SPECIFICATION

Title of Invention: INSPECTION APPARATUS AND INSPECTION METHOD

Technical Field

[0001]

The present disclosure relates to an inspection apparatus and an inspection method.

Background

[0002]

Patent Document 1 discloses a manufacturing method for forming a shell structure by laminating and bonding a substrate and a jig (contact substrate). The shell structure thus formed can suppress a contact pressure applied to the substrate from a probe of an inspection apparatus, and can also suppress oxidation of a conductive part of the substrate by sealing the contact part between the conductive part of the substrate and a contact part of the jig.

[0003]

In the case of inspecting such type of shell structure, for example, the shell structure is transferred into a housing of the inspection apparatus, and a probe is brought into contact with an electrode of a jig. Accordingly, the inspection apparatus can inspect electrical characteristics of semiconductor devices connected to the conductive part by transmitting an electric signal from the probe to the electrode of the jig, and then to the conductive part of the substrate via the electrode of the jig and the contact portion. In addition, the inspection apparatus can inspect whether or not the semiconductor devices satisfy a temperature

condition by performing the inspection in a state where the temperature of the substrate is adjusted to a target temperature.

Prior Art Documents

Patent Documents

[0004]

Patent Document 1: Japanese Laid-Open Patent Publication No. 2023-95494

Summary

Problems to Be Resolved by the Invention

[0005]

The present disclosure provides a technology capable of stably inspecting a substrate while efficiently adjusting the temperature of the substrate.

Means for Solving the Problems

[0006]

According to one aspect of the present disclosure, an inspection apparatus for inspecting a shell structure in which a portion where a conductive part of a substrate and a contact part of a jig are electrically connected is sealed, the inspection apparatus comprises a housing, a probe configured to contact an electrode of the jig that is electrically connected to the contact part within the housing, a temperature adjustment medium circulation part configured to supply a temperature adjustment medium into the housing and discharge the temperature adjustment medium from the housing, and a control part. The control part controls (A) a process of loading the shell structure into the housing and mounting the shell

structure in a state where the probe and the electrode are in contact with each other, (B) a process of, after the process of (A), supplying the temperature adjustment medium from the temperature adjustment medium circulation part into the housing and adjusting a temperature of the shell structure by immersing at least a part of the shell structure in the temperature adjustment medium, and (C) a process of inspecting the substrate of the shell structure via the probe while performing the process of (B).

Effect of the Invention

[0007]

According to one aspect, it is possible to stably inspect a substrate while efficiently adjusting the temperature of the substrate.

Brief Description of the Drawings

[0008]

FIG. 1A is a side cross-sectional view before formation of a shell structure.

FIG. 1B is a side cross-sectional view after formation of the shell structure.

FIG. 2 is an enlarged side cross-sectional view of a part of the shell structure.

FIG. 3 is a plan view schematically illustrating the overall configuration of an inspection system.

FIG. 4 is a side cross-sectional view schematically illustrating an inspection apparatus according to a first embodiment.

FIG. 5 is a side cross-sectional view illustrating an inspection state of the shell structure of the inspection apparatus.

FIG. 6 is a flowchart illustrating an inspection method of the inspection

apparatus.

FIG. 7 is a side cross-sectional view schematically illustrating an inspection apparatus according to a second embodiment.

FIG. 8 is a side view schematically illustrating an inspection apparatus according to a third embodiment.

Detailed Description

[0009]

Hereinafter, embodiments of the present disclosure will be described with reference to the accompanying drawings. Throughout the drawings, like reference numerals are assigned to like parts, and redundant description thereof may be omitted.

[0010]

To facilitate understanding of the inspection apparatus 60 according to the present disclosure, first, a shell structure 100 formed for inspection will be described with reference to FIGS. 1 and 2. FIG. 1A is a side cross-sectional view before the formation of the shell structure 100. FIG. 1B is a side cross-sectional view after the formation of the shell structure 100. FIG. 2 is an enlarged side cross-sectional view of a part of the shell structure 100.

[0011]

The shell structure 100 is formed for the inspection of the substrate W and is disassembled after the inspection of the substrate W. The shell structure 100 is formed by laminating and bonding the substrate W, which is an inspection target, and a contact jig 110.

[0012]

The substrate W to be inspected may be a wafer in which a plurality of

semiconductor devices, which are devices under test (DUT), are arranged in a matrix form. For example, the substrate W is formed of silicon, a compound semiconductor (SiC, GaAs, GaN, InP, or the like). The substrate W is not limited to a wafer, and may be a carrier having semiconductor devices, a glass substrate, a single chip, an electronic circuit board, or the like. Further, the semiconductor devices of the substrate W may be backside-illumination imaging devices in which light is incident from a surface on the opposite side of a wiring layer.

[0013]

The substrate W includes a plate-shaped substrate body Wm and a plurality of conductive parts Wc. The substrate body Wm is formed in a perfect circular shape in plan view, and has therein a plurality of semiconductor devices. The diameter of the substrate body Wm is set to, for example, 30 cm. This substrate body Wm has one surface Ws1 facing the contact jig 110, and the other surface Ws2 on the opposite side thereof. In addition, although FIG. 1A illustrates one surface Ws1 and the other surface Ws2 that are flat, one surface Ws1 and the other surface Ws2 may have irregularities depending on the respective semiconductor devices. Further, the substrate body Wm may be formed in another shape such as a quadrangular shape in plan view.

[0014]

The plurality of conductive parts Wc are formed on one surface Ws1 of the substrate body Wm and are electrically connected to appropriate semiconductor devices of the substrate body Wm. The conductive parts Wc may include electrode pads of the semiconductor devices, metal bumps, and the like. Although FIG. 1A illustrates that the conductive parts Wc are embedded in the substrate body Wm, the conductive parts Wc may protrude from one surface Ws1 of the substrate W.

[0015]

The conductive parts Wc are formed of a conductive metal material such as aluminum (Al) or copper (Cu). The conductive parts Wc are arranged side by side at an interval of 10 μm or less, for example.

[0016]

The contact jig 110 is detachably bonded to the substrate W. The contact jig 110 includes a jig body 111, a plurality of contact parts 112, and a plurality of electrode pads 113.

[0017]

The jig body 111 is formed in a perfect circular shape substantially having the same diameter as the substrate body Wm, and has a portion to be bonded to the substrate body Wm in an outer peripheral part 110o. In the jig body 111, the plurality of adjacent contact parts 112 are insulated from each other and the plurality of electrode pads 113 are insulated from each other. The jig body 111 may have a shape different from that of the substrate W, and may be formed in a polygonal shape such as a perfect circular shape with a diameter greater than that of the substrate W or a quadrangular shape, for example.

[0018]

The jig body 111 has a recess 111c on the inner side of the annular outer peripheral part 111o. The recess 111c is formed on one surface 111s1 side of the jig body 111. Inside the recess 111c, a plurality of groups of contact parts 112 are formed to correspond to the conductive parts Wc of the semiconductor device of the substrate W. Between the groups of the contact parts 112, a plurality of pillars 114 protruding from the recess 111c are provided. In a state where the contact jig 110 and the substrate W are bonded, the pillars 114 are in contact with the substrate body Wm, thereby maintaining the depth of the recess 111c.

[0019]

The jig body 111 is formed of a material having, for example, a thermal expansion coefficient equivalent to the thermal expansion coefficient of the substrate body Wm to suppress misalignment between the substrate W and the contact jig 110 during temperature changes of the shell structure 100. For example, the jig body 111 may be a contact substrate formed of the same material as the substrate body Wm. Alternatively, the jig body 111 may be a glass substrate having a thermal expansion coefficient equivalent to that of the substrate W, or a substrate formed by laminating a semiconductor substrate and a glass substrate.

[0020]

The plurality of contact parts 112 are brought into contact with the conductive parts Wc by the bonding of the substrate W and the contact jig 110 and are electrically connected. Therefore, the contact parts 112 are formed at locations facing the conductive parts Wc of the substrate W. In addition, the jig body 111 has a contact pressure adjustment part 115 that is elastically deformable by the contact between the contact parts 112 and the conductive parts Wc.

[0021]

FIG. 2 is a cross-sectional view illustrating an enlarged view of the contact parts 112 and the contact pressure adjustment part 115 of the contact jig 110. For example, the contact pressure adjustment part 115 is provided for each of the plurality of contact parts 112. The contact pressure adjustment part 115 includes a hollow part 116 formed inside the jig body 111, a bridge part 117 that covers the hollow part 116 on the bottom surface side of the recess 111c, and a protrusion 118 protruding from the intermediate portion of the bridge part 117. The bridge part 117 is elastically deformable in a thickness direction of the jig body 111 since the

hollow part 116 is located on the opposite side of the protrusion 118. The contact pressure adjustment part 115 may collectively adjust contact pressures of the plurality of contact parts 112, and may have a series of hollow parts 116 and bridge parts 117 across the plurality of contact parts 112, for example.

[0022]

The contact parts 112 are formed of a metal film (for example, a copper foil or an aluminum foil) that is continuous along the surfaces of the bridge parts 117 and the surfaces of the protrusions 118 on the bottom surface of the recess 111c. The contact parts 112 protrude from the bottom surface of the recess 111c by covering the protruding ends of the protrusions 118, and can be in direct contact with the conductive parts Wc of the substrate W. Each contact part 112 coincides with the opening of the recess 111c or slightly protrudes from the opening of the recess 111c in a state where the contact jig 110 and the substrate W are not bonded. Then, when the bridge parts 117 are appropriately bent in a state where the contact parts 112 are brought into contact with the conductive parts Wc of the substrate W, the contact pressure adjustment part 115 can reduce the contact pressure applied from the protrusions 118 to the conductive parts Wc while maintaining the contact of the contact parts 112.

[0023]

Inside the contact jig 110, a plurality of wirings 119 are provided to electrically connect each of the plurality of contact parts 112 to a corresponding one of the plurality of electrode pads 113 while avoiding the hollow parts 116. As illustrated in FIGS. 1A and 1B, the wirings 119 extend inside the jig body 111 without contact with each other, and are widened in an in-plane direction while being bent or curved from the contact parts 112 toward the electrode pads 113.

[0024]

The plurality of electrode pads 113 are formed on the other surface 111s2 of the jig body 111. The electrode pads 113 have an area greater than that of the conductive parts Wc. Further, the interval between the electrode pads 113 is set to be greater than that of the conductive parts Wc of the substrate W. Even if the area or interval of the electrode pads 113 is greater than that of the conductive parts Wc, the conductive parts Wc can be stably electrically connected to the electrode pads 113 by the configuration of the contact parts 112 and the wirings 119. For example, the interval between the electrode pads 113 can be set to 50 μm to 500 μm. The electrode pads 113 are formed of a metal material such as Al or Cu. The metal material of the electrode pads 113 may be plated with gold (Au) or the like.

[0025]

A bonding part 120 is formed on the outer peripheral part 111o of one surface 111s1 of the contact jig 110. The outer peripheral part 111o protrudes with respect to the bottom surface of the recess 111c, and forms an annular portion extending in a circumferential direction. The bonding part 120 covers the entire protruding end surface of the outer peripheral part 111o. The bonding part 120 may be formed of an adhesive, or may be a modified layer formed by modifying the surface of the jig body 111.

[0026]

One surface 111s1 of the contact jig 110 is bonded to one surface Ws1 of the substrate W via the bonding part 120, thereby sealing the recess 111c to define an internal space 101. In the internal space 101, the contact portions between the conductive parts Wc and the contact parts 112 are formed. By bonding the substrate W and the contact jig 110 in a reduced-pressure atmosphere, the internal space 101 can be maintained in the reduced-pressure atmosphere. Therefore,

the shell structure 100 can suppress oxidation due to the exposure of the conductive parts Wc to the atmosphere. Alternatively, in the shell structure 100, the bonding of the substrate W and the contact jig 110 may be performed in an inert gas atmosphere. Hence, the shell structure 100 can maintain the internal space 101 in the inert gas atmosphere.

[0027]

Further, the contact jig 110 may have a detection sensor (not shown) for detecting an indicator for determining the bonding state between the substrate W and the contact jig 110. The indicator for determining the bonding state may be a pressure (contact pressure) applied to the substrate W from the contact parts 112 of the contact jig 110, a pressure (vacuum level) in the sealed internal space 101, or the like.

[0028]

The shell structure 100 formed for inspection is basically configured as described above. Hereinafter, an inspection system 1 that forms the shell structure 100 and performs the inspection will be described with reference to FIG. 3. FIG. 3 is a plan view schematically illustrating the overall configuration of the inspection system 1.

[0029]

The inspection system 1 stocks a plurality of contact jigs 110 therein, performs inspection by forming the shell structure 100 while transferring the substrate W to respective locations in the inspection system 1, and disassembles the shell structure 100 after the inspection. The inspection system 1 includes a transfer module 10, a reduction treatment apparatus (plasma processing apparatus) 20, a position adjustment apparatus 25, an adhesive application apparatus 30, a bonding apparatus 40, a shell structure determination apparatus 50, an inspection

apparatus 60, a pre-peeling processing apparatus 70, a peeling apparatus 75, a jig cleaning apparatus 80, and a substrate cleaning apparatus 85. The inspection system 1 further includes a controller 90 that controls the operations of the respective apparatuses.

[0030]

The transfer module 10 transfers the substrate W in three areas: a formation area 11 for forming the shell structure 100, an inspection area 12 for inspecting the substrate W, and a disassembly area 13 for disassembling the shell structure 100. The formation area 11, the inspection area 12, and the disassembly area 13 each extend linearly. The transfer module 10 connects the formation area 11 and the inspection area 12 to be perpendicular to each other, and also connects the inspection area 12 and the disassembly area 13 to be perpendicular to each other, thereby having a substantially C shape as a whole. Further, the formation area 11, the inspection area 12, and the disassembly area 13 are not necessarily continuous, and a part or all of them may be provided at separate locations.

[0031]

Each area of the transfer module 10 has a transfer frame 14 extending linearly, and a transfer device (not shown) moving along the length direction of the transfer frame 14. Depending on the transfer mechanism of the transfer device, the transfer frame 14 may be formed as a flat travel surface, or may have a guide rail. The transfer device moves on the transfer frame 14 while supporting the substrate W with an arm (not shown) to transfer the substrate W to the position where the apparatuses face each other. Further, the transfer device loads and unloads the substrate W to and from the respective apparatuses by advancing and retracting the arm at a position corresponding to each apparatus.

[0032]

In order to form the shell structure 100, in the formation area 11, the reduction treatment apparatus 20, the position adjustment apparatus 25, the adhesive application apparatus 30, the bonding apparatus 40, and the shell structure determination apparatus 50 are connected in that order from the upstream side toward the downstream side in the transfer direction of the substrate W. In the formation area 11, the apparatuses are installed on opposite sides of with the transfer frame 14, for example.

[0033]

The transfer module 10 is configured such that the pressure of the formation area 11 can be reduced to a vacuum atmosphere, whereas the inspection area 12 and the disassembly area 13 are maintained in an air atmosphere. Accordingly, when the shell structure 100 is formed in the formation area 11, the internal space 101 of the shell structure 100 is easily set to a vacuum atmosphere (oxygen-free state), and re-oxidation of the conductive parts Wc of the substrate W that has been subjected to reduction treatment can be prevented. Further, the inspection system 1 may have a configuration in which an inert gas such as nitrogen (N_2) gas is supplied to create an inert gas atmosphere, thereby suppressing the oxidation of the conductive parts Wc of the substrate W, instead of setting the formation area 11 to a vacuum atmosphere. In the inspection system 1, the area to be set to a vacuum atmosphere is not limited to the formation area 11, and a vacuum atmosphere may be formed across the formation area 11, the inspection area 12, and the disassembly area 13, for example.

[0034]

The formation area 11 of the transfer module 10 forms a sealed space with respect to the outside, and has a load-lock module 15 at each of the inlet and the

outlet of the formation area 11. For example, the transfer module 10 forms a sealed space over the entire length of the formation area 11 by side panels and a ceiling panel that cover the transfer frame 14. When the substrate W transferred from the outside is received in the load-lock module 15 on the inlet side, the pressure is reduced from an air atmosphere to a vacuum atmosphere and, then, the substrate W is unloaded by the transfer device inside the formation area 11. When the substrate W (the shell structure 100) is received in the load-lock module 15 on the outlet side by the transfer device inside the formation area 11, the pressure is increased from a vacuum atmosphere to an air atmosphere and, then, the substrate W is unloaded by the transfer device in the inspection area 12.

[0035]

In the inspection area 12, only the inspection apparatus 60 is connected. The transfer device of the inspection area 12 receives the shell structure 100 formed in the formation area 11 and transfers it to the inspection apparatus 60, and also transfers the shell structure 100 inspected in the inspection apparatus 60 to the disassembly area 13.

[0036]

In the disassembly area 13, the pre-peeling processing apparatus 70, the peeling apparatus 75, the jig cleaning apparatus 80, and the substrate cleaning apparatus 85 are connected in that order from the upstream side toward the downstream side in the transfer direction of the substrate W to disassemble the shell structure 100. On the upstream side of the disassembly area 13 (or on the downstream side or the upstream side of the inspection area 12), a buffer part 16 that temporarily supports the shell structure 100 of the inspection area 12 is provided. Also in the disassembly area 13, the apparatuses are installed on opposite sides of the transfer frame 14, for example.

[0037]

The reduction treatment apparatus 20 installed in the formation area 11 performs plasma processing on the substrate W before forming the shell structure 100 to remove an oxide film formed on the surfaces of the conductive parts Wc of the substrate W. Thus, the substrate W with one surface Ws1 facing upward (facing upward in a vertical direction) is loaded into the reduction treatment apparatus 20. A known apparatus may be used as the reduction treatment apparatus 20, and supplies an etching gas to generate plasma, thereby etching the surfaces of the conductive parts Wc made of aluminum, for example. The type of etching gas may be selected appropriately according to the material of the conductive parts Wc, and a hydrogen-containing gas, a chlorine-containing gas, or the like may be used, for example. Preferably, hydrogen gas, which does not require detoxification and does not corrode the devices, is used as the etching gas. Since the substrate W after the removal of the oxide film moves through a vacuum atmosphere of the formation area 11, the re-oxidation thereof is suppressed, thereby forming the shell structure 100.

[0038]

When the substrate W after the removal of the oxide film is loaded into the position adjustment apparatus 25 by the transfer module 10, the position adjustment apparatus 25 detects misalignment and circumferential orientation (posture) of the substrate W, and adjusts the misalignment and the posture of the substrate W in cooperation with the transfer device of the formation area 11. In order to bond the substrate W and the contact jig 110 in the bonding apparatus 40, the position adjustment apparatus 25 inverts the substrate W having one surface Ws1 facing upward, so that the one surface Ws1 faces downward. The transfer device of the formation area 11 unloads the substrate W having one surface Ws1

facing downward and transfers it to the bonding apparatus 40.

[0039]

When the contact jig 110 is transferred by the transfer device of the formation area 11, the adhesive application apparatus 30 applies an adhesive to the surface of the outer peripheral part 111o of the contact jig 110 to form the bonding part 120 (see FIG. 1A). In an embodiment, a UV curable resin is used as the adhesive. The adhesive application apparatus 30 has, e.g., a nozzle (not shown) for applying the adhesive, and forms the bonding part 120 over the entire circumference in the circumferential direction of the protruding end surface of the outer peripheral part 111o. The transfer device of the formation area 11 unloads the contact jig 110 having the bonding part 120 and transfers it to the bonding apparatus 40.

[0040]

The bonding apparatus 40 bonds the substrate W and the contact jig 110 in a processing chamber. The bonding apparatus 40 holds one surface Ws1 of the substrate W facing downward by an upper chuck (not shown), and holds one surface 111s1 of the contact jig 110 facing upward by a lower chuck (not shown), for example. Then, the bonding apparatus 40 adjusts the horizontal positions of the substrate W and the contact jig 110, and raises the lower chuck to bring the bonding part 120 of the outer peripheral part 111o of the contact jig 110 into contact with the outer peripheral part of the substrate W. The bonding apparatus 40 irradiates UV light onto the bonding part 120 from a UV irradiation apparatus (not shown), thereby bonding the substrate W and the contact jig 110 to form the shell structure 100 (see also FIG. 1B). The transfer device of the formation area 11 unloads the shell structure 100 and transfers it to the shell structure determination apparatus 50.

[0041]

The shell structure determination apparatus 50 accommodates the shell structure 100 and connects an inspection device (not shown) to the connector of the detection sensor of the contact jig 110. The shell structure determination apparatus 50 operates the inspection device (not shown) to measure the contact pressure of the shell structure 100 and the pressure in the internal space via the detection sensor, and transmits the measurement information to a determination part (not shown). The determination part determines the bonding state of the shell structure 100 based on the acquired measurement information. The determination part may be provided in the controller 90 instead of being provided in the shell structure determination apparatus 50.

[0042]

For example, the determination part stores in advance a contact pressure allowable range for comparing the contact pressure of the shell structure 100 and an internal pressure allowable range for comparing the internal pressure of the shell structure 100. The determination part compares the measurement information of each contact pressure from the detection sensor with the contact pressure allowable range, determines an abnormal bonding state when each contact pressure is outside the contact pressure allowable range, and determines a normal bonding state when each contact pressure is within the contact pressure allowable range. Alternatively, the determination part compares the measurement information of the internal pressure from the detection sensor with the internal pressure allowable range, determines an abnormal bonding state when the internal pressure is outside the internal pressure allowable range, and determines a normal bonding state when the internal pressure is within the internal pressure allowable range.

[0043]

When an abnormal bonding state of the shell structure 100 is determined, the inspection system 1 transfers the shell structure 100 to the disassembly area 13 to disassemble the shell structure 100 without performing the inspection by the inspection apparatus 60, and returns the disassembled substrate W to the formation area 11 to re-form the shell structure 100. Accordingly, the inspection system 1 can avoid in advance the abnormality in the electrical characteristics of the substrate W caused by the abnormal bonding state, and stably inspect the substrate W.

[0044]

The shell structure 100 formed in the formation area 11 is transferred by the transfer device to the inspection area 12 of the inspection system 1, and the substrate W of the shell structure 100 is inspected by the inspection apparatus 60 installed in the inspection area 12. The configuration of the inspection apparatus 60 will be described in detail later. After the inspection by the inspection apparatus 60, the shell structure 100 is transferred to the disassembly area 13 by the transfer device in the inspection area 12.

[0045]

When the shell structure 100 is transferred by the transfer device of the disassembly area 13, the pre-peeling processing apparatus 70 of the disassembly area 13 performs pre-processing for disassembly on the shell structure 100. For example, a hot plate apparatus that heats the shell structure 100 to a target temperature is used as the pre-peeling processing apparatus 70. The target temperature is a temperature at which the adhesive force of the adhesive (UV curable resin) of the bonding part 120 can be reduced. As a result, the bonding part 120 bonding the substrate W and the contact jig 110 of the shell structure 100

can be easily peeled.

[0046]

When the shell structure 100 of the pre-peeling processing apparatus 70 is transferred by the transfer device of the disassembly area 13, the peeling apparatus 75 of the disassembly area 13 peels the substrate W and the contact jig 110 from each other. The peeling apparatus 75 may be, e.g., an apparatus configured to insert a blade into the bonding part 120 from a side portion of the shell structure 100 and pull the substrate W upward with respect to the contact jig 110. As a result, the substrate W and the contact jig 110 are smoothly peeled off.

[0047]

When the contact jig 110 peeled by the peeling apparatus 75 is transferred to the jig cleaning apparatus 80, the jig cleaning apparatus 80 of the disassembly area 13 performs a process of removing the adhesive (the bonding part 120) attached to the contact jig 110. The inspection system 1 can reuse the contact jig 110 for the inspection of the substrate W by transferring the contact jig 110 to the adhesive application apparatus 30 after the removal of the adhesive from the contact jig 110. Further, the inspection system 1 has a storage module (not shown) that stores a plurality of contact jigs 110. The contact jig 110 from the jig cleaning apparatus 80 may be stored in the storage module, and the contact jig 110 may be transferred from the storage module to the adhesive application apparatus 30.

[0048]

The substrate W peeled by the peeling apparatus 75 is transferred to the substrate cleaning apparatus 85, the substrate cleaning apparatus 85 of the disassembly area 13 performs a process of removing the adhesive (the bonding part 120) attached to the substrate W. In the inspection system 1, after the removal of the adhesive from the substrate W, the substrate W is transferred to the

downstream side of the disassembly area 13 and is unloaded from the transfer module 10, and then accommodated in a carrier such as a front opening unified pod (FOUP).

[0049]

The controller 90 of the inspection system 1 is implemented by a computer including a processor, a memory, an input/output interface, and a communication interface (all not shown). The processor is a combination of one or a plurality of a central processing unit (CPU), a graphics processing unit (GPU), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), a circuit including a plurality of discrete semiconductors, and the like, and executes a program stored in the memory. The memory includes a main storage device including a semiconductor memory or the like, and an auxiliary storage device including a disk, a drive, a semiconductor memory (flash memory), or the like.

[0050]

The controller 90 of the inspection system 1 controls the operations of the transfer module 10 and the respective apparatuses, sequentially transfers a plurality of substrates W to form the shell structure 100, and controls sequential inspecting the substrates W of the shell structure 100 by the inspection apparatus 60. Further, the controller 90 executes control for unloading the substrate W by sequentially peeling the inspected shell structure 100 into the substrate W and the contact jig 110.

[0051]

Next, the inspection apparatus 60 installed in the inspection area 12 of the inspection system 1 will be described with reference to FIG. 4. FIG. 4 is a side cross-sectional view schematically illustrating the inspection apparatus 60 according to a first embodiment. FIG. 5 is a side cross-sectional view illustrating

the inspection state of the shell structure 100 in the inspection apparatus.

[0052]

The inspection apparatus 60 according to an embodiment inspects electrical characteristics of the substrate W of the shell structure 100 while adjusting the temperature of the shell structure 100 by immersing the shell structure 100. Specifically, the inspection apparatus 60 includes a housing 61, a probe card 62, a temperature adjustment medium circulation part 63, a suction part 64, and a heating part 65. The inspection apparatus 60 further includes a control part 69 that performs information communication with the controller 90, and controls the respective components of the inspection apparatus 60.

[0053]

The housing 61 is formed, e.g., in a substantially cylindrical shape or a substantially prismatic shape having a ceiling wall 611, a bottom wall 612, and a sidewall 613. The ceiling wall 611, the bottom wall 612, and the sidewall 613 are integrally continuous with one another. A space enclosed by the ceiling wall 611, the bottom wall 612, and the sidewall 613 constitutes an inspection space 61s for accommodating and inspecting the shell structure 100. The inspection space 61s can retain a temperature adjustment medium (liquid) supplied by the temperature adjustment medium circulation part 63. The housing 61 may have enhanced thermal insulation against the outside by forming a thermal insulation space in the solid walls such as the ceiling wall 611, the bottom wall 612, and the sidewall 613.

[0054]

On the sidewall 613 of the housing 61, a transfer port (not shown) is provided for the transfer device of the inspection area 12 to load and unload the shell structure 100 into and from the inspection space 61s. The transfer port is opened and closed by a gate valve (not shown). The gate valve prevents leakage

of the liquid supplied to the inspection space 61s by liquid-tightly sealing the housing 61 in a closed state.

[0055]

On the bottom wall 612, which is on the lower side of the housing 61 in the vertical direction, a pogo frame 614 is provided to support a plurality of probes 622 of the probe card 62 that are inserted therethrough. The pogo frame 614 constitutes a mounting part on which the shell structure 100 loaded into the housing 61 is placed. The housing 61 has an annular seal member 615, such as an O-ring, surrounding the outer peripheral part of the pogo frame 614. The seal member 615 accommodates all the probes 622 therein.

[0056]

The probe card 62 is set in a tester 66 on the lower side of the housing 61 in the vertical direction, thereby constituting a part of an inspection mechanism that inspects the substrate W of the shell structure 100. The tester 66 supplies power to the substrate W and transmits and receives signals via the probe card 62. The probe card 62 includes a body 621, a plurality of probes 622 protruding from the upper surface of the body 621, and an annular seal member 623, such as an O-ring, surrounding all the probes 622.

[0057]

The body 621 is electrically connected to a motherboard of the tester 66 via an interface (not shown). The probes 622 protrude from the upper surface of the body 621, and are inserted into respective holes in the pogo frame 614. The pogo frame 614 supports the protruding posture of the probes 622 in a vertical direction. The protruding ends of the probes 622 slightly protrude from the upper surface of the bottom wall 612 (the pogo frame 614) of the housing 61. By maintaining the linearity of the probes 622, the probes 622 can stably contact with the electrode

pads 113 of the mounted shell structure 100 (the contact jig 110).

[0058]

The temperature adjustment medium circulation part 63 separately includes a supply mechanism 631 and a discharge mechanism 636 connected to the housing 61, and supplies and discharges liquid, which is a temperature adjustment medium, into and from the inspection space 61s of the housing 61. The temperature adjustment medium supplied to the housing 61 is not particularly limited, and may include water, Fluorinert (Registered Trademark), Galden (Registered Trademark), and the like. Hereinafter, the temperature adjustment medium is also simply referred to as “liquid.”

[0059]

The supply mechanism 631 includes one or more common pipes 632 connected to the housing 61, a high-temperature chiller part 633 that supplies high-temperature liquid to the common pipe 632, and a low-temperature chiller part 634 that supplies low-temperature liquid to the common pipe 632. The supply mechanism 631 further includes a switching part 635 that connects the common pipe 632, a high-temperature pipe 633a of the high-temperature chiller part 633, and a low-temperature pipe 634a of the low-temperature chiller part 634, and is configured to switch the flow paths therein.

[0060]

The common pipe 632 is connected to the sidewall 613 of the housing 61 to introduce liquid into the housing 61. The common pipe 632 may be provided with a pump or the like (not shown). In order to suppress turbulence of the liquid in the housing 61, the common pipe 632 may be connected to the bottom wall 612 of the housing 61 to introduce the liquid from the side of the bottom wall 612.

[0061]

In the high-temperature chiller part 633, a heating device 633b, an on-off valve 633c, a pump 633d, a tank 633e, and the like are installed in the high-temperature pipe 633a. The heating device 633b may include a heater wire, a heat pump, or the like to increase the temperature of the liquid in the high-temperature pipe 633a to a preset target temperature. In the embodiment, the heating device 633b is installed in the high-temperature pipe 633a, but the high-temperature chiller part 633 may have a configuration in which the heating device 633b is provided in the tank 633e to heat the liquid in the tank 633e. The on-off valve 633c opens and closes the flow path of the high-temperature pipe 633a. The pump 633d pressure-feeds the liquid retained in the tank 633e to the downstream side (the switching part 635 side) of the high-temperature pipe 633a. The configuration of the high-temperature chiller part 633 is not limited thereto, and may be provided with a flow rate controller or the like, for example.

[0062]

Similarly to the high-temperature chiller part 633, in the low-temperature chiller part 634, a refrigeration device 634b, an on-off valve 634c, a pump 634d, a tank 634e, and the like are installed in the low-temperature pipe 634a. The refrigeration device 634b may include a heat exchanger or the like to decrease the temperature of the liquid in the low-temperature pipe 634a to a preset target temperature. The on-off valve 634c opens and closes the flow path of the low-temperature pipe 634a. The pump 634d pressure-feeds the liquid retained in the tank 634e to the downstream side (the switching part 635 side) of the low-temperature pipe 634a. The configuration of the low-temperature chiller part 634 is also not limited thereto, and may be provided with a flow rate controller or the like, for example.

[0063]

The switching part 635 may be a three-way switching valve, and selectively introduces the high-temperature liquid of the high-temperature pipe 633a and the low-temperature liquid of the low-temperature pipe 634a into the common pipe 632. Alternatively, the switching part 635 may be configured to individually adjust the opening degree of the flow path of the high-temperature pipe 633a and the opening degree of the flow path of the low-temperature pipe 634a, and mix the high-temperature liquid of the high-temperature pipe 633a and the low-temperature liquid of the low-temperature pipe 634a and introduce the mixture into the common pipe 632. The supply mechanism 631 may be provided with a temperature sensor (not shown), for example, in the flow path of the common pipe 632 (or in the housing 61), and may be configured to adjust the temperature of the liquid supplied to the housing 61 based on the detected temperature of the liquid detected by the temperature sensor.

[0064]

The discharge mechanism 636 of the temperature adjustment medium circulation part 63 includes a discharge pipe 636a connected to the bottom wall 612 of the housing 61, a control valve 636b that adjusts the opening and closing of the flow path of the discharge pipe 636a and the opening degree of the flow path, and a pump 636c. The discharge mechanism 636 further includes a switching part 636d that selectively circulates the liquid of the discharge pipe 636a to the high-temperature chiller part 633 and the low-temperature chiller part 634.

[0065]

The discharge pipe 636a has a common pipe on the upstream side of the switching part 636d, and has a branching pipe for branching the discharge of the high-temperature liquid and the discharge of the low-temperature liquid on the downstream side of the switching part 636d. Then, the temperature adjustment

medium circulation part 63 forms a circulation circuit that circulates the high-temperature liquid discharged from the housing 61 to the high-temperature chiller part 633, and circulates the low-temperature liquid discharged from the housing 61 to the low-temperature chiller part 634. The temperature adjustment medium circulation part 63 may discharge the liquid of the housing 61 without circulating it. For example, in the case of adjusting the temperature by mixing the liquid of the high-temperature chiller part 633 and the liquid of the low-temperature chiller part 634, the temperature adjustment medium circulation part 63 may be configured to discharge the liquid.

[0066]

The temperature adjustment medium circulation part 63 having the supply mechanism 631 and the discharge mechanism 636 can retain the liquid in the inspection space 61s of the housing 61 by supplying the liquid from the supply mechanism 631 while closing the control valve 636b. On the contrary, the temperature adjustment medium circulation part 63 can discharge the liquid retained in the inspection space 61s of the housing 61 by stopping the supply of the liquid from the supply mechanism 631 while opening the control valve 636b. Alternatively, the temperature adjustment medium circulation part 63 can circulate the liquid of the housing 61 while retaining a certain amount of the liquid in the housing 61 by adjusting the opening degree of the control valve 636b while supplying the liquid from the supply mechanism 631.

[0067]

For example, as illustrated in FIG. 5, the temperature adjustment medium circulation part 63 immerses the entire exposed portion of the shell structure 100 in the liquid in the housing 61. Accordingly, the temperature adjustment medium circulation part 63 can efficiently adjust the temperature of the shell structure 100.

The inspection apparatus 60 inspects the substrate W in a state where the shell structure 100 is immersed. The temperature adjustment medium circulation part 63 does not necessarily immerse the entire exposed portion of the shell structure 100. For example, the supply amount of the liquid may be adjusted such that the other surface Ws2 of the substrate W is not immersed in the liquid.

[0068]

Referring back to FIG. 4, the suction part 64 of the inspection apparatus 60 has a function of sealing the contact portions between the electrode pads 113 of the contact jig 110 and the probes 622 by performing suctioning of the shell structure 100 loaded into the housing 61 toward the base sides of the probes 622. The suction part 64 includes a suction hole 641 formed in the bottom wall 612 (the pogo frame 614) of the housing 61, a suction pipe 642 connected to the suction hole 641, and a suction mechanism 643 provided in the suction pipe 642.

[0069]

The suction hole 641 is provided on the inner side of the seal member 615 and forms a sealed space by the shell structure 100 and the seal member 615 by performing suctioning of the contact jig 110 upon loading of the shell structure 100. Thus, the seal member 615 prevents the liquid from entering the contact portions between the electrode pads 113 of the contact jig 110 and the probes 622. The suction hole 641 may utilize holes of a plurality of lift pins 616 for receiving or transferring the shell structure 100 with the transfer device of the inspection area 12, for example.

[0070]

The suction mechanism 643 is provided outside the housing 61, and generates a suction force in the suction hole 641 through the suction pipe 642 under the control of the control part 69. The suction mechanism 643 may be

configured by appropriately combining an automatic pressure control (APC) valve, a turbo molecular pump for performing suctioning of a processing gas, a vacuum pump, and the like. The suction part 64 may be configured to promote peeling of the shell structure 100 and the seal member 615 by supplying a gas to the shell structure 100 side (the previously sealed space) through the suction pipe 642 and the suction hole 641 upon releasing the suction of the shell structure 100.

[0071]

The heating part 65 of the inspection apparatus 60 is provided inside or outside the housing 61, and has a function of increasing the temperature of the substrate W of the shell structure 100. For example, the heating part 65 may be provided on the ceiling wall 611, and may be an LED device 651 that emits irradiation light. The LED device 651 finely adjusts (increases) the temperature of the substrate W by emitting irradiation light to the substrate W. Further, the device for performing fine adjustment of the temperature of the substrate W is not limited to the LED device 651, and may be a halogen lamp capable of easily transferring heat.

[0072]

Further, the LED device 651 may be configured to detect in-plane temperature distribution of the substrate W by a temperature sensor (not shown) during the inspection of the shell structure 100 (the substrate W), and to locally increase the temperature of the low-temperature portion of the substrate W when the in-plane temperature distribution is not uniform. In other words, it is preferable that the LED device 651 has an irradiation part partitioned to increase the temperature by irradiating a part of the substrate W with irradiation light. Accordingly, the LED device 651 can easily make the in-plane temperature distribution of the substrate W uniform. The heating part 65 is not limited to a

device that increases the temperature by irradiating the substrate W with light, and may be configured to adjust the temperature of the substrate W by increasing the temperature of the liquid supplied to the housing 61 using a heater or the like. In this case, the heating part 65 may be provided on the bottom wall 612, the sidewall 613, or the like to heat the entire liquid in the housing 61.

[0073]

Similarly to the controller 90, the control part 69 of the inspection apparatus 60 may be a computer including a processor, a memory, an input/output interface, a communication interface, and the like. The control part 69 controls the respective components of the inspection apparatus 60 to perform immersion of the shell structure 100 and inspect the substrate W of the shell structure 100. The control part 69 of the inspection apparatus 60 may also serve as the controller 90.

[0074]

The inspection apparatus 60 according to the embodiment is basically configured as described above, and its operation will be described below with reference to FIG. 6. FIG. 6 is a flowchart illustrating an inspection method of the inspection apparatus 60.

[0075]

The control part 69 of the inspection apparatus 60 controls steps S101 to S107 of FIG. 6 to execute the inspection method for inspecting the shell structure 100.

[0076]

Based on the command from the controller 90, the inspection apparatus 60, in cooperation with the transfer device of the inspection area 12, loads the shell structure 100 held by the transfer device into the inspection space 61s of the housing 61, and mounts the shell structure 100 at the mounting position in the

housing 61 (step S101). The orientation of the shell structure 100 is adjusted before it is loaded into the housing 61 by the transfer device of the inspection area 12. For example, the inspection system 1 has an alignment function that adjusts the orientation of the shell structure 100 in the load-lock module 15 on the outlet side. The transfer device of the inspection area 12 can hold the shell structure 100 with its orientation adjusted in the case of unloading the substrate W from the load-lock module 15. The inspection system 1 may include a dedicated aligner device (not shown) in the inspection area 12.

[0077]

When the shell structure 100 is mounted at the mounting position by lowering the lift pins 616, the probes 622 protruding from the pogo frame 614 of the housing 61 are brought into contact with the electrode pads 113 of the contact jig 110. Since the orientation of the shell structure 100 is adjusted in advance, the electrode pads 113 and the probes 622 can be brought into stable contact with each other.

[0078]

As described above, the electrode pads 113 of the contact jig 110 of the shell structure 100 have an area greater than that of the conductive parts Wc of the substrate W. Thus, even if the location of the shell structure 100 is misaligned, a state in which the probes 622 of the inspection apparatus 60 and the electrode pads 113 face each other can be easily maintained. Hence, the alignment function of the load-lock module 15 on the outlet side may be set to roughly (approximately) adjust the orientation of the shell structure 100. As a result, the time for the orientation control of the shell structure 100 can be shortened, and the substrate W can be inspected efficiently.

[0079]

Next, the inspection apparatus 60 operates the suction part 64 to perform suctioning of the shell structure 100, thereby hermetically sealing the space between the shell structure 100, the bottom wall 612, and the seal member 615 (step S102). Due to the suction of the suction part 64, the plurality of electrode pads 113 and the plurality of probes 622 are brought into contact with each other with an appropriate contact pressure, making it possible to stably transmit and receive electric signals to and from the probe card 62. Further, due to the suction of the suction part 64, the shell structure 100 and the bottom wall 612 of the housing 61 are sealed with the seal member 615 interposed therebetween. Accordingly, even if liquid is supplied into the housing 61, it is possible to prevent the liquid from entering the contact portions of the electrode pads 113 and the probes 622.

[0080]

In the inspection apparatus 60, after the shell structure 100 has been suctioned, the temperature adjustment medium circulation part 63 supplies liquid, which is a temperature adjustment medium, to the inspection space 61s of the housing 61 (step S103). In this case, the temperature adjustment medium circulation part 63 blocks the outflow of the liquid from the housing 61 by closing the control valve 636b of the discharge mechanism 636. The temperature adjustment medium circulation part 63 introduces the liquid adjusted to the target temperature in the supply mechanism 631 into the housing 61. For example, in the case of increasing the temperature of the shell structure 100 to a first temperature (e.g., 80°C), the liquid is heated to the first temperature by the high-temperature chiller part 633 and supplied to the housing 61. In the case of decreasing the temperature of the shell structure 100 to a second temperature (e.g., -20°C), the liquid is cooled to the second temperature by the low-temperature chiller part 634 and supplied to the housing 61. Accordingly, the temperature of

the shell structure 100 immersed in the liquid is efficiently adjusted to the target temperature. When the temperature decreases during the inflow of the temperature adjustment medium into the housing 61, the inspection apparatus 60 may finely adjust the temperature of the shell structure 100 using the heating part 65.

[0081]

In a state where the shell structure 100 is immersed in liquid and the temperature is adjusted, the inspection apparatus 60 inspects the electrical characteristics of the substrate W of the shell structure 100 (step S104). In this inspection, the inspection apparatus 60 outputs an electrical signal from the probe card 62 to the shell structure 100 via the probes 622. The shell structure 100 transfers the electrical signal to the conductive parts Wc of the substrate W through the wirings 119 and the contact parts 112 of the contact jig 110. The shell structure 100 transfers the electrical signal output from the conductive parts Wc of the substrate W to the probes 622 through the contact parts 112 and the wirings 119. Accordingly, the inspection apparatus 60 can perform inspection in a state where the temperature of the substrate W is adjusted to a target temperature, and can appropriately determine whether the substrate W at that temperature is defective or not.

[0082]

After the inspection of the substrate W, the inspection apparatus 60 operates the temperature adjustment medium circulation part 63 to discharge the liquid retained in the housing 61 (step S105). In other words, the inspection apparatus 60 discharges the entire liquid in the inspection space 61s by opening the control valve 636b of the discharge mechanism 636.

[0083]

Next, the inspection apparatus 60 releases the suction of the shell structure 100 by the suction part 64 so that the shell structure 100 can be unloaded from the housing 61 (step S106). Since the liquid is discharged before the suction is released as described above, the electrode pads 113 and the probes 622 are prevented from coming into contact with the liquid even when the suction is released.

[0084]

Finally, the control part 69 transfers the shell structure 100 to the transfer device in cooperation with the transfer device of the inspection area 12 based on the command from the controller 90, and unloads the shell structure 100 from the inspection space 61s of the housing 61 (step S107).

[0085]

As described above, in the inspection apparatus 60 according to the embodiment, the temperature of the shell structure 100 (the substrate W) is adjusted by immersing the shell structure 100 in the liquid, thereby enabling efficient temperature control. In particular, since the temperature control is performed in a state where the liquid is in direct contact with the substrate W, the rate of temperature change can be increased, and the uniformity of the in-plane temperature distribution of the substrate W can be improved. Further, by separately providing the high-temperature chiller part 633 and the low-temperature chiller part 634, the inspection apparatus 60 can easily switch between supplying the high-temperature liquid and the low-temperature liquid. The inspection apparatus 60 does not require a chuck for suctioning the shell structure 100 and a temperature module, and thus facilitates downsizing.

[0086]

The shell structure 100 has a structure in which the outer peripheral part is

sealed, so that the temperature of the substrate W can be stably adjusted without contaminating the conductive parts Wc (the semiconductor devices) of the substrate W with the liquid. As described above, in the contact jig 110 of the shell structure 100, the electrode pads 113 are enlarged and the intervals therebetween are widened, so that the alignment precision can be lowered. Accordingly, the inspection apparatus 60 may not require a mechanism for precise orientation control, and the cost can be reduced.

[0087]

In the inspection apparatus 60, by keeping the shell structure 100 immersed even during the inspection, heat can be effectively removed even if the substrate W generates heat due to the power supply during the inspection. For example, when the inspection apparatus 60 inspects the electrical characteristics of the substrate W while adjusting the temperature of the shell structure 100 with the low-temperature liquid supplied by the low-temperature chiller part 634, the substrate W may generate heat. As the substrate W generates heat, the liquid near the shell structure 100 boils. However, the liquid in which the shell structure 100 is immersed can allow the gas vaporized by the boiling to escape upward without remaining on the substrate W. Hence, the liquid causes circulation near the shell structure 100, which makes it possible to efficiently perform boiling cooling of the shell structure 100. The boiling cooling can remove heat through the same mechanism even in the case of the high-temperature liquid supplied by the high-temperature chiller part 633.

[0088]

The inspection apparatus 60 according to the embodiment is not limited to the above-described configuration, and can adopt various modifications. For example, the inspection apparatus 60 may have a fixing mechanism that

mechanically fixes the shell structure 100 transferred to the housing 61. The inspection apparatus 60 may omit the suction part 64 by allowing the fixing mechanism to liquid-tightly fix the shell structure 100.

[0089]

In the above-described embodiment, the temperature adjustment medium circulation part 63 has both the high-temperature chiller part 633 and the low-temperature chiller part 634. However, the present disclosure is not limited thereto, and the temperature adjustment medium circulation part 63 may have either one of the high-temperature chiller part 633 and the low-temperature chiller part 634. In other words, the supply mechanism 631 may control the temperature of the liquid using a single device provided with a heat exchanger, a heater, and the like.

[0090]

In the embodiment described above, the area and interval of the electrode pads 113 of the shell structure 100 are greater than those of the conductive parts Wc. However, the electrode pads 113 may have an area that is substantially the same as that of the conductive parts Wc and an interval greater than that of the conductive parts Wc. On the contrary, the electrode pads 113 may have an area greater than that of the conductive parts Wc and an interval that is substantially the same as that of the conductive parts Wc. Alternatively, the area and interval of the electrode pads 113 may be the same as those of the conductive parts Wc.

[0091]

FIG. 7 is a side cross-sectional view schematically illustrating an inspection apparatus 60A according to a second embodiment. The inspection apparatus 60A according to the second embodiment differs from the inspection apparatus 60 according to the first embodiment in that it is configured to hold the shell structure

100 on the ceiling wall 611 (the pogo frame 614), which is the upper side of the housing 61 in the vertical direction, and immerse the substrate W.

[0092]

Specifically, the inspection apparatus 60A includes the probe card 62 (the probes 622) and the suction part 64 on the ceiling wall 611. In the probe card 62, the probes 622 protrude downward from the body 621. In the ceiling wall 611, the seal member 615 is provided around each probe 622. The suction part 64 includes the suction hole 641 in the pogo frame 614 of the ceiling wall 611, and holds the shell structure 100 on the ceiling wall 611 side by performing suctioning of the shell structure 100. As a result, in the shell structure 100, the contact jig 110 is located on the upper side, and the substrate W is located on the lower side.

[0093]

The temperature adjustment medium circulation part 63 supplies liquid, which is a temperature adjustment medium, to the housing 61 so that the substrate W of the shell structure 100 can be immersed, for example. Even in this state, the inspection apparatus 60A can efficiently and uniformly adjust the temperature of the substrate W by the supplied liquid. In other words, the inspection apparatuses 60 and 60A do not necessarily have a configuration in which the entire shell structure 100 exposed in the inspection space 61s is immersed, and may have a configuration in which a part of the shell structure 100 is immersed.

[0094]

The inspection apparatus 60A can stably inspect the electrical characteristics of the substrate W of the immersed shell structure 100 by using the tester 66 and the probe card 62. In particular, the inspection apparatus 60A has a configuration in which the shell structure 100 is held on the upper side and the liquid is prevented from reaching the contact portions between the electrode pads

113 and the probes 622. Accordingly, the inspection apparatus 60A can more reliably prevent the probes 622 from becoming wet during the unloading of the shell structure 100. In addition, the inspection apparatus 60A may adjust the temperature of the shell structure 100 in a state where the entire inspection space 61s of the housing 61 is filled with the liquid.

[0095]

FIG. 8 is a side view schematically illustrating an inspection apparatus 60B according to a third embodiment. The inspection apparatus 60B according to the third embodiment differs from the above-described inspection apparatuses 60 and 60A in that it includes a plurality of inspection parts 67, each including the housing 61, the probe card 62, the temperature adjustment medium circulation part 63, the suction part 64, the heating part 65, and the tester 66. For example, in the inspection apparatus 60B, the plurality of inspection parts 67 are arranged in four rows in a transverse direction (horizontal direction) and stacked in three stages in a longitudinal direction (vertical direction). In other words, the plurality of inspection parts 67 are formed in a multi-stage structure stacked in multiple stages in the vertical direction. The inspection apparatus 60B includes a transfer device 68 that transfers the shell structure 100 to a target inspection part 67 among the plurality of inspection parts 67. The transfer device 68 may be the transfer device of the inspection area 12.

[0096]

The temperature adjustment medium circulation part 63 for circulating liquid that is a temperature adjustment medium has a common pipe and a common chiller connected to the respective inspection parts 67, and may be configured to selectively supply and discharge the temperature adjustment medium to the respective inspection parts 67 by opening and closing a valve in the pipe. The

same applies to the suction part 64.

[0097]

The inspection apparatus 60B configured as described above can simultaneously perform temperature control and inspection on a plurality of shell structures 100 by transferring the shell structure 100 to the plurality of inspection parts 67. In particular, the housing 61 of the inspection part 67 can be minimized by omitting a chuck or a prober device, as described above. Even when the inspection apparatus 60B includes the plurality of inspection parts 67, the footprint of the apparatus can be minimized.

[0098]

Hereinafter, the technical idea and effects of the present disclosure described in the above embodiments will be described.

[0099]

According to a first aspect of the present disclosure, there is provided the inspection apparatuses 60, 60A, and 60B for inspecting the shell structure 100 in which a portion where a conductive parts Wc of the substrate W and the contact parts 112 of the jig (the contact jig 110) are electrically connected is sealed, each apparatus including the housing 61, the probes 622 configured to contact the electrodes (the electrode pads 113) of the jig that is electrically connected to the contact parts 112 within the housing 61, the temperature adjustment medium circulation part 63 configured to supply the temperature adjustment medium into the housing 61 and discharge the temperature adjustment medium from the housing 61, and the control part 69. The control part 69 controls: (A) a process of loading the shell structure 100 into the housing 61 and mounting the shell structure 100 in a state where the probes 622 and the electrodes are brought into contact with each other; (B) a process of, after the process of (A), supplying the

temperature adjustment medium from the temperature adjustment medium circulation part 63 into the housing 61 and adjusting a temperature of the shell structure 100 by immersing at least a part of the shell structure 100 in the temperature adjustment medium; and (C) a process of inspecting the substrate W of the shell structure 100 via the probes 622 while performing the process of (B).

[0100]

Accordingly, the inspection apparatuses 60, 60A, and 60B can efficiently adjust the temperature of the substrate W by supplying the temperature adjustment medium into the housing using the temperature adjustment medium circulation part and immersing the shell structure in the temperature adjustment medium. Further, the inspection apparatuses 60, 60A, and 60B can stably inspect the temperature-adjusted substrate W by immersing the shell structure 100 in a state where the probes are in contact with the electrodes (the electrode pads 113) of the shell structure 100. Hence, the inspection apparatuses 60, 60A, and 60B can inspect the substrate W efficiently and with high precision.

[0101]

The inspection apparatuses 60, 60A, and 60B includes the suction part 64 on the base side of the probes 622 and configured to apply suction to the shell structure 100, and the control part 69, between the process of (A) and the process of (B), causes the suction part 64 to apply suction to the shell structure 100 as a process of (D), and continues performing the process of (D) during the process of (B) and the process of (C). Accordingly, the inspection apparatuses 60, 60A, and 60B can stably maintain the state in which the shell structure 100 and the probe 622 are electrically connected.

[0102]

The housing 61 has the seal member 615 configured to liquid-tightly seal

the outer peripheral portion of the surface of the jig (the contact jig 110) having the electrode in a state where the probe 622 and the electrodes (the electrode pad 113) are in contact with each other. Due to the seal member 615, it is possible to liquid-tightly close the contact portions of the probes 622 and the electrodes, so that the inspection apparatuses 60, 60A, and 60B can inspect the substrate W more stably.

[0103]

The housing 61 has the probe 622 and the suction part 64 on the lower side of the housing 61 in the vertical direction. In the process of (D), the suction part 64 applies suction to the shell structure 100 in a state where the shell structure 100 is placed on the lower side of the housing 61 in the vertical direction in the process of (A). Accordingly, in the inspection apparatuses 60 and 60B, the shell structure 100 located on the lower side of the housing 61 in the vertical direction can be easily immersed in the liquid and inspected.

[0104]

The housing 61 has the probes 622 and the suction part 64 on the upper side of the housing 61 in the vertical direction. In the process of (D), the suction part 64 applies suction to the shell structure 100 in a state where the shell structure 100 is placed on the upper side of the housing 61 in the vertical direction in the process of (A). In this case as well, in the inspection apparatus 60, the shell structure 100 can be immersed in the liquid, and the probe 622 can be more reliably prevented from becoming wet.

[0105]

The temperature adjustment medium circulation part 63 includes the high-temperature chiller part 633 configured to supply the temperature adjustment medium adjusted to the first temperature to the housing 61, and the low-temperature chiller part 634 configured to supply the temperature adjustment

medium adjusted to the second temperature lower than the first temperature to the housing 61. Hence, the inspection apparatuses 60, 60A, and 60B can inspect the substrate W adjusted to an appropriate temperature in a wide temperature range.

[0106]

In the process of (B), the control part 69 selects either the temperature adjustment medium of the first temperature or the temperature adjustment medium of the second temperature and supplies it to the housing 61. Accordingly, in the inspection apparatuses 60, 60A, and 60B, it is possible to adjust the temperature of the shell structure 100 within a shorter period time.

[0107]

In the process of (B), the control part 69 mixes the temperature adjustment medium of the first temperature and the temperature adjustment medium of the second temperature and supplies the mixture to the housing 61. Hence, in the inspection apparatuses 60, 60A, and 60B, it is possible to easily adjust the temperature of the shell structure 100 to various temperatures.

[0108]

The temperature adjustment medium circulation part 63 includes the discharge mechanism 636 that discharges the temperature adjustment medium supplied to the housing 61. In the process of (B), the control part 69 supplies the temperature adjustment medium to the housing 61 in a state where the discharge of the temperature adjustment medium by the discharge mechanism 636 is restricted, or supplies the temperature adjustment medium to the housing 61 while discharging the temperature adjustment medium by the discharge mechanism 636. Accordingly, in the inspection apparatus 60, it is possible to easily immerse the substrate W in the temperature adjustment medium in the housing 61 to execute temperature control.

[0109]

The temperature adjustment medium circulation part 63 has the circulation circuit that circulates the temperature adjustment medium discharged by the discharge mechanism 636 to supply it again to the housing 61. Thus, in the inspection apparatuses 60, 60A, and 60B, it is possible to reduce the disposal of the temperature adjustment medium, thereby reducing the operating cost.

[0110]

In the process of (B) and the process of (C), the entire shell structure 100 exposed in the housing 61 is immersed in the temperature adjustment medium. Accordingly, in the inspection apparatuses 60, 60A, and 60B, it is possible to adjust the temperature of the shell structure 100 more efficiently and uniformly.

[0111]

The housing 61 is provided with the heating part 65 that increases the temperature of the shell structure 100 or the temperature adjustment medium. Accordingly, even when the temperature is decreased due to the supply of the temperature adjustment medium to the housing 61, the temperature of the shell structure 100 in the housing 61 can be finely adjusted in the inspection apparatuses 60, 60A, and 60B.

[0112]

In the process of (C), boiling cooling is performed for the heat generated by the substrate W during the inspection. Accordingly, in the inspection apparatuses 60, 60A, and 60B, it is possible to smoothly decrease the temperature of the substrate W during the inspection, thereby performing the inspection stably.

[0113]

The electrodes (the electrode pads 113) of the shell structure 100 have an area greater than that of the conductive parts Wc of the substrate W. Thus, in the

inspection apparatuses 60, 60A, and 60B, the contact state between the electrodes and the probes 622 can be easily obtained even if the position of the shell structure 100 is roughly adjusted in the case of mounting the shell structure 100 in the housing 61.

[0114]

In the shell structure 100, the interval between adjacent electrodes (the electrode pads 113) is greater than that between adjacent conductive parts Wc. Accordingly, in the inspection apparatuses 60, 60A, and 60B, the electrodes (the electrode pads 113) and the probes 622 can be more easily brought into contact with each other.

[0115]

The inspection apparatus further includes the plurality of inspection parts 67, each including the housing 61, the probes 622, and the temperature adjustment medium circulation part 63, and the transfer device 68 capable of transferring the shell structures 100 to each of the plurality of inspection parts 67. Accordingly, the inspection apparatus 60B can efficiently inspect the plurality of shell structures 100 (the substrates W).

[0116]

The plurality of inspection parts 67 are formed in a multi-stage structure stacked in multiple stages in the vertical direction. Hence, the inspection apparatus 60B can efficiently inspect the plurality of shell structures 100 while improving the footprint of the inspection area 12.

[0117]

A second aspect of the present disclosure relates to the inspection method for inspecting the shell structure 100 in which a portion where the conductive parts Wc of the substrate W and the contact parts 112 of the jig (the contact jig 110) are

electrically connected is sealed. The inspection method includes: (A) a process of loading the shell structure 100 into the housing 61 and mounting the shell structure 100 in a state where the probes 622 provided in the housing 61 are in contact with the electrodes (the electrode pads 113) of the jig that is electrically connected to the contact parts 112 of the shell structure 100; (B) a process of, after the process of (A), supplying the temperature adjustment medium from the temperature adjustment medium circulation part 63 into the housing 61 and adjusting the temperature of the shell structure 100 by immersing at least a part of the shell structure 100 in the temperature adjustment medium; and (C) a process of inspecting the substrate W of the shell structure 100 via the probes 622 while performing the process of (B). In this case as well, the inspection method allows the substrate to be stably inspected while efficiently adjusting the temperature of the substrate.

[0118]

The inspection apparatuses 60, 60A, and 60B and the inspection method according to the embodiments of the present disclosure are considered to be illustrative in all respects and not restrictive. The above-described embodiments can be changed and modified in various forms without departing from the scope of the appended claims and the gist thereof. The above-described embodiments may include other configurations without contradicting each other and may be combined without contradicting each other.

[0119]

This application claims priority to Japanese Patent Application No. 2024-026789 filed on February 26, 2024, the entire contents of which are incorporated herein by reference.

Description of Reference Numerals

[0120]

60: inspection apparatus

61: housing

622: probe

63: temperature adjustment medium circulation part

69: control part

100: shell structure

110: contact jig

112: contact part

113: electrode pad

W: substrate

Wc: conductive part