

ELECTROCHEMICAL MECHANICAL POLISHING AND PLANARIZATION APPARATUS

BACKGROUND OF THE INVENTION

[0001] The present invention belongs to the technical field of fabrication of semiconductor integrated circuit chips, and particularly relates to an electrochemical mechanical polishing and planarization device.

DESCRIPTION OF RELATED ART

[0002] The manufacturing process for wafer substrates and semiconductor devices includes processes such as polishing and surface planarization. Generally, the technique such as mechanical polishing, chemical mechanical polishing, or planarization is employed. A pressure is applied to the back side of a wafer by means of a wafer carrier (a polishing head), parameters such as the pressure, the rotational speed of the polishing head, the rotational speed of a platen, and the flow rate of a polishing slurry are controlled, and the front surface or film surface of a wafer substrate is polished or planarized on a polishing pad. Compared with mechanical polishing, chemical mechanical polishing and planarization, by adjusting the formulation of the polishing slurry, induce a chemical reaction on the surface of the wafer, which can achieve higher polishing or planarization efficiency, as well as better polishing or planarization effects, including higher flatness, less defects, and so on. Based on chemical mechanical polishing and planarization described above, for conductive substrates or conductive film materials, electrochemical mechanical polishing and planarization may further induce an electrochemical reaction on the wafer substrate or the film surface by means of a current path formed on the basis of the conductive properties of the wafer substrate or the film on the wafer surface, and the rate of the surface chemical reaction is increased by precise control of a circuit system, thereby improving mechanical polishing and planarization efficiency.

[0003] Generally, in the chemical mechanical polishing or planarization process, when a wafer is driven by the polishing head to be polished on the polishing pad, the polishing head will rotate

to drive a flexible membrane to rotate so as to drive the wafer to rotate for polishing. If a conventional flexible membrane is employed in an electrochemical process to drive wafer polishing, the polishing head, when rotating, drives a conductive disc to rotate by means of the flexible membrane, the flexible membrane has to withstand a tensile force generated by rotation
5 of the polishing head and generated when a polishing arm drives the polishing head to sweep across the polishing pad, and under a harsh polishing condition, the excessive tensile force applied to the flexible membrane during the polishing process may cause a rupture of the flexible membrane, leading to safety incidents. Furthermore, in the existing CMP process, from the beginning of polishing when the flexible membrane is pulled to the end of polishing when the
10 polishing head stops operating, the retraction of the flexible membrane occurring when the polishing head moves away from the polishing pad may cause the wafer to scrape against the polishing pad, thereby compromising the polishing process.

BRIEF SUMMARY OF THE INVENTION

[0004] To overcome the defects in the prior art, the present invention provides an
15 electrochemical mechanical polishing and planarization device. A wafer substrate is adsorbed by means of the negative pressure of a rigid conductive disc, electrical conduction is implemented by cooperation between the rigid conductive disc and a conductive drive unit, and the conductive drive unit functions for both electrical conduction and mechanical drive, such that the service life of a polishing head is prolonged while effective electrochemical mechanical polishing of the wafer
20 substrate is guaranteed.

[0005] The technical solution adopted by the present invention to solve the technical problems is as follows: an electrochemical mechanical polishing and planarization device includes at least a polishing head. The polishing head includes:

[0006] a polishing head body;

25 **[0007]** a rigid conductive disc, at least a portion of a lower surface of the rigid conductive disc being coplanar, and the rigid conductive disc being used for adsorbing a wafer substrate;

[0008] a conductive drive unit, at least a portion of the conductive drive unit being connected to a power supply, and at least a portion of the conductive drive unit being in contact and transmission fit with the rigid conductive disc to drive the rigid conductive disc to rotate circumferentially;

5 **[0009]** a movement clearance, formed between the polishing head body and the conductive drive unit, and/or formed between the conductive drive unit and the rigid conductive disc, and/or formed between the rigid conductive disc and the polishing head body; and

[0010] a retaining ring, located below the polishing head body, the retaining ring being a ring part in contact with a polishing pad, and the rigid conductive disc moving in a region defined by
10 the retaining ring.

[0011] Further, air holes are formed in the coplanar portion of the lower surface of the rigid conductive disc, the air holes communicate with a third air chamber in the rigid conductive disc, and when the third air chamber is in a negative pressure state, the rigid conductive disc adsorbs the wafer substrate.

15 **[0012]** Further, the electrochemical mechanical polishing and planarization device further includes a pressure-controllable second air chamber, and the second air chamber is used for driving the rigid conductive disc to ascend and descend.

[0013] Further, the rigid conductive disc and the conductive drive unit are connected integrally; or, the rigid conductive disc and the conductive drive unit are arranged separately.

20 **[0014]** Further, the movement clearance includes at least a radial movement clearance and an axial movement clearance.

[0015] Further, the conductive drive unit includes a guide rod and a second drive portion, the second drive portion is connected to the rigid conductive disc, a first drive portion in transmission fit with the second drive portion is formed on the polishing head body, the movement clearance is
25 formed between the first drive portion and the second drive portion, and the second drive portion remains in contact with the first drive portion to implement electrical conduction.

[0016] Further, the conductive drive unit includes a guide block and a wire electrically connected to the guide block, and the guide block is connected to the polishing head body, such that the polishing head body drives the rigid conductive disc to rotate circumferentially by means of the guide block, and conducts current to the rigid conductive disc when driving the rigid
5 conductive disc to rotate circumferentially; a groove allowing the guide block to extend therein is formed in the rigid conductive disc, and the movement clearance is formed between the guide block and the groove.

[0017] Further, a plurality of guide blocks are arranged in a circumferential direction of the polishing head body at intervals, and the guide blocks remain in contact with the groove to
10 implement electrical conduction.

[0018] Further, one wire is arranged, or the number of the wires corresponds to that of the guide blocks; in a case where one wire is arranged, all the guide blocks are connected into a whole by means of a ring body.

[0019] Further, the conductive drive unit includes a guide rod and a second drive portion, the
15 guide rod is connected to external power, a third drive portion in transmission fit with the second drive portion is formed on the rigid conductive disc, and the movement clearance is formed between the second drive portion and the third drive portion.

[0020] Further, the conductive drive unit includes an elastic unit, and the elastic unit is connected to the polishing head body and the rigid conductive disc, such that the second air
20 chamber is defined by the polishing head body, the elastic unit and the rigid conductive disc.

[0021] Further, the rigid conductive disc is provided with a flange, the flange extends into the polishing head body and is in sealing fit with the polishing head body by means of a sealing element to form the second air chamber and the movement clearance, and the flange is electrically connected to the polishing head body.

[0022] Further, a rotation direction of the rigid conductive disc is the same as or opposite to a
25 rotation direction of the polishing head body.

[0023] Further, the lower surface of the rigid conductive disc is coplanar; or, the coplanar portion of the lower portion of the rigid conductive disc forms a thickened or thinned region to form a height difference from nanoscale to microscale.

[0024] Further, a flexible conductive fabric is attached to the lower surface of the rigid conductive disc, the flexible conductive fabric includes holes, and the holes match at least some of the air holes of the rigid conductive disc in position.

[0025] The present invention has the following beneficial effects: (1) circuit conduction between the polishing head and the wafer substrate is implemented by means of the rigid conductive disc to perform electrochemical mechanical polishing, such that the long-term stability of electrochemical reactions is guaranteed, and the process stability of electrochemical mechanical polishing is higher; (2) the wafer substrate is adsorbed by means of the negative pressure of the rigid conductive disc, such that the problem that when a flexible membrane drives the wafer substrate for polishing, the flexible membrane is pulled to be ruptured or the elastic modulus changes in a harsh polishing condition, thereby prolonging the service life of a flexible member in the polishing head; (3) the wafer substrate is adsorbed by means of the negative pressure of the rigid disc, such that when the polishing head leaves the polishing pad, the situation where the wafer substrate scrapes against the polishing pad due to the retraction of the flexible membrane is avoided, thus ensuring that the wafer substrate is quickly and effectively separated from the polishing pad, and guaranteeing that the polishing process proceeds smoothly; (4) in a case where the flexible membrane is used as a drive component to drive a wafer substrate for polishing, the balance state of the flexible membrane will fluctuate in regions such as grooves in the polishing pad, thereby affecting the polishing velocity and exerting a negative impact on polishing efficiency; whereas, the stability of rigid drive in the rigid disc is higher, thereby effectively solving the abovementioned problems and achieving better process stability; (5) the conductive drive unit not only functions for electrical conduction, but also is able to mechanically drive the rigid conductive disc to drive the wafer substrate for polishing, and the movement clearance provides a movement

space for up-down floating and left-right floating of the rigid conductive disc, thus making polishing more flexible; (6) by cooperation between the flange and the polishing head body, the rotation direction of the rigid conductive disc may be automatically controlled, and may be kept the same as the rotation direction of the retaining ring and the rigid conductive disc or opposite to the rotation direction of the retaining ring and the rigid conductive disc, thus providing more possibilities for the polishing process.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0026] FIG. 1 is a first schematic structural stereogram of an electrochemical mechanical polishing and planarization device according to Embodiment 1 of the present invention.

10 **[0027]** FIG. 2 is a second schematic structural stereogram of the electrochemical mechanical polishing and planarization device according to Embodiment 1 of the present invention.

[0028] FIG. 3 is a schematic structural stereogram of a rigid conductive disc and an elastic unit according to Embodiment 1 of the present invention.

15 **[0029]** FIG. 4 is a cutaway structural view of the rigid conductive disc according to Embodiment 1 of the present invention.

[0030] FIG. 5 is a partial sectional view of the rigid conductive disc according to Embodiment 1 of the present invention.

[0031] FIG. 6 is a sectional view of the electrochemical mechanical polishing and planarization device according to Embodiment 1 of the present invention.

20 **[0032]** FIG. 7 is a schematic structural stereogram of the rigid conductive disc according to Embodiment 1 of the present invention.

[0033] FIG. 8 is a schematic structural stereogram of a polishing head body according to Embodiment 1 of the present invention.

25 **[0034]** FIG. 9 is a schematic structural stereogram of an electrochemical mechanical polishing and planarization device according to Embodiment 2 of the present invention.

[0035] FIG. 10 is a front view of the electrochemical mechanical polishing and planarization

device according to Embodiment 2 of the present invention.

[0036] FIG. 11 is a schematic structural stereogram of a rigid conductive disc and an elastic unit according to Embodiment 2 of the present invention.

5 [0037] FIG. 12 is a first sectional view of the electrochemical mechanical polishing and planarization device according to Embodiment 2 of the present invention.

[0038] FIG. 13 is a second sectional view of the electrochemical mechanical polishing and planarization device according to Embodiment 2 of the present invention.

[0039] FIG. 14 is a schematic structural stereogram of a rigid conductive disc and an elastic unit according to Embodiment 3 of the present invention.

10 [0040] FIG. 15 is a sectional view of an electrochemical mechanical polishing and planarization device according to Embodiment 3 of the present invention.

[0041] FIG. 16 is a schematic structural diagram of the cooperation between the rigid conductive disc, a conductive drive unit and external power according to Embodiment 3 of the present invention.

15 [0042] FIG. 17 is an enlarged view of part A in FIG. 16.

[0043] FIG. 18 is a schematic structural stereogram of the rigid conductive disc according to Embodiment 3 of the present invention.

[0044] FIG. 19 is a sectional view of an electrochemical mechanical polishing and planarization device according to Embodiment 4 of the present invention.

20 [0045] FIG. 20 is a schematic structural diagram of the cooperation between a rigid conductive disc and a conductive drive unit according to Embodiment 4 of the present invention.

[0046] FIG. 21 is a schematic structural stereogram of a polishing head body according to Embodiment 4 of the present invention.

25 [0047] FIG. 22 is a sectional view of an electrochemical mechanical polishing and planarization device according to Embodiment 5 of the present invention.

[0048] FIG. 23 is a schematic structural stereogram of a rigid conductive disc according to

Embodiment 5 of the present invention.

[0049] FIG. 24 is a sectional view of an electrochemical mechanical polishing and planarization device according to Embodiment 6 of the present invention.

5 [0050] FIG. 25 is a schematic structural diagram of the cooperation between a rigid conductive disc, a conductive drive unit and external power according to Embodiment 6 of the present invention.

[0051] FIG. 26 is a schematic structural stereogram of the rigid conductive disc according to Embodiment 6 of the present invention.

10 [0052] Reference signs: 1, polishing head body; 11, first air chamber; 12, ring groove; 2, rigid conductive disc; 21, air hole; 32, third air chamber; 23, groove; 24, flange; 25, air passage; 3, conductive drive unit; 31, guide rod; 311, outer gear ring; 312, external power; 32, second drive portion; 33, first drive portion; 34, guide block; 35, wire; 36, ring body; 37, third drive portion; 4, movement clearance; 41, radial movement clearance; 42, axial movement clearance; 5, retaining ring; 6, second air chamber; 7, elastic unit; 8, sealing element.

15 DETAILED DESCRIPTION OF THE INVENTION

[0053] To allow those skilled in the art to gain a better understanding of the technical solutions of the present invention, the technical solutions in the embodiments of the present invention are clearly and completely described below in conjunction with accompanying drawings of the embodiments of the present invention. Obviously, the embodiments described below are merely
20 illustrative ones rather than all possible ones of the present invention. All other embodiments obtained by those ordinarily skilled in the art based on the following ones without creative labor should also fall within the protection scope of the present invention.

[0054] Embodiment 1

25 [0055] As shown in FIGS. 1 and 2, an electrochemical mechanical polishing and planarization device includes at least a polishing head. The polishing head includes a polishing head body 1, a rigid conductive disc 2, a conductive drive unit 3, a movement clearance 4, and a retaining ring 5

located below the polishing head body 1.

[0056] The rigid conductive disc 2 is made from a rigid material, such as a metal, a conductive material or other rigid conductive materials. The metal may be specifically aluminum, titanium or stainless steel, the other conductive materials may be conductive ceramic, graphite, and the like, and all these materials are conductive materials, such that the rigid conductive disc 2, together with a wafer substrate, a platen and a power supply, may form a conduction path necessary for electrochemical mechanical polishing, power is conducted to the rigid conductive disc 2 and then conducted to the wafer substrate for surface modification, and then mechanical polishing is performed. In this embodiment, a lower surface of the rigid conductive disc 2 is coplanar. Of course, in other embodiments, a specific region of a horizontal portion of the rigid conductive disc 2 may be thickened or thinned on the basis of the thickness and topography of the wafer substrate to form a thickened region or a thinned region, such that a height difference from nanoscale to microscale is formed between different regions. In other embodiments, insulating treatment and chamfering treatment may be performed on a side surface of the rigid conductive disc 2, where the insulating treatment includes, but is not limited to, hard anodizing, surface coating, and the like.

[0057] In this embodiment, the rigid conductive disc 2 is a disc-shaped structure. As shown in FIG. 5, an upper surface of the rigid conductive disc 2 is airtight. At least a portion of the lower surface of the rigid conductive disc 2 is coplanar, and a plurality of air holes 21 are formed in the coplanar portion of the lower surface. A third air chamber 22, communicating with the air holes 21, is formed in the rigid conductive disc 2. A sealed connection is necessary for the third air chamber 22 to prevent contamination of the polishing head caused by leakage of a polishing slurry. The other functional components may be connected in any manners as long as the internal environment of the polishing head is not affected, such as air tube connection, screw and sealing ring-based connection of a main body, chamber design of a flexible membrane and other sealing designs, which may be implemented by existing techniques and will not be detailed here. The

diameter of the air holes 21 is 0.1-3 mm, and the total area of all the air holes 21 accounts for 0.1-5% of the area of the lower surface of the rigid conductive disc 2. When a negative pressure is formed in the third air chamber 22, the lower surface of the rigid conductive disc 2, to be precise the coplanar portion of the lower surface, may directly come into contact and adsorb the wafer substrate.

[0058] In this embodiment, all the air holes 21 communicate with each other. As shown in FIG. 4, air passages 25, which radially intersect and communicate with each other, are formed in the rigid conductive disc 2. The air passages 25 communicate with the third air chamber 22, and the air holes 21 are correspondingly formed in a region where the air passages 25 are located, such that negative pressures formed by all the air holes 21 are relatively uniform.

[0059] One of the logics for determining whether the wafer substrate is loaded onto the polishing head body 1 is to perform a pressure hold test after the third air chamber 22 is vacuumized, to detect the vacuum condition of the third air chamber 22. If the negative pressure is held, it is determined that the wafer substrate is loaded onto the polishing head body 1; otherwise, it is determined that the wafer substrate is not loaded onto the polishing head body 1.

[0060] The retaining ring 5 may be a ring part in contact with a polishing pad, and the rigid conductive disc 2 moves in a region defined by the retaining ring 5.

[0061] A first air chamber 11 is formed in the polishing head body 1 and used for controlling ascending, descending and a vertical stroke of a portion of the polishing head body 1 to drive the rigid conductive disc 2 and the wafer substrate to ascend and descend. The polishing head further includes a second air chamber 6, the pressure in which is controllable. The second air chamber 6 is used for driving the rigid conductive disc 2 to ascend and descend.

[0062] In this embodiment, the conductive drive unit 3 further includes an elastic unit 7, which is connected to the polishing head body 1 and the rigid conductive disc 2. Specifically, as shown in FIG. 3, the elastic unit 7 is made from an elastic material and is approximately a ring structure. One side of the elastic unit 7 is connected to an outer ring of the rigid conductive disc 2, and the

other side of the elastic unit 7 is fixedly connected between the polishing head body 1 and the retaining ring 5. The elastic unit 7 defines the second air chamber 6, together with the polishing head body 1 and the rigid conductive disc 2. The pressure in the second air chamber 6 is controllable, such that the elastic unit 7 may be driven to move flexibly by regulating the pressure in the second air chamber 6, so as to assist the rigid conductive disc 2 and the wafer substrate in floating to implement electrochemical mechanical polishing of the wafer substrate. Herein, the floating of the rigid conductive disc 2 and the wafer substrate refers to improving motions of the rigid conductive disc 2 and the wafer substrate by means of the elastic unit 7 under the precondition of mechanical drive of the polishing head 1 and the rigid conductive disc 2, where motions include vertical floating and radial floating. The method for controlling the pressure in the second air chamber 6 may be implemented by existing techniques, and will not be detailed here.

[0063] Of course, on the basis that a circuit for electrochemical mechanical polishing and planarization of the wafer substrate is connected to the rigid conductive disc 2 directly from electrodes of the power supply, the circuit may also be connected to the rigid conductive disc 2 from the elastic unit 7 to fulfill the functions of the rigid conductive disc 2. The present invention has no specific limitation in this aspect.

[0064] A portion of the conductive drive unit 3 extends out from the polishing head body 1 and is connected to the power supply, and a portion of the conductive drive unit 3 is in contact and transmission fit with the rigid conductive disc 2 to drive the rigid conductive disc 2 to rotate circumferentially. Herein, the power supply is not specifically limited as long as it can supply power.

[0065] The movement clearance 4 is formed between the polishing head body 1 and the conductive drive unit 3; or, the movement clearance 4 is formed between the conductive drive unit 3 and the rigid conductive disc 2; or, the movement clearance 4 is formed between the rigid conductive disc 2 and the polishing head body 1; or, the movement clearance 4 is formed between the polishing head body 1 and the conductive drive unit 3, and the movement clearance 4 is also

formed between the conductive drive unit 3 and the rigid conductive disc 2; or, the movement clearance 4 is formed between the polishing head body 1 and the conductive drive unit 3, and the movement clearance 4 is also formed between the rigid conductive disc 2 and the polishing head body 1; or, the movement clearance 4 is formed between the conductive drive unit 3 and the rigid conductive disc 2, and the movement clearance 4 is also formed between the rigid conductive disc 2 and the polishing head body 1.

[0066] The conductive drive unit 3 includes a guide rod 31 and a second drive portion 32. The second drive portion 32 is connected to the rigid conductive disc 2, and in this case, the rigid conductive disc 2 is integrally connected to the second drive portion 32 of the conductive drive unit 3. The guide rod 31 is connected to the rigid conductive disc 2, and in this case, the rigid conductive disc 2 is integrally connected to the guide rod 31. Of course, the guide rod 31 may be connected to the second drive portion 32, and in this case, the rigid conductive disc 2 is integrally connected to the guide rod 31 and the second drive portion 32.

[0067] A first drive portion 33 in transmission fit with the second drive portion 32 is formed on the polishing head body 1, and the movement clearance 4 is formed between the first drive portion 33 and the second drive portion 32.

[0068] Specifically, as shown in FIGS. 6-8, the guide rod 31 is a hollow columnar structure, and has a bottom end integrally connected to the upper surface (a surface not provided with the air holes 21) of the rigid conductive disc 2 as well as a top end extending out from the polishing head body 1. The second drive portion 32 includes a plurality of sector-shaped lugs which are arranged around the guide rod 31 at intervals, and the sector-shaped lugs are fixedly connected to an outer wall of the guide rod 31. The specific shape of the lugs is not limited, and the lugs may also be square.

[0069] The first drive portion 33 is a grooved structure allowing the second drive portion 32 to extend therein. When the polishing head body 2 rotates circumferentially, the first drive portion 33 cooperates with the second drive portion 32 to drive the rigid conductive disc 2 to rotate

circumferentially. The sectional area of the first drive portion 33 is greater than that of the second drive portion 32, such that when the second drive portion 32 is attached to the bottom of a groove of the first drive portion 33 to implement electrical conduction, the second drive portion 32 may also move in the first drive portion 33 in a radial direction (herein, the radial direction refers to a diameter direction of the rigid conductive disc 2); or, the power supply is connected to the first drive portion 33 to power on the first drive portion 33, the second drive portion 32 is attached to the side wall of the groove of the first drive portion 33 to implement electrical conduction, and at the same time, the second drive portion 32 may move in the first drive portion 33 in an axial direction. In other words, the second drive portion 32 is attached to at least the side wall or bottom wall of the first drive portion 33 to implement electrical conduction.

[0070] Of course, in other embodiments, the first drive portion 33 may be a lug, and the second drive portion 32 may be a groove. The present invention has no specific limitation in this aspect.

[0071] A radial movement clearance 41 and an axial movement clearance 42 between the first drive portion 33 and the second drive portion 33 form the movement clearance 4, that is, the movement clearance 4 is formed between the polishing head body 1 and the conductive drive unit 3, such that when the pressure in the second air chamber 6 is regulated, the elastic unit 7 may be driven to move flexibly to assist the rigid conductive disc 2 and the wafer substrate in floating in the movement clearance 4. The rigid conductive disc 2, together with the wafer substrate, the platen and the power supply, may form the conduction path for electrochemical chemical polishing, and power is conducted to the rigid conductive disc 2 by means of the guide rod 31 and is then conducted to the wafer substrate for surface modification, such that electrochemical mechanical polishing of the wafer substrate is implemented.

[0072] Embodiment 2

[0073] As shown in FIGS. 9-11, in this embodiment, the conductive drive unit 3 includes a guide block 34 and a wire 35 electrically connected to the guide block 34. The guide block 34 is connected to the polishing head body 1. A groove 23 allowing the guide block 34 to extend therein

is formed in the rigid conductive disc 2, and in this case, the rigid conductive disc 2 and the conductive drive unit 3 are arranged separately. When the polishing head body 1 rotates circumferentially, the guide block 34 cooperates with the groove 23 to drive the rigid conductive disc 2 to rotate circumferentially. The sectional area of the groove 23 is greater than that of the guide block 34, such that the guide block 34 may move in the groove 23 in a radial direction (herein, the radial direction refers to a diameter direction of the rigid conductive disc 2) while being attached to the bottom of the groove 23 to implement electrical conduction; or, the guide block 34 may move in the groove 23 in an axial direction while being attached to the side wall of the groove 23 to implement electrical conduction. In other words, the polishing head body 1 drives the rigid conductive disc 2 to rotate circumferentially by means of the guide block 34, and conducts current to the rigid conductive disc 2 when driving the guide block 34 to rotate circumferentially, and the guide block 34 is attached to at least the side wall or bottom wall of the groove 23 to implement electrical conduction.

[0074] In this embodiment, a plurality of guide blocks 34 are arranged in the circumferential direction of the polishing head body 1 at intervals, and correspondingly, the number of the grooves 23 is the same as that the guide blocks 34. One wire 35 is arranged, or the number of the wires 35 corresponds to the number of the guide blocks 34.

[0075] In a case where one wire 35 is arranged, all the guide blocks 34 are connected into a whole by means of a ring body 36, as shown in FIGS. 12 and 13.

[0076] A radial movement clearance 41 and an axial movement clearance 42 between the guide block 34 and the groove 23 form the movement clearance 4, that is, the movement clearance 4 is formed between the conductive drive unit 3 and the rigid conductive disc 2. Because the guide block 34 is connected to the polishing head body 1, the movement clearance 4 may also be considered as being formed between the rigid conductive disc 2 and the polishing head body 1, such that when the pressure in the second air chamber 6 is regulated, the elastic unit 7 may be driven to move flexibly to assist the rigid conductive disc 2 and the wafer substrate in floating in

the movement clearance 4. The rigid conductive disc 2, together with the wafer substrate, the platen and the power supply, may form a conduction path necessary for electrochemical mechanical polishing, and power is conducted to the guide block 34 by means of the wire 35 and then conducted to the wafer substrate for surface modification, such that electrochemical mechanical polishing of the wafer substrate is implemented.

[0077] The other structures in this embodiment are the same as those in Embodiment 1, and will not be detailed here.

[0078] Embodiment 3

[0079] As shown in FIGS. 14-18, the conductive drive unit 3 includes a guide rod 31 and a second drive portion 32, a top end of the guide rod 31 is connected to external power 312, and the external power 312 may be a motor. A third drive portion 37 in transmission fit with the second drive portion 32 is formed on the rigid conductive disc 2, that is, the rigid conductive disc 2 and the conductive drive unit 3 are arranged separately. The movement clearance 4 is formed between the second drive portion 32 and the third drive portion 37.

[0080] Specifically, the guide rod 31 is a columnar or hollow columnar structure, a bottom end of the guide rod 31 is integrally connected to the second drive portion 32, and the top end of the guide rod 31 extends out from the polishing head body 1 and is provided with an outer gear ring 311. The motor is in transmission with the outer gear ring 311 to drive the guide rod 31 to rotate circumferentially, so as to drive the second drive portion 32 to rotate. The second drive portion 32 includes a plurality of sector-shaped lugs which are arranged around the guide rod 31 at intervals, and the sector-shaped lugs are fixedly connected to an outer wall of the guide rod 31.

[0081] The third drive portion 37 is a grooved structure formed on the upper surface (a surface not provided with the air holes 21) of the rigid conductive disc 2, and allows the second drive portion 32 to extend therein. When the second drive portion 32 rotates circumferentially, the second drive portion 32 cooperates with the third drive portion 37 to drive the rigid conductive disc 2 to rotate circumferentially.

[0082] The power supply is connected to the second drive portion 32 to power on the second drive portion 32, and the sectional area of the third drive portion 37 is greater than that of the second drive portion 32, such that the second drive portion 32 may move in the third drive portion 37 in a radial direction (herein, the radial direction refers to a diameter direction of the rigid
5 conductive disc 2) while being attached to the bottom of a groove of the third drive portion 37 to implement electrical conduction; or, the second drive portion 32 may move axially within the third drive portion 37 while the second drive portion 32 is attached to the side wall of the groove of the third drive portion 37 to achieve electrical conduction. In other words, the second drive portion 32 is attached to at least the side wall or bottom wall of the third drive portion 37 to implement
10 electrical conduction.

[0083] Of course, in other embodiments, the third drive portion 37 may be a lug, and the second drive portion 32 may be a groove. The present invention has no specific limitation in this aspect.

[0084] A radial movement clearance 41 and an axial movement clearance 42 between the third drive portion 37 and the second drive portion 32 form the movement clearance 4, such that when
15 the pressure in the second air chamber 6 is regulated, the elastic unit 7 may be driven to move flexibly to assist the rigid conductive disc 2 and the wafer substrate in floating in the movement clearance 4. The rigid conductive disc 2, together with the wafer substrate, the platen and the power supply, may form a conduction path necessary for electrochemical mechanical polishing, and power is conducted to the rigid conductive disc 2 by means of the guide rod 31 and is then
20 conducted to the wafer substrate for surface modification, such that electrochemical mechanical polishing of the wafer substrate is implemented.

[0085] The other structures in this embodiment are the same as those in Embodiment 1, and will not be detailed here.

[0086] Embodiment 4

25 [0087] As shown in FIGS. 19-21, this embodiment is different from Embodiment 1 in that in this embodiment, the elastic unit 7 is omitted; on the basis that the rigid conductive disc 2 is a

disc-shaped structure, the rigid conductive disc 2 is further provided with a flange 24, the flange 24 extends perpendicularly towards the polishing head body 1 from an outer ring, the flange 24 extends into the polishing head body 1 and is in sealing fit with the polishing head body 1 by means of a sealing element 8 to form the second air chamber 6 and the movement clearance 4, and the flange 24 may be electrically connected to the polishing head body 1, that is, a circuit for electrochemical mechanical polishing and planarization of the wafer substrate is connected to the rigid conductive disc 2 from the flange 24.

[0088] Specifically, a ring groove 12 with the single-sided radial width greater than the thickness of the flange 24 is formed in the polishing head body 1, such that a radial movement clearance 41 of the movement clearance 4 is formed. The sealing element 8 is clamped on a side wall of the ring groove 12, an outer wall of the flange 24 abuts against the sealing element 8 to realize sealing fit, and the flange 24 may float leftward and rightward in the ring groove 12. The depth of the ring groove 12 is greater than the height of the flange 24 extending into the ring groove 12, such that an axial movement clearance 42 of the movement clearance 4 is formed, that is, the flange 24 may float upward and downward in the ring groove 12.

[0089] Identical with Embodiment 1, the conductive drive unit 3 includes a guide rod 31 and a second drive portion 32, the second drive portion 32 is connected to the rigid conductive disc 2, a first drive portion 33 in transmission fit with the second drive portion 32 is formed on the polishing head body 1, and the movement clearance 4 is formed between the first drive portion 33 and the second drive portion 32. In other words, the movement clearance 4 is formed between the conductive drive unit 3 and the rigid conductive disc 2, and the movement clearance 4 is also formed between the rigid conductive disc 2 and the polishing head body 1.

[0090] In this embodiment, free of the limitation of the elastic unit 7, the flange 24 may rotate by any angle in the ring groove 12. That is to say, the rotation direction of the rigid conductive disc 2 may be the same as or opposite to the rotation direction of the polishing head body 1.

[0091] For example, to reduce the wastage of the retaining ring 5, the rotation direction of the

retaining ring 5 is consistent with the rotation direction of the rigid conductive disc 2, that is, the rotation direction of the rigid conductive disc 2 is the same as the rotation direction of the polishing head body 1. If the rotation direction of the rigid conductive disc 2 is opposite to the rotation direction of the polishing head body 1, the surface removal rate of the wafer substrate may be increased. Specifically, the platen rotates anticlockwise, and the rigid conductive disc 2 drives the wafer substrate to rotate clockwise, such that the polishing removal rate is greatly increased. The other structures in this embodiment are the same as those in Embodiment 1, and will not be detailed here.

[0092] Embodiment 5

[0093] As shown in FIGS. 22 and 23, in this embodiment, the elastic unit 7 is omitted, and on the basis that the rigid conductive disc 2 is a disc-shaped structure, the rigid conductive disc 2 is further provided with a flange 24. The specific matching structure of the flange 24 is the same as that in Embodiment 1, and will not be repeated here.

[0094] Identical with Embodiment 1, the conductive drive unit 3 includes a guide block 34 and a wire 35 electrically connected to the guide block 34, the guide block 34 is connected to the polishing head body 1, and a groove 23 allowing the guide block 34 to extend therein is formed in the rigid conductive disc 2. When the polishing head body 1 rotates circumferentially, the guide block 34 cooperates with the groove 23 to drive the rigid conductive disc 2 to rotate circumferentially. A radial movement clearance 41 and an axial movement clearance 42 between the guide block 34 and the groove 23 form the movement clearance 4.

[0095] Of course, the position of the guide block 34 and the position of the groove 23 may be exchanged, that is, the guide block 34 is connected to the rigid conductive disc 2, and the groove 23 allowing the guide block 34 to extend therein is formed in the polishing head body 1, such that the movement clearance 4 is formed between the polishing head body 1 and the conductive drive unit 3, and under the condition that the movement clearance 4 is formed between the polishing head body 1 and the conductive drive unit 3, the movement clearance 4 is also formed between

the rigid conductive disc 2 and the polishing head body 1.

[0096] The other structures in this embodiment are the same as those in Embodiment 1 and will not be repeated here.

[0097] Embodiment 6

5 [0098] As shown in FIGS. 24-26, in this embodiment, the elastic unit 7 is omitted, and on the basis that the rigid conductive disc 2 is a disc-shaped structure, the rigid conductive disc 2 is further provided with a flange 24. The specific matching structure of the flange 24 is the same as that in Embodiment 4, and will not be repeated here.

[0099] Identical with Embodiment 3, the conductive drive unit 3 includes a guide rod 31 and a
10 second drive portion 32, a top end of the guide rod 31 is connected to external power 312, a third drive portion 37 in transmission fit with the second drive portion 32 is formed on the rigid conductive disc 2, and the movement clearance 4 is formed between the second drive portion 32 and the third drive portion 37. In this way, the movement clearance 6 is formed between the conductive drive unit 3 and the rigid conductive disc 2, and the movement clearance 4 is also
15 formed between the rigid conductive disc 2 and the polishing head body 1.

[0100] Of course, the position of the second drive portion 32 and the position of the third drive portion 37 may be exchanged, that is, the second drive portion 32 is arranged on the rigid conductive disc 2, and the third drive portion 37 is arranged on the conductive drive unit 3.

[0101] The other structures in this embodiment are the same as those in Embodiment 1, and
20 will not be detailed here.

[0102] Embodiment 7

[0103] On the basis of Embodiment 1 and Embodiment 3, a radial clearance and an axial clearance are formed between the outer wall of the guide rod 31 and the polishing head body 1, such that the movement clearance 4 is formed between the polishing head body 1 and the
25 conductive drive unit 4, and the movement clearance 4 is also formed between the conductive drive unit 3 and the rigid conductive disc 2.

[0104] Embodiment 8

[0105] In this embodiment, a flexible conductive fabric is attached to the lower surface of the rigid conductive disc 2, and the electrical resistivity of the flexible conductive fabric is less than $10^{-3}\text{m}\Omega\cdot\text{cm}$. The flexible conductive fabric includes air holes, and the air holes match at least some of the air holes 21 of the rigid conductive disc 2 in position, such that the air path is smoother during pressurization or vacuumizing of the air chamber, and the wafer substrate may be better adsorbed during vacuum treatment of the air chamber.

[0106] The other structures in this embodiment are the same as those in Embodiments 1-7, and will not be detailed here.

[0107] The above specific embodiments are used for explaining the present invention rather than limiting the present invention. Any modifications and transformations made to the present invention based on the spirit of the present invention and within the protection scope of the claims should fall within the protection scope of the present invention.

CLAIMS

1. An electrochemical mechanical polishing and planarization device, comprising at least a polishing head, wherein the polishing head comprises:

a polishing head body (1);

5 a rigid conductive disc (2), at least a portion of a lower surface of the rigid conductive disc (2) being coplanar, and the rigid conductive disc (2) being used for adsorbing a wafer substrate;

a conductive drive unit (3), at least a portion of the conductive drive unit (3) being connected to a power supply, and at least a portion of the conductive drive unit (3) being in contact and transmission fit with the rigid conductive disc (2) to drive the rigid conductive disc (2) to rotate
10 circumferentially;

a movement clearance (4), formed between the polishing head body (1) and the conductive drive unit (3), and/or formed between the conductive drive unit (3) and the rigid conductive disc (2), and/or formed between the rigid conductive disc (2) and the polishing head body (1); and

a retaining ring (5), located below the polishing head body (1), the retaining ring (5) being a
15 ring part in contact with a polishing pad, and the rigid conductive disc (2) moving in a region defined by the retaining ring (5).

2. The electrochemical mechanical polishing and planarization device according to claim 1, wherein air holes (21) are formed in the coplanar portion of the lower surface of the rigid conductive disc (2), the air holes (21) communicate with a third air chamber (22) in the rigid
20 conductive disc (2), and when the third air chamber (22) is in a negative pressure state, the rigid conductive disc (2) adsorbs the wafer substrate.

3. The electrochemical mechanical polishing and planarization device according to claim 1, further comprising a pressure-controllable second air chamber (6), wherein the second air chamber (6) is used for driving the rigid conductive disc (2) to ascend and descend.

25 4. The electrochemical mechanical polishing and planarization device according to claim 3, wherein the rigid conductive disc (2) and the conductive drive unit (3) are connected integrally;

or, the rigid conductive disc (2) and the conductive drive unit (3) are arranged separately.

5 5. The electrochemical mechanical polishing and planarization device according to claim 3, wherein the movement clearance (4) comprises at least a radial movement clearance (41) and an axial movement clearance (42).

6. The electrochemical mechanical polishing and planarization device according to claim 3, wherein the conductive drive unit (3) comprises a guide rod (31) and a second drive portion (32), the second drive portion (32) is connected to the rigid conductive disc (2), a first drive portion (33) in transmission fit with the second drive portion (32) is formed on the polishing head body (1), the movement clearance (4) is formed between the first drive portion (33) and the second drive portion (32), and the second drive portion (32) remains in contact with the first drive portion (33) to implement electrical conduction.

7. The electrochemical mechanical polishing and planarization device according to claim 3, wherein the conductive drive unit (3) comprises a guide block (34) and a wire (35) electrically connected to the guide block (34), and the guide block (34) is connected to the polishing head body (1), such that the polishing head body (1) drives the rigid conductive disc (2) to rotate circumferentially by means of the guide block (34), and conducts current to the rigid conductive disc (2) when driving the rigid conductive disc (2) to rotate circumferentially; a groove (23) allowing the guide block (34) to extend therein is formed in the rigid conductive disc (2), and the movement clearance (4) is formed between the guide block (34) and the groove (23).

8. The electrochemical mechanical polishing and planarization device according to claim 7, wherein a plurality of said guide blocks (34) are arranged in a circumferential direction of the polishing head body (1) at intervals, and the guide blocks (34) remain in contact with the groove (23) to implement electrical conduction.

9. The electrochemical mechanical polishing and planarization device according to claim 7, wherein one such said wire (35) is arranged, or the number of the wires (35) corresponds to that of the guide blocks (34); in a case where one such said wire (35) is arranged, all the guide blocks

(34) are connected into a whole by means of a ring body (36).

10. The electrochemical mechanical polishing and planarization device according to claim 3, wherein the conductive drive unit (3) comprises a guide rod (31) and a second drive portion (32), the guide rod (31) is connected to external power, a third drive portion (37) in transmission fit with the second drive portion (32) is formed on the rigid conductive disc (2), and the movement clearance (4) is formed between the second drive portion (32) and the third drive portion (37).

11. The electrochemical mechanical polishing and planarization device according to claim 6, 7 or 10, wherein the conductive drive unit (3) comprises an elastic unit (7), and the elastic unit (7) is connected to the polishing head body (1) and the rigid conductive disc (2), such that the second air chamber (6) is defined by the polishing head body (1), the elastic unit (7) and the rigid conductive disc (2).

12. The electrochemical mechanical polishing and planarization device according to claim 6, 7 or 10, wherein the rigid conductive disc (2) is provided with a flange (24), the flange (24) extends into the polishing head body (1) and is in sealing fit with the polishing head body (1) by means of a sealing element (8) to form the second air chamber (6) and the movement clearance (4), and the flange (24) is electrically connected to the polishing head body (1).

13. The electrochemical mechanical polishing and planarization device according to claim 12, wherein a rotation direction of the rigid conductive disc (2) is the same as or opposite to a rotation direction of the polishing head body (1).

14. The electrochemical mechanical polishing and planarization device according to claim 1 or 2, wherein the lower surface of the rigid conductive disc (2) is coplanar; or, the coplanar portion of the lower portion of the rigid conductive disc (2) forms a thickened or thinned region to form a height difference from nanoscale to microscale.

15. The electrochemical mechanical polishing and planarization device according to claim 2, wherein a flexible conductive fabric is attached to the lower surface of the rigid conductive disc (2), the flexible conductive fabric comprises holes, and the holes match at least some of the air

holes (21) of the rigid conductive disc (2) in position.