

HOLDING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a holding apparatus for holding a workpiece.

Description of the Related Art

A plurality of device chips including respective devices such as integrated circuits (ICs), large scale integration (LSI) circuits, or the like are manufactured by dividing a semiconductor wafer with the devices formed thereon. Packaged devices are manufactured by dividing a packaged substrate in which a plurality of device chips mounted on a substrate are covered by a sealing material of resin, i.e., a molding resin. The package devices are incorporated in various electronic equipment typified by cellular phones and personal computers. In recent years, as electric equipment becomes smaller and thinner, device chips and packaged devices are required to be thinner. It has therefore been customary to grind semiconductor wafers and packaged substrates to thinner profiles before they are divided.

For dividing workpieces typified by semiconductor wafers and packaged substrates, there has been used a

cutting apparatus that cuts workpieces with an annular cutting blade, for example. For thinning workpieces, there has been used a grinding apparatus that grinds workpieces with grinding stones, for example. Processing apparatus such as cutting apparatus, grinding apparatus, and so on include a holding table for holding a workpiece thereon. For example, Japanese Patent Laid-Open No. 2004-14939 discloses a holding table having a porous plate made of a porous material such as porous ceramics or the like. The porous plate has an upper surface functioning as a holding surface for holding a workpiece thereon, the holding surface being connected to a suction source. With the workpiece placed on the holding surface of the porous plate, the suction source is actuated to apply a negative pressure to the holding surface to hold the workpiece under suction on the holding table.

SUMMARY OF THE INVENTION

When the workpiece is held on the holding table and processed by the processing apparatus, foreign matter such as debris or chips from the processed workpiece tends to be deposited on the workpiece and the porous plate of the holding table. If the workpiece with foreign matter deposited thereon is placed on the holding table,

the foreign matter may find its way between the workpiece and the holding table. When the workpiece is held under suction on the holding table with the foreign matter being present between the workpiece and the holding table, regions of the workpiece that are kept contact with the foreign matter are liable to be deformed. The workpiece thus deformed is subject to local stresses and tends to be broken.

It is therefore an object of the present invention to provide a holding apparatus that is capable of preventing a workpiece held thereby from being broken.

In accordance with an aspect of the present invention, there is provided a holding apparatus for holding a workpiece, including holding means for holding the workpiece on a holding surface and drawing an outer circumferential area of the workpiece under suction with an annular suction area defined in an area of the holding surface that is covered by the workpiece, pressure measuring means for measuring a pressure in a suction channel connected to the annular suction area, and control means for determining that no foreign matter is present between the workpiece and the holding surface if the pressure measured by the pressure measuring means is lower than a preset threshold value and determining that

foreign matter is present between the workpiece and the holding surface if the pressure measured by the pressure measuring means is higher than the threshold value.

The holding apparatus according to the aspect of the present invention includes the holding means that draws the outer circumferential area of the workpiece under suction with the annular suction area. The holding means does not hold the workpiece under suction if foreign matter is present between the workpiece and the holding means. Therefore, the area of the workpiece that contacts the foreign matter is prevented from being locally deformed, and hence the workpiece is prevented from being broken.

The holding apparatus according to the aspect of the present invention also includes the pressure measuring means that measures the pressure in the suction channel connected to the annular suction area, and the control means that determines whether foreign matter is present on the basis of the pressure measured by the pressure measuring means. Consequently, when the workpiece is placed on the holding means, it is possible to confirm whether foreign matter is present between the workpiece and the holding table or not.

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 an appended claim with reference to the attached drawings showing a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a perspective view of a holding apparatus;

FIG. 1B is a perspective view of the holding apparatus with a workpiece held thereby;

FIG. 2 is a cross-sectional view of the holding apparatus with the workpiece held thereby; and

FIG. 3 is a cross-sectional view of the holding apparatus with foreign matter having entered between the workpiece and a holding table.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A holding apparatus according to a preferred embodiment of the present invention will be described in detail below with reference to the accompanying drawings. First, an example of the structure of the holding apparatus, i.e., a holding mechanism, will be described

below. FIG. 1A illustrates in perspective the holding apparatus, i.e., the holding mechanism, denoted by 2. As illustrated in FIG. 1A, the holding apparatus 2 includes a holding table, i.e., holding means, 4 for holding a workpiece 11 thereon. The holding table 4 is made of a nonporous material such as nonporous metal, glass, ceramics, or like, and is of a circular shape as viewed in plan. The holding table 4 has an upper surface functioning as a holding surface 4a for holding the workpiece 11 thereon.

The workpiece 11 is a member to be processed, cleaned, or otherwise treated while being held on the holding table 4, i.e., an object to be held or an object to be treated. For example, the workpiece 11 is a disk-shaped wafer made of silicon or the like, and has a face side 11a and a reverse side 11b. The workpiece 11 is demarcated into a plurality of areas by a grid of intersecting projected dicing lines or streets 13. Devices 15 such as integrated circuits (ICs), large scale integration (LSI) circuits, light emitting diodes (LEDs), or the like formed in the respective areas on the face side 11a. The workpiece 11 is not limited to any particular material, shape, structure, size, and the like. For example, the workpiece 11 may be a wafer of any shape

and size and may be made of a semiconductor other than silicon, such as GaAs, InP, GaN, SiC, or the like, sapphire, glass, ceramics, resin, metal, or the like. The devices 15 are not limited to any type, number, shape, structure, size, layout, and the like.

The holding surface 4a of the holding table 4 is of a shape and size able to support the workpiece 11 in its entirety. Specifically, the holding surface 4a is of a circular shape that is large in diameter than the workpiece 11. For example, in case the workpiece 11 has a diameter of approximately 300 mm, then the holding surface 4a may have a diameter of approximately 310 mm. The workpiece 11 is placed on the holding table 4 such that the central position of the workpiece 11 is aligned with the central position of the holding table 4. The shape and size of the holding surface 4a may be changed depending on the shape and size of the workpiece 11.

The holding table 4 has an annular recess, i.e., a suction region, 4b defined in the holding surface 4a along the outer circumferential edge of the holding table 4. The recess 4b is defined in an area of the holding surface 4a that is covered by the workpiece 11 when the workpiece 11 is placed on the holding table 4. Specifically, the recess 4b is of an annular shape that

is smaller in diameter than the workpiece 11. For example, the recess 4b is defined at a position that is spaced approximately 3 to 6 mm from the outer circumferential edge of the holding table 4 toward the center of the holding table 4, and has a predetermined width ranging from approximately 1 to 2 mm, for example. In FIG. 1A, the recess 4b is illustrated as being of a continuous lineal shape, though it is not limited to any shape. For example, a plurality of continuous lineal recesses 4b may be arranged annularly along the outer circumferential edge of the holding table 4. The recess 4b may be defined as a discrete lineal recess, i.e., a dotted-line recess, along the outer circumferential edge of the holding table 4. Alternatively, two or more annular lineal recesses 4b having different diameters may be defined concentrically in the holding surface 4a.

The holding table 4 is connected to a rotary actuator, not depicted, such as an electric motor. When the rotary actuator is energized, it rotates the holding table 4 around a rotational axis generally parallel to Z-axis directions, i.e., vertical directions or upward and downward directions. The holding table 4 is also connected to a moving mechanism, not depicted, that moves the holding table 4 along X-axis directions, i.e., first

horizontal directions, and Y-axis directions, i.e., second horizontal directions.

When the workpiece 11 is placed on the holding surface 4a of the holding table 4, an area of the workpiece 11 along the outer circumferential edge thereof, i.e., an outer circumferential area thereof, overlaps the recess 4b. Then, when a negative pressure from a suction source 10 (see FIG. 2) connected to the recess 4b is applied to the recess 4b, the area of the workpiece 11 along the outer circumferential edge thereof, i.e., the outer circumferential area thereof, that overlaps the recess 4b is drawn under suction toward the holding surface 4a, whereupon the workpiece 11 is held under suction on the holding table 4. Thus, the recess 4b represents a suction area for drawing the outer circumferential area of the workpiece 11 under suction. FIG. 1B illustrates in perspective the holding apparatus 2 with the workpiece 11 held thereby. The workpiece 11 held by the holding apparatus 2 is processed, treated, or otherwise treated in various ways.

FIG. 2 illustrates in cross section the holding apparatus 2 with the workpiece 11 held thereby. The recess 4b defined in the holding table 4 is connected to a suction channel 6 defined in the holding table 4. The

suction channel 6 is connected through a valve 8 to the suction source 10 which may be an ejector or the like. The suction channel 6 is also connected through a valve 12 to a fluid supply source 14 that supplies the suction channel 6 with a fluid such as air or the like. A pressure measuring unit, i.e., pressure measuring means, 16 for measuring the pressure in the suction channel 6 is connected to the suction channel 6. The holding apparatus 2 also includes a controller, i.e., control means, 30 connected to various components of the holding apparatus 2, including the valve 8, the suction source 10, the valve 12, the fluid supply source 14, the pressure measuring unit 16, the rotary actuator, the moving mechanism, and the like. The controller 30 includes a computer or the like for controlling operation of the components of the holding apparatus 2.

For holding the workpiece 11 on the holding apparatus 2, the workpiece 11 is placed on the holding surface 4a of the holding table 4. For example, the workpiece 11 is placed on the holding table 4 such that the face side 11a is exposed upwardly and the reverse side 11b faces the holding surface 4a of the holding table 4. At this time, the recess 4b in its entirety that is defined in the holding table 4 is covered by the

workpiece 11, and the outer circumferential area of the workpiece 11 overlaps the recess 4b.

With the workpiece 11 placed on the holding table 4, the valve 8 is opened and the valve 12 is closed. As a result, the vacuum pressure from the suction source 10 acts through the suction channel 6 and the recess 4b on the reverse side 11b of the workpiece 11, drawing the outer circumferential area of the workpiece 11 under suction. The workpiece 11 is now held under suction on the holding table 4.

For removing the workpiece 11 from the holding apparatus 2, the valve 8 is closed and the valve 12 is opened. The workpiece 11 is now released from the suction force from the suction source 10. Further, the fluid supply source 14 supplies the fluid such as air or the like to the suction channel 6. The fluid supplied to the suction channel 6 flows therefrom into the recess 4b, from which the fluid is ejected upwardly. When the fluid is thus supplied to the suction channel 6 for removing the workpiece 11 from the holding table 4, therefore, the vacuum that has been developed in the suction channel 6 and the recess 4b is cancelled and the fluid is applied to the reverse side 11b of the workpiece 11. The fluid applied to the reverse side 11b of the workpiece 11

assists in removing the workpiece 11 from the holding table 4. The workpiece 11 can thus easily be removed from the holding table 4. The fluid supplied from the fluid supply source 14 is not limited to any particular components insofar as it can assist in removing the workpiece 11 from the holding table 4. For example, the fluid may be water or a mixture of water and air. The fluid supply source 14 may be altered in structure depending on the components of the fluid.

The holding apparatus 2 is incorporated in a processing apparatus for processing the workpiece 11, a cleaning apparatus for cleaning the workpiece 11, or the like. The processing apparatus may be a cutting apparatus for cutting the workpiece 11 with an annular cutting blade, a grinding apparatus for grinding the workpiece 11 with grinding stones, a polishing apparatus for polishing the workpiece 11 with a polishing pad, a laser processing apparatus for processing the workpiece 11 with a laser beam applied thereto, or the like. The controller 30 of the holding apparatus 2 may be integrally combined with a controller of the processing apparatus, the cleaning apparatus, or the like.

When the workpiece 11 is held by the holding apparatus 2 and processed by the processing apparatus,

foreign matter such as debris or chips produced from the processed workpiece 11 may be deposited on the workpiece 11 or the holding table 4. If the workpiece 11 with foreign matter deposited thereon is placed on the holding table 4, the foreign matter may find its way between the workpiece 11 and the holding table 4. FIG. 3 illustrates in cross section the holding apparatus 2 with foreign matter 17 having entered between the workpiece 11 and the holding table 4. If the foreign matter 17 is sandwiched between the workpiece 11 and the holding table 4 when the workpiece 11 is placed on the holding table 4, as illustrated in FIG. 3, the workpiece 11 has one end, i.e., the right end in FIG. 3, kept in contact with the holding table 4 and the other end, i.e., the left end in FIG. 3, kept out of contact with the holding table 4.

It is assumed that the holding surface 4a of the holding table 4 is in the form of a porous plate made of a porous material and the area of the holding surface 4a that overlaps the workpiece 11 functions as a suction area in its entirety. When the negative pressure from the suction source 10 acts on the holding surface 4a, the end of the workpiece 11 that is kept in contact with the holding table 4 is initially drawn under suction to the holding surface 4a. Then, the workpiece 11 is drawn under

suction to the holding surface 4a progressively from the one end to the other end of the workpiece 11 by the suction force that acts on the entire area of the holding surface 4a that overlaps the workpiece 11. As a result, the foreign matter 17 is sandwiched between the workpiece 11 and the holding surface 4a, and the workpiece 11 is held on and along the holding surface 4a and only an area of the workpiece 11 that contacts the foreign matter 17 remains out of contact with the holding surface 4a. Therefore, the area of the workpiece 11 that contacts the foreign matter 17 is deformed and subject to local stresses, tending to cause the workpiece 11 to be broken.

On the other hand, in the holding apparatus 2 according to the present embodiment, the outer circumferential area of the workpiece 11 is drawn under suction by the annular suction area, i.e., the recess 4b, of the holding table 4, and the workpiece 11 has a central area that is not drawn under suction by the holding table 4. Accordingly, the suction force acting on the workpiece 11 from the holding table 4 is moderately weaker than if the workpiece 11 were drawn under suction in its entirety. In case the foreign matter 17 is present between the workpiece 11 and the holding table 4, when the negative pressure from the suction source 10 acts in

the recess 4b, the reverse side 11b of the workpiece 11 is not brought into intimate contact with the holding surface 4a, and the workpiece 11 is not held under suction on the holding surface 4a. The workpiece 11 is thus prevented from being broken or damage which would otherwise be caused if the workpiece 11 were held on and along the holding surface 4a while in contact with the foreign matter 17.

If the workpiece 11 is processed, cleaned, or otherwise treated while the workpiece 11 is not being properly held on the holding table 4 because of the foreign matter 17 being present between the workpiece 11 and the holding table 4, as illustrated in FIG. 3, then the workpiece 11 may fall off the holding table 4 and be broken. Therefore, when the workpiece 11 is placed on the holding table 4, it is preferable to confirm whether foreign matter 17 is present between the workpiece 11 and the holding table 4 or not. The holding apparatus 2 determines whether foreign matter 17 is present or not, using the pressure measuring unit 16 and the controller 30.

Specifically, the workpiece 11 is placed on the holding table 4 while the pressure measuring unit 16 is measuring the pressure in the suction channel 6. In case

no foreign matter 17 is present between the workpiece 11 and the holding table 4, the entire reverse side 11b of the workpiece 11 is held in contact with the holding surface 4a, and the workpiece 11 is properly held on the holding table 4, as illustrated in FIG. 2. A pressure P_1 in the suction channel 6 at this time is measured by the pressure measuring unit 16. In case the foreign matter 17 is present between the workpiece 11 and the holding table 4, the workpiece 11 is not properly held on the holding table 4, but one end of the workpiece 11 is kept in contact with the holding table 4 and the other end thereof is kept out of contact with the holding table 4, as illustrated in FIG. 3. A pressure P_2 in the suction channel 6 at this time is measured by the pressure measuring unit 16.

In case the entire reverse side 11b of the workpiece 11 is not held in contact with the holding surface 4a, as illustrated in FIG. 3, the negative pressure from the suction source 10 leaks from the region of the recess 4b that is not covered by the workpiece 11. Therefore, the pressure P_2 in the suction channel 6 is unlikely to drop, but is higher than the pressure P_1 in the suction channel 6 measured when the recess 4b is covered in its entirety by the workpiece 11, as

illustrated in FIG. 2. In other words, the pressure in the suction channel 6 varies depending on whether foreign matter 17 is present or not. The controller 30 determines whether foreign matter 17 is present or not on the basis of the value of the pressure in the suction channel 6.

Specifically, the controller 30 includes a determining section 32 for determining whether the foreign matter 17 is present or not on the basis of the value of the pressure in the suction channel 6 and a storage section 34 for storing various data to be used in processing sequences of the determining section 32. The pressure in the suction channel 6 that is measured by the pressure measuring unit 16 is input to the determining section 32. The storage section 34 stores a threshold value P_{th} corresponding to the boundary between the pressure P_1 in the suction channel 6 measured when no foreign matter 17 is present and the pressure P_2 in the suction channel 6 measured when the foreign matter 17 is present. The threshold value P_{th} satisfies the relationship: $P_1 < P_{th} < P_2$, and is acquired in advance by experimentation, for example.

The determining section 32 compares the pressure P in the suction channel 6 measured by the pressure measuring unit 16 with the threshold value P_{th} stored in

the storage section 34. If the pressure P is lower than the threshold value P_{th} , then the determining means 32 determines that no foreign matter 17 is present between the workpiece 11 and the holding surface 4a. If the pressure P is higher than the threshold value P_{th} , then the determining means 32 determines that foreign matter 17 is present between the workpiece 11 and the holding surface 4a. The determined result produced by the determining section 32 is displayed on a display unit, not depicted, of the holding apparatus 2, for example, or output from the controller 30 out of the holding apparatus 2. If the determining means 32 determines that foreign matter 17 is present, then the workpiece 11 and the holding table 4 are cleaned, for example, to remove the foreign matter 17.

As described above, the holding apparatus 2 according to the present embodiment includes the holding table 4 that draws the outer circumferential area of the workpiece 11 under the suction force from the annular recess 4b defined in the holding surface 4a. In case foreign matter 17 is present between the workpiece 11 and the holding surface 4a, the workpiece 11 is not held under suction on the holding table 4. Therefore, the area of the workpiece 11 that contacts the foreign matter 17

is prevented from being locally deformed, and hence the workpiece 11 is prevented from being broken. The holding apparatus 2 includes the pressure measuring unit 16 that measures the pressure in the suction channel 6 connected to the recess 4b and the controller 30 that determines whether foreign matter 17 is present or not on the basis of the pressure measured by the pressure measuring unit 16. Consequently, when the workpiece 11 is placed on the holding table 4, it is possible to confirm whether foreign matter 17 is present between the workpiece 11 and the holding table 4 or not.

According to the present embodiment, the annular recess 4b is defined in the holding table 4 by way of example. However, the structure of the holding table 4 may be changed or modified insofar as changes and modifications are capable of holding the workpiece 11 under suction on the holding table 4. For example, the holding table 4 may further include one or more recesses defined therein that are open at the holding surface 4a inwardly of the recess 4b, i.e., inwardly of the recess 4b in radial directions of the holding table 4.

More specifically, the holding table 4 may have a cylindrical recess defined centrally therein that has a predetermined diameter ranging from approximately 1 to 6

mm, for example. The cylindrical recess is connected to the suction channel 6 and functions as a suction port for applying suction forces to hold the workpiece 11 under suction on the holding table 4 and also as an ejection port for ejecting a fluid to the workpiece 11 to remove the workpiece 11 from the holding table 4. The cylindrical recess makes it more reliable to hold the workpiece 11 on the holding table 4 and also makes it easier to remove the workpiece 11 from the holding table 4.

The structural details, processes, and the like. of the holding apparatus 2 according to the present embodiment can be changed or modified insofar as changes and modifications fall within the scope 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 claim and all changes and modifications as fall within the equivalence of the scope of the claim is therefore to be embraced by the invention.

WHAT IS CLAIMED IS:

1. A holding apparatus for holding a workpiece,
comprising:

holding means for holding the workpiece on a holding surface and drawing an outer circumferential area of the workpiece under suction with an annular suction area defined in an area of the holding surface that is covered by the workpiece;

pressure measuring means for measuring a pressure in a suction channel connected to the annular suction area; and

control means for determining that no foreign matter is present between the workpiece and the holding surface if the pressure measured by the pressure measuring means is lower than a preset threshold value and determining that foreign matter is present between the workpiece and the holding surface if the pressure measured by the pressure measuring means is higher than the threshold value.