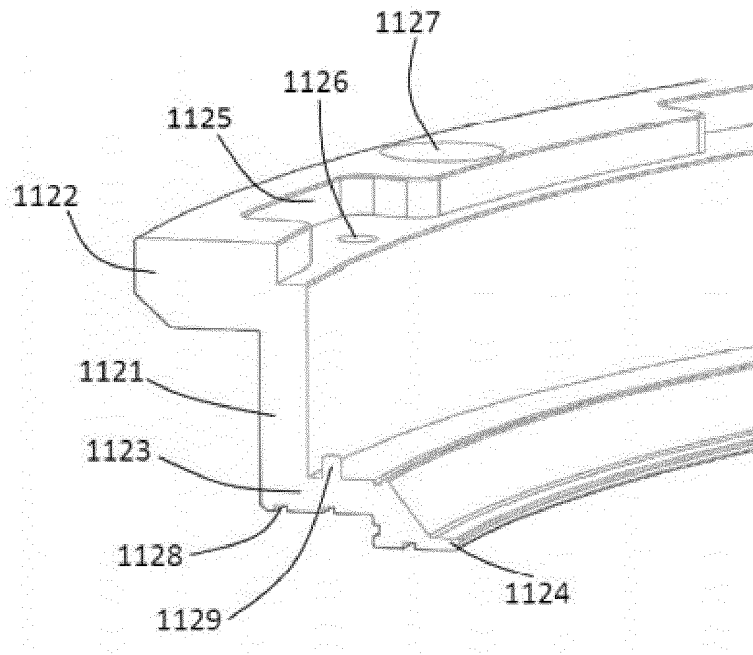


FIG. 9

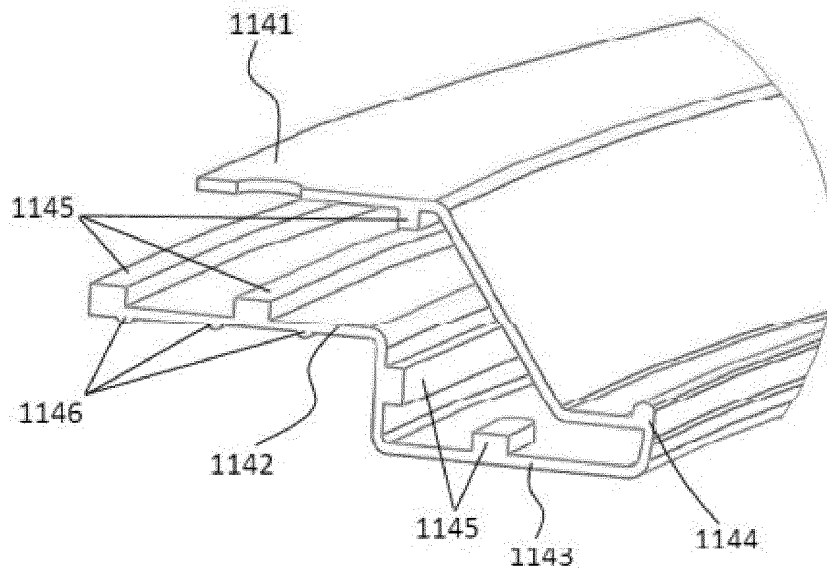


FIG. 10

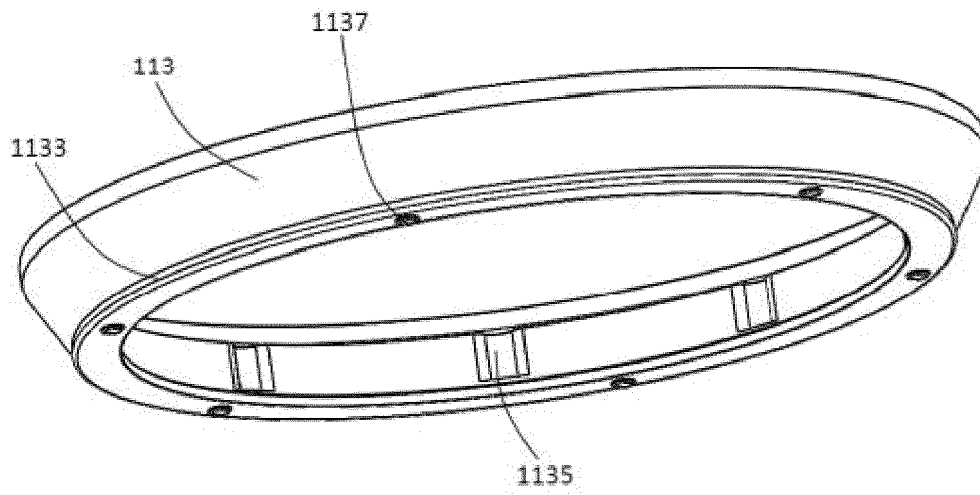


FIG. 11

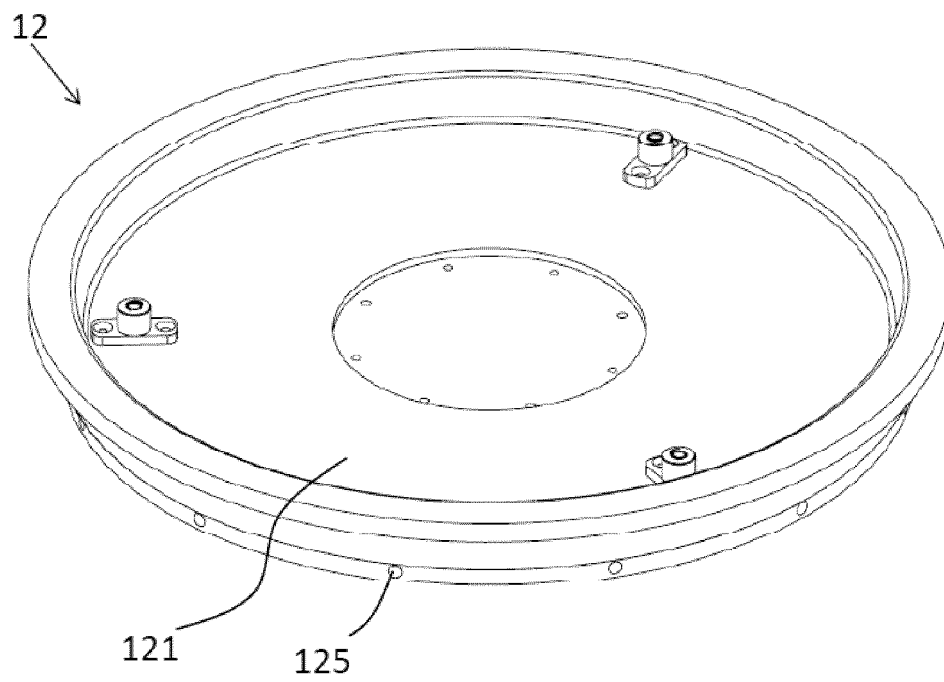


FIG. 12

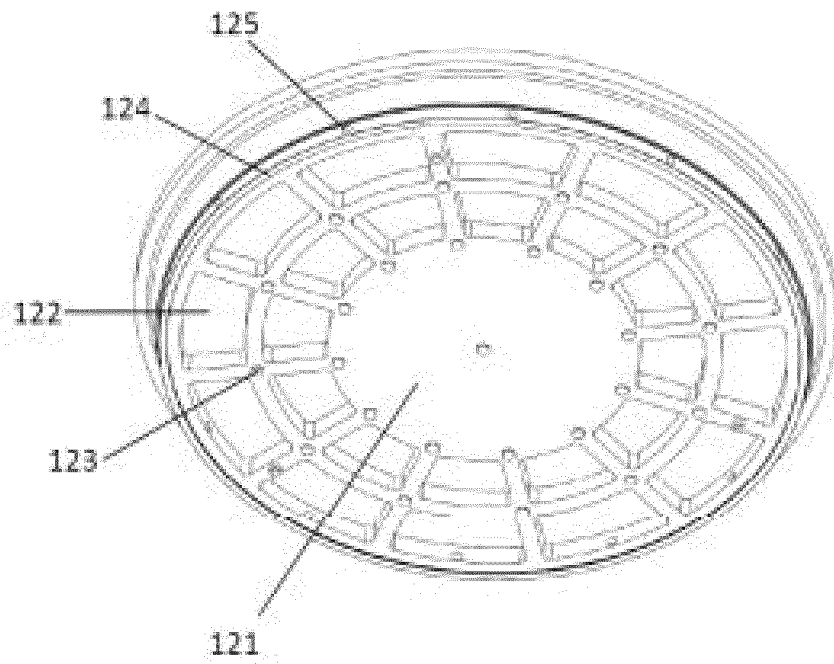


FIG. 13

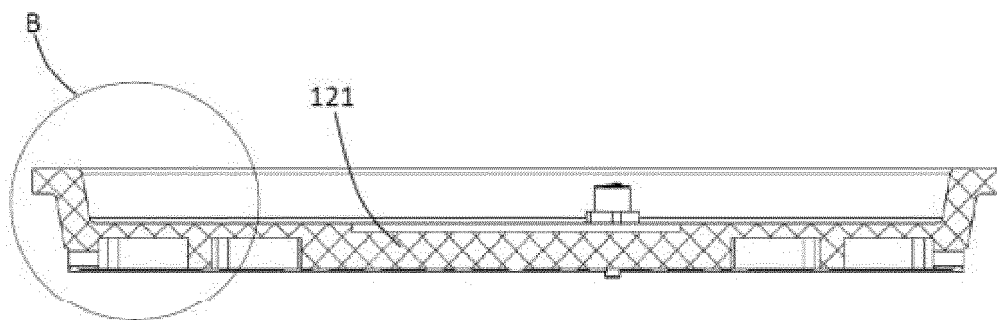


FIG. 14

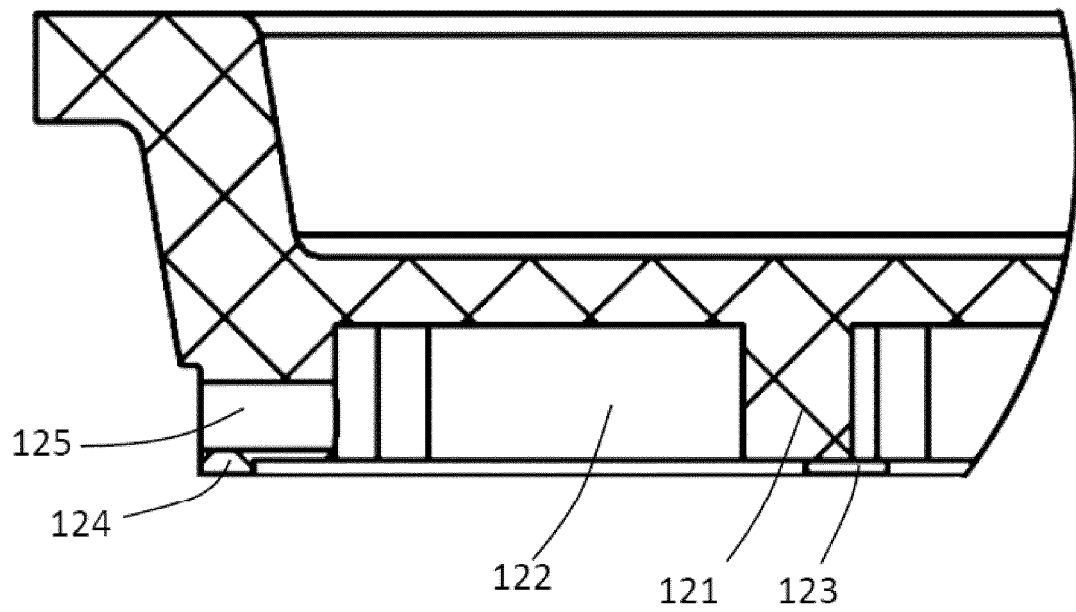


FIG. 15

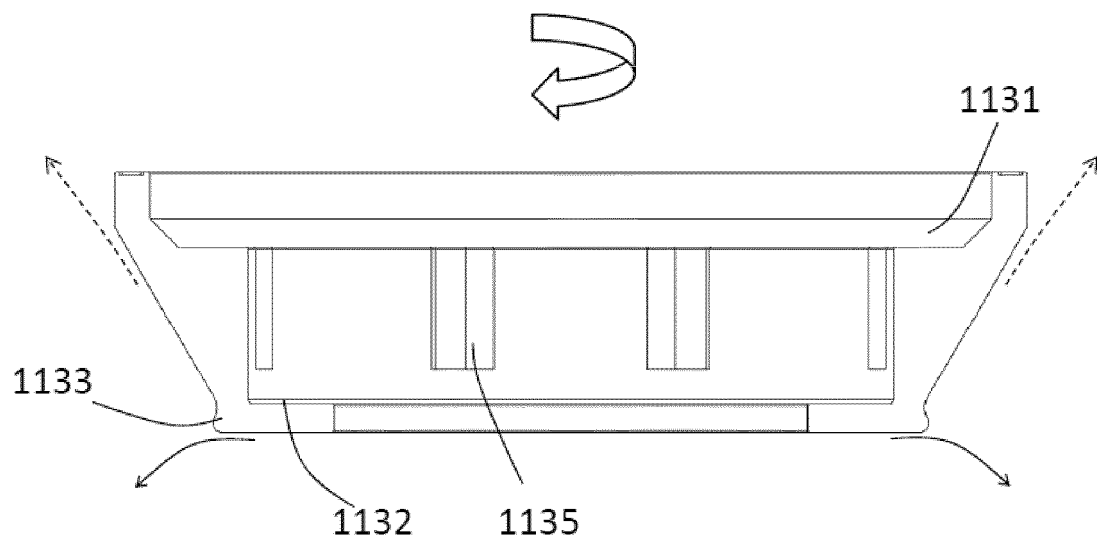


FIG. 16a

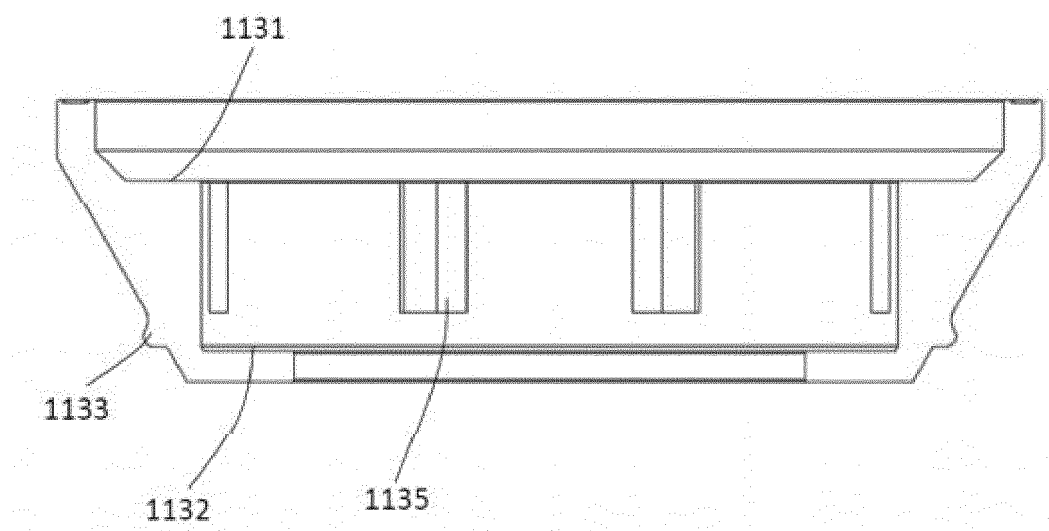


FIG. 16b

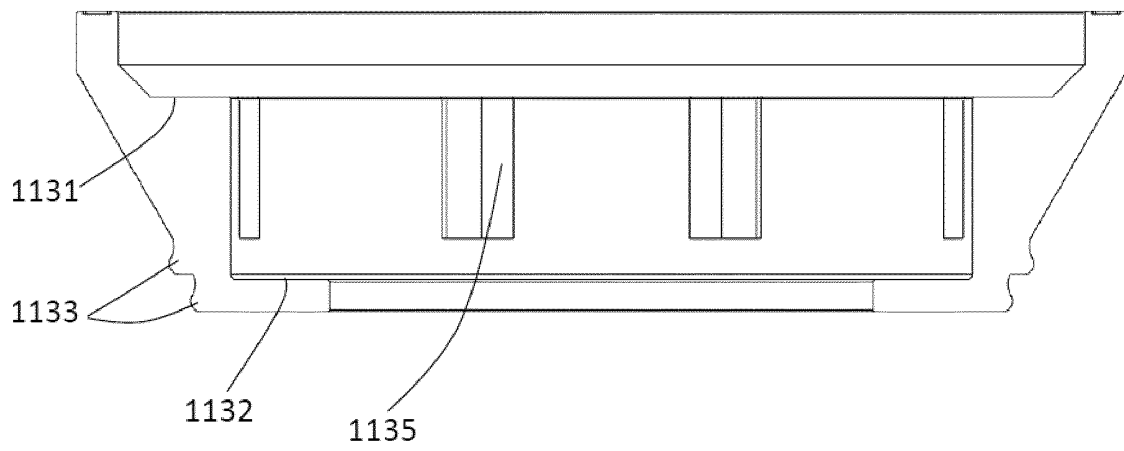


FIG. 16c

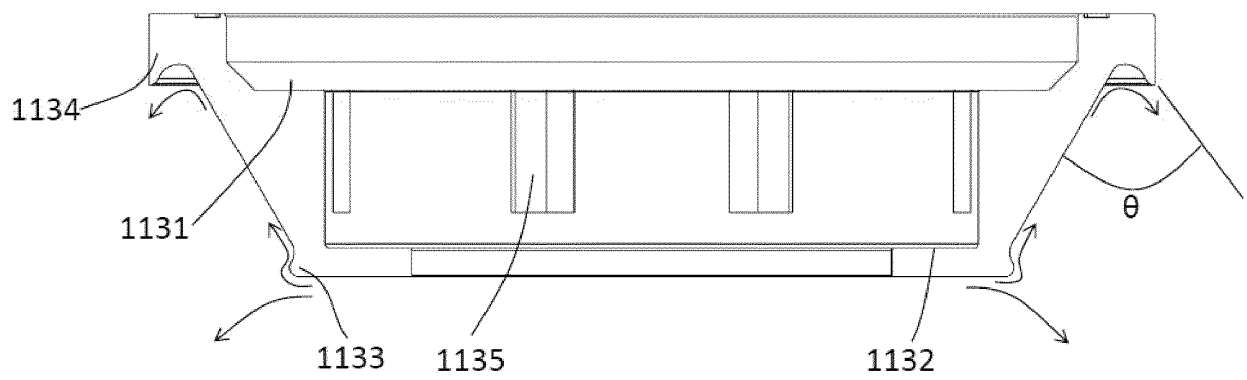


FIG. 16d

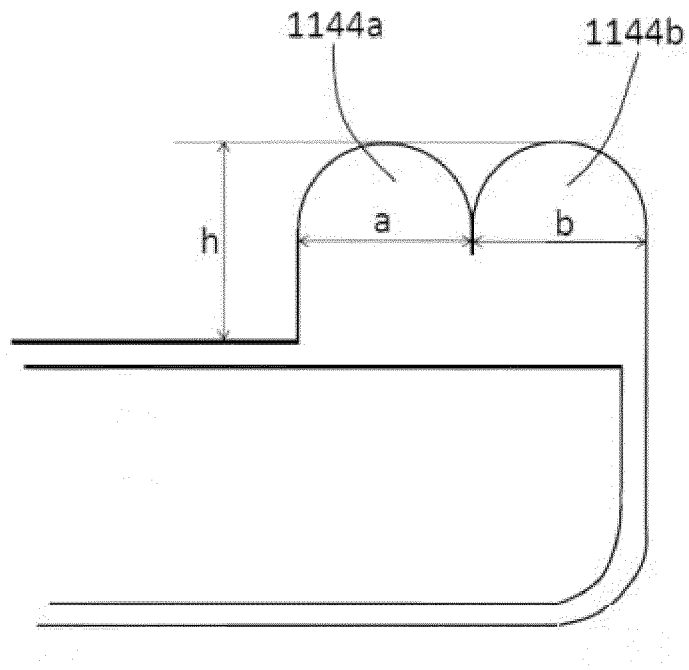


FIG. 17a

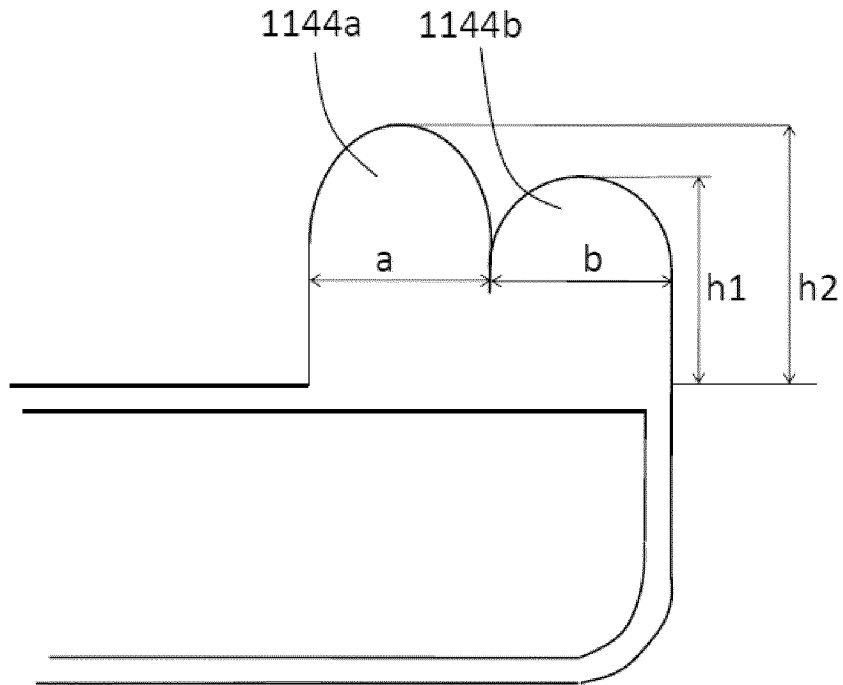


FIG. 17b

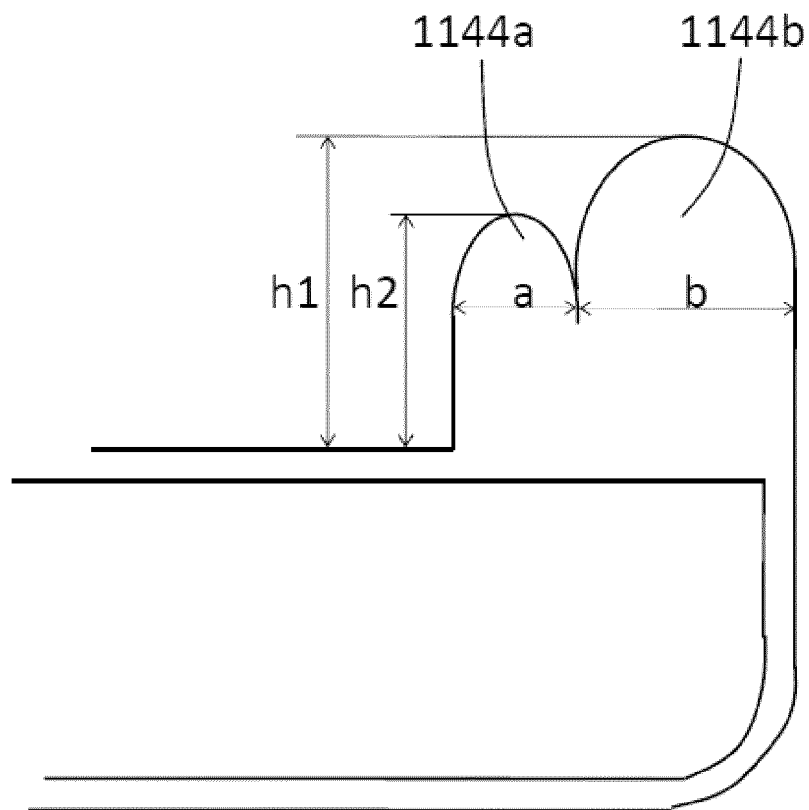


FIG. 17c

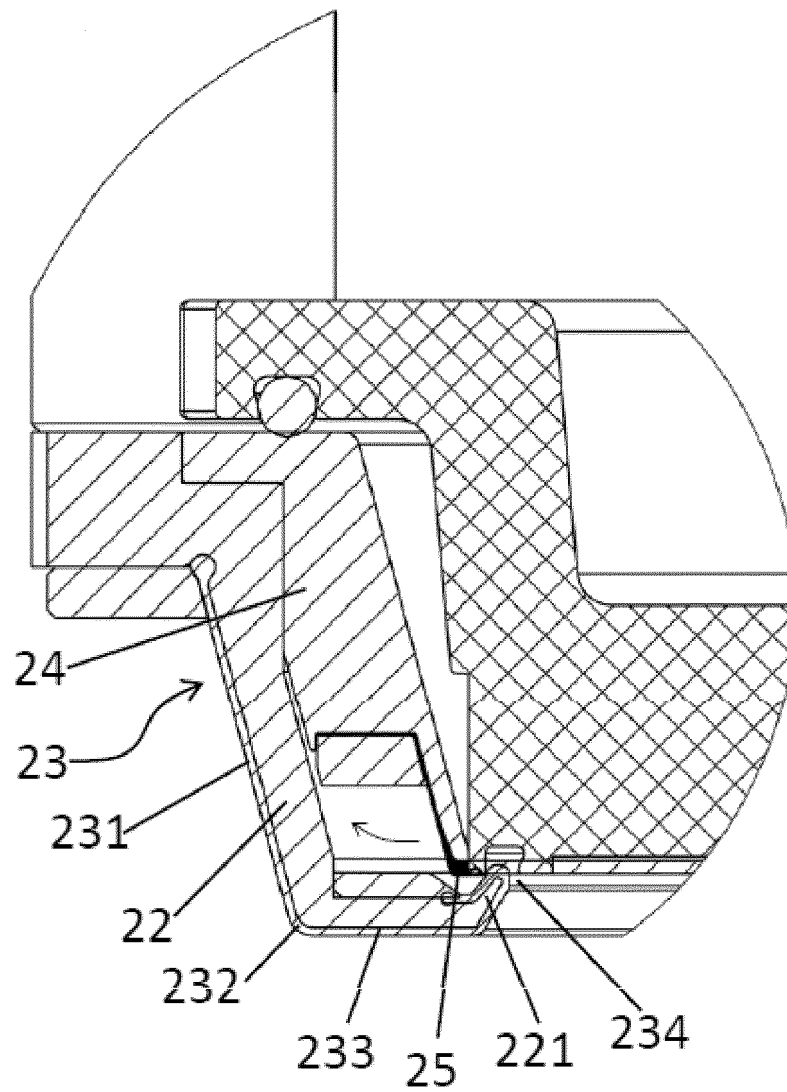


FIG. 18

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2021/131846

A. CLASSIFICATION OF SUBJECT MATTER

C25D 17/08(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C25D17/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI, VEN, WPABSC, USTXT, WOTXT, Web of Science: 盛美半导体, 王晖, 王坚, 贾照伟, 金一诺, 杨宏超, 基板, 晶片, 晶圆, 电镀, 夹具, 夹盘, 杯形, 杯状, 电镀杯, 保持, 固持, 阻挡, 遮挡, 挡液, 挡水, 防止, 飞溅, 护罩, 防溅罩, 保护盖, 旋转, 倾斜, 支撑, ACM SEMICONDUCTOR EQUIP, Wang hui, Wang jian, Jia zhaowei, Jin yinuo, Yang hongchao, substrate, plate, hold+, electroplat+, electrochemical, chuck, cup, driv+ device, protect+, cover

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 111032925 A (ACM RESEARCH (SHANGHAI) INC.) 17 April 2020 (2020-04-17) description paragraphs 0042-0065, figures 10-16, 22-25	1-14, 17-24
Y	CN 111032925 A (ACM RESEARCH (SHANGHAI) INC.) 17 April 2020 (2020-04-17) description paragraphs 0042-0065, figures 10-16, 22-25	15-16, 22-24
Y	US 2009107835 A1 (NOVELLUS SYSTEMS INC.) 30 April 2009 (2009-04-30) description, paragraphs 0040-0041, and figures 7-8	15-16, 22-24
A	CN 101798698 A (NOVELLUS SYSTEMS, INC.) 11 August 2010 (2010-08-11) entire document	1-24
A	CN 111593395 A (EBARA CORPORATION) 28 August 2020 (2020-08-28) entire document	1-24
A	CN 108291325 A (ACM RESEARCH (SHANGHAI), INC.) 17 July 2018 (2018-07-17) entire document	1-24
A	WO 2019041154 A1 (ACM RES SHANGHAI INC) 07 March 2019 (2019-03-07) entire document	1-24

☒ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

* Special categories of cited documents:

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“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

21 January 2021

Date of mailing of the international search report

16 February 2022

Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/
CN)
No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing
100088, China

Facsimile No. (86-10)62019451

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No. PCT/CN2021/131846

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