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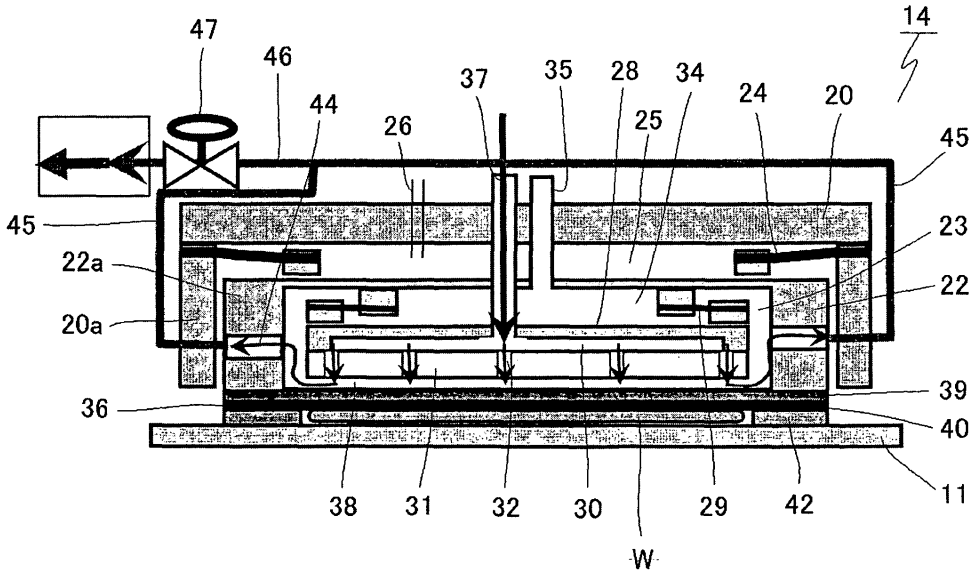
(54) **Polishing apparatus**

(57) The polishing apparatus (10) is capable of improving accuracy of polishing a work (W). The work (W) is pressed onto a polishing cloth (11), with an elastic sheet (36), by a pressing force generated by second pressing means (34) and applied to a carrier (28) and inner pressure of a first fluid chamber (38) generated by a fluid supplied thereto, so as to polish the work (W). The fluid, which has been downwardly supplied into the first fluid chamber (38), horizontally flows outward in the first fluid chamber (38), collides with a side wall of a concave part (23) of a board-shaped member (22) and flows upward, and then the fluid is discharged outside from a fluid outlet (44), thereby a fluid feeding member (31) follows movement of the elastic sheet (36) and maintains parallel thereto, and the fluid feeding member (31) is centered in the first fluid chamber (38).

FIG.2

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## Description

FIELD

**[0001]** The present invention relates to a polishing apparatus for polishing a work, e.g., wafer, and to a method of polishing.

BACKGROUND

**[0002]** A single-side polishing apparatus for polishing a work, e.g., semiconductor wafer, is known. In the single-side polishing apparatus, the work held by a polishing head is pressed onto a polishing surface of a polishing plate, on which a polishing cloth is adhered, and the polishing plate is relatively moved with respect to the polishing head so as to polish the surface of the work.

**[0003]** A conventional single-side polishing apparatus is disclosed in Japanese Laid-open Patent Publication No. P2000-317819A. The single-side polishing apparatus has a polishing head for holding a wafer, the wafer is pressed onto a polishing pad (polishing cloth) adhered on a rotary polishing plate so as to polish the surface of the wafer. The polishing head comprises: a main body section facing the polishing plate and being capable of rotating; a carrier being loosely fitted in the polishing head and being capable of moving in the vertical direction; and a retainer ring enclosing the wafer and being brought into contact with the polishing pad with the wafer. The retainer ring is attached to the carrier by an O-ring, an air spraying member is provided on a lower face of the carrier, a protection sheet covers an outer face of the air spraying member, and the wafer is pressed onto the polishing pad, together with the protection sheet, by air (air layer) sprayed from the air spraying member.

**[0004]** In the polishing apparatus disclosed in Japanese Laid-open Patent Publication No. P2000-317819A, the air layer is formed between the air spraying member and the protection sheet, and the wafer is pressed onto the polishing pad (polishing cloth), together with the protection sheet, by the air layer. With this structure, even if concavities and convexities exist in a surface of the polishing cloth, the wafer is pressed, together with the protection sheet, by the air layer. Therefore, the wafer can move to follow the concavities and convexities, so that the wafer can be polished with high polishing accuracy and damaging the wafer can be prevented by the protection sheet.

**[0005]** However, in the polishing apparatus disclosed in Japanese Laid-open Patent Publication No. P2000-317819A, the O-ring is provided between the retainer ring and the carrier, so the carrier and the air spraying member fixed to the carrier hardly move in the horizontal direction. Namely, the carrier and the air spraying member can move only in the vertical direction with maintaining the horizontal state. When the wafer moves to follow the concavities and convexities of the polishing cloth, the wafer sometimes inclines with respect to the air spraying member which always maintains the horizontal state. Air is downwardly sprayed from the air spraying member. If the wafer inclines with respect to the horizontal plane, a distance between the wafer and the air spraying member is vary from place to place, so pressure applied to the wafer must be uneven and the wafer cannot be polished evenly.

**[0006]** These days, sizes of wafers are getting larger and larger. So, even if such unevenness is minute, it will highly affect the polishing accuracy.

SUMMARY

**[0007]** A preferred embodiment of the invention may provide a polishing apparatus, which is capable of highly improving polishing accuracy.

**[0008]** The polishing apparatus of the present invention, which polishes a surface of a work, comprises:

a polishing plate having a surface on which a polishing cloth is adhered;
a polishing head for pressing the work onto the polishing cloth; and
a driving mechanism for relatively moving the polishing head with respect to the polishing plate,
the polishing apparatus is characterized in,
that the polishing head includes:

a main body section;
a board-shaped member having a concave part whose open end is aimed downward, the board-shaped member being suspended from the main body section and movable in the vertical direction;
a carrier being located in the concave part of the board-shaped member, being supported by the board-shaped member and being capable of inclining, in a state where a prescribed gap is formed between an outer circumferential face of the carrier and a side wall of the concave part, with respect to the horizontal plane, the carrier having a fluid feeding member which has a plurality of spraying ports from which a fluid is sprayed downward;
fluid supplying means for supplying the fluid to the carrier so as to spray the fluid downward from the fluid feeding member;
an elastic sheet being provided to the board-shaped member and covering a lower side of the fluid feeding member so as to form a first fluid chamber, the elastic sheet being capable of holding the work on a lower surface thereof;
a ring-shaped member being provided to an outer edge part of the lower surface of the elastic sheet, the ring-shaped member being capable of enclosing the work held on the lower surface of the elastic sheet;
first pressing means for pressing the board-

shaped member downward so as to press the ring-shaped member onto the polishing cloth with the elastic sheet;
second pressing means for pressing the carrier downward; and
a fluid outlet for discharging the fluid from the first fluid chamber, the fluid outlet being formed in the board-shaped member, at a position higher than a lower surface of the fluid feeding member, and

that the work is pressed onto the polishing cloth, with the elastic sheet, by a pressing force generated by the second pressing means and applied to the carrier and inner pressure of the first fluid chamber generated by the fluid supplied to the first fluid chamber, so as to polish the work, and
the fluid, which has been downwardly supplied into the first fluid chamber, horizontally flows outward in the first fluid chamber, collides with the side wall of the concave part and flows upward, and then the fluid is discharged outside from the fluid outlet, thereby the fluid feeding member follows movement of the elastic sheet and maintains parallel to the elastic sheet, and the fluid feeding member is centered in the first fluid chamber.

**[0009]** By employing the polishing apparatus of the present invention, the work can be uniformly polished with high polishing accuracy.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0010]** Embodiments of the present invention will now be described by way of examples and with reference to the accompanying drawings, in which:

Fig. 1 is a schematic explanation view of an embodiment of a polishing apparatus;
Fig. 2 is a schematic sectional view of a polishing head;
Fig. 3 is an explanation view showing inclination of a work; and
Fig. 4 is a schematic sectional view of another polishing head.

## DETAILED DESCRIPTION OF THE EMBODIMENTS

**[0011]** Preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

**[0012]** Fig. 1 is a schematic explanation view of a polishing apparatus of the present embodiment.

**[0013]** The polishing apparatus 10 comprises: a polishing plate 12 having an upper surface on which a polishing cloth 11 for polishing a work W (see Fig. 2) is adhered; a polishing head 14 for holding the work W on a lower surface and pressing the work W onto the polishing cloth 11; and a driving mechanism for relatively moving the polishing head 14 with respect to the polishing plate 12.

**[0014]** The driving mechanism is constituted by a first rotary driving unit (not shown) for rotating the polishing plate 12 about a rotary shaft 15 and a second rotary driving unit (not shown) for rotating the polishing head 14 about a rotary shaft 16. Further, the polishing head 14 has a vertical driving unit (not shown) and a horizontal driving unit (not shown), holds the work W on the lower surface, and presses the work W onto the polishing cloth 11. While pressing the work W onto the polishing cloth 11, the driving mechanism relatively rotates the polishing plate 12 and the polishing head 14 so as to polish the lower surface of the work W. A slurry supply nozzle 18 supplies slurry to the polishing cloth 11 adhered on the polishing plate 12.

**[0015]** Fig. 2 is a schematic sectional view of the polishing head 14.

**[0016]** A main body section 20 has a side wall 20a and a concave part whose open end is aimed downward.

**[0017]** A board-shaped member 22 has a side wall 22a and a concave part 23 whose open end is aimed downward. The board-shaped member 22 is suspended, in the main body section 20, by a ring-shaped rubber diaphragm 24 having enough elasticity, and capable of moving in the vertical direction. The side wall 20a acts as a guide for the vertical movement of the board-shaped member 22.

**[0018]** A third fluid chamber 25 is formed, between the board-shaped member 22 and the main body section 20, by the diaphragm 24. Air is supplied from a compressed air source (not shown), e.g., air compressor, to the third fluid chamber 25 via a fluid path 26 formed in the rotary shaft 16 (not shown in Fig. 2) of the polishing head 14. The fluid path 26 is connected to the compressed air source by a rotary joint (not shown). The fluid path 26, the compressed air source, etc. constitute third fluid supplying means.

**[0019]** Further, the third fluid chamber 25, the third fluid supplying means, etc. constitute first pressing means.

**[0020]** A carrier 28 is located in the concave part 23 of the board-shaped member 22, supported by a diaphragm 29 and capable of inclining, in a state where a prescribed gap is formed between an outer circumferential face of the carrier 28 and an inner face of the side wall 22a of the concave part 23, with respect to the horizontal plane.

**[0021]** A second fluid chamber 34 is formed, between the carrier 28 and the board-shaped member 22, by the diaphragm 29. Air is supplied from the compressed air source (not shown) to the second fluid chamber 24 via a fluid path 35 formed in the rotary shaft 16 (not shown in Fig. 2) of the polishing head 14. The fluid path 35 is connected to the compressed air source by a rotary joint (not shown). The fluid path 35, the compressed air source, etc. constitute second fluid supplying means.

**[0022]** Further, the third second chamber 34, the second fluid supplying means, etc. constitute second press-

ing means.

**[0023]** An air reservoir 30 is formed in the carrier 28. A fluid feeding member 31 is fixed to the carrier 28 and covers the lower side of the air reservoir 30. A plurality of spraying ports, which are capable of spraying air downward, are formed in the fluid feeding member 31. Air is supplied from the compressed air source (not shown) to the air reservoir 30 via a fluid path 37 formed in the rotary shaft 16 (not shown in Fig. 2) of the polishing head 14. The fluid path 37 is connected to the compressed air source by a rotary joint (not shown). The fluid path 37, the compressed air source, etc. constitute first fluid supplying means.

**[0024]** An elastic sheet 36 covers the lower side of the fluid feeding member 31, and an outer edge of the elastic sheet 36 is air-tightly fixed to a lower end of the side wall 22a of the board-shaped member 22 by suitable means (not shown). With this structure, a first fluid chamber 38 is formed under the fluid feeding member 31.

**[0025]** The elastic sheet 36 is a two-layered sheet constituted by a sheet-shaped member 39, which is composed of rubber and has enough elasticity, and a holding member 40, which is provided under the sheet-shaped member 39 and has many holes for holding the work W by surface tension of water.

**[0026]** A ring-shaped member 42 composed of plastic, which encloses the work W held on a lower surface of the elastic sheet 36, is attached to a lower edge of the elastic sheet 36.

**[0027]** While polishing the work W, air is supplied to the third fluid chamber 25 so as to press the board-shaped member 22 downward, and the ring-shaped member 42 is pressed onto the polishing cloth 11 with the elastic sheet 36. By downwardly pressing the polishing cloth 11 near an outer edge of the work W until reaching a level with the lower surface of the work W, excessive polishing of the outer edge of the work W can be prevented.

**[0028]** A plurality of fluid outlets 44 for discharging the fluid from the first fluid chamber 38 are formed, in the board-shaped member 22, at positions higher than the lower surface of the fluid feeding member 31. The fluid outlets 44 are equiangularly arranged.

**[0029]** In the present embodiment, discharge pipes 45 are respectively connected to the fluid outlets 44, and the discharge pipes 45 are connected to a collecting pipe 46. A relief valve 47 is provided to the collecting pipe 46. The relief valve 47 maintains inner pressure of the first fluid chamber 38 at prescribed pressure. When the inner pressure of the first fluid chamber 38 is higher than the prescribed pressure, the relief valve 47 discharges air from the first fluid chamber 38.

**[0030]** Note that, number of the fluid outlet 44 may be one.

**[0031]** The discharge pipes 45 are extended outside of the main body section 20 via large through-holes formed in the side wall 20a.

**[0032]** Air discharged by the relief valve 47 may be collected and introduced to the compressed air source (not shown) to reuse. With this structure, running cost of the apparatus can be reduced and the apparatus is better for the environment.

**[0033]** Note that, the discharge pipes 45 and the relief valve 47 may be omitted. Further, the fluid may be directly discharged from the fluid outlets 44.

**[0034]** The polishing apparatus of the present embodiment has the above described structure. Next, a polishing method in the polishing apparatus will be explained.

**[0035]** As described above, air is supplied into the third fluid chamber 25 to press the board-shaped member 22 (the press action is performed by the first pressing means) and the ring-shaped member 42 is pressed onto the polishing cloth 11 with the side wall 22a of the board-shaped member 22 and the elastic sheet 36 while polishing the work W, so that excessive polishing of the outer edge of the work W can be prevented.

**[0036]** Air is supplied into the second fluid chamber 34 so as to press the carrier 28 downward. Further, air is supplied into the first fluid chamber 38 so as to press the elastic sheet 36.

**[0037]** Therefore, a pressing force for pressing the carrier 28, which is applied by the second fluid chamber 34 (the second pressing means), and the inner pressure of the air supplied into the first fluid chamber 38 are applied to the work W via the elastic sheet 36, so that the work W is pressed onto the polishing cloth 11 and polished thereon.

**[0038]** Note that, air supplied into the first fluid chamber 38 is always discharged outward from the fluid outlets 44. A prescribed air layer must be always formed in the first fluid chamber 38. Thus, the inner pressures of the first fluid chamber 38 and the second fluid chamber 34 are suitably set so as not to break the air layer in the first fluid chamber 38 by the inner pressure of the second fluid chamber 34. By providing the relief valve 47, the inner pressure of the first fluid chamber 38 can be easily controlled.

**[0039]** While polishing the work W, the air, which has been downwardly supplied into the first fluid chamber 38, horizontally flows outward in the first fluid chamber 38, collides with the inner face of the side wall 22a of the concave part 23 of the board-shaped member 22 and flows upward, and then the air is discharged outside from the fluid outlets 44. The fluid outlets 44 are located at positions sufficiently-higher than a lower surface of the fluid feeding member 31. Since the air horizontally flows outward in the first fluid chamber 38, collides with the inner face of the side wall 22a of the concave part 23 of the board-shaped member 22 and flows upward, the carrier 28 (the fluid feeding member 31) is centered by a reactive force generated by colliding the air with the ring-shaped side wall 22a.

**[0040]** As described above, the carrier 28 (the fluid feeding member 31) is floated and the carrier 28 does not directly act on the work W. Therefore, even if concavities and convexities exist on the surface of the pol-

ishing cloth 11 like gurge, the wafer can move to follow the concavities and convexities thereon.

**[0041]** In the present embodiment, the carrier 28 (the fluid feeding member 31) is supported by the board-shaped member 22 and capable of inclining, with respect to the horizontal plane, in a state where a prescribed gap is formed between an outer circumferential face of the carrier 28 and the inner face of the side wall 22a of the concave part 23.

**[0042]** In a state where the surface of the polishing cloth 11 is horizontal, the carrier 28 (the fluid feeding member 31) is also horizontal. If concavities and convexities exist in the surface of the polishing cloth 11, the work W is inclined, with respect to the horizontal carrier 28 (the fluid feeding member 31), as shown in Fig. 3. Note that, the inclination of the work W is exaggerated in Fig. 3. In the conventional polishing apparatus disclosed in Japanese Laid-open Patent Publication No. P2000-317819A, the horizontal state of the carrier is maintained, so a distance between the carrier (the fluid feeding member) and the work is varied, so the work cannot be uniformly pressed and cannot be evenly polished.

**[0043]** On the other hand, in the present embodiment, the carrier 28 (the fluid feeding member 31) is inclinable with respect to the board-shaped member 22. As shown in Fig. 3, when the work W is inclined and a distance between the carrier 28 (the fluid feeding member 31) and the work W is varied, pressure (a reactive force) applied to the carrier 28 (the fluid feeding member 31) from a part X of the work W, at which the distance is short, is higher; on the other hand, pressure (a reactive force) applied to the carrier 28 (the fluid feeding member 31) from a part Y of the work W, at which the distance is longer, is lower. Since the work W contacts the polishing cloth 11, one part of the carrier 28 (the fluid feeding member 31), which corresponds to the part X of the work W and to which the higher pressure (the reactive force) is applied, is moved away from the work W; the other part of the carrier 28 (the fluid feeding member 31), which corresponds to the part Y of the work W and to which the lower pressure (the reactive force) is applied, is moved close to the work W. With this action, the carrier 28 (the fluid feeding member 31) is inclined and made parallel to the work W. Therefore, the distance between the carrier 28 (the fluid feeding member 31) and the work W is made constant, so that the pressing force can be uniformly applied to the work W and the work W can be evenly polished.

**[0044]** As described above, the air pressure is applied to the carrier 28 (the fluid feeding member 31) so as to center the carrier 28 (the fluid feeding member 31). Even if the carrier 28 (the fluid feeding member 31) is inclined and shifted from the center of the board-shaped member 22, the carrier 28 (the fluid feeding member 31) is always biased toward the center of the board-shaped member 22.

**[0045]** In the present embodiment, the carrier 28 has the above described floating structure, and no load is applied from the work W while the polishing operation. Therefore, the diaphragm 29, which suspends the carrier 28, need not have high rigidity, so the carrier 28 can be easily inclinably suspended.

**[0046]** Fig. 4 is a schematic sectional view of another polishing head 14. Note that, the structural elements shown in Fig. 2 are assigned the same symbols and explanation will be omitted.

**[0047]** In the present embodiment, an air reservoir of the carrier 28 is divided into a plurality of reservoirs, e.g., a central air reservoir 30a and an outer air reservoir 30b. Fluid supplying means 50a and 50b respectively supply air to the air reservoirs 30a and 30b. A flow volume controller 52 is provided to the fluid supplying means 50a so as to control flow volume of the air supplied to the air reservoir 30a. Another flow volume controller (not shown) may be provided to the fluid supplying means 50b. Note that, a pressure controller or controllers may be employed instead of the flow volume controller or controllers.

**[0048]** In the present embodiment, the pressing force applied to a center zone and an outer zone of the work W can be controlled. Namely, polishing conditions can be precisely controlled.

**[0049]** Note that, the work W may be coaxially divided into three zones or more, and the pressing force can be controlled in the zones respectively.

**[0050]** In each of the above described embodiments, the fluid is air. The fluid may be a liquid. Further, the first pressing means (the third fluid chamber 25, etc.) and the second pressing means (the second fluid chamber 34, etc.) may be mechanical means, e.g., spring, screw mechanism.

**[0051]** All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiments of the present invention has been described in detail, it should be understood that the various changes, substitutions, and alternations could be made hereto.

## Claims

1. A polishing apparatus (10) for polishing a surface of a work (W) comprising: a polishing plate (12) having a surface on which a polishing cloth (11) is adhered; a polishing head (14) for pressing the work (W) onto the polishing cloth (11); and a driving mechanism for relatively moving the polishing head (14) with respect to the polishing plate (12),
the polishing apparatus (10) being **characterized in, that** the polishing head (14) includes:

a main body section (20);
a board-shaped member (22) having a concave part (23) whose open end is aimed downward, the board-shaped member (22) being suspended from the main body section (20) and movable in the vertical direction;
a carrier (28) being located in the concave part (23) of the board-shaped member (22), being supported by the board-shaped member (22) and being capable of inclining, in a state where a prescribed gap is formed between an outer circumferential face of the carrier (28) and a side wall of the concave part (23), with respect to the horizontal plane, the carrier (28) having a fluid feeding member (31) which has a plurality of spraying ports (32) from which a fluid is sprayable downward;
fluid supplying means (37) for supplying the fluid to the carrier (28) so as to spray the fluid downward from the fluid feeding member (31);
an elastic sheet (36) being provided to the board-shaped member (22) and covering a lower side of the fluid feeding member (31) so as to form a first fluid chamber (38), the elastic sheet (36) being capable of holding the work (W) on a lower surface thereof;
a ring-shaped member (42) being provided to an outer edge part of the lower surface of the elastic sheet (36), the ring-shaped member (42) being capable of enclosing the work (W) held on the lower surface of the elastic sheet (36);
first pressing means (25) for pressing the board-shaped member (22) downward so as to press the ring-shaped member (42) onto the polishing cloth (11) with the elastic sheet (36);
second pressing means (34) for pressing the carrier (28) downward; and
a fluid outlet (44) for discharging the fluid from the first fluid chamber (38), the fluid outlet (44) being formed in the board-shaped member (22), at a position higher than a lower surface of the fluid feeding member (31), the arrangement being such that, in use,
the work (W) is pressed onto the polishing cloth (11), with the elastic sheet (36), by a pressing force generated by the second pressing means (34) and applied to the carrier (28) and inner pressure of the first fluid chamber (38) generated by the fluid supplied to the first fluid chamber (38), so as to polish the work (W), and
the fluid, which has been downwardly supplied into the first fluid chamber (38), horizontally flows outward in the first fluid chamber (38), collides with the side wall of the concave part (23) and flows upward, and then the fluid is discharged outside from the fluid outlet (44), thereby the fluid feeding member (31) follows movement of the elastic sheet (36) and maintains parallel to the elastic sheet (36), and the fluid feeding member (31) is centered in the first fluid chamber (38).

**2.** The polishing apparatus (10) according to claim 1, wherein the carrier (28) is supported by the board-shaped member (22) with a diaphragm (29) and capable of inclining in the state where the prescribed gap is formed between the outer circumferential face of the carrier (28) and the side wall of the concave part (23), and
the second pressing means includes:

a second fluid chamber (34) being formed, by the diaphragm (29), between the carrier (28) and the board-shaped member (22); and
second fluid supplying means (35) for supplying the fluid to the second fluid chamber (34).

**3.** The polishing apparatus (10) according to claim 1 or 2,
wherein the board-shaped member (22) is suspended, by a diaphragm (24), from the main body section (20) and movable in the vertical direction, and
the first pressing means includes:

a third fluid chamber (25) being formed, by the diaphragm (24), between the board-shaped member (22) and the main body section (20); and
third fluid supplying means (26) for supplying the fluid to the third fluid chamber (25).

**4.** The polishing apparatus (10) according to one of claims 1-3,
wherein a discharge pipe (45) is connected to the fluid outlet (44), a relief valve (47) is provided to the discharge pipe (45), and inner pressure of the first fluid chamber (38) is maintainable, at prescribed pressure, by the relief valve (47).

**5.** The polishing apparatus (10) according to claim 4, wherein the fluid discharged from the discharge pipe (45) is collected and reused.

**6.** The polishing apparatus (10) according to one of claims 1-5,
wherein in use the pressing force, which is applied to the work (W) via the elastic sheet (36), is different in a plurality of coaxial zones of the work (W), and flow volume of the fluid toward the first fluid chamber (38) is presettable for each of the coaxial zones.

**7.** The polishing apparatus (10) according to one of claims 1-6,
wherein the fluid fed into the fluid chambers (38, 34, 25) is air.

**8.** The polishing apparatus (10) according to one of claims 1-7,
wherein the elastic sheet (36) is a two-layered sheet constituted by a sheet-shaped member (39) and a holding member (40) provided under the sheet-shaped member (39).

**9.** A method of polishing comprising using polishing apparatus according to any preceding claim to polish a work (W).

FIG.1

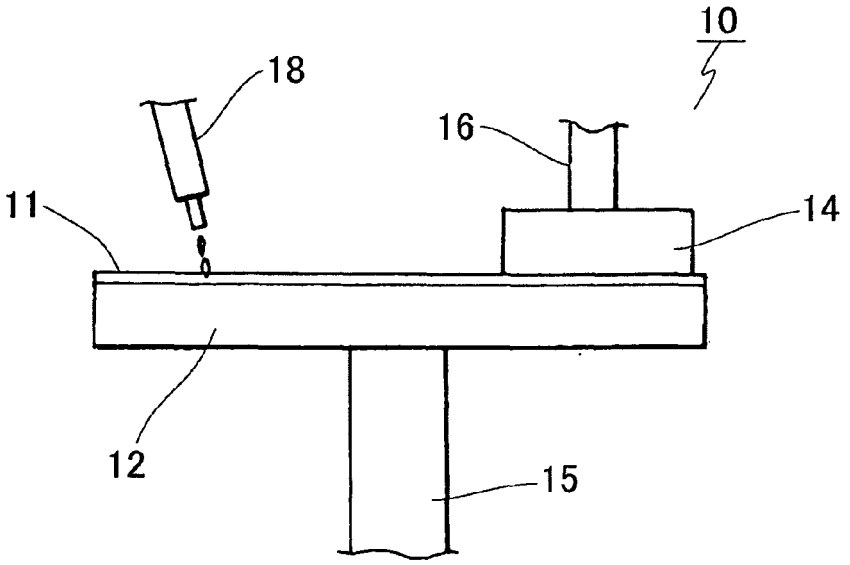
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FIG.2

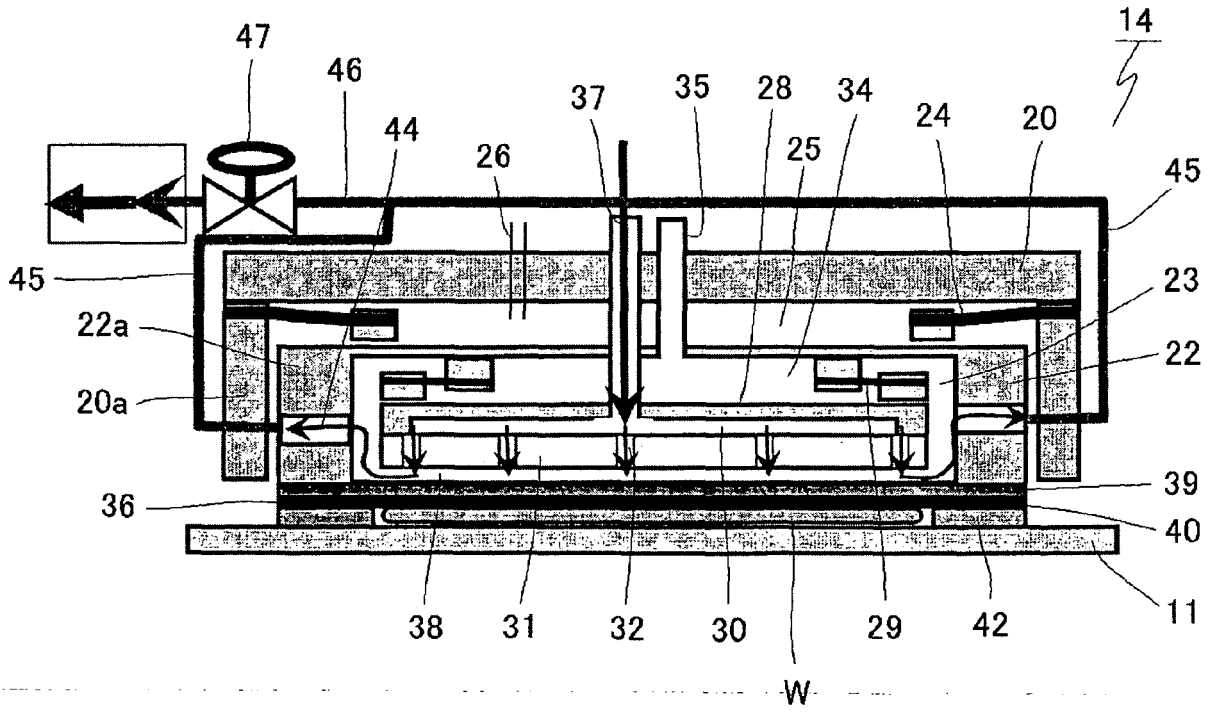
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FIG.3

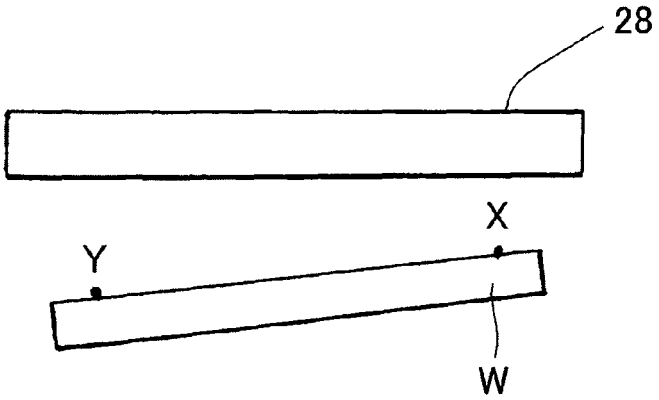
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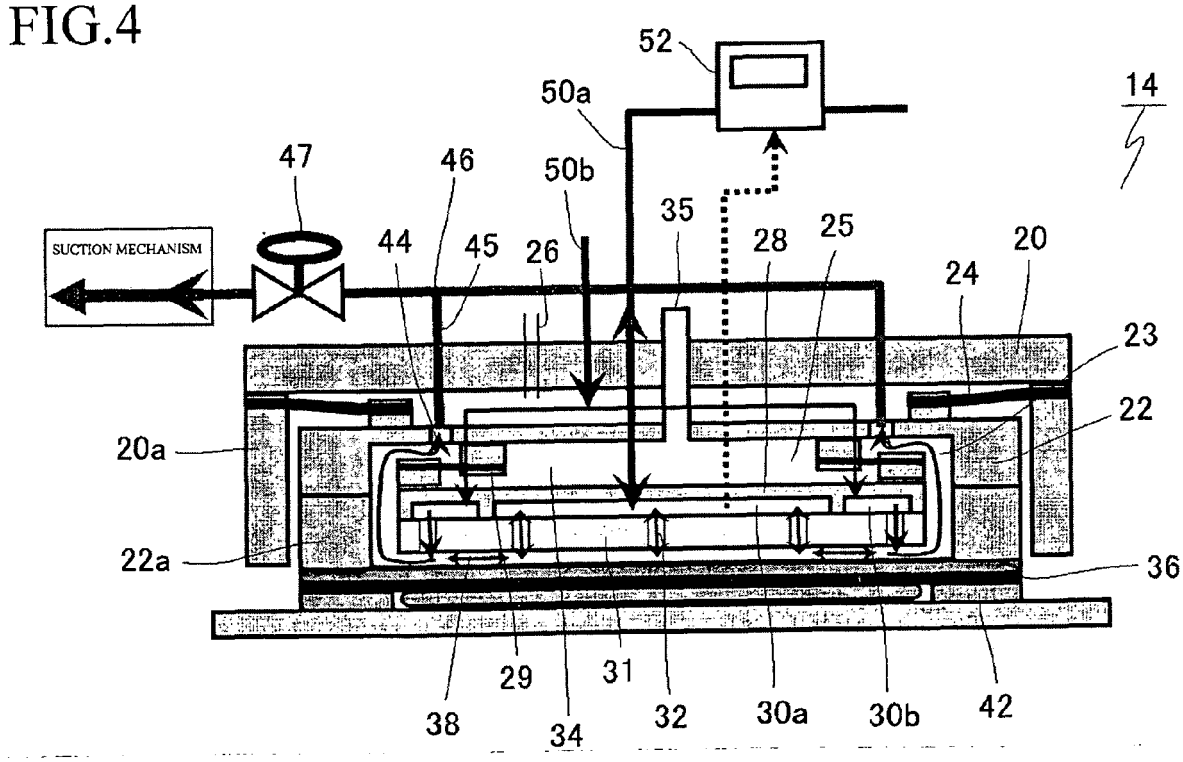
FIG.4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SUCTION MECHANISM
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## REFERENCES CITED IN THE DESCRIPTION

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