

CLEANING DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a cleaning device.

Description of the Related Art

In a manufacturing process of various electronic parts such as semiconductor device chips, a plate-shaped workpiece such as a silicon wafer, a glass substrate, or a resin package substrate formed with devices is processed by using a cutting blade, a laser beam, or the like. When the workpiece is thus processed, processing swarf such as cutting swarf and debris may be generated and adhere to the front surface of the workpiece.

Therefore, after the processing, the workpiece is, for example, cleaned by a cleaning device having a cleaning chamber that accommodates a chuck table having a flat holding surface and a nozzle for supplying a cleaning liquid to the holding surface. Generally, the chuck table can suck the workpiece by generating a negative pressure in a space on the holding surface, can be separated from the workpiece by generating a positive pressure in the space on the holding surface, and can be rotated with a straight line that passes through the center of the holding surface

and is orthogonal to the holding surface, as a rotational axis.

In the cleaning device, the cleaning liquid is supplied from the nozzle to the front surface of the workpiece, in a state in which the back surface side of the workpiece is held under suction by the chuck table and the chuck table is being rotated. As a result, cutting swarf or debris adhering to the front surface of the workpiece is removed. The chuck table used in this way is supported by a spindle unit in a rotatable manner.

The spindle unit has a spindle that supports the chuck table, and a bearing that supports the spindle in a rotatable manner. By an operation of a motor connected to an end portion of the spindle, the chuck table is rotated together with the spindle. In addition, in the spindle unit, the spindle and the bearing are accommodated in a case for the purpose of preventing a lubricant such as grease provided inside the bearing from scattering to the surroundings.

Further, the space on the holding surface of the chuck table communicates with a negative pressure supply pipe and a positive pressure supply pipe which are connected to the case, through a negative pressure or positive pressure supply pipe formed inside the spindle and a

pressure variable section which is a space defined by oil seals between the case and the spindle. By an operation of a negative pressure supply source connected to the negative pressure supply pipe, a negative pressure is generated in the space on the holding surface, and, by an operation of a positive pressure supply source connected to the positive pressure supply pipe, a positive pressure is generated in the space on the holding surface. Note that a lubricating oil is often provided at the boundary between the oil seals and the spindle so as not to hinder rotation of the spindle.

Here, the spindle has an end portion projecting from the case, to be connected to the chuck table. In addition, the cleaning chamber accommodating the chuck table is provided with an opening into which the end portion of the spindle is inserted. Therefore, the space between the case and the spindle and the cleaning chamber may communicate with each other through this opening. In this case, the lubricant scattered from the bearing and/or the lubricating oil scattered from the boundary between the oil seal and the spindle or the like may enter the cleaning chamber and may adhere to the front surface of the workpiece.

Therefore, in such a device having a chuck table, generally, a seal member that interrupts the communication between the space on the chuck table side and the space on

the spindle unit side is provided (see, for example, Japanese Patent Laid-open No. 2018-73930). This seal member includes, for example, a V ring, and a lip section thereof is provided in such a manner as to make contact with a rotatable sealed section.

SUMMARY OF THE INVENTION

In the case where the seal member makes contact with the rotatable sealed section, the seal member is worn attendant on rotation of the sealed section, and therefore, it is difficult to interrupt the communication between the space on the chuck table side and the space on the spindle unit side for a long period of time.

In consideration of this point, it is an object of the present invention to provide a cleaning device by which communication between the space on the spindle unit side and the cleaning chamber accommodating the chuck table can be interrupted for a long period of time.

In accordance with an aspect of the present invention, there is provided a cleaning device including a chuck table that holds a workpiece on a holding surface, a nozzle that supplies a cleaning liquid to the workpiece held by the chuck table, and a spindle unit that supports the chuck table in a rotatable manner, the cleaning device cleaning

the workpiece in a cleaning chamber that accommodates the chuck table and the nozzle. The spindle unit has a spindle that supports the chuck table, a bearing that supports the spindle in a rotatable manner, and a case that accommodates a part of the spindle and the bearing. A pressure variable section and an opening section are provided between the case and the spindle. The pressure variable section is disposed between a negative pressure supply pipe and a positive pressure supply pipe which are connected to the case and a negative pressure or positive pressure supply pipe formed inside the spindle and communicating with a space on the holding surface, and is disposed at a position farther from the chuck table than the bearing. The opening section is provided between the bearing and the pressure variable section and is opened through a through-hole formed in the case or through an opening pipe connected to the case. The spindle has an end portion projecting from the case. A part of the cleaning chamber is defined by a cover member having an opening into which the end portion of the spindle is inserted. A seal section that interrupts communication between a space between the case and the spindle and the cleaning chamber is provided between the cover member and the end portion of the spindle. The seal section has an annular magnet ring provided on an inner

circumferential surface defining the opening of the cover member, and a magnetic fluid provided on an inner side of the magnet ring and making contact with the end portion of the spindle.

Further, in the present invention, it is preferable that the end portion of the spindle have a cylindrical sealed section making contact with the magnetic fluid, and a cylindrical extension section extending from the sealed section toward the chuck table side and being the same as the sealed section in diameter.

In the present invention, the seal section that interrupts the communication between the space between the case and the spindle and the cleaning chamber has the magnetic fluid which makes contact with the spindle. Therefore, in the present invention, the communication between the space and the cleaning chamber is interrupted without causing solids to make contact with each other. As a result, wear of the seal section attendant on rotation of the spindle is reduced, and the communication between the space and the cleaning chamber can be interrupted for a long period of time.

Further, in the present invention, the opening section is provided between the bearing and the pressure variable section. As a result, even in the case where

leakage from the pressure variable section to the opening section occurs due to variation in pressure in the pressure variable section, variation in pressure around the bearing is restrained. Therefore, scattering of a lubricant such as grease provided inside the bearing is restrained.

In addition, in the case where such opening section is provided, variation in pressure around the seal section is also restrained. Therefore, outflow of the magnetic fluid contained in the seal section is prevented. As a result, the communication between the space between the case and the spindle and the cleaning chamber can be interrupted for a long period of time.

The above and other objects, features and advantages of the present invention and the manner of realizing them will become more apparent, and the invention itself will best be understood from a study of the following description and appended claims with reference to the attached drawings showing a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view schematically depicting an example of a processing apparatus;

FIG. 2 is a partially cut perspective view schematically depicting an example of a cleaning device;

FIG. 3 is a partially sectional side view schematically depicting a spindle, a case, a cover member, and the like; and

FIG. 4 is an enlarged view of a part of FIG. 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will be described referring to the attached drawings. FIG. 1 is a perspective view schematically depicting an example of a processing apparatus (cutting apparatus) that has a cleaning device. Note that an X-axis direction (front-rear direction) and a Y-axis direction (left-right direction) depicted in FIG. 1 are mutually orthogonal directions on a horizontal plane, and a Z-axis direction (upward-downward direction) is a direction (vertical direction) orthogonal to the X-axis direction and the Y-axis direction.

A cutting apparatus 2 depicted in FIG. 1 includes a base 4 that supports each of constituent elements. An upper surface of the base 4 is formed with a rectangular opening 4a of which the longitudinal direction is parallel to the X-axis direction. A moving table 6 and bellows-like dustproof and droplet-proof covers 8 which contract and extend attendant on movement of the moving table 6 are provided in the opening 4a. An X-axis direction moving

mechanism (not illustrated) that moves the moving table 6 along the X-axis direction is provided below the dustproof and droplet-proof covers 8.

A chuck table 10 is provided on an upper surface of the moving table 6. The chuck table 10 has a disk-shaped porous plate 10a exposed on an upper side and has a function of holding under suction the workpiece placed on the porous plate 10a. An upper surface of the porous plate 10a is generally flat and constitutes a holding surface for holding the workpiece. A suction passage (not illustrated) having one end connected to a suction source (not illustrated) such as an ejector provided outside the chuck table 10 is formed inside the chuck table 10.

The other end of the suction passage reaches the porous plate 10a. Therefore, when the suction source is operated in a state in which the workpiece is placed on the holding surface, the workpiece is held onto the chuck table 10 under suction. Further, the chuck table 10 is connected to a chuck table rotational drive source (not illustrated) such as a motor. When the chuck table rotational drive source is operated, the chuck table 10 is rotated with a straight line that passes through the center of the holding surface and that is orthogonal to the holding surface, as a rotational axis.

A support structure 12 is provided in the vicinity of the opening 4a on the upper surface of the base 4. The support structure 12 includes an upright section 12a extending along the Z-axis direction from the upper surface of the base 4, and an arm section 12b extending along the Y-axis direction from an upper end portion of the upright section 12a in such a manner as to bridge the opening 4a. On a front surface side of the arm section 12b, a Y-axis direction moving mechanism 14 is provided.

The Y-axis direction moving mechanism 14 includes a pair of Y-axis guide rails 16 fixed to a front surface of the arm section 12b and extending along the Y-axis direction. A Y-axis moving plate 18 is connected to a front surface side of the pair of Y-axis guide rails 16 in such a manner as to be slidable along the pair of Y-axis guide rails 16.

In addition, a screw shaft 20 extending along the Y-axis direction is disposed between the pair of Y-axis guide rails 16. A motor (not illustrated) for rotating the screw shaft 20 is connected to one end portion of the screw shaft 20. A nut section (not illustrated) accommodating a ball that rolls on the surface of the rotating screw shaft 20 is provided on the surface formed with a spiral groove of the screw shaft 20, to constitute a ball screw.

In other words, when the screw shaft 20 is rotated,

the ball is circulated in the nut section, and the nut section is moved along the Y-axis direction. In addition, the nut section is fixed to a rear surface side of the Y-axis moving plate 18. Therefore, when the screw shaft 20 is rotated by the motor connected to one end portion of the screw shaft 20, the Y-axis moving plate 18 is moved along the Y-axis direction together with the nut section.

On a front surface side of the Y-axis moving plate 18, a Z-axis direction moving mechanism 22 is provided. The Z-axis direction moving mechanism 22 includes a pair of Z-axis guide rails 24 fixed to a front surface of the Y-axis moving plate 18 and extending along the Z-axis direction. A Z-axis moving plate 26 is connected on a front surface side of the pair of Z-axis guide rails 24 in such a manner as to be slidable along the pair of Z-axis guide rails 24.

In addition, a screw shaft 28 extending along the Z-axis direction is disposed between the pair of Z-axis guide rails 24. A motor 30 for rotating the screw shaft 28 is connected to one end portion of the screw shaft 28. A nut section (not illustrated) accommodating a ball that rolls on the surface of the rotating screw shaft 28 is provided on the surface formed with a spiral groove of the screw shaft 28, to constitute a ball screw.

In other words, when the screw shaft 28 is rotated, the ball is circulated in the nut section, and the nut section is moved along the Z-axis direction. In addition, the nut section is fixed to a rear surface side of the Z-axis moving plate 26. Therefore, when the screw shaft 28 is rotated by the motor 30, the Z-axis moving plate 26 is moved along the Z-axis direction together with the nut section.

A cutting unit 32 is fixed to a lower portion of the Z-axis moving plate 26. The cutting unit 32 has a cylindrical spindle housing 34 of which the longitudinal direction is parallel to the Y-axis direction. A cylindrical spindle (not illustrated) of which the longitudinal direction is parallel to the Y-axis direction is accommodated in the spindle housing 34. The spindle is supported by the spindle housing 34 in a rotatable state.

A tip portion of the spindle projects to an outside of the spindle housing 34, and a cutting blade 36 having an annular cutting edge is mounted to the tip portion. In addition, a base end portion of the spindle is connected to a cutting blade rotational drive source (not illustrated) such as a motor incorporated in the spindle housing 34.

At a position adjacent to the cutting unit 32 in the

X-axis direction, there is provided an imaging unit 38 which is fixed to a lower portion of the Z-axis moving plate 26. The imaging unit 38 includes, for example, a light source such as a light emitting diode (LED), an objective lens, and an imaging element such as a charge coupled device (CCD) image sensor or a complementary metal oxide semiconductor (CMOS) image sensor.

Processing of the workpiece in the cutting apparatus 2 is conducted, for example, in the following order. First, the workpiece held by the chuck table 10 under suction is imaged by the imaging unit 38. Next, based on the image obtained by the imaging, alignment between the cutting unit 32 and the workpiece is performed. Specifically, the Y-axis direction moving mechanism 14 and/or the Z-axis direction moving mechanism 22 adjusts the position of the cutting unit 32, and/or the X-axis direction moving mechanism and/or the chuck table rotational drive source adjusts the position and/or orientation of the chuck table 10 holding the workpiece under suction.

Subsequently, the cutting blade 36, in a rotating state, is brought into contact with the workpiece. Specifically, in a state in which the spindle with the cutting blade 36 mounted to the tip portion thereof is rotated by the cutting blade rotational drive source, the

Y-axis direction moving mechanism 14 and/or the Z-axis direction moving mechanism 22 moves the cutting unit 32, and/or the X-axis direction moving mechanism and/or the chuck table rotational drive source moves the chuck table 10 holding the workpiece under suction. As a result, desired processing is applied to the workpiece.

In addition, a cleaning device 40 is provided at a position on a front side of the support structure 12 on the upper surface of the base 4. FIG. 2 is a partially cut perspective view schematically depicting the cleaning device 40. The cleaning device 40 has a chuck table 42. The chuck table 42 has a disk-shaped porous plate 42a exposed on the upper side and has a function of holding under suction the workpiece placed on the porous plate 42a. An upper surface of the porous plate 42a is generally flat, and constitutes a holding surface for holding the workpiece.

Around the chuck table 42, a cleaning chamber main body 44 surrounding the chuck table 42 is provided. The cleaning chamber main body 44 has a cylindrical outer circumferential wall 44a, an annular bottom wall 44b extending radial-directionally inward from a lower end portion of the outer circumferential wall 44a, and a cylindrical inner circumferential wall 44c erected from an inner end portion of the bottom wall 44b.

The outer circumferential wall 44a is provided with an exhaust port (not illustrated), and the exhaust port is connected to an exhaust pump (not illustrated) through an exhaust pipe 46. In addition, the bottom wall 44b is provided with a drain port 48, and a drain pipe 50 extending downward is connected to the drain port 48. Besides, a plurality of (for example, three) support legs 52 are fixed to a lower surface of the bottom wall 44b. The plurality of support legs 52 are provided substantially at regular intervals along a circumferential direction of the bottom wall 44b and support the cleaning chamber main body 44.

A disk-shaped lid (not illustrated) is provided on the upper side of the cleaning chamber main body 44. A diameter of the lid is longer than an inside diameter of the outer circumferential wall 44a. A lower surface of the lid is disposed in such a manner as to make contact with an upper surface of the outer circumferential wall 44a, so that cutting swarf adhering to the workpiece or a cleaning liquid used for cleaning is prevented from scattering onto the upper surface of the base 4 at the time of cleaning the workpiece.

A cleaning unit 54 and a drying unit 56 are disposed inside the outer circumferential wall 44a. The cleaning unit 54 and the drying unit 56 respectively have pipe-

shaped shaft sections 54a and 56a which are inserted into the bottom wall 44b. The shaft sections 54a and 56a are pipe-shaped members extending in a direction perpendicular to the holding surface of the chuck table 42 on an outside of the chuck table 42. Rotational drive sources (not illustrated) such as a motor for rotating the shaft sections 54a and 56a are connected to lower end sides of the shaft sections 54a and 56a.

Arm sections 54b and 56b are connected to upper end portions of the shaft sections 54a and 56a. The arm sections 54b and 56b are pipe-shaped members extending in a direction parallel to the holding surface of the chuck table 42 in a length corresponding to the distance from the upper end portions of the shaft sections 54a and 56a to the center of the chuck table 42. Nozzles 54c and 56c directed downward are provided at tip portions of the arm sections 54b and 56b (end portions of the arm sections 54b and 56b on the side of not being connected to the shaft sections 54a and 56a).

Further, the shaft section 54a and the arm section 54b communicate with a cleaning liquid supply source (not illustrated). Therefore, for example, when the cleaning liquid is supplied from the cleaning liquid supply source to the shaft section 54a and the arm section 54b after the

shaft section 54a is rotated to position the nozzle 54c above the chuck table 42, the cleaning liquid is supplied from the nozzle 54c to the holding surface of the chuck table 42.

In addition, the shaft section 56a and the arm section 56b communicate with an air supply source (not illustrated). Therefore, for example, when air is supplied from the air supply source to the shaft section 56a and the arm section 56b after the shaft section 56a is rotated to position the nozzle 56c above the chuck table 42, the air is supplied from the nozzle 56c to the holding surface of the chuck table 42.

A spindle unit 58 is vertically passed through a cylindrical space present inside the inner circumferential wall 44c. The spindle unit 58 has a spindle 60 including ferritic or martensitic stainless steel or the like. The spindle 60 is connected to the chuck table 42 on an upper end side thereof and supports the chuck table 42. In addition, a motor 62 is connected to a lower end portion of the spindle 62, and when the motor 62 is operated, the chuck table 42 is rotated with a straight line that passes through the center of the holding surface and that is orthogonal to the holding surface, as a rotational axis.

The motor 62 is supported by a support mechanism 64

in a vertically movable manner. The support mechanism 64 includes a plurality of (for example, three) air cylinders 66 which are attached to the motor 62, and support legs 68 are connected to lower portions of the respective air cylinders 66. When the plurality of air cylinders 66 are simultaneously operated, the motor 62 and the chuck table 42 are moved upward or downward.

For example, at the time of conveying in and conveying out the workpiece in relation to the cleaning device 40, the support mechanism 64 is operated to position the chuck table 42 at a predetermined conveying-in/conveying-out position, and at the time of cleaning the workpiece, the chuck table 42 is positioned at a cleaning position below the conveying-in/conveying-out position. Note that, in FIG. 2, the cleaning device 40 in a state in which the chuck table 42 is at the conveying-in/conveying-out position is schematically depicted.

A case 70 and a cover member 72 are provided around the spindle 60. FIG. 3 is a partially sectional side view schematically depicting the spindle 60, the case 70, the cover member 72, and the like, and FIG. 4 is an enlarged view of a part of FIG. 3. Note that, in FIGS. 3 and 4, the cleaning device 40 in a state in which the chuck table 42 is at the cleaning position is schematically depicted.

The case 70 has a cylindrical shape of which an outside diameter is shorter than an inside diameter of the inner circumferential wall 44c, and is fixed to the motor 62 through a connection member (not illustrated). An outer race of a bearing 74 is fixed to an inner circumferential surface of an upper portion of the case 70. The bearing 74 has an inner race making contact with the spindle 60, to support the spindle 60 in a rotatable manner.

In addition, three through-holes penetrating the case 70 in the radial direction are provided in the case 70 in such a manner as to be aligned in the vertical direction. A pipe-shaped opening pipe 76 is connected to the through-hole closest to the bearing 74, of the three through-holes. The opening pipe 76 provides communication between an annular space (opening section) A between the case 70 and the spindle 60 and a space outside the case 70. Note that the opening pipe 76 may be absent. In other words, the opening section A may communicate with the space outside the case 70 through a through-hole penetrating the case 70.

A pipe-shaped negative pressure supply pipe 78 and a pipe-shaped positive pressure supply pipe 80 are connected to the remaining two through-holes, respectively. The negative pressure supply pipe 78 provides communication

between an annular space (pressure variable section) B farther from the bearing 74 than the opening section A, between the case 70 and the spindle 60, and a negative pressure supply source (suction source) such as an ejector. In addition, the positive pressure supply pipe 80 provides communication between the pressure variable section B and a positive pressure supply source such as an air supply source.

Further, annular oil seals 82a and 82b are provided respectively at a boundary between the opening section A and the pressure variable section B and at a boundary between an external space below the pressure variable section B and the pressure variable section B. In addition, the pressure variable section B can communicate with a negative pressure or positive pressure supply pipe 60a formed inside the spindle 60. The negative pressure or positive pressure supply pipe 60a communicates with the space on the holding surface of the chuck table 42 through a flow path (not illustrated) formed inside the chuck table 42.

The cover member 72 has an annular top wall 72a, and a cylindrical side wall 72b extending downward from an outer end portion of the top wall 72a. Note that an inside diameter of the top wall 72a is longer than an inside

diameter of the bearing 74. In addition, an outside diameter of the top wall 72a and an inside diameter of the side wall 72b are longer than an outside diameter of the inner circumferential wall 44c.

An upper end portion of the spindle 60 projecting from the case 70 is inserted into an inner side of the top wall 72a. In other words, the cover member 72 has an opening into which the upper end portion of the spindle 60 is inserted. In addition, an annular seal section 84 that interrupts communication between the space between the case 70 and the spindle 60 (for example, the opening section A and the pressure variable section B) and the space on the chuck table 42 side is provided between the cover member 72 and the upper end portion of the spindle 60.

The seal section 84 has an annular magnet ring 84a provided on an inner circumferential surface of the top wall 72a. The magnet ring 84a includes a permanent magnet provided such that an N pole and an S pole make contact respectively with a pair of annular ball pieces 84b. In addition, a magnetic fluid 84c is provided between the ball pieces 84b and the spindle 60.

The magnetic fluid 84c is held along magnetic flux lines configured between the magnetic ring 84a and the ball pieces 84b, and the spindle 60. Note that the magnetic

fluid 84c is, for example, an alkylnaphthalene-based magnetic fluid containing ferromagnetic particulates of magnetite or manganese zinc ferrite or the like and a surface active agent. Alternatively, the magnetic fluid 84c may be a fluorine-oil-based magnetic fluid containing ferromagnetic particulates and a surface active agent.

Here, due to inclination of the spindle 60 at the time of transport of the cleaning device 40 or the like, there is a risk that the magnetic fluid 84c which is a fluid may spread to outside of the space between the spindle 60 and the ball pieces 84b. The spindle 60 preferably has such a shape that a magnetic field capable of restraining outflow of the magnetic fluid 84c even in such a case is formed.

For example, the upper end portion of the spindle 60 projecting from the case 70 and inserted into the opening of the cover member 72 (the inner side of the top wall 72a) preferably has a cylindrical sealed section making contact with the magnetic fluid 84c, and an extension section extending upward from the sealed section and being the same as the sealed section in diameter. If the extension section is provided in this way, outflow of the magnetic fluid 84c is restrained even in the case where the magnetic fluid 84c spreads upward from the space between the spindle 60 and

the ball pieces 84b.

In addition, when the spindle 60 is rotated, frictional heat is generated due to friction between the spindle 60 and the magnetic fluid 84c. When the spindle 60 is heated by the frictional heat, for example, the oil seals 82a and 82b may be deteriorated.

Therefore, it is preferable to weaken the magnetic force of the magnet ring 84a insofar as the magnetic fluid 84c in an amount capable of interrupting the communication between the two spaces described above can be held between the ball pieces 84b and the spindle 60. For example, it is preferable that the magnetic force of the magnet ring 84a be 400 to 800 G.

Similarly, it is preferable to reduce the thickness of the magnet ring 84a insofar as the magnetic fluid 84c in an amount capable of interrupting the communication between the two spaces described above can be held between the ball pieces 84b and the spindle 60. For example, it is preferable to reduce the thickness of the magnet ring 84a such that the magnetic fluid 84c making contact with the pair of ball pieces 84b is not separated but is united, as depicted in FIG. 4. Specifically, the thickness of the magnet ring 84a is preferably 3 to 5 mm.

Note that a lower surface of the top wall 72a of the

cover member 72 sufficiently approaches an upper surface of the inner circumferential wall 44c of the cleaning chamber main body 44, in a state in which the chuck table 42 is at the cleaning position, as depicted in FIG. 3. Therefore, in the cleaning device 40, a cleaning chamber is defined by the cleaning chamber main body 44, the lid disposed in such a manner as to make contact with the upper surface of the outer circumferential wall 44a of the cleaning chamber main body 44, the cover member 72, and the seal section 84.

Cleaning of the workpiece in the cleaning device 40 included in the cutting apparatus 2 is conducted, for example, in the following order. First, the workpiece processed as described above is placed on the chuck table 42 located at the conveying-in/conveying-out position. Next, the chuck table 42 is moved to the cleaning position, after which the workpiece is held on the chuck table 42 under suction.

Subsequently, the lid is disposed in such a manner as to make contact with the upper surface of the outer circumferential wall 44a of the cleaning chamber main body 44, to constitute the cleaning chamber, and the shaft section 54a of the cleaning unit 54 is rotated to position the nozzle 54c above the workpiece. Next, in a state in

which the cleaning chamber is evacuated through the exhaust pipe 46, the cleaning liquid is supplied from the nozzle 54c to the workpiece while the chuck table 42 is being rotated. As a result, cutting swarf and the like adhering to a front surface of the workpiece are removed.

Subsequently, the shaft section 54a of the cleaning unit 54 is rotated to retract the nozzle 54c from above the workpiece, and the shaft section 56a of the drying unit 56 is rotated to position the nozzle 56c above the workpiece. Next, air is supplied from the nozzle 56c to the workpiece while the chuck table 42 is being rotated. As a result, the cleaning liquid and the like adhering to the front surface of the workpiece are removed.

Subsequently, the shaft section 56a of the drying unit 56 is rotated to retract the nozzle 56c from above the workpiece. Next, the chuck table 42 is moved to the conveying-in/conveying-out position, after which the workpiece is conveyed out from the chuck table 42. By the above operations, the cleaning of the workpiece is completed.

In the cleaning device 40, the seal section 84 that interrupts the communication between the space between the case 70 and the spindle 60 (for example, the opening section A and the pressure variable section B) and the cleaning

chamber has the magnetic fluid 84c making contact with the spindle 60. Therefore, in the cleaning device 40, the communication between the space and the cleaning chamber is interrupted, without causing solids to make contact with each other. As a result, wear of the seal section 84 attendant on rotation of the spindle 60 is reduced, and the communication between the space and the cleaning chamber can be interrupted for a long period of time.

Further, in the cleaning device 40, the opening section A is provided between the bearing 74 and the pressure variable section B. As a result, even in the case where leakage from the pressure variable section B to the opening section A occurs due to variation in pressure in the pressure variable section B, variation in pressure around the bearing 74 is restrained. Accordingly, scattering of a lubricant such as grease provided inside the bearing 74 is restrained.

In addition, in the case where such an opening section A is provided, variation in pressure around the seal section 84 is also restrained. Therefore, outflow of the magnetic fluid 84c contained in the seal section 84 is prevented. As a result, the communication between the space between the case 70 and the spindle 60 and the cleaning chamber can be interrupted for a long period of

time.

Note that the configurations, methods, and the like according to the embodiment described above can be modified, as required, insofar as the modifications do not depart from the gist of the present invention.

The present invention is not limited to the details of the above described preferred embodiment. The scope of the invention is defined by the appended claims and all changes and modifications as fall within the equivalence of the scope of the claims are therefore to be embraced by the invention.

WHAT IS CLAIMED IS:

1. A cleaning device comprising:

a chuck table that holds a workpiece on a holding surface;

a nozzle that supplies a cleaning liquid to the workpiece held by the chuck table; and

a spindle unit that supports the chuck table in a rotatable manner;

the cleaning device cleaning the workpiece in a cleaning chamber that accommodates the chuck table and the nozzle,

wherein the spindle unit has

a spindle that supports the chuck table,

a bearing that supports the spindle in a rotatable manner, and

a case that accommodates a part of the spindle and the bearing,

a pressure variable section and an opening section are provided between the case and the spindle,

the pressure variable section is disposed between a negative pressure supply pipe and a positive pressure supply pipe which are connected to the case and a negative pressure or positive pressure supply pipe formed inside the spindle and communicating with a space on the holding

surface, and is disposed at a position farther from the chuck table than the bearing,

the opening section is provided between the bearing and the pressure variable section and is opened through a through-hole formed in the case or through an opening pipe connected to the case,

the spindle has an end portion projecting from the case,

a part of the cleaning chamber is defined by a cover member having an opening into which the end portion of the spindle is inserted,

a seal section that interrupts communication between a space between the case and the spindle and the cleaning chamber is provided between the cover member and the end portion of the spindle, and

the seal section has

an annular magnet ring provided on an inner circumferential surface defining the opening of the cover member, and

a magnetic fluid provided on an inner side of the magnet ring and making contact with the end portion of the spindle.

2. The cleaning device according to claim 1, wherein the end portion of the spindle has a cylindrical sealed

section making contact with the magnetic fluid, and a cylindrical extension section extending from the sealed section toward the chuck table side and being the same as the sealed section in diameter.