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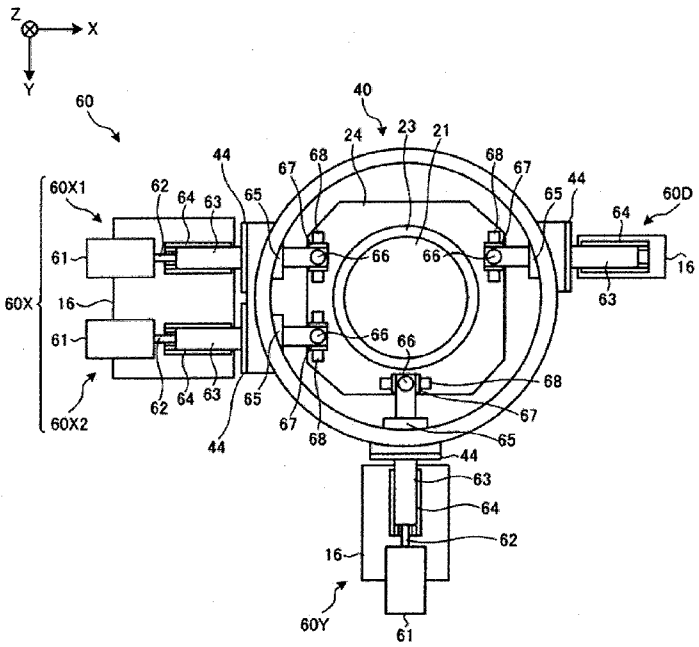
(54) Title: JOINT APPARATUS, JOINT SYSTEM, AND JOINT METHOD

FIG.7



(57) Abstract: A joint apparatus includes: a first holding unit which attracts and holds a first substrate; a second holding unit which attracts and holds a second substrate; a pressurization unit which presses the first substrate and the second substrate against each other; a first adjustment unit which adjusts a position of the first holding unit along a first horizontal direction; and a second adjustment unit which adjusts the position of the first holding unit along a second horizontal direction perpendicular to the first horizontal direction. The first holding unit is rotated around a vertical axis using the first adjustment unit and the second adjustment unit.

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[Name of Document] DESCRIPTION

[Title of the Invention] JOINT APPARATUS, JOINT SYSTEM, AND JOINT METHOD

[Technical Field]

[0001] (Cross-reference to related application)

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2015-007245, filed in Japan on January 16, 2015, the entire contents of which are incorporated herein by reference.

[0002] Disclosed embodiments relate to a joint apparatus, a joint system, and a joint method.

[Background Art]

[0003] Conventionally, a joint system is known which joins substrates such as semiconductor wafers, glass substrates or the like together (refer to Patent Document 1).

[Prior Art Document]

[Patent Document]

[0004] [Patent Document 1] Japanese Patent Application Laid-open No. 2012-069900

[Disclosure of the Invention]

[Problems to Be Solved by the Invention]

[0005] However, there is room for further improvement in terms of improving the joint accuracy in the above-described prior art.

[0006] An aspect of an embodiment has an object to provide a joint apparatus, a joint system, and a joint method, capable of improving the joint accuracy.

[Means for Solving the Problems]

[0007] A joint apparatus according to one aspect of an embodiment includes a first holding unit, a second holding unit, a pressurization unit, a first adjustment unit, and a second adjustment unit. The first holding unit attracts and holds a first substrate. The second holding unit is disposed to face the first holding unit in a vertical direction and attracts and holds a second substrate. The pressurization unit makes the first holding unit and the second holding unit relatively approach to each other to thereby press the first substrate and the second substrate against each other. The first adjustment unit adjusts a position of the first holding unit along a first horizontal direction. The second adjustment unit includes a plurality of moving mechanisms that apply force along a second horizontal direction perpendicular to the first horizontal direction to the first holding unit, and adjusts the position of the first holding unit along the second horizontal direction using the plurality of moving mechanisms. Further, the joint apparatus according the embodiment rotates the first holding unit around a vertical axis using the plurality of moving mechanisms included in the second adjustment unit and the first adjustment unit.

[Effect of the Invention]

[0008] According to one aspect of an embodiment, the joint accuracy can be improved.

[Brief Description of the Drawings]

[0009] [FIG. 1] FIG. 1 is a view illustrating a configuration of a joint system according to an embodiment;

[FIG. 2] FIG. 2 is a view illustrating a configuration of a thermal treatment apparatus;

[FIG. 3] FIG. 3 is a view illustrating a configuration of a joint apparatus;

[FIG. 4] FIG. 4 is a view illustrating a configuration of a first holding unit and its periphery;

[FIG. 5] FIG. 5 is a view illustrating a configuration of a cooling unit;

[FIG. 6] FIG. 6 is a schematic side view illustrating a configuration of a horizontal position adjustment unit;

[FIG. 7] FIG. 7 is a schematic bottom view illustrating the configuration of the horizontal position adjustment unit;

[FIG. 8] FIG. 8 is a view illustrating a configuration of a second holding unit and its periphery;

[FIG. 9] FIG. 9 is a view illustrating configurations of a pressurization unit and a horizontal degree adjustment unit;

[FIG. 10] FIG. 10 is a view illustrating a configuration of an abutting part;

[FIG. 11] FIG. 11 is a view illustrating a configuration of an abutting part according to a modification example;

[FIG. 12] FIG. 12 is a view of the horizontal degree adjustment unit as viewed from above;

[FIG. 13] FIG. 13 is a view illustrating a configuration of an alignment mark detection unit;

[FIG. 14] FIG. 14 is a view illustrating an example of an alignment mark provided on a first substrate;

[FIG. 15] FIG. 15 is a view illustrating an example of an alignment mark provided on a second substrate;

[FIG. 16] FIG. 16 is a view illustrating rated ranges of operating temperatures of electrostatic chucks;

[FIG. 17] FIG. 17 is a view illustrating rated ranges of operating

temperatures of the electrostatic chucks according to a modification example;

[FIG. 18] FIG. 18 is a flowchart illustrating a series of processing procedure executed in the joint system;

[FIG. 19] FIG. 19 is a flowchart illustrating a processing procedure of joint processing;

[FIG. 20] FIG. 20 is a view illustrating an operation example of horizontal degree adjustment processing;

[FIG. 21] FIG. 21 is a view illustrating the operation example of the horizontal degree adjustment processing;

[FIG. 22] FIG. 22 is a view illustrating the operation example of the horizontal degree adjustment processing;

[FIG. 23] FIG. 23 is a view illustrating an operation example of horizontal position adjustment processing;

[FIG. 24] FIG. 24 is a view illustrating the operation example of the horizontal position adjustment processing;

[FIG. 25] FIG. 25 is a view illustrating the operation example of the horizontal position adjustment processing;

[FIG. 26] FIG. 26 is a view illustrating an operation example of temporary pressurization processing; and

[FIG. 27] FIG. 27 is a view illustrating an operation example of main pressurization processing.

[Best Mode for Carrying out the Invention]

[0010] Hereinafter, embodiments of a joint apparatus, a joint system, and a joint method disclosed in this application will be described in detail referring to the accompanying drawings. Note that this invention is not

limited by the embodiments described below.

[0011] <1. Configuration of Joint System 100>

First, a configuration of a joint system according to an embodiment will be described referring to FIG. 1. FIG. 1 is a view illustrating the configuration of the joint system according to this embodiment. Note that to clarify the positional relationship, an X-axis direction, a Y-axis direction, and a Z-axis direction perpendicular to one another are defined, and a Z-axis positive direction is assumed to be a vertical upward direction in the following.

[0012] A joint system 100 according to this embodiment illustrated in FIG. 1 joins a first substrate W1 and a second substrate W2 to form a superposed substrate T.

[0013] As illustrated in FIG. 1, the joint system 100 includes a transfer-in/out station 1, an aligner 2 with a reversing mechanism (hereinafter, simply described as an "aligner 2"), a load lock chamber 3, a transfer chamber 4, a thermal treatment apparatus 5, and a joint apparatus 6.

[0014] The transfer-in/out station 1 includes a mounting table 7 and a transfer region 8. The mounting table 7 includes a plurality of (for example, four) cassette mounting plates 101. On the cassette mounting plates 101, cassettes C1 to C3 are mounted respectively each of which is capable of housing a plurality of (for example, 25) substrates in a horizontal state. The cassette C1 is a cassette that houses the first substrate W1, the cassette C2 is a cassette that houses the second substrate W2, and the cassette C3 is a cassette that houses the superposed substrate T.

[0015] The transfer region 8 is disposed adjacent to a Y-axis positive direction side of the mounting table 7. In the transfer region 8, a transfer

path 102 extending along the X-axis direction and a first transfer apparatus 103 movable along the transfer path 102 are provided. The first transfer apparatus 103 is movable also in the Y-axis direction and turnable around a Z-axis, and transfers-in/out the first substrate W1, the second substrate W2, and the superposed substrate T to/from the cassettes C1 to C3, the aligner 2, and the load lock chamber 3. Note that, on the cassette mounting plate 101, a cassette for collecting defective substrates and the like may be mounted in addition to the cassettes C1 to C3.

[0016] The aligner 2 is disposed adjacent to a Y-axis positive direction side of the transfer region 8. The aligner 2 adjusts horizontal positions of the first substrate W1 and the second substrate W2. For example, the aligner 2 performs pre-alignment processing of detecting positions of orientation flats or notches formed on the first substrate W1 and the second substrate W2, and aligning the detected positions of the orientation flats or notches to a predetermined position. Further, the aligner 2 includes a reversing mechanism that reverses the front and rear surfaces of the first substrate W1.

[0017] The load lock chamber 3 is disposed adjacent to a Y-axis positive direction side of the transfer region 8 via a gate valve 9a. Inside the load lock chamber 3, a delivery unit is provided which delivers the first substrate W1, the second substrate W2, and the superposed substrate T. The delivery unit is a wafer mounting unit (cooling plate) with a cooling function and can cool the superposed substrate T after joint processing to, for example, room temperature.

[0018] The transfer chamber 4 is disposed to a Y-axis positive direction side of the load lock chamber 3 via a gate valve 9b. In the transfer chamber 4, a second transfer apparatus 104 is disposed. The second transfer

apparatus 104 includes an arm part expandable and contactable along the horizontal direction and a base part turnable around a Z-axis, and transfers-in/out the first substrate W1, the second substrate W2, and the superposed substrate T to/from the load lock chamber 3, the thermal treatment apparatus 5, and the joint apparatus 6.

[0019] The thermal treatment apparatus 5 is disposed adjacent to an X-axis positive direction side of the transfer chamber 4 via a gate valve 9c. Before the joint processing by the joint apparatus 6, the thermal treatment apparatus 5 performs pre-heat treatment of heating the first substrate W1 and the second substrate W2 to a predetermined temperature. The configuration of the thermal treatment apparatus 5 will be described later.

[0020] The joint apparatus 6 is disposed adjacent to a Y-axis positive direction side of the transfer chamber 4 via a gate valve 9d. The joint apparatus 6 joins the first substrate W1 and the second substrate W2 to form the superposed substrate T. The configuration of the joint apparatus 6 will be described later.

[0021] The joint system 100 further includes a control device 200. The control device 200 controls an operation of the joint system 100. The control device 200 is, for example, a computer and includes not-illustrated control unit and storage unit. The storage unit is composed of, for example, a storage device such as a RAM (Random Access Memory), a ROM (Read Only Memory), or a hard disk, and stores a program for controlling various kinds of processing such as the joint processing and so on. The control unit is, for example, a CPU (Central Processing Unit), and reads and executes the program stored in the storage unit to thereby control the operation of the joint system 100.

[0022] Note that the program may be the one which is recorded, for example, on a computer-readable recording medium and installed from the recording medium into the storage unit of the control device 200. Examples of the computer-readable recording medium include a hard disk (HD), a flexible disk (FD), a compact disk (CD), a magneto-optical disk (MO), and a memory card.

[0023] <2. Configuration of Thermal Treatment Apparatus 5>

Next, a configuration of the thermal treatment apparatus 5 will be described referring to FIG. 2. FIG. 2 is a view illustrating the configuration of the thermal treatment apparatus 5.

[0024] As illustrated in FIG. 2, the thermal treatment apparatus 5 includes a chamber 501, a first holding unit 502, and a second holding unit 503.

[0025] The chamber 501 is a container whose inside can be sealed, and houses the first holding unit 502 and the second holding unit 503. The chamber 501 includes a transfer-in/out port 511 that is opened/closed by the gate valve 9c, a suction port 512 for sucking gas inside the chamber 501, and a supply port 513 for supplying processing gas into the chamber 501. To the suction port 512, a suction apparatus 514 is connected. To the supply port 513, a processing gas supply source 516 is connected via a valve 515.

[0026] Into the chamber 501, the processing gas that removes an oxide film on the surfaces of the first substrate W1 and the second substrate W2 is supplied from the processing gas supply source 516. In this embodiment, a formic acid gas is used as the processing gas, but the processing gas does not always have to be the formic acid gas.

[0027] The first holding unit 502 includes an electrostatic chuck 521, a heating unit 522, and a cooling unit 523. The electrostatic chuck 521 with

an attraction surface directed downward is attached to a lower surface of the cooling unit 523, and the cooling unit 523 is attached to a ceiling surface of the chamber 501. Further, the heating unit 522 is built in the electrostatic chuck 521.

[0028] The electrostatic chuck 521 includes an internal electrode and a dielectric, and attracts the first substrate W1 to the attraction surface using an electrostatic force generated by applying voltage to the internal electrode. The heating unit 522 is, for example, a sheathed heater or a ceramic heater, and heats the electrostatic chuck 521 to thereby heat the first substrate W1 held by the electrostatic chuck 521. The cooling unit 523 is configured, for example, by stacking a cooling jacket and a heat insulating material.

[0029] The second holding unit 503 has an electrostatic chuck 531, a heating unit 532, and a cooling unit 533. The electrostatic chuck 531 with an attraction surface directed upward is attached to an upper surface of the cooling unit 533, and the cooling unit 533 is attached to a bottom surface of the chamber 501. Further, the heating unit 532 is built in the electrostatic chuck 531. The configurations of the electrostatic chuck 531, the heating unit 532, and the cooling unit 533 are the same as those of the electrostatic chuck 521, the heating unit 522, and the cooling unit 523 included in the first holding unit 502, and therefore description thereof will be omitted here.

[0030] <3. Configuration of Joint Apparatus 6>

Next, a configuration of the joint apparatus 6 will be described referring to FIG. 3. FIG. 3 is a view illustrating the configuration of the joint apparatus 6.

[0031] As illustrated in FIG. 3, the joint apparatus 6 includes a frame structure 10, a first holding unit 20, a second holding unit 30, a chamber 40, a

suspending mechanism 50, and a horizontal position adjustment unit 60. The joint apparatus 6 further includes a pressurization unit 70, a horizontal degree adjustment unit 80, and alignment mark detection units 90.

[0032] The chamber 40 is a container whose inside can be sealed and which houses the first holding unit 20 and the second holding unit 30. The chamber 40 is provided with a suction port 41 for sucking gas inside the chamber 40. To the support port 41, a suction device 42 is connected. Note that the chamber 40 is composed of a first support member 11, a second support member 12, and a partition wall 45 provided between the first support member 11 and the second support member 12.

[0033] The first holding unit 20 is a holding unit that holds the first substrate W1 and is provided at a lower surface of the first support member 11 of the frame structure 10 via a spacer 14. The first holding unit 20 has a not-illustrated heating unit built therein.

[0034] The suspending mechanism 50 holds the first holding unit 20 while suspending the first holding unit 20 from above. By the suspending mechanism 50, the first holding unit 20 is disposed spaced from the spacer 14. The horizontal position adjustment unit 60 adjusts the horizontal position of the first holding unit 20. The horizontal position means the position and the orientation in the horizontal direction. The configurations of the suspending mechanism 50 and the horizontal position adjustment unit 60 will be described later.

[0035] The second holding unit 30 is a holding unit that holds the second substrate W2 and is provided to be able to approach to and separate from an upper surface of the second support member 12 of the frame structure 10. Further, the second holding unit 30 is disposed below and opposite the first

holding unit 20. The second holding unit 30 has a not-illustrated heating unit built therein.

[0036] The pressurization unit 70 includes a fixed shaft 71 connected to a central portion of the second holding unit 30, a movable shaft 72 disposed on the same axis with the fixed shaft 71, and a drive unit 73 that moves the movable shaft 72 in the vertical direction. The pressurization unit 70 moves the movable shaft 72 in the vertical direction using the drive unit 73 to bump the movable shaft 72 against the fixed shaft 71. This causes the second holding unit 30 to approach to the first holding unit 20 so as to press the second substrate W2 held by the second holding unit 30 against the first substrate W1 held by the first holding unit 20.

[0037] The horizontal degree adjustment unit 80 is connected to the second holding unit 30 on an outer peripheral side of the pressurization unit 70. The horizontal degree adjustment unit 80 includes a support plate 81, a plurality of first support post members 82 each having one end connected to the support plate 81, a plurality of drive units 83 each connected to the other end of the first support post member 82 and moving the first support post member 82 along the vertical direction, and a plurality of second support post members 84 each having one end connected to the second holding unit 30 and another end connected to the support plate 81. The horizontal degree adjustment unit 80 individually moves the plurality of first support post members 82 along the vertical direction using the plurality of drive units 83 to make heights of outer peripheral portions of the second holding unit 30 coincide with one another. This adjusts the horizontal degree of the second holding unit 30. Note that the drive units 73, 83 of the pressurization unit 70 and the horizontal degree adjustment unit 80 are fixed to a third support

member 13 of the frame structure 10.

[0038] The alignment mark detection unit 90 includes an imaging unit 91 provided above the first support member 11, and a light source 92 provided below the second support member 12. The light source 92 is disposed outside the chamber 40 and radiates light to the first substrate W1 and the second substrate W2 via a through hole formed in the second support member 12 and the second holding unit 30. The light radiated from the light source 92 is infrared light. The imaging unit 91 is disposed outside the chamber 40 and images alignment marks provided on the first substrate W1 and the second substrate W2 via a through hole formed in the first support member 11, the spacer 14, and the first holding unit 20. An imaged result by the imaging unit 91 is outputted to the control device 200.

[0039] The joint apparatus 6 is configured as described above, and reduces the pressure inside the chamber 40 using the suction device 42, and heats the first substrate W1 and the second substrate W2 using the heating units built in the first holding unit 20 and the second holding unit 30. The joint apparatus 6 further adjusts the horizontal position of the first holding unit 20 using the horizontal position adjustment unit 60 on the basis of a detection result by the alignment mark detection unit 90. Further, the joint apparatus 6 adjusts the horizontal degree of the second holding unit 30 using the horizontal degree adjustment unit 80. Then, the joint apparatus 6 presses the first substrate W1 and the second substrate W2 against each other using the pressurization unit 70 to form the superposed substrate T. Note that the first substrate W1 and the second substrate W2 are joined together by metal provided on the first substrate W1 and metal provided on the second substrate W2.

[0040] <4-1. Configuration of First Holding Unit 20 and its Periphery>

Next, the configuration of the above-described joint apparatus 6 will be concretely described. First, the configuration of the first holding unit 20 and its periphery will be described referring to FIG. 4. FIG. 4 is a view illustrating the configuration of the first holding unit 20 and its periphery.

[0041] As illustrated in FIG. 4, the first holding unit 20 includes an electrostatic chuck 21, a heating unit 22, a cooling unit 23, and a plate 24. To an upper surface of the plate 24, the suspending mechanism 50 is connected. Further, to an outer peripheral portion of a lower surface of the plate 24, the horizontal position adjustment unit 60 is connected. The cooling unit 23 is smaller in diameter than the plate 24 and is attached to a central portion of the lower surface of the plate 24. The electrostatic chuck 21 is smaller in diameter than the cooling unit 23 and is attached to a central portion of a lower surface of the cooling unit 23. The heating unit 22 is built in the electrostatic chuck 21. Note that the electrostatic chuck 21 does not always have to be smaller in diameter than the cooling unit 23.

[0042] The electrostatic chuck 21 includes an internal electrode and a dielectric, and attracts the first substrate W1 to an attraction surface using an electrostatic force generated by applying voltage to the internal electrode. The heating unit 22 is, for example, a sheathed heater or a ceramic heater, and heats the electrostatic chuck 21 to thereby heat the first substrate W1 held by the electrostatic chuck 21.

[0043] The cooling unit 23 is configured, for example, by stacking a cooling jacket and a heat insulating material. Here, the configuration of the cooling unit 23 will be described referring to FIG. 5. FIG. 5 is a view illustrating the configuration of the cooling unit 23.

[0044] As illustrated in FIG. 5, the cooling unit 23 includes a first cooling jacket 231, a second cooling jacket 232, and a heat insulating material 233. The first cooling jacket 231 is provided adjacent to the plate 24, the second cooling jacket 232 is provided adjacent to the first holding unit 20, and the heat insulating material 233 is provided between the first cooling jacket 231 and the second cooling jacket 232.

[0045] The first cooling jacket 231 operates at all times during a series of joint processing. This makes it possible to suppress heat effect on the plate 24, the imaging unit 91 and so on. On the other hand, the second cooling jacket 232 operates only during the time when cooling the superposed substrate T after the first substrate W1 and the second substrate W2 are joined together. This makes it possible to efficiently cool the superposed substrate T.

[0046] Note that the cooling units 523, 533 included in the first holding unit 502 and the second holding unit 503 of the thermal treatment apparatus 5 may have the same configuration as that of the above-described cooling unit 23.

[0047] Returning to FIG. 4, the suspending mechanism 50 includes a main body part 51, a wire 52, a support body 53, an elastic member 54, a sealing member 55, and a fixing part 56.

[0048] The main body part 51 is a cylindrical member and disposed at the top of the first support member 11. The wire 52 is inserted into the main body part 51, and also inserted into a through hole 58 that vertically penetrates the first support member 11 and the spacer 14 (corresponding to an example of an "upper member") to reach the inside of the chamber 40. The support body 53 is a columnar member inserted into the main body part 51,

and fixes an upper end portion of the wire 52 at its lower end portion. The elastic member 54 is, for example, a coil spring, and elastically supports the support body 53 with respect to the main body part 51. The sealing member 55 seals the space between the main body part 51 and the support body 53. The fixing part 56 is provided at a lower end portion of the wire 52 and fixed to the plate 24 of the first holding unit 20.

[0049] The suspending mechanism 50 is configured as described above and holds the first holding unit 20 while suspending it spaced from the spacer 14 using the wire 52. Note that the joint apparatus 6 includes a plurality of suspending mechanisms 50.

[0050] Note that the suspending mechanism 50 only needs to support the first holding unit 20 while permitting movement of the first holding unit 20 in the vertical direction, and is not limited to the configuration illustrated in the above.

[0051] The imaging unit 91 of the alignment mark detection unit 90 images the alignment marks provided on the first substrate W1 and the second substrate W2 via a through hole 94 vertically penetrating the first support member 11, the spacer 14, the plate 24, the cooling unit 23, and the electrostatic chuck 21.

[0052] At the top of the first support member 11, a transparent member 95 is provided which closes the through hole 94. The transparent member 95 is formed of, for example, quartz glass. The transparent member 95 can keep the sealing property of the chamber 40 while ensuring the field of view of the imaging unit 91.

[0053] The alignment mark detection unit 90 includes a raising and lowering unit 93 that raises and lowers the imaging unit 91. The raising and

lowering unit 93 is provided at the top of the first support member 11. The raising and lowering unit 93 includes a rail 931 extending along the vertical direction, and a moving unit 932 movable along the rail 931. The imaging unit 91 is attached to the moving unit 932 with the field of view directed vertically downward.

[0054] <4-2. Configuration of Horizontal Position Adjustment Unit 60>

Next, the concrete configuration of the horizontal position adjustment unit 60 will be described referring to FIG. 6 and FIG. 7. FIG. 6 is a schematic side view illustrating the configuration of the horizontal position adjustment unit 60. FIG. 7 is a schematic bottom view illustrating the configuration of the horizontal position adjustment unit 60.

[0055] As illustrated in FIG. 6 and FIG. 7, the horizontal position adjustment unit 60 includes a first adjustment unit 60Y that adjusts the position of the first holding unit 20 along a Y-axis direction (corresponding to an example of a "first horizontal direction"), and a second adjustment unit 60X that adjusts the position of the first holding unit 20 along an X-axis direction (corresponding to an example of a "second horizontal direction").

[0056] The second adjustment unit 60X includes two moving mechanisms 60X1, 60X2 that apply force along the X-axis direction to the plate 24 of the first holding unit 20. The two moving mechanisms 60X1, 60X2 are arranged in parallel along the Y-axis direction, and the moving mechanism 60X1 is arranged on a Y-axis negative direction side of a central position of the electrostatic chuck 21 and the moving mechanisms 60X2 is arranged on a Y-axis positive direction side of the central position of the electrostatic chuck 21. Note that an example that the second adjustment unit 60X includes two moving mechanisms 60X1, 60X2 is illustrated here, but the

second adjustment unit 60X may include three or more moving mechanisms.

[0057] The moving mechanism 60X1 includes a drive unit 61 fixed to the first support member 11 via a fixing plate 16, a shaft 62 that moves along the X-axis direction by the drive unit 61, a first moving member 63 that moves along the X-axis direction together with the shaft 62, and a first guide unit 64 that supports the first moving member 63 slidably in the X-axis direction.

[0058] At a position of the chamber 40 facing the moving mechanism 60X1, an opening 43 is provided so that the first moving member 63 of the moving mechanism 60X1 is inserted into the opening 43. At an opening end on the outside (on the moving mechanism 60X1 side) of the opening 43, a first flange unit 44 is provided which projects to the inside of the opening 43.

[0059] The moving mechanism 60X1 includes a second flange unit 65 provided at a middle portion of the first moving member 63, a second moving member 67 that includes a shaft part 66 extending in the vertical direction and is pivotally supported at the tip portion of the first moving member 63 to be rotatable around the vertical axis via the shaft part 66, and a second guide unit 68 that is fixed to an outer peripheral portion of the lower surface of the plate 24 and supports the second moving member 67 slidably in the Y-axis direction.

[0060] In addition, the moving mechanism 60X1 further includes a bellows 69 having one end connected to the first flange unit 44 and another end connected to the second flange unit 65. The bellows 69 makes it possible to move the plate 24 provided inside the chamber 40 from outside the chamber 40 while ensuring the sealing property of the chamber 40.

[0061] As illustrated in FIG. 6, the moving mechanism 60X1 is configured such that only the second flange unit 65, the shaft part 66, the

second moving member 67, and the second guide unit 68 are arranged inside the chamber 40, and the drive unit 61, the shaft 62, the first moving member 63, and the first guide unit 64 are arranged outside the chamber 40. This configuration makes it possible to reduce the volume capacity of the chamber 40 and improve the suction efficiency and the heating efficiency. It is also possible to suppress dust occurrence in the chamber 40.

[0062] The moving mechanism 60X1 is configured as described above and moves the shaft 62 along the X-axis direction by the drive unit 61 to move the first moving member 63 connected to the shaft 62 along the X-axis direction to thereby move the second moving member 67 pivotally supported at the first moving member 63 along the X-axis direction. This makes it possible to apply force along the X-axis direction to the plate 24. Note that the configuration of the moving mechanism 60X2 is the same as that of the moving mechanism 60X1 and therefore description thereof will be omitted here.

[0063] The second adjustment unit 60X can move the second moving member 67 of the moving mechanism 60X1 and the second moving member 67 of the moving mechanism 60X2 by the same distance to thereby move the first holding unit 20 along the X-axis direction.

[0064] The horizontal position adjustment unit 60 further includes a driven mechanism 60D. The driven mechanism 60D has the same configuration as those of the moving mechanisms 60X1, 60X2 and the first adjustment unit 60Y except that it does not include the drive unit 61 nor the shaft 62. The driven mechanism 60D is configured such that the second moving member 67 and the first moving member 63 are moved in a driven manner accompanying the movement of the plate 24. Note that the

horizontal position adjustment unit 60 does not always have to include the driven mechanism 60D.

[0065] The first adjustment unit 60Y has the same configuration as that of the moving mechanism 60X1. The first adjustment unit 60Y is disposed in an orientation in which the shaft 62 and the first moving member 63 extend along the Y-axis direction, and moves the shaft 62 along the Y-axis direction by the drive unit 61 to move the first moving member 63 connected to the shaft 62 along the Y-axis direction to thereby move the second moving member 67 pivotally supported by the first moving member 63 along the Y-axis direction. This moves the plate 24 along the Y-axis direction.

[0066] Note that the example of the case where the first adjustment unit 60Y is disposed at a position where the axes of the shaft 62 and the first moving member 63 pass through the center of the plate 24 (center of the electrostatic chuck 21) is illustrated here, but the first adjustment unit 60Y may be disposed at a position where the axes of the shaft 62 and the first moving member 63 are displaced from the center of the plate 24 (center of the electrostatic chuck 21).

[0067] The horizontal position adjustment unit 60 according to this embodiment can rotate the first holding unit 20 around the vertical axis using the two moving mechanisms 60X1, 60X2 included in the second adjustment unit 60X and the first adjustment unit 60Y. More specifically, the horizontal position adjustment unit 60 moves the second moving member 67 included in the moving mechanism 60X1 and the second moving member 67 included in the moving mechanism 60X2 in the X-axis direction by different movement amounts, and moves the first moving member 63 of the first adjustment unit 60Y along the Y-axis direction.

[0068] This allows the horizontal position adjustment unit 60 to rotate the first holding unit 20 around the vertical axis without changing the central position of the first holding unit 20. The first holding unit 20 is rotated around the vertical axis to change the orientation in the horizontal direction of the first substrate W1 held by the first holding unit 20.

[0069] <4-3. Configuration of Second Holding Unit 30 and its Periphery>

Next, the configuration of the second holding unit 30 and its periphery will be described referring to FIG. 8. FIG. 8 is a view illustrating the configuration of the second holding unit 30 and its periphery.

[0070] As illustrated in FIG. 8, the second holding unit 30 includes an electrostatic chuck 31, a heating unit 32, a cooling unit 33, and a plate 34. The plate 34 is provided to be able to approach to and separate from an upper surface of the second support member 12. The cooling unit 33 is attached to an upper surface of the plate 34, and the electrostatic chuck 31 is attached to an upper surface of the cooling unit 33. The heating unit 32 is built in the electrostatic chuck 31.

[0071] The electrostatic chuck 31 has an internal electrode and a dielectric, and attracts the second substrate W2 to an attraction surface using an electrostatic force generated by applying voltage to the internal electrode. The heating unit 32 is, for example, a sheathed heater or a ceramic heater, and heats the electrostatic chuck 31 to thereby heat the second substrate W2 held by the electrostatic chuck 31. The cooling unit 33 has the same configuration as that of the cooling unit 23 illustrated in FIG. 5.

[0072] Further, as illustrated in FIG. 8, the light source 92 of the alignment mark detection unit 90 with its optical axis directed upward is fixed to the second support member 12 via a not-illustrated fixing unit. The light

source 92 radiates light to the first substrate W1 and the second substrate W2 via a through hole 96 vertically penetrating the second support member 12, the plate 34, the cooling unit 33, and the electrostatic chuck 31.

[0073] At a lower portion of the second support member 12, a transparent member 97 is provided which closes the through hole 96. The transparent member 97 is formed of, for example, quartz glass. The transparent member 97 can keep the sealing property of the chamber 40 without interfering with the optical path of the light source 92.

[0074] <4.4 Configurations of Pressurization Unit 70 and Horizontal Degree Adjustment Unit 80>

Next, the configurations of the pressurization unit 70 and the horizontal degree adjustment unit 80 will be described referring to FIG. 9. FIG. 9 is a view illustrating the configurations of the pressurization unit 70 and the horizontal degree adjustment unit 80.

[0075] As illustrated in FIG. 9, the fixed shaft 71 of the pressurization unit 70 has an upper end portion connected to a central portion of a lower surface of the plate 34. The fixed shaft 71 penetrates the second support member 12 and has a lower end portion located below the second support member 12. At the lower end portion of the fixed shaft 71, a flange unit 74 is provided.

[0076] The pressurization unit 70 includes a bellows 75 that covers the outer periphery of the fixed shaft 71. The bellows 75 has one end connected to a lower portion of the second support member 12 and another end connected to the flange unit 74. The bellows 75 makes it possible to move the plate 34 provided inside the chamber 40 from outside the chamber 40 while ensuring the sealing property of the chamber 40.

[0077] The movable shaft 72 of the pressurization unit 70 includes an abutting part 721 abutting on a lower end surface of the fixed shaft 71. Here, the configuration of the abutting part 721 will be described referring to FIG. 10. FIG. 10 is a view illustrating the configuration of the abutting part 721.

[0078] As illustrated in FIG. 10, an abutting surface of the abutting part 721 with the fixed shaft 71 is a convex curved surface. On the other hand, an abutting surface of the fixed shaft 71 with the abutting part 721 is a concave curved surface. This configuration makes it possible to stably press the fixed shaft 71. Note that the abutting surface of the abutting part 721 with the fixed shaft 71 may be a concave curved surface and the abutting surface of the fixed shaft 71 with the abutting part 721 may be a convex curved surface.

[0079] Further, the configuration of the abutting part 721 is not limited to the above example. A modification example of the abutting part 721 will be described referring to FIG. 11. FIG. 11 is a view illustrating the configuration of the abutting part 721 according to the modification example.

[0080] As illustrated in FIG. 11, the movable shaft 72 may include an elastic member 722 such as rubber on the abutting surface of the abutting part 721 with the fixed shaft 71. In this case, the abutting surfaces of the abutting part 721 and the fixed shaft 71 are flat surfaces. This configuration also makes it possible to stably press the fixed shaft 71. Note that the elastic member 722 may be provided on the abutting surface of the fixed shaft 71 with the abutting part 721.

[0081] The pressurization unit 70 is configured as described above and moves the movable shaft 72 vertically upward using the drive unit 73 to bump the movable shaft 72 against the fixed shaft 71, thereby making the second

holding unit 30 connected to the fixed shaft 71 approach to the first holding unit 20 so as to press the second substrate W2 held by the second holding unit 30 against the first substrate W1 held by the first holding unit 20.

[0082] Returning to FIG. 9, the configuration of the horizontal degree adjustment unit 80 will be described. The second support post member 84 of the horizontal degree adjustment unit 80 has an upper end portion connected to the second holding unit 30 on an outer peripheral side of the pressurization unit 70. Further, the second support post member 84 penetrates the second support member 12 and has a lower end portion connected to the support plate 81.

[0083] The horizontal degree adjustment unit 80 includes a below 85 that covers the outer periphery of the second support post member 84. The bellows 85 has one end connected to a lower portion of the second support member 12 and another end connected to an upper portion of the support plate 81. The bellows 85 makes it possible to move the plate 34 provided inside the chamber 40 from outside the chamber 40 while ensuring the sealing property of the chamber 40.

[0084] The second support post member 84 is provided with a load cell 86. The load cell 86 is a pressure detection unit that detects pressing force applied on the first substrate W1 and the second substrate W2 when the horizontal degree adjustment unit 80 is used to press the first substrate W1 and the second substrate W2. The detection result by the load cell 86 is outputted to the control device 200.

[0085] FIG. 12 is a view of the horizontal degree adjustment unit 80 as viewed from above. As illustrated in FIG. 12, the support plate 81 of the horizontal degree adjustment unit 80 is a flat plate in an almost triangle shape

in plan view. The horizontal degree adjustment unit 80 includes three first support post members 82, three drive units 83, and three second support post members 84.

[0086] The three first support post members 82 are connected to respective apex portions of the support plate 81. The three drive units 83 are connected to the other end sides of the first support post members 82 respectively. The three second support post members 84 are provided corresponding to the three first support post members 82 respectively and connected to the support plate 81 on an inner peripheral side of the corresponding first support post members 82.

[0087] The horizontal degree adjustment unit 80 is configured as described above and individually moves the three first support post members 82 along the vertical direction using the three drive units 83 to adjust the horizontal degree of the second holding unit 30.

[0088] <4-5. Configuration of Alignment Mark Detection Unit 90>

Next, the configuration of the alignment mark detection unit 90 will be described referring to FIG. 13 to FIG. 15. FIG. 13 is a view illustrating the configuration of the alignment mark detection unit 90. Further, FIG. 14 is a view illustrating an example of an alignment mark M1 provided on the first substrate W1, and FIG. 15 is a view illustrating an example of an alignment mark M2 provided on the second substrate W2.

[0089] As illustrated in FIG. 13, the alignment marks M1, M2 have been formed beforehand on the first substrate W1 and the second substrate W2. The alignment mark M1 has, for example, a cross shape as illustrated in FIG. 14. Further, the alignment mark M2 has, for example, a shape made by hollowing the inside of a quadrangle into a cross as illustrated in FIG. 15. In

later-described horizontal position adjustment processing, the horizontal position adjustment unit 60 is used to adjust the horizontal position of the first holding unit 20 to thereby align the cross shape of the alignment mark M1 with the cross shape of the alignment mark M2.

[0090] The light source 92 of the alignment mark detection unit 90 radiates light vertically upward from below the second holding unit 30. The light radiated from the light source 92 passes through the transparent member 97, the through hole 96, the second substrate W2, the first substrate W1, the through hole 94, and the transparent member 95, and reaches the imaging unit 91. The imaging unit 91 of the alignment mark detection unit 90 images the alignment marks M1, M2 via the transparent member 95 and the through hole 94. Note that the alignment mark M2 is imaged through the alignment mark M1.

[0091] The alignment marks M1, M2 are each formed at least at two places at one end portion and the other end portion of the first substrate W1 and the second substrate W2. Further, the joint apparatus 6 includes one alignment mark detection unit 90 on each of one end side and the other end side of the first substrate W1 and the second substrate W2.

[0092] <5. Configurations of Electrostatic Chucks 521, 531, 21, 31>

Next, the configurations of the electrostatic chucks 521, 531 included in the thermal treatment apparatus 5 and the electrostatic chucks 21, 31 included in the joint apparatus 6 will be described referring to FIG. 16. FIG. 16 is a view illustrating rated ranges of operating temperatures of the electrostatic chucks 521, 531, 21, 31.

[0093] In the joint system 100 according to this embodiment, the temperature of the first substrate W1 and the second substrate W2 is increased

from room temperature to a first temperature in the thermal treatment apparatus 5, then the temperature of the first substrate W1 and the second substrate W2 is increased to a second temperature higher than the first temperature in the joint apparatus 6, and then the first substrate W1 and the second substrate W2 are joined together.

[0094] The second temperature is, for example, a temperature at which the metal on the first substrate W1 and the metal on the second substrate W2 can be joined together. In the joint system 100 according to this embodiment, the second temperature is, for example, 300℃ to 400℃. Meanwhile, the first temperature is, for example, 150℃ to 250℃.

[0095] Here, at present, there is no electrostatic chuck that can appropriately hold the substrate in a wide temperature range from room temperature to about 400℃. This is because the volume resistivity of the dielectric included in the electrostatic chuck fluctuates according to temperature.

[0096] Hence, in the joint system 100 according to this embodiment, two kinds of electrostatic chucks (the electrostatic chucks 521, 531 and the electrostatic chucks 21, 31) which are different in rated range of operating temperature are provided in the thermal treatment apparatus 5 and the joint apparatus 6 respectively to heat the first substrate W1 and the second substrate W2 stepwise by the thermal treatment apparatus 5 and the joint apparatus 6. This makes it possible to increase the temperature of the first substrate W1 and the second substrate W2 from room temperature to 300℃ to 400℃ while appropriately holding the first substrate W1 and the second substrate W2 by the electrostatic chucks and thereby realize joint of the first substrate W1 and the second substrate W2 with high accuracy. Further,

performing the heat treatment of the first substrate W1 and the second substrate W2 dividedly by the thermal treatment apparatus 5 and the joint apparatus 6 makes it possible to improve the throughput of a series of substrate processing.

[0097] FIG. 16 illustrates a rated range of operating temperature R1 of the electrostatic chucks 521, 531 provided in the thermal treatment apparatus 5 and a rated range of operating temperature R2 of the electrostatic chucks 21, 31 provided in the joint apparatus 6. Here, the rated range of operating temperature is a temperature range in which the electrostatic chuck can be appropriately operated, namely, a temperature range decided as a temperature range in which leak current, reduction in attraction power and the like do not occur.

[0098] As illustrated in FIG. 16, in the joint system 100 according to this embodiment, an electrostatic chuck with a rated range of operating temperature R1 having an upper limit lower than the first temperature is used as the electrostatic chucks 521, 531 in the thermal treatment apparatus 5. The upper limit of the rated range of operating temperature R1 is, for example, 200℃. Further, in the joint system 100 according to this embodiment, an electrostatic chuck with a rated range of operating temperature R2 having a lower limit higher than the first temperature is used as the electrostatic chucks 21, 31 in the joint apparatus 6. The lower limit of the rated range of operating temperature R2 is, for example, 270℃.

[0099] As described above, in the joint system 100 according to this embodiment, the rated range of operating temperature R1 of the electrostatic chucks 521, 531 and the rated range of operating temperature R2 of the electrostatic chucks 21, 31 are not overlapped but separated from each other,

and the first temperature exists between the rated range of operating temperature R1 and the rated range of operating temperature R2.

[0100] As described above, at present, there is no electrostatic chuck that covers the wide temperature range from room temperature to about 400℃. Therefore, it is conceivable that, in addition to the thermal treatment apparatus 5 including the electrostatic chucks 521, 531 with the rated range of operating temperature R1, a thermal treatment apparatus including an electrostatic chuck that has a rated range of operating temperature including the first temperature is separately provided, so that two thermal treatment apparatuses are used to increase the temperature of the first substrate W1 and the second substrate W2 from room temperature to the first temperature. However, this may cause an increase in manufacturing cost and a decrease in throughput. In contrast, in the joint system 100 according to this embodiment, the above configuration can prevent the increase in manufacturing cost and the decrease in throughput.

[0101] Note that the temperature of the first substrate W1 and the second substrate W2 is increased from room temperature in the thermal treatment apparatus 5 in this embodiment, but not limited to this. For example, there also is a conceivable process of heating the first substrate W1 and the second substrate W2 to the first temperature in the thermal treatment apparatus 5 that has been pre-heated to the first temperature. The configurations of the electrostatic chucks 521, 531, 21, 31 in this case will be described referring to FIG. 17. Fig. 17 is a view illustrating the rated ranges of operating temperatures of the electrostatic chucks 521, 531, 21, 31 according to a modification example.

[0102] As illustrated in FIG. 17, in the case where the thermal treatment

apparatus 5 is pre-heated to the first temperature, an electrostatic chuck with a rated range of operating temperature R3 having a lower limit higher than room temperature and an upper limit higher than the lower limit of the rated range of operating temperature R2 can be used as the electrostatic chucks 521, 531 in the thermal treatment apparatus 5.

[0103] <6. Concrete Operation of Joint System 100>

Next, the concrete operation of the joint system 100 will be described referring to FIG. 18. FIG. 18 is a flowchart illustrating a series of processing procedure executed in the joint system 100.

[0104] As illustrated in FIG. 18, in the joint system 100, first of all, the first transfer apparatus 103 in the transfer-in/out station 1 takes the first substrate W1 out of the cassette C1 mounted on the cassette mounting plate 101 and transfers the first substrate W1 to the aligner 2. The first substrate W1 is transferred with a non-joint surface directed downward. Note that, of plate surfaces of the first substrate W1, a plate surface on the side where electronic circuits are to be formed is a joint surface, and a surface on the opposite side to the joint surface is the non-joint surface.

[0105] The first substrate W1 transferred to the aligner 2 is subjected to pre-alignment processing by the aligner 2 (Step S101). For example, the aligner 2 performs processing of detecting the position of the orientation flat or notch formed on the first substrate W1 and aligning the detected position of the orientation flat or notch to a predetermined position.

[0106] Subsequently, the aligner 2 performs reversal processing of reversing the front and rear surfaces of the first substrate W1 (Step S102). This brings the first substrate W1 into a state that the non-joint surface is directed upward. Then, the first substrate W1 is transferred by the first

transfer apparatus 103 from the aligner 2 to the load lock chamber 3, and is transferred by the second transfer apparatus 104 in the transfer chamber 4 from the load lock chamber 3 to the thermal treatment apparatus 5. Then, the first substrate W1 with the joint surface directed downward is attracted and held by the electrostatic chuck 521 included in the first holding unit 502 of the thermal treatment apparatus 5.

[0107] On the other hand, in the joint system 100, the same processing as the above-described pre-alignment processing is performed also on the second substrate W2 (Step S103). Specifically, the first transfer apparatus 103 takes the second substrate W2 out of the cassette C2 mounted on the cassette mounting plate 101 and transfers the second substrate W2 to the aligner 2. In this event, the second substrate W2 is transferred with a non-joint surface directed downward. Then, the second substrate W2 transferred to the aligner 2 is subjected to pre-alignment processing by the aligner 2.

[0108] Then, the second substrate W2 is transferred by the first transfer apparatus 103 from the aligner 2 to the load lock chamber 3, and is transferred by the second transfer apparatus 104 from the load lock chamber 3 to the thermal treatment apparatus 5. Then, the second substrate W2 with a joint surface directed upward is attracted and held by the electrostatic chuck 531 included in the second holding unit 503 of the thermal treatment apparatus 5. Note that the order of Steps S101 to S103 does not always have to be this order.

[0109] Subsequently, in the joint system 100, pre-thermal processing of preliminarily heating the first substrate W1 and the second substrate W2 prior to the joint processing is performed (Step S104). In this pre-thermal processing, the heating units 522, 532 provided respectively in the first

holding unit 502 and the second holding unit 503 are used to heat the first substrate W1 and the second substrate W2 from room temperature to the first temperature. A temperature increase rate in the pre-thermal processing is, for example, 10 ℃/min. Note that the load lock chamber 3, the transfer chamber 4, and the thermal treatment apparatus 5 are kept at an intermediate vacuum such as about 10 Pa to about 20 Pa.

[0110] Subsequently, in the thermal treatment apparatus 5, gas processing is performed (Step S105). In the gas processing, the processing gas supply source 516 supplies the formic acid gas into the chamber 501. This removes the oxide films on the surfaces of the metals provided respectively on the first substrate W1 and the second substrate W2. Thereafter, the first substrate W1 and the second substrate W2 are taken by the second transfer apparatus 104 out of the thermal treatment apparatus 5, and the first substrate W1 with the joint surface directed downward is held by the first holding unit 20 of the joint apparatus 6, and the second substrate W2 with the joint surface directed upward is held by the second holding unit 30 of the joint apparatus 6. In this event, the inside of the chamber 40 of the joint apparatus 6 is kept at an intermediate vacuum such as about 10 Pa to about 20 Pa as in the load lock chamber 3, the transfer chamber 4, and the thermal treatment apparatus 5. Therefore, until the first substrate W1 and the second substrate W2 after the gas processing are joined together in the joint apparatus 6, it is possible to prevent oxide films from being formed on the surfaces of the metals provided respectively on the first substrate W1 and the second substrate W2. Note that the gas processing is performed, for example, at 200℃ to 250℃ in the pre-thermal processing illustrated at Step S104.

[0111] As described above, in the joint system 100, the gas processing is

performed in the thermal treatment apparatus 5 with the gate valve 9c blocking the thermal treatment apparatus 5 and the transfer chamber 4, thus making it possible to prevent contamination of the transfer chamber 4 with the processing gas.

[0112] Subsequently, in the joint system 100, joint processing is performed (Step S106). In this joint processing, the joint apparatus 6 performs processing of joining the first substrate W1 and the second substrate W2 together. A concrete processing procedure of the joint processing will be described later.

[0113] Subsequently, in the joint system 100, transfer-out processing is performed (Step S107). In this transfer-out processing, the second transfer apparatus 104 in the transfer chamber 4 takes the superposed substrate T out of the joint apparatus 6 and mounts the superposed substrate T on the delivery unit in the load lock chamber 3. The superposed substrate T mounted on the delivery unit is cooled by the delivery unit (cooling plate) from 200℃ to room temperature. Thereafter, the first transfer apparatus 103 in the transfer-in/out station 1 takes the superposed substrate T out of the load lock chamber 3 and houses the superposed substrate T into the cassette C3 mounted on the cassette mounting plates 101. With this, a series of processing ends.

[0114] As described above, in the joint system 100, the superposed substrate T is cooled to a predetermined temperature (here, 200℃) higher than room temperature in the joint apparatus 6, and then the superposed substrate T is cooled to room temperature on the delivery unit in the load lock chamber 3. Accordingly, as compared to the case of cooling the temperature of the superposed substrate T to room temperature in the joint apparatus 6, the

processing time (tact time) in the joint apparatus 6 can be shortened.

[0115] <Processing Procedure of Joint Processing>

Next, the concrete processing procedure of the joint processing at step S106 will be described referring to FIG. 19 to FIG. 27. FIG. 19 is a flowchart illustrating the processing procedure of the joint processing. FIG. 20 to FIG. 22 are views illustrating an operation example of horizontal degree adjustment processing. FIG. 23 to FIG. 25 are views illustrating an operation example of horizontal position adjustment processing. FIG. 26 is a view illustrating an operation example of temporary pressurization processing. FIG. 27 is a view illustrating an operation example of main pressurization processing. Note that, in FIG. 20 to FIG. 22, FIG. 26 and FIG. 27, the alignment mark detection unit 90 is omitted.

[0116] As illustrated in FIG. 19, the joint apparatus 6 starts to increase the temperature of the first substrate W1 held by the first holding unit 20 and the second substrate W2 held by the second holding unit 30, using the heating units 22, 32 (see FIG. 4, FIG. 8) (Step S201). Note that the first holding unit 20 and the second holding unit 30 are in a state that they have been preliminarily heated to the first temperature by the heating units 22, 32, and the joint apparatus 6 holds the first substrate W1 and the second substrate W2 by the first holding unit 20 and the second holding unit 30, and then increases the temperature of the first holding unit 20 and the second holding unit 30 from the first temperature to the second temperature.

[0117] Subsequently, the joint apparatus 6 reduces the pressure in the chamber 40 using the suction device 42 (Step S202). Inside the chamber 40 is set to a pressure lower than those in the load lock chamber 3, the transfer chamber 4, and the thermal treatment apparatus 5, in other words, a high

degree of vacuum. For example, in the joint system 100, the load lock chamber 3, the transfer chamber 4, and the thermal treatment apparatus 5 are set to an intermediate vacuum such as about 10 Pa to about 20 Pa, whereas the inside of the chamber 40 of the joint apparatus 6 is set to a high degree of vacuum of 0.005 Pa or lower.

[0118] Subsequently, the joint apparatus 6 performs the horizontal degree adjustment processing of adjusting the horizontal degree of the second holding unit 30 before the temperature of the first substrate W1 and the second substrate W2 reaches the second temperature (Step S203).

[0119] In the horizontal degree adjustment processing, as illustrated in FIG. 20, the joint apparatus 6 raises the second holding unit 30 using the three drive units 83 (see FIG. 12) of the horizontal degree adjustment unit 80 to cause the second substrate W2 held by the second holding unit 30 to abut against the first substrate W1 held by the first holding unit 20. The detection results by the load cells 86 in this event are outputted to the control device 200.

[0120] Subsequently, as illustrated in FIG. 21, the joint apparatus 6 lowers the second holding unit 30 using the three drive units 83 of the horizontal degree adjustment unit 80. Further, the control device 200 decides the driving amounts of the drive units 83 according to the aforementioned detection results by the load cells 86, namely, the moving amounts of the second support post members 84. Then, the joint apparatus 6 individually drives the drive units 83 according to the driving amounts decided by the control device 200 to thereby adjust the horizontal degree of the second holding unit 30.

[0121] For example, it is assumed that the pressure detected by the load

cell 86 on the right side of the two load cells 86 illustrated in FIG. 21 is larger than the pressure detected by the load cell 86 on the left side. In this case, it is considered that the right side of the second holding unit 30 is in partial contact with the first holding unit 2, in other words, the right side of the second holding unit 30 is inclined upward.

[0122] Hence, as illustrated in FIG. 22, the joint apparatus 6 drives, for example, only the drive unit 83 on the left side to raise only the second support post member 84 on the left side to thereby raise the left side of the second holding unit 30. This can make the second holding unit 30 horizontal. Note that the joint apparatus 6 may repeat the above-described horizontal degree adjustment processing until the difference between the pressures detected by the load cells 86 falls within a predetermined range.

[0123] As described above, with the joint system 100 according to this embodiment, adjusting the horizontal degree of the second holding unit 30 using the horizontal degree adjustment unit 80 makes it possible to prevent the partial contact of the second holding unit 30 with the first holding unit 20, thereby realizing the joint of the first substrate W1 and the second substrate W2 with high accuracy. Further, in the joint system 100 according to this embodiment, before the temperature of the first substrate W1 and the second substrate W2 reaches the second temperature, namely, before the temperature reaches a temperature at which the metal on the first substrate W1 and the metal on the second substrate W2 can be joined together, the horizontal degree adjustment processing of adjusting the horizontal degree of the second holding unit 30 is performed. This makes it possible to prevent the first substrate W1 and the second substrate W2 from being joined together when the second substrate W2 is once brought into abutment with the first substrate

W1 in the horizontal degree adjustment processing.

[0124] Subsequently, the joint apparatus 6 performs horizontal position adjustment processing of adjusting the horizontal position of the first holding unit 20 (Step S204).

[0125] First, as illustrated in FIG. 23, the joint apparatus 6 moves the imaging unit 91 using the raising and lowering unit 93 of the alignment mark detection unit 90 so that only the first substrate W1 of the first substrate W1 and the second substrate W2 is located within a depth of field D of the imaging unit 91. In this state, the joint apparatus 6 images the alignment marks M1, M2 provided on the first substrate W1 and the second substrate W2. Thereby, an image is obtained in which the alignment mark M1 is in focus but the alignment mark M2 is out of focus. Image data of this image is outputted to the control device 200. The control device 200 performs edge detection on the acquired image data to detect the alignment mark M1.

[0126] Subsequently, as illustrated in FIG. 24, the joint apparatus 6 moves the imaging unit 91 using the raising and lowering unit 93 of the alignment mark detection unit 90 so that only the second substrate W2 of the first substrate W1 and the second substrate W2 is located within the depth of field D of the imaging unit 91. In this state, the joint apparatus 6 images the alignment marks M1, M2 provided on the first substrate W1 and the second substrate W2. Thereby, an image is obtained in which the alignment mark M2 is in focus but the alignment mark M1 is out of focus. Image data of this image is outputted to the control device 200. The control device 200 performs edge detection on the acquired image data to detect the alignment mark M2.

[0127] Then, the control device 200 causes the horizontal position

adjustment unit 60 to perform adjustment processing of adjusting the position and the orientation in the horizontal direction of the first holding unit 20 on the basis of the detection results of the alignment marks M1, M2. Specifically, the control device 200 controls the horizontal position adjustment unit 60 to make the position of the cross shape (see FIG. 14) of the alignment mark M1 align with the cross shape (see FIG. 15) of the alignment mark M2 to thereby adjust the position and the orientation in the horizontal direction of the first holding unit 20.

[0128] The horizontal position adjustment unit 60 moves the first holding unit 20 in the horizontal direction and rotates the first holding unit 20 around the vertical axis, using the first adjustment unit 60Y and the second adjustment unit 60X. This eliminates mainly the positional displacement of the first substrate W1 and the second substrate W2 due to an error in transfer by the first transfer apparatus 103 and the second transfer apparatus 104 (first adjustment processing).

[0129] As described above, in the joint system 100 according to this embodiment, in each of the state that only the first substrate W1 of the first substrate W1 and the second substrate W2 is located within the depth of field D and the state that only the second substrate W2 is located within the depth of field D, the imaging unit 91 performs imaging processing of imaging the alignment marks M1, M2. Then, in the joint system 100 according to this embodiment, the horizontal position adjustment unit 60 performs adjustment processing of adjusting the position in the horizontal direction of the first holding unit 20 on the basis of the imaging result by the imaging unit 91.

[0130] Thus, an image in which only the alignment mark M1 is in focus and an image in which only the alignment mark M2 is in focus can be

obtained, and the alignment marks M1, M2 can be appropriately detected using the images. In other words, using the images in which both the alignment marks M1, M2 are in focus makes it possible to prevent erroneous detection of the alignment marks M1, M2.

[0131] Further, in the joint system 100 according to this embodiment, controlling the raising and lowering unit 93 of the alignment mark detection unit 90 to raise or lower the imaging unit 91 in the imaging processing to thereby switch between the state that the first substrate W1 is located within the depth of field D and the state that the second substrate W2 is located within the depth of field D. Thus, as compared with, for example, the case of moving the first holding unit 20 and the second holding unit 30 to switch between the state that the first substrate W1 is located within the depth of field D and the state that the second substrate W2 is located within the depth of field D, the horizontal position and the horizontal degree after adjustment of the first holding unit 20 and the second holding unit 30 can be maintained.

[0132] Further, the joint system 100 according to this embodiment includes the imaging unit 91 that images the alignment marks M1, M2 provided on one end side of the first substrate W1 and the second substrate W2, and the imaging unit 91 that images the alignment marks M1, M2 provided on other end side of the first substrate W1 and the second substrate W2 (see FIG. 4). Thus, in the joint system 100 according to this embodiment, the above-described adjustment processing is performed on the basis of the imaging results by the two imaging units 91, thereby accurately adjusting, in particular, the orientation in the horizontal direction of the first holding unit 20.

[0133] Thereafter, as illustrated in FIG. 25, the joint apparatus 6 raises the

second holding unit 30 using the horizontal degree adjustment unit 80 to make the second substrate W2 close to the first substrate W1 to an extent of not coming into contact with the first substrate W1. In this state, the joint apparatus 6 performs again the adjustment processing using the image data used for the first adjustment processing (second adjustment processing).

[0134] As described above, in the joint system 100 according to this embodiment, after performing the imaging processing and the adjustment processing with the second holding unit 30 located at a first position away from the first holding unit 20, the horizontal degree adjustment unit 80 is controlled to move the second holding unit 30 to a second position closer to the first holding unit 20 than the first position, and then performs again the adjustment processing with the second holding unit 30 located at the second position. Thus, even if the positional displacement of the second holding unit 30 occurs when the second substrate W2 is made to approach to the first substrate W1 after the first adjustment processing, the second adjustment processing can eliminate the positional displacement afterwards. In other words, performing the adjustment processing in a state that the first substrate W1 and the second substrate W2 are made close each other to the extent possible makes it possible to reduce as much as possible the positional displacement accompanying the rise of the second holding unit 30 thereafter.

[0135] Further, in the joint system 100 according to this embodiment, the space is provided between the first holding unit 20 and the spacer 14 directly thereabove (see FIG. 4). Thus, even if the first holding unit 20 is moved by the horizontal position adjustment processing, there occurs no friction between the first holding unit 20 and the spacer 14. Accordingly, it is possible to prevent occurrence of dust or the like due to the friction between

the first holding unit 20 and the spacer 14.

[0136] Note that the example of the case where the second adjustment processing is performed after the second substrate W2 is moved to the second position has been illustrated here, but the joint apparatus 6 may continuously perform the second adjustment processing while raising the second holding unit 30 toward the second position.

[0137] The joint apparatus 6 continuously images the alignment marks M1, M2 using the imaging unit 91 even after the horizontal position adjustment processing and thereby can monitor the presence or absence of the positional displacement of the first substrate W1 and the second substrate W2 in the temporary pressurization processing (Step S205) and the main pressurization processing (Step S206) at subsequent stages. Note that when it has been determined that the displacement amount between the alignment mark M1 and the alignment mark M2 exceeds a threshold in the temporary pressurization processing and the main pressurization processing, the control device 200 may stop the temporary pressurization processing or the main pressurization processing or issue an alarm to an operator to thereby report it.

[0138] Subsequently, the joint apparatus 6 performs the temporary pressurization processing (Step S205). Specifically, as illustrated in FIG. 26, the joint apparatus 6 raises the second holding unit 30 using the horizontal degree adjustment unit 80 to bring the second substrate W2 into contact with the first substrate W1 and presses the second substrate W2 against the first substrate W1 with a first pressing force. The first pressing force is, for example, 12 kN.

[0139] Subsequently, the joint apparatus 6 performs the main pressurization processing (Step S206). Specifically, as illustrated in FIG. 27,

the joint apparatus 6 presses the second substrate W2 against the first substrate W1 using the pressurization unit 70 with a second pressing force. The second pressing force is, for example, 40 kN to 60 kN. This joins the first substrate W1 and the second substrate W2 to form the superposed substrate T.

[0140] As described above, the joint system 100 according to this embodiment presses the second substrate W2 against the first substrate W1 with the second pressing force larger than the first pressing force using the pressurization unit 70 in a state of pressing the second substrate W2 against the first substrate W1 with the first pressing force using the horizontal degree adjustment unit 80. This can prevent positional displacement of the first substrate W1 and the second substrate W2 during the main pressurization processing. Accordingly, with the joint system 100 according to this embodiment, the joint accuracy can be improved.

[0141] Further, as described above, in the joint system 100 according to this embodiment, the first holding unit 20 is held in a state of being suspended by the suspending mechanism 50 (see FIG. 4). Therefore, when the pressing force is applied to the first holding unit 20 in the temporary pressurization processing and the main pressurization processing, the first holding unit 20 moves upward to come into abutment with the spacer 14 directly above it. This transmits the pressing force applied to the first holding unit 20 to the spacer 14 directly above it and the first support member 11. On the other hand, the wire 52 of the suspending mechanism 50 is loosened when the first holding unit 20 is raised. Accordingly, the pressing force applied to the first holding unit 20 is not transmitted to the suspending mechanism 50.

[0142] As described above, the joint system 100 according to this

embodiment can make it less likely to apply a load on the mechanism that supports the first holding unit 20 in a state of being movable in the horizontal direction.

[0143] Subsequently, the joint apparatus 6 decreases the temperature of the superposed substrate T at a predetermined temperature decrease rate (Step S207). Then, after the temperature of the superposed substrate T is decreased to a predetermined temperature (for example, 200℃), the joint apparatus 6 lowers the movable shaft 72 of the pressurization unit 70, and lowers the second holding unit 30 using the horizontal degree adjustment unit 80, and ends the joint processing.

[0144] As has been described above, the joint apparatus 6 according to this embodiment includes the first holding unit 20, the second holding unit 30, the pressurization unit 70, the first adjustment unit 60Y, and the second adjustment unit 60X. The first holding unit 20 attracts and holds the first substrate W1. The second holding unit 30 is disposed to face the first holding unit 20 in the vertical direction and attracts and holds the second substrate W2. The pressurization unit 70 makes the first holding unit 20 and the second holding unit 30 relatively approach to each other to thereby press the first substrate W1 and the second substrate W2 against each other. The first adjustment unit 60Y adjusts the position of the first holding unit 20 along the first horizontal direction (Y-axis direction). The second adjustment unit 60X has a plurality of moving mechanisms 60X1, 60X2 that apply force along the second horizontal direction (X-axis direction) perpendicular to the first horizontal direction to first holding unit 20, and adjusts the position of the first holding unit 20 along the second horizontal direction using the plurality of moving mechanisms 60X1, 60X2. Further, the joint apparatus 6

according to this embodiment rotates the first holding unit 20 around the vertical axis using the plurality of moving mechanisms 60X1, 60X2 included in the second adjustment unit 60X and the first adjustment unit 60Y.

[0145] Accordingly, with the joint system 100 according to this embodiment, the joint accuracy can be improved.

[0146] In the above-described embodiment, the example of the case where the first substrate W1 and the second substrate W2 are heated by increasing the temperature thereof in the pre-thermal processing (Step S104) and the joint processing (Step S106) has been exemplified as the series of substrate processing performed by the joint system 100. However, the heating method of the first substrate W1 and the second substrate W2 is not limited to the above example.

[0147] For example, the pre-thermal processing (Step S104) may be processing of heating the first substrate W1 and the second substrate W2 at a fixed temperature. In this case, it is only necessary to heat the first holding unit 502 and the second holding unit 503 to the first temperature in advance. Further, the joint processing (Step S106) may also be processing of heating the first substrate W1 and the second substrate W2 at a fixed temperature. In this case, it is only necessary to heat the first holding unit 20 and the second holding unit 30 to the second temperature in advance.

[0148] As described above, heating the first substrate W1 and the second substrate W2 at the fixed temperatures in the pre-thermal processing (Step S104) and the joint processing (Step S106) makes it possible to shorten the time required for the heating as compared with the case of heating the first substrate W1 and the second substrate W2 by increasing the temperature thereof.

[0149] Note that in the joint system 100, the first substrate W1 and the second substrate W2 may be heated at the fixed temperature in the pre-thermal processing, and then the first substrate W1 and the second substrate W2 may be heated by increasing the temperature thereof in the joint processing. Further, in the joint system 100, the first substrate W1 and the second substrate W2 may be heated by increasing the temperature thereof in the pre-thermal processing, and then the first substrate W1 and the second substrate W2 may be heated at the fixed temperature in the joint processing. Furthermore, in the joint system 100, the first substrate W1 and the second substrate W2 may be heated at the fixed temperature in the pre-thermal processing, and then the first substrate W1 and the second substrate W2 may be heated at the fixed temperature in the joint processing.

[0150] Further, in the above-described embodiment, the example of the case of performing the imaging processing of imaging the alignment marks M1, M2 in each of the state that one of the first substrate W1 and the second substrate W2 is located within the depth of field of the imaging unit 91 and the state that the other of the first substrate W1 and the second substrate W2 is located within the depth of field of the imaging unit 91 has been described. However, the imaging processing is not limited to the above example. For example, in the joint system 100, the imaging processing of imaging the alignment marks M1, M2 in the state that both the first substrate W1 and the second substrate W2 are located in the depth of field of the imaging unit 91.

[0151] Further, the example of the case where the pressurization unit 70 moves the second holding unit 30 in the vertical direction has been described in the above-described embodiment, but the pressurization unit 70 may be the one that moves the first holding unit 20 in the vertical direction. Further, the

example of the case where the horizontal position adjustment unit 60 adjusts the horizontal position of the first holding unit 20 has been described in the above-described embodiment, the horizontal position adjustment unit 60 may adjust the horizontal position of the second holding unit 30. Further, the example of the case where the first holding unit 20 is located above the second holding unit 30 has been illustrated in the above-described embodiment, but the first holding unit 20 may be located below the second holding unit 30. Further, the example of the case where the imaging unit 91 is located above the first support member 11 and the light source 92 is located below the second support member 12 has been described in the above-described embodiment, but the light source 92 may be located above the first support member 11 and the imaging unit 91 may be located below the second support member 12.

[0152] Further effects and modifications can be readily derived by the person skilled in the art. Therefore, the aspect in a wider range of the present invention is not limited to specific details and representative embodiments expressed and described as above. Accordingly, various changes can be made without departing from the spirit and scope of the general invention concept defined by accompanying What Is Claimed and equivalents thereof.

[Explanation of Codes]

[0153]

W1 first substrate

W2 second substrate

T superposed substrate

5 thermal treatment apparatus

6 joint apparatus
20 first holding unit
30 second holding unit
40 chamber
50 suspending mechanism
60 horizontal position adjustment unit
70 pressurization unit
80 horizontal degree adjustment unit
90 alignment mark detection unit
100 joint system

CLAIMS

[Name of Document]

[Claim 1] A joint apparatus configured to join substrates together, comprising:

a first holding unit which attracts and holds a first substrate;

a second holding unit which is disposed to face the first holding unit in a vertical direction and attracts and holds a second substrate;

a pressurization unit which makes the first holding unit and the second holding unit relatively approach to each other to thereby press the first substrate and the second substrate against each other;

a first adjustment unit which adjusts a position of the first holding unit along a first horizontal direction; and

a second adjustment unit which includes a plurality of moving mechanisms that apply force along a second horizontal direction perpendicular to the first horizontal direction to the first holding unit, and adjusts the position of the first holding unit along the second horizontal direction using the plurality of moving mechanisms,

wherein the first holding unit is rotated around a vertical axis using the plurality of moving mechanisms included in the second adjustment unit and the first adjustment unit.

[Claim 2] The joint apparatus according to claim 1,

wherein the moving mechanism comprises:

a first moving member;

a drive unit which moves the first moving member along the second horizontal direction;

a second moving member which is pivotally supported at the first moving member to rotate around the vertical axis; and

a guide unit which is provided on the first holding unit and supports the second moving member to slide in the first horizontal direction.

[Claim 3] The joint apparatus according to claim 2,

wherein the second adjustment unit comprises the plurality of moving mechanisms in parallel along the first horizontal direction.

[Claim 4] The joint apparatus according to claim 2, further comprising:

a chamber which houses the first holding unit and the second holding unit and whose inside is to be sealed; and

a suction device which sucks gas inside the chamber,

wherein the drive unit included in the moving mechanism is disposed outside the chamber.

[Claim 5] The joint apparatus according to claim 4,

wherein the chamber comprises:

an opening; and

a first flange unit which projects to an inside of the opening, and

wherein the moving mechanism comprises:

a second flange unit which is provided at the first moving member; and

a bellows which has one end connected to the first flange unit and another end connected to the second flange unit.

[Claim 6] The joint apparatus according to claim 1,

wherein the first holding unit is disposed above the second holding unit and suspended spaced from an upper member disposed just thereabove.

[Claim 7] The joint apparatus according to claim 6, further comprising:

a suspending mechanism which suspends the first holding unit,

the suspending mechanism comprising:

a wire which is inserted into a through hole formed in the upper member;

a support body which is provided above the upper member and supports an upper end side of the wire; and

a fixing part which is provided at a lower end side of the wire and fixed to the first holding unit.

[Claim 8] A joint system configured to join substrates together, comprising:

a transfer-in/out station in which a first substrate and a second substrate are mounted;

a substrate transfer apparatus which transfers the first substrate and the second substrate mounted in the transfer-in/out station; and

a joint apparatus which joins the first substrate and the second substrate transferred by the substrate transfer apparatus,

wherein the joint apparatus comprises:

a first holding unit which attracts and holds the first substrate;

a second holding unit which is disposed to face the first holding unit in a vertical direction and attracts and holds the second substrate;

a pressurization unit which makes the first holding unit and the second holding unit relatively approach to each other to thereby press the first substrate and the second substrate against each other;

a first adjustment unit which adjusts a position of the first holding unit along a first horizontal direction; and

a second adjustment unit which includes a plurality of moving mechanisms that apply force along a second horizontal direction

perpendicular to the first horizontal direction to the first holding unit, and adjusts the position of the first holding unit along the second horizontal direction using the plurality of moving mechanisms,

wherein the first holding unit is rotated around a vertical axis using the plurality of moving mechanisms included in the second adjustment unit and the first adjustment unit.

[Claim 9] A joint method of joining substrates together, comprising:

a first holding step of attracting and holding a first substrate by a first holding unit which attracts and holds the first substrate;

a second holding step of attracting and holding a second substrate by a second holding unit which is disposed to face the first holding unit in a vertical direction and attracts and holds the second substrate;

a pressurization step of pressing the first substrate and the second substrate against each other by a pressurization unit which makes the first holding unit and the second holding unit relatively approach to each other to thereby press the first substrate and the second substrate against each other;

a horizontal position adjustment step of adjusting a position of the first holding unit along a first horizontal direction by a first adjustment unit which adjusts the position of the first holding unit along the first horizontal direction; adjusting the position of the first holding unit along a second horizontal direction perpendicular to the first horizontal direction by a second adjustment unit which includes a plurality of moving mechanisms that apply force along the second horizontal direction, and adjusts the position of the first holding unit along the second horizontal direction using the plurality of moving mechanisms; and rotating the first holding unit around a vertical axis using the plurality of moving mechanisms included in the second adjustment

unit and the first adjustment unit.

FIG.1

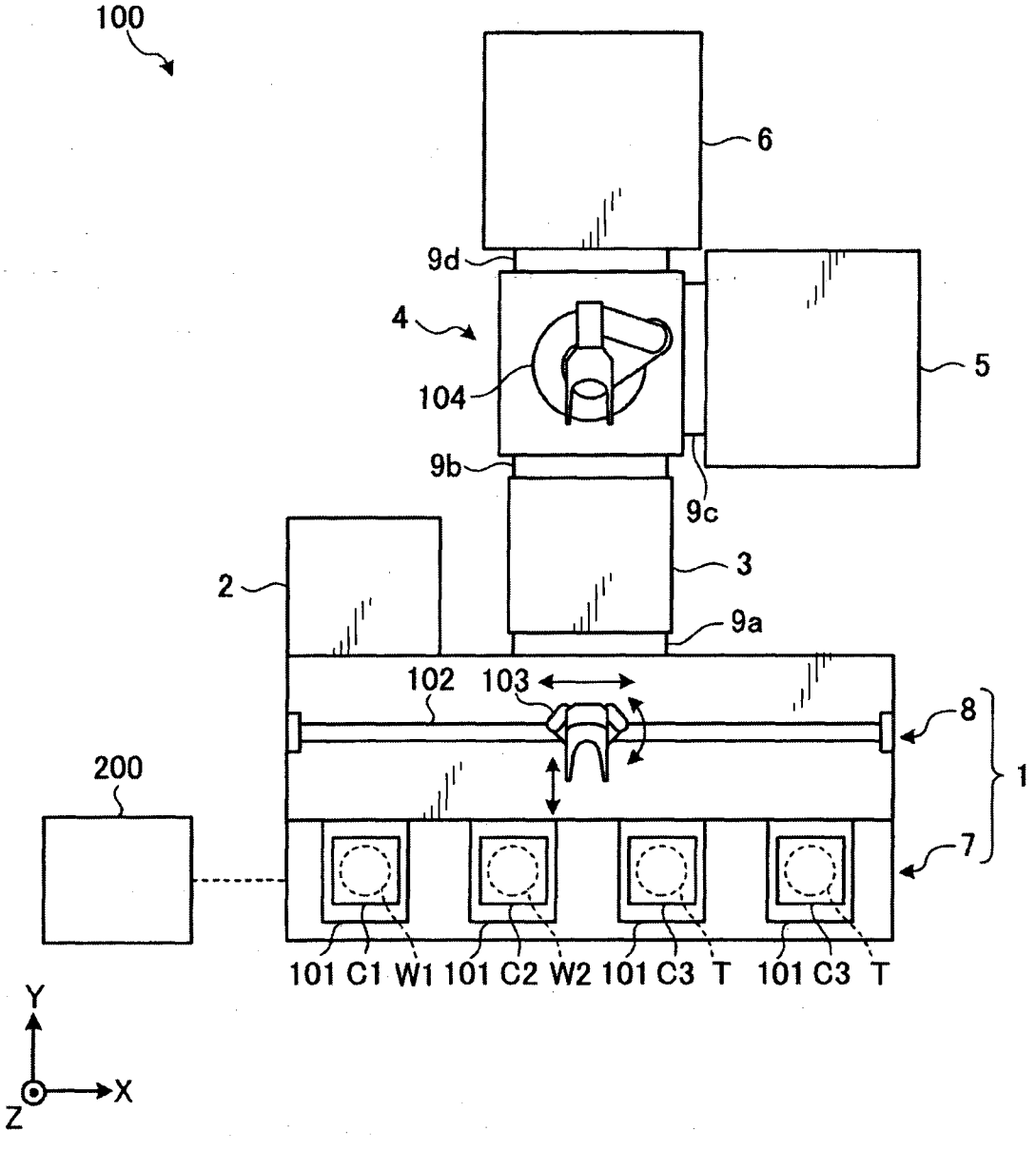
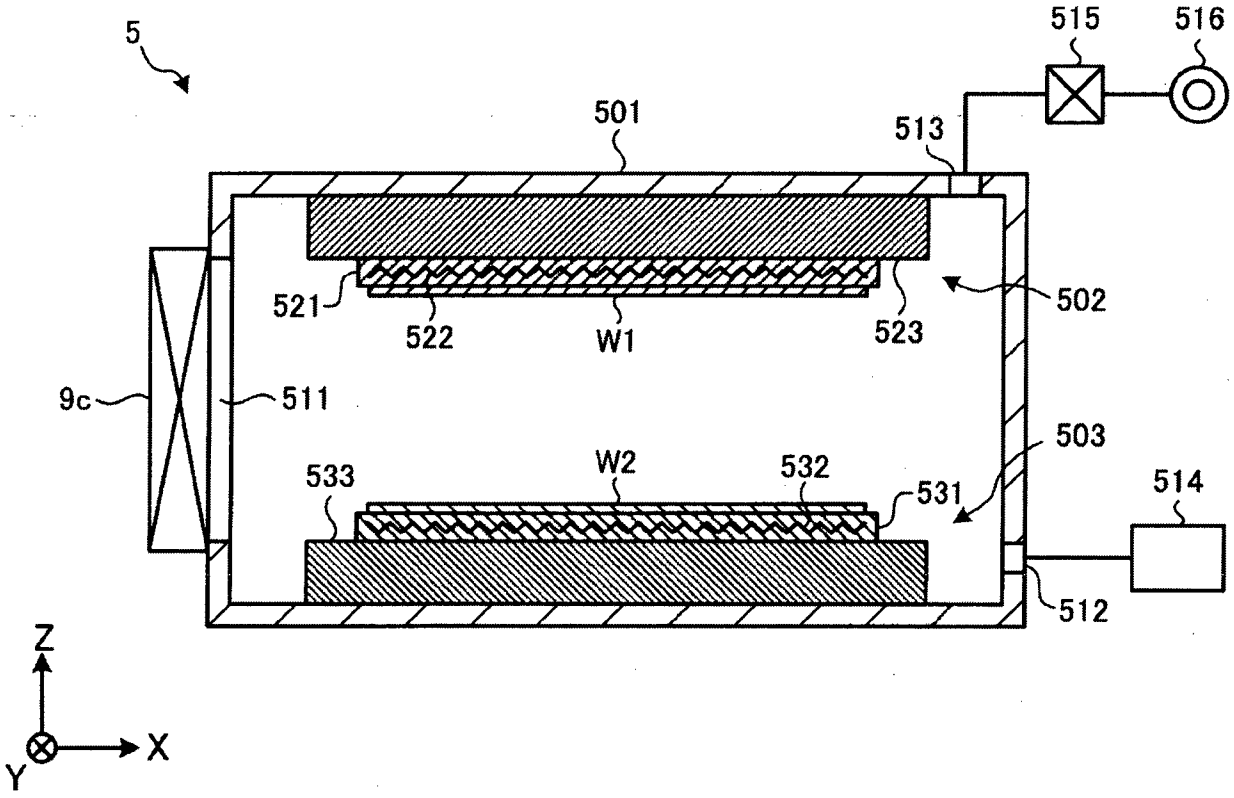

100
6
9d
4
104
5
9b
9c
3
2
9a
102
103
8
1
200
7
101 C1 W1 101 C2 W2 101 C3 T 101 C3 T
Y
X
Z

FIG.2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515
516
501
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W1
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9c
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503
W2
533
532
531
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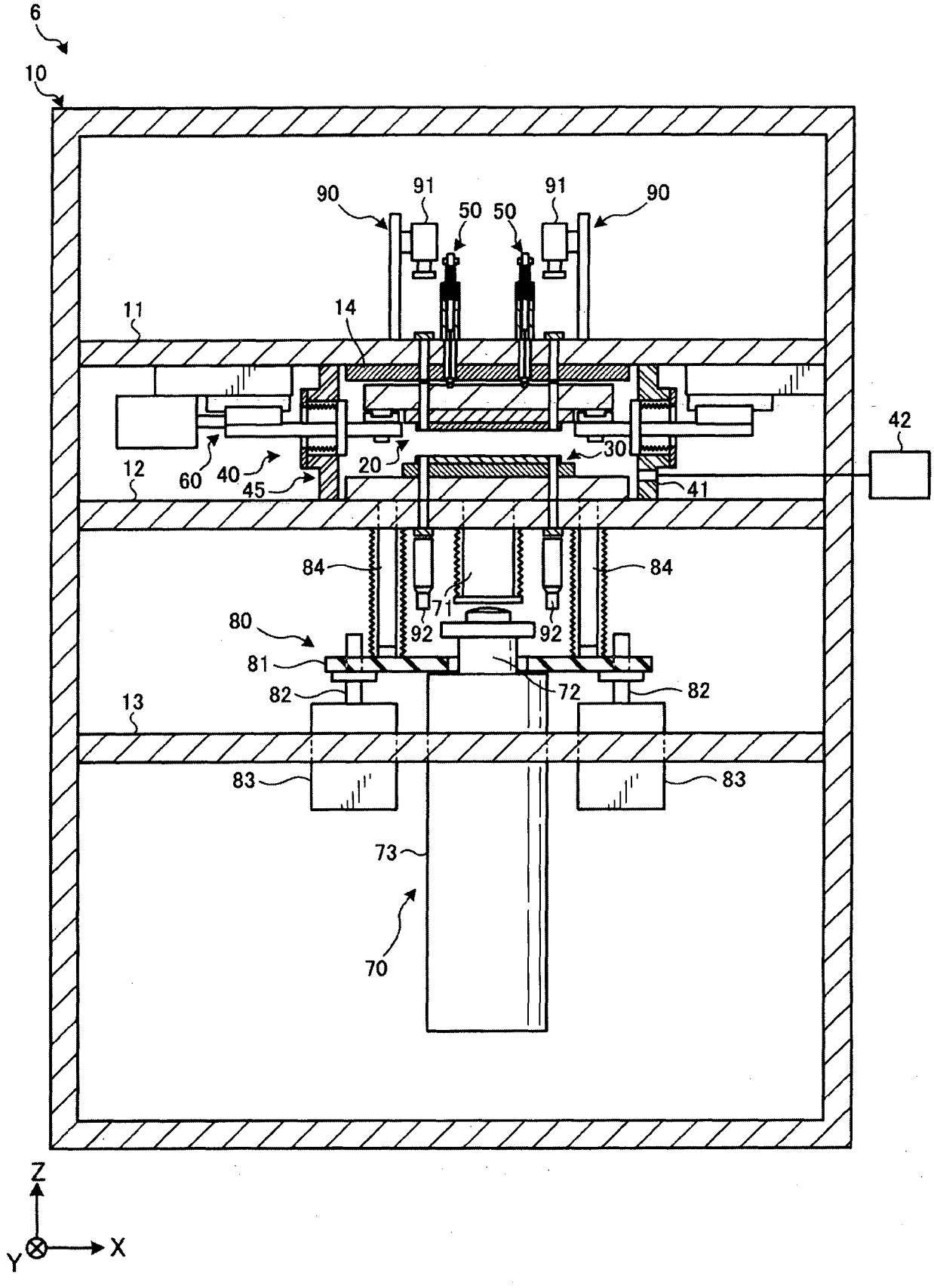
512
Z
X
Y

FIG.3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73
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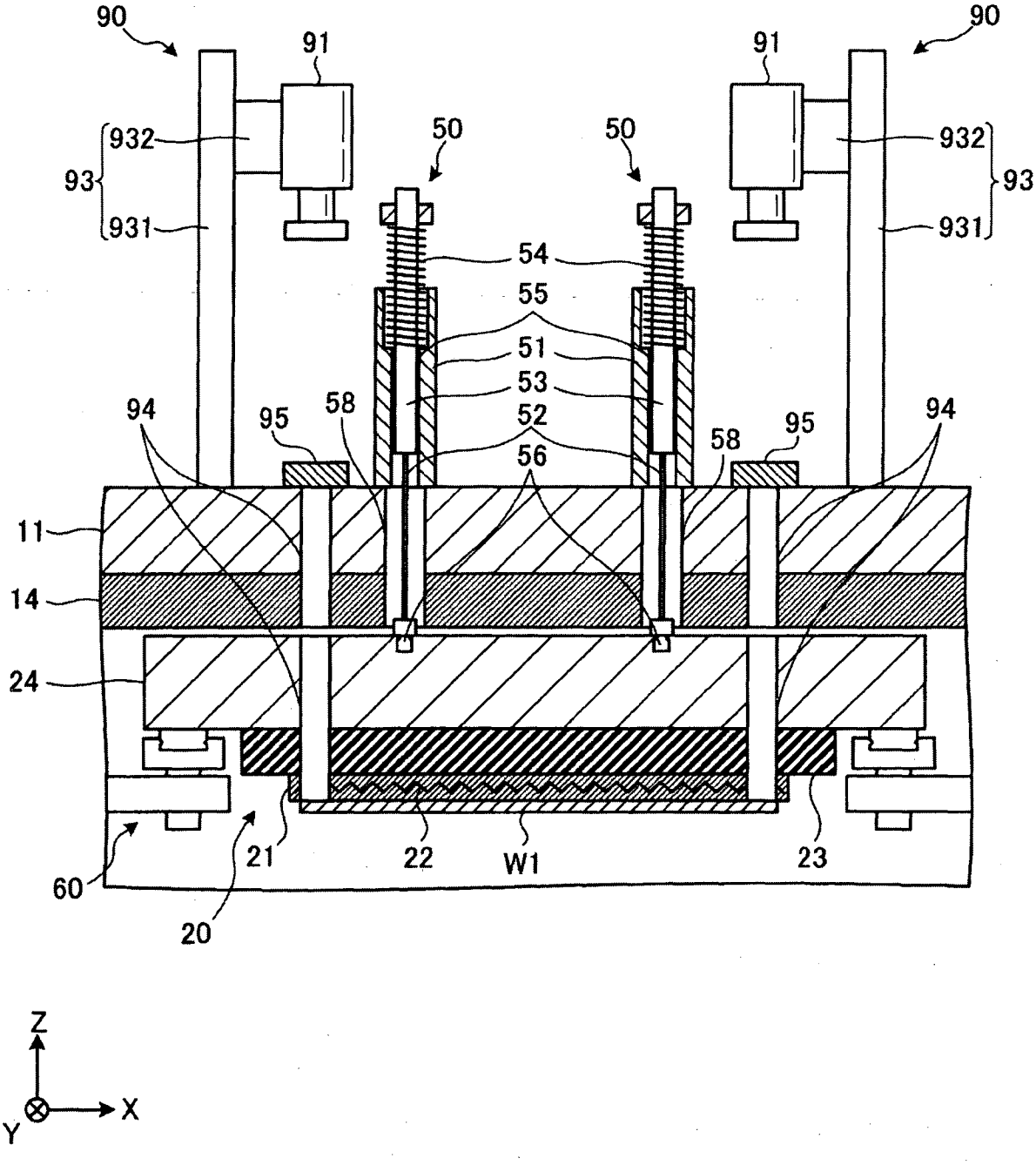
Z
Y
X

FIG.4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931
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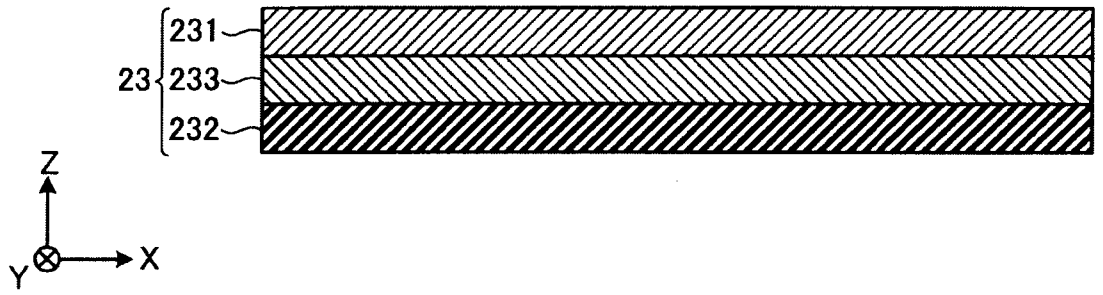
21
22
W1
23
20
Z
X
Y

FIG.5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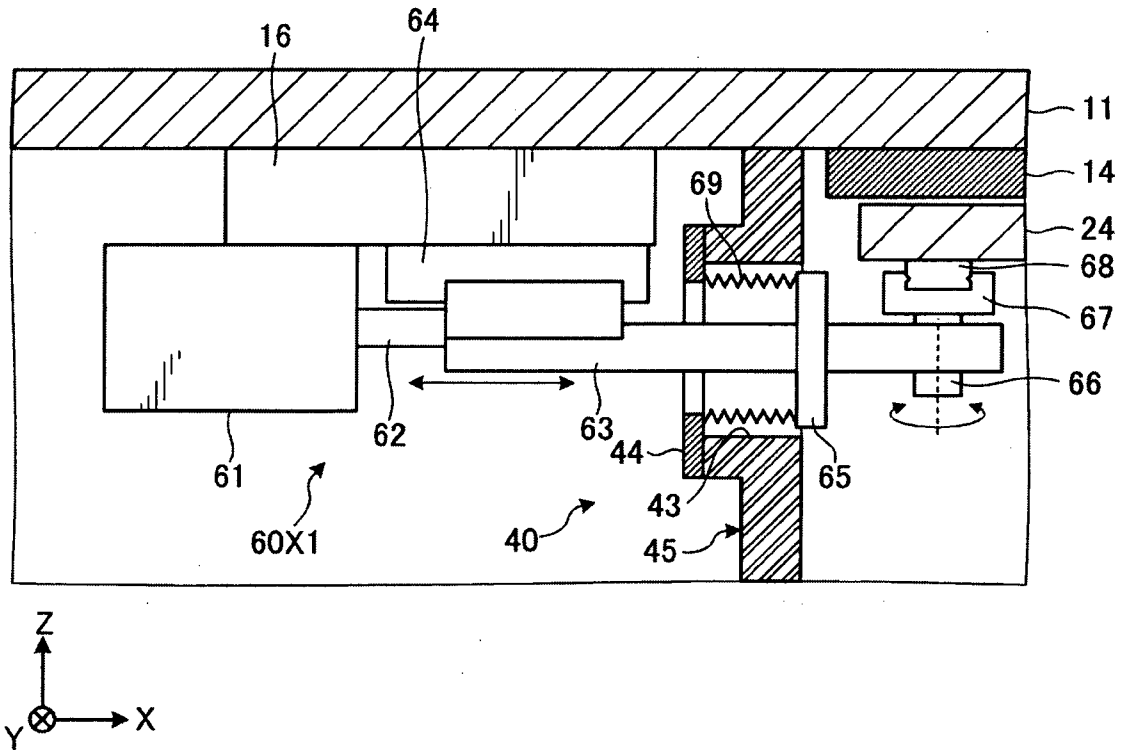
232
Z
Y
X

FIG.6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64
11
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65
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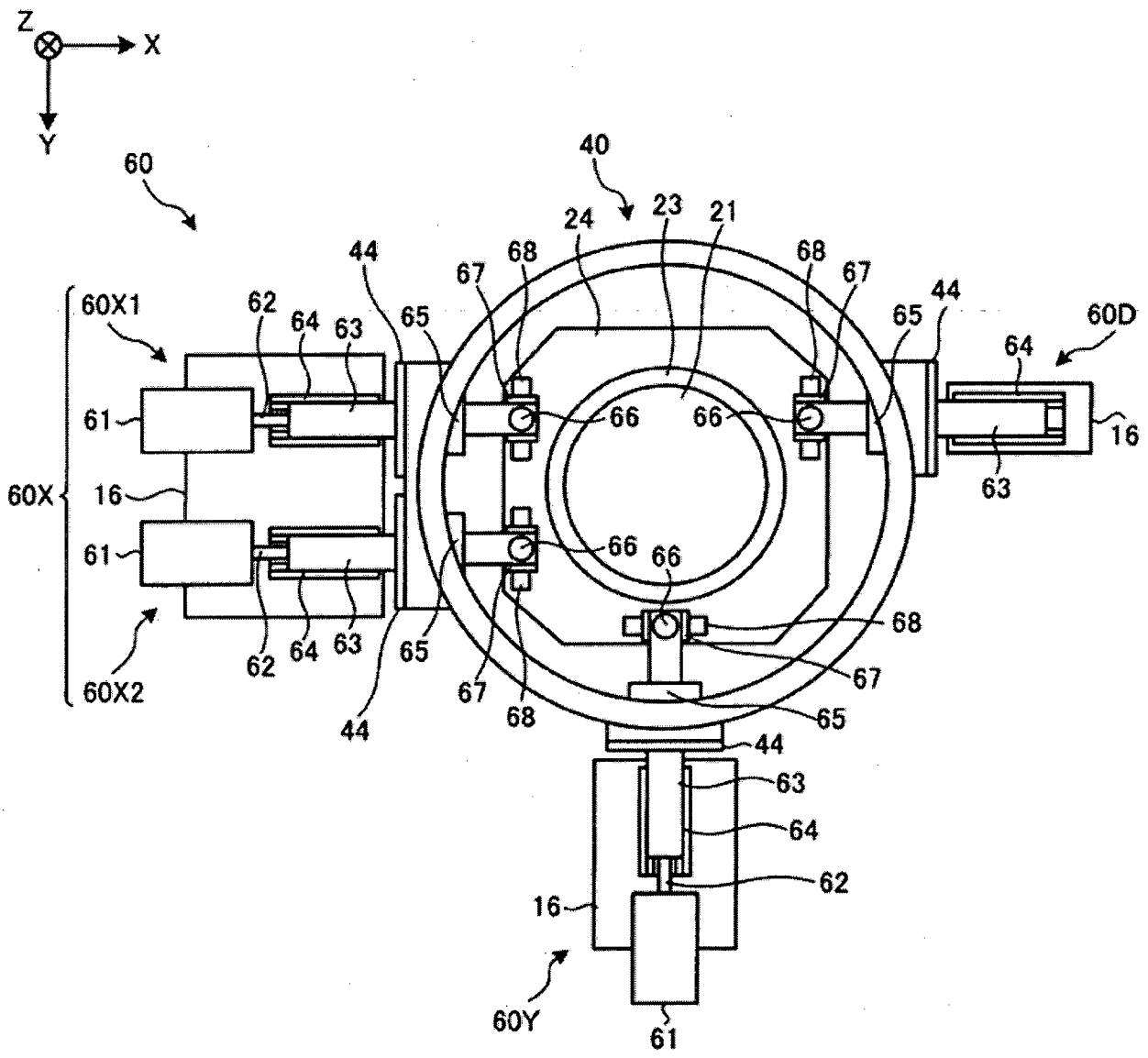
43
60X1
40
45
Z
Y
X

FIG.7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X
Y
60
40
24
23
21
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67
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65
65
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60X1
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64
63
66
66
16
61
60X
16
61
66
66
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68
44
63
64
62
16
60Y
61

FIG.8

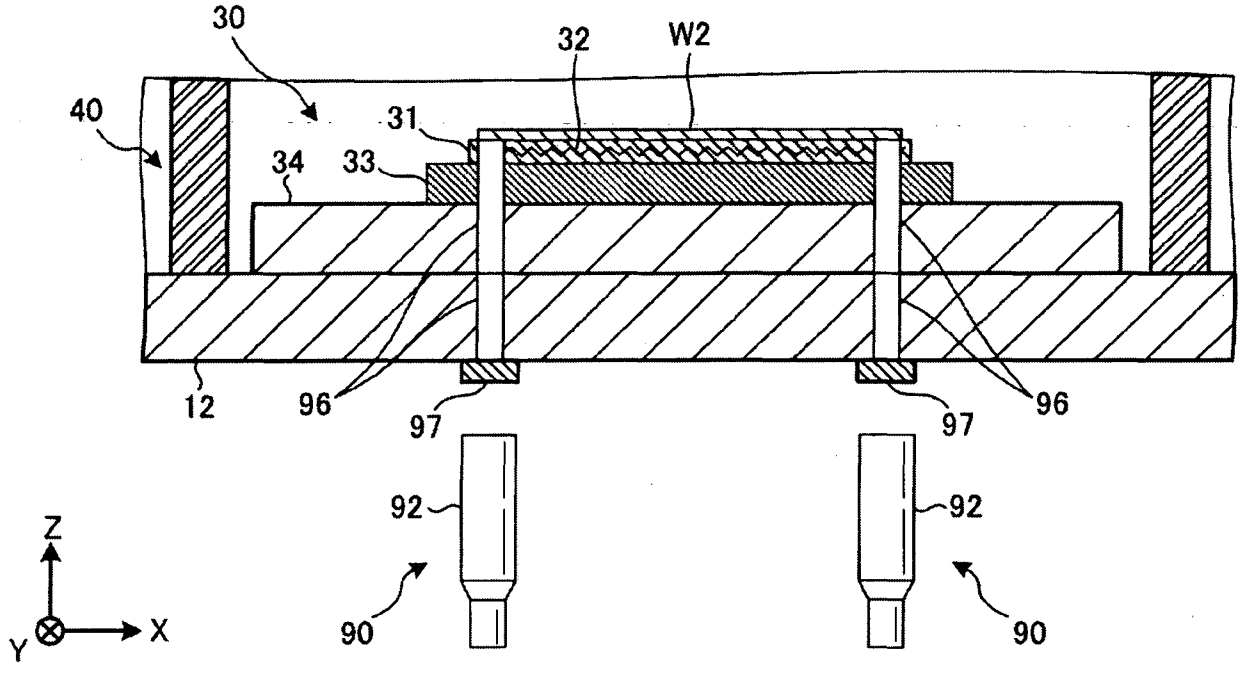
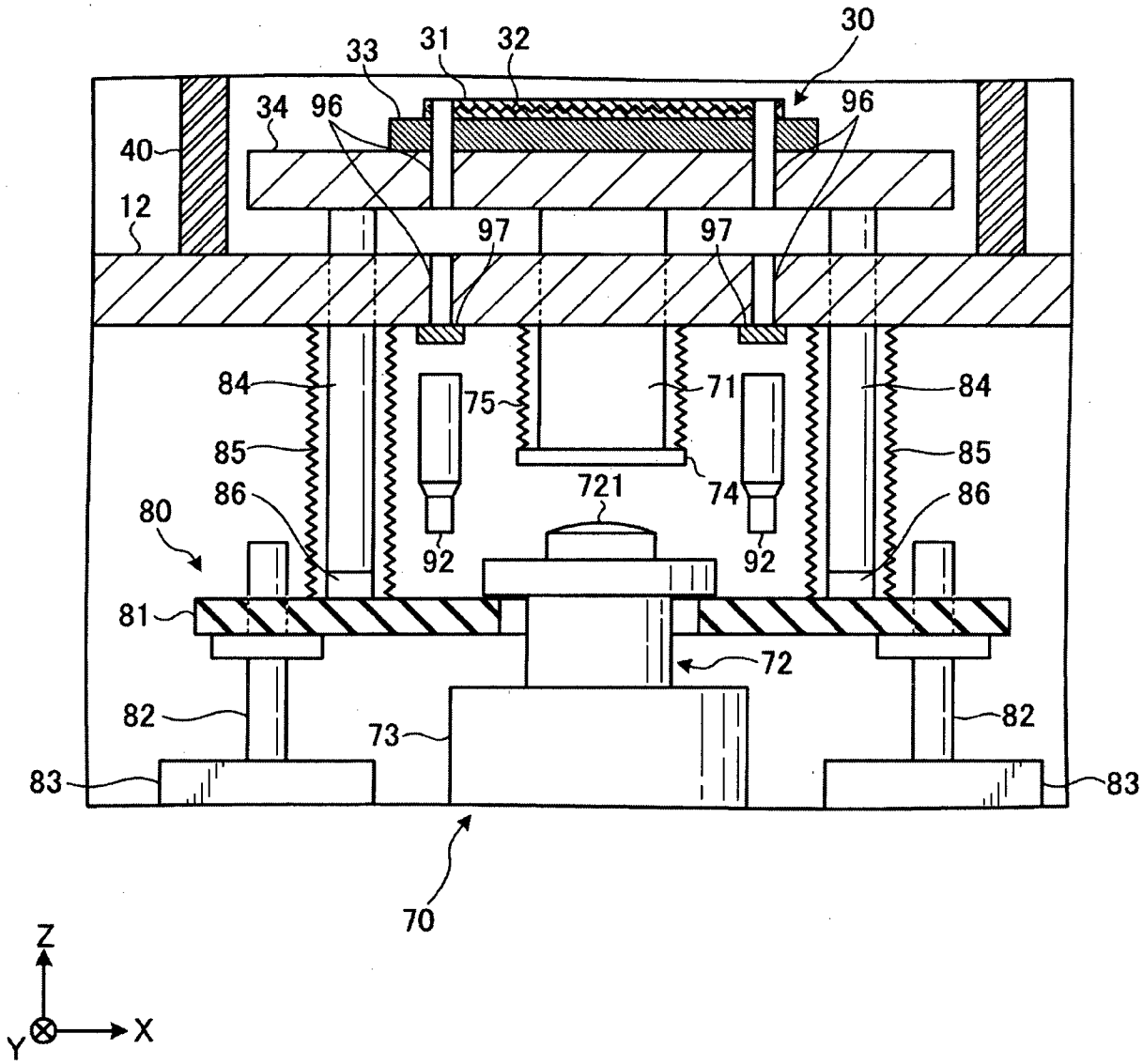


FIG.9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Z
Y
X

FIG.10

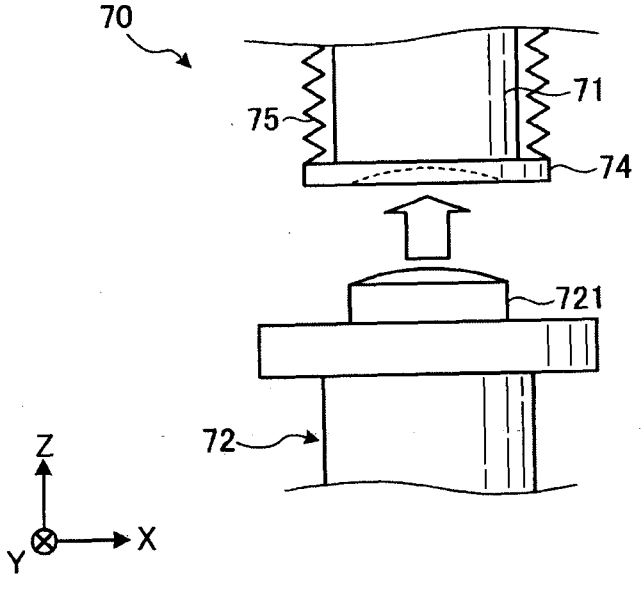


FIG.11

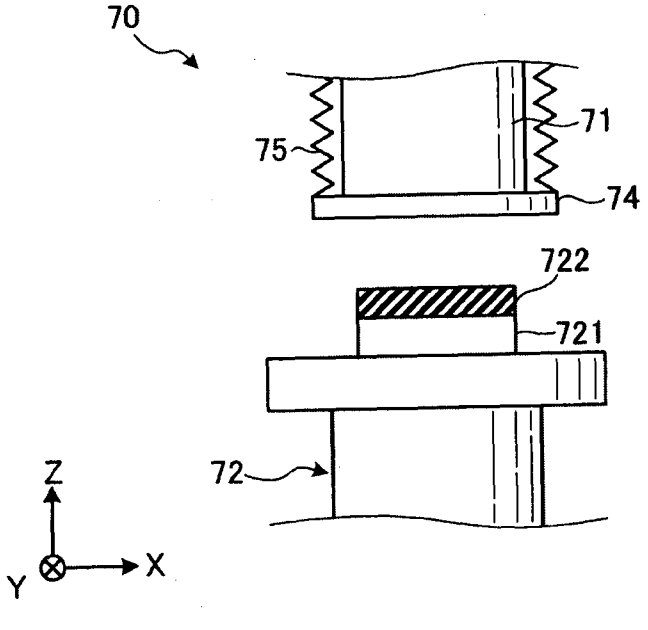


FIG.12

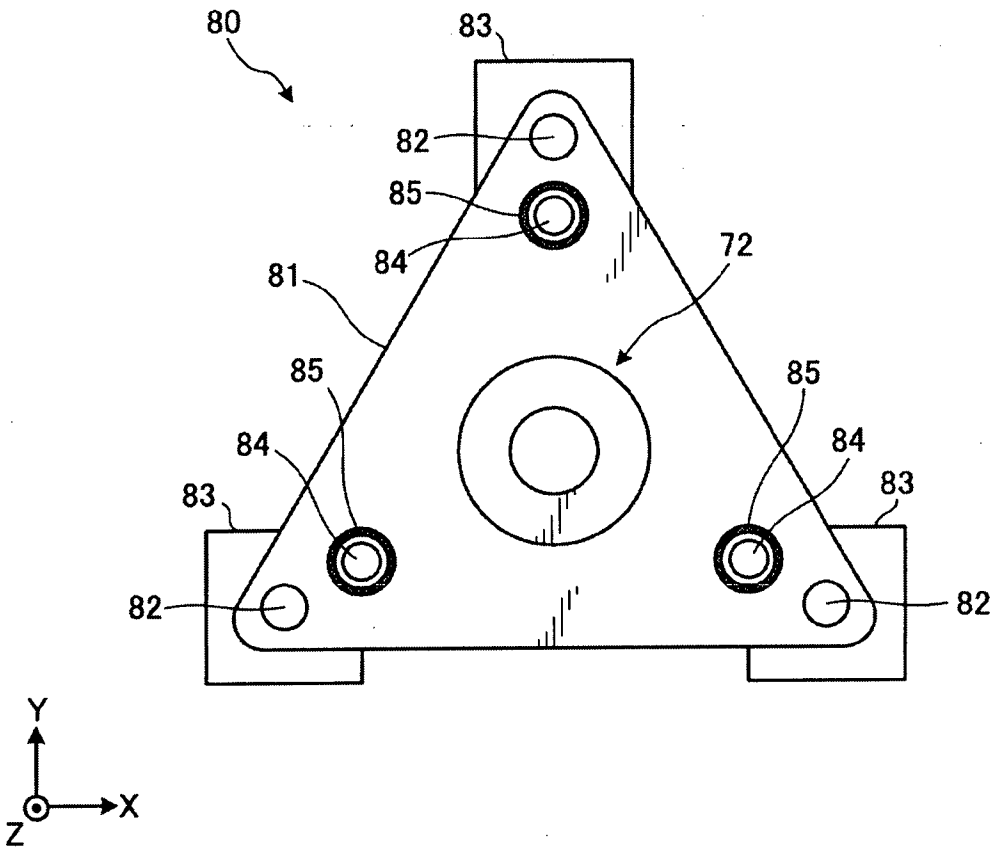


FIG.13

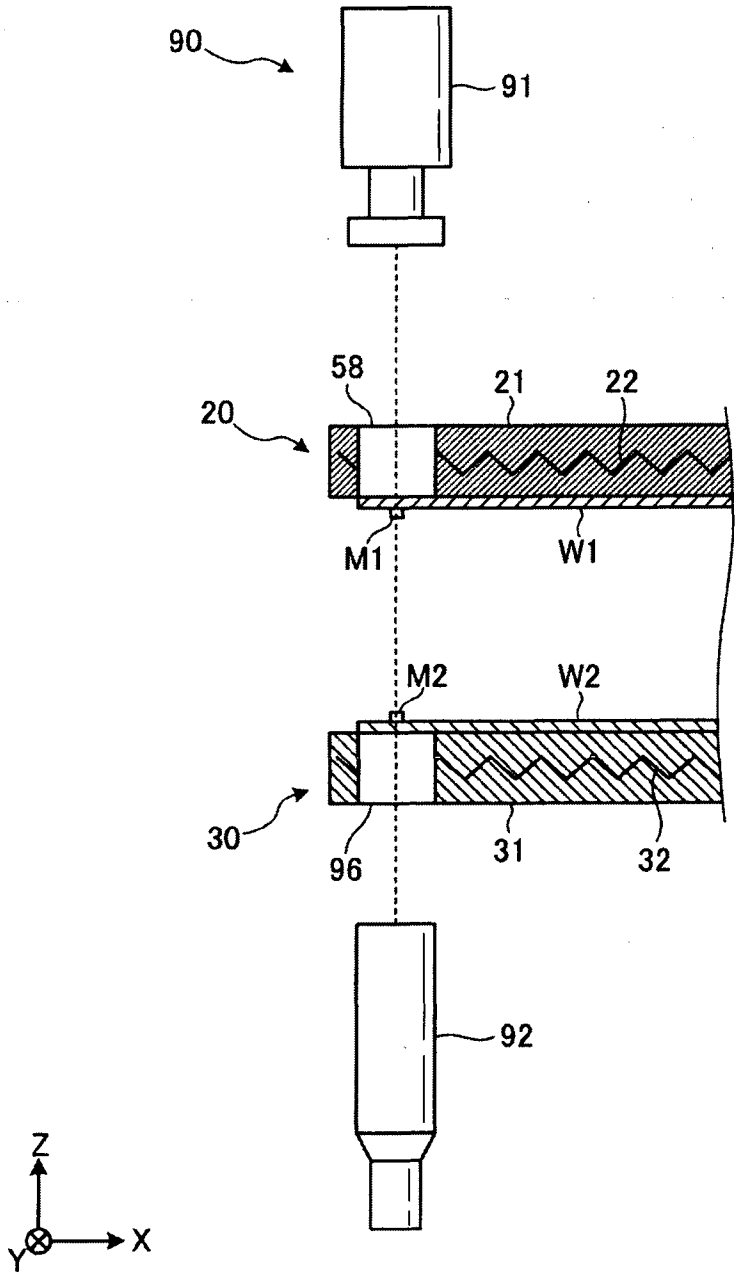


FIG.14

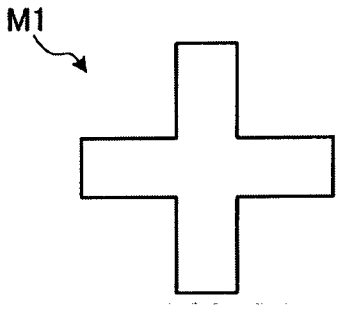


FIG.15

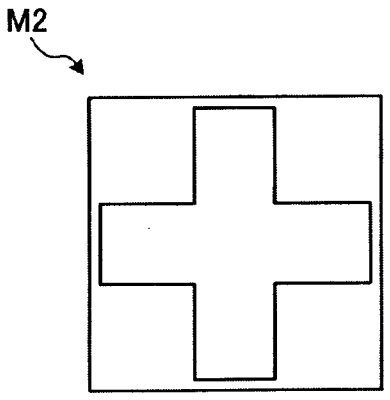


FIG.16

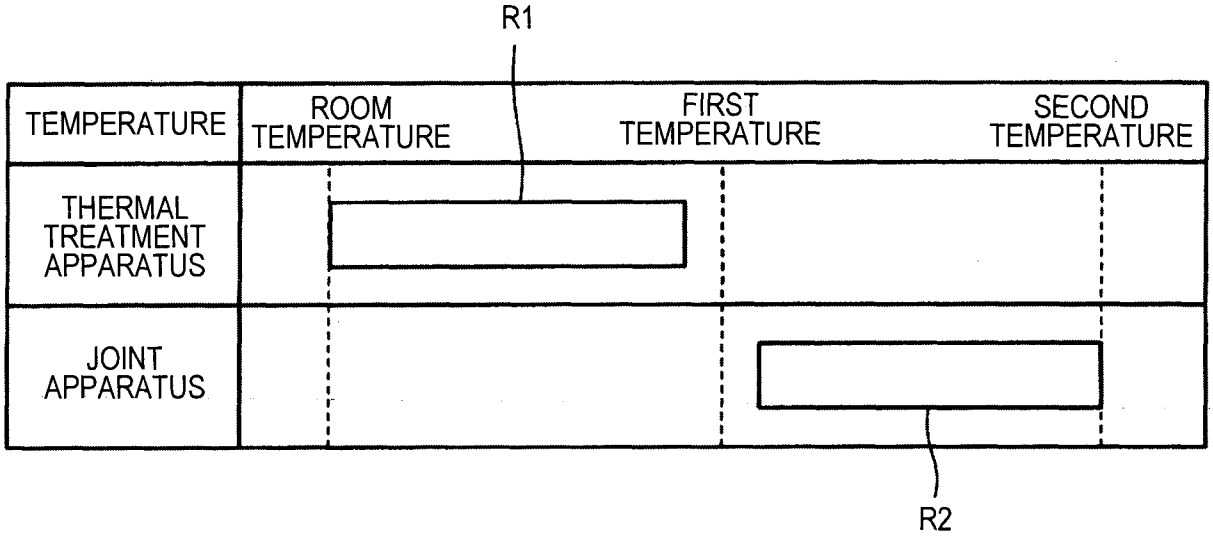

R1
TEMPERATURE
ROOM TEMPERATURE
FIRST TEMPERATURE
SECOND TEMPERATURE
THERMAL TREATMENT APPARATUS
JOINT APPARATUS
R2

FIG.17

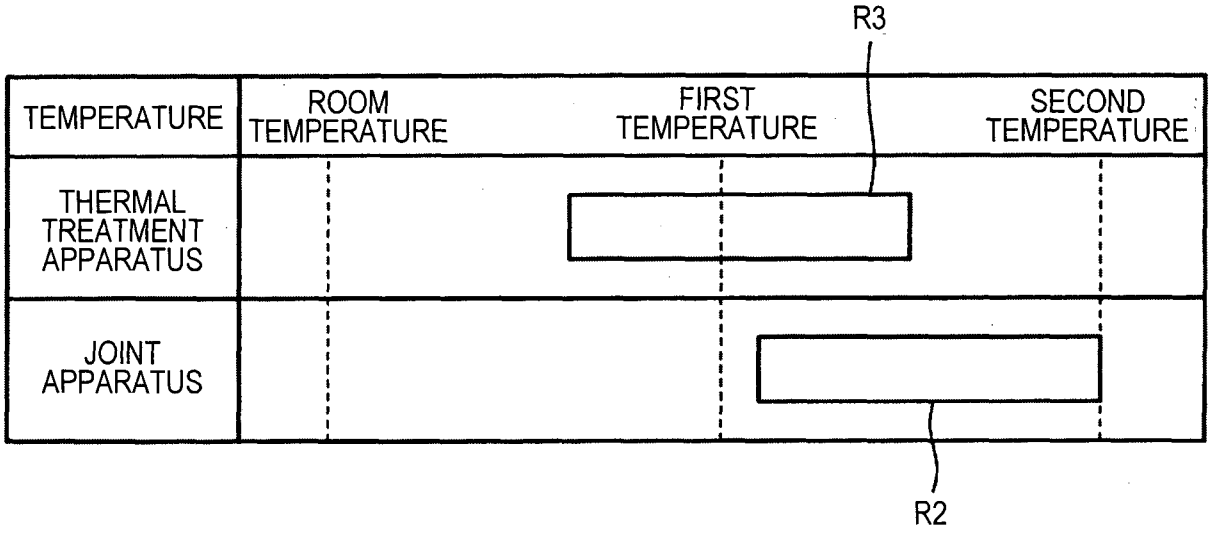

R3
TEMPERATURE
ROOM TEMPERATURE
FIRST TEMPERATURE
SECOND TEMPERATURE
THERMAL TREATMENT APPARATUS
JOINT APPARATUS
R2

FIG.18

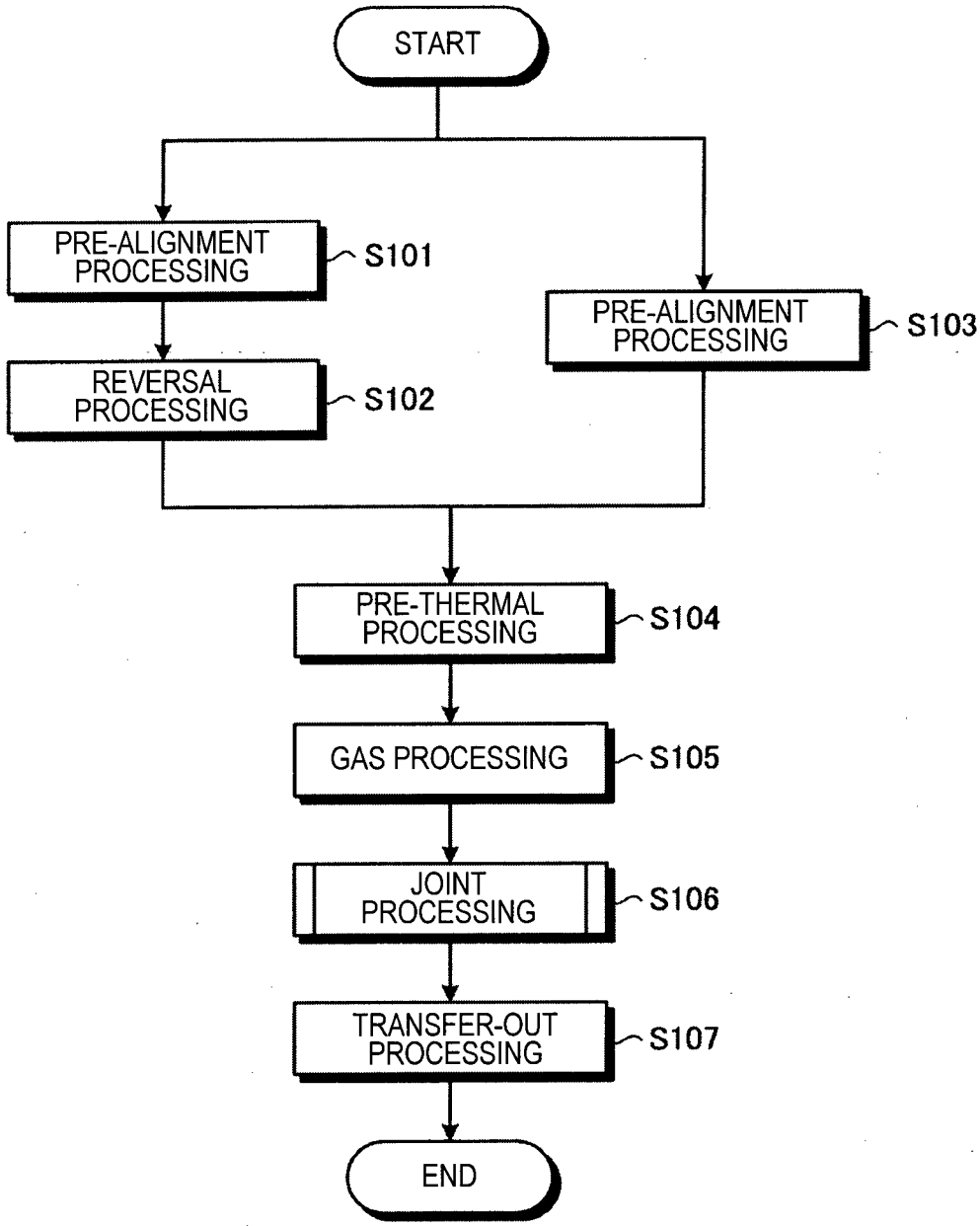

START
PRE-ALIGNMENT PROCESSING
S101
REVERSAL PROCESSING
S102
PRE-ALIGNMENT PROCESSING
S103
PRE-THERMAL PROCESSING
S104
GAS PROCESSING
S105
JOINT PROCESSING
S106
TRANSFER-OUT PROCESSING
S107
END

FIG.19

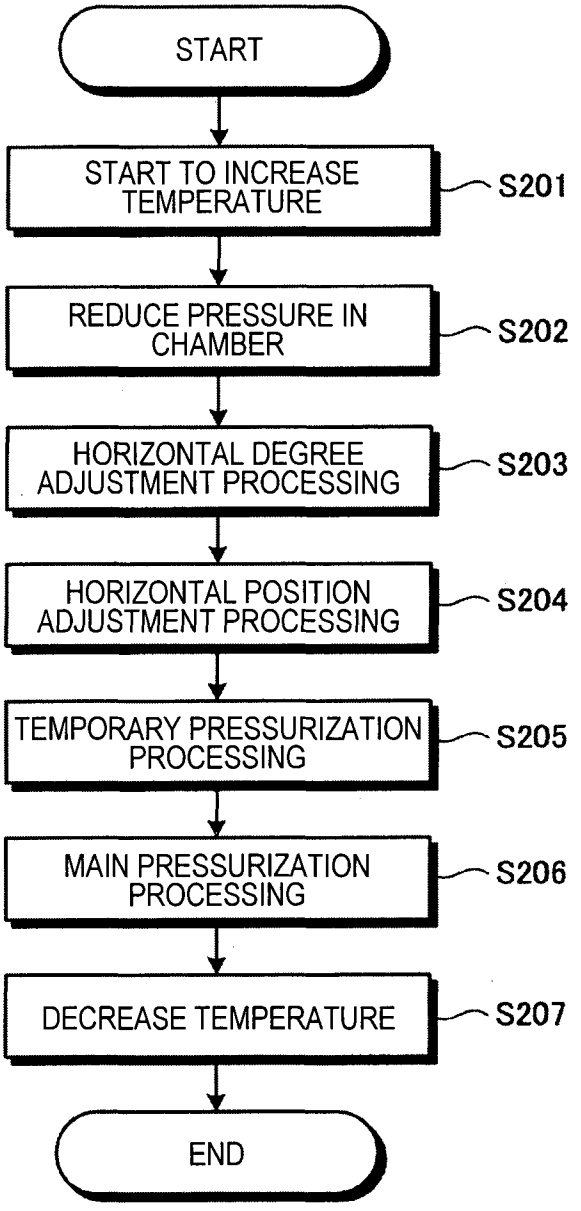
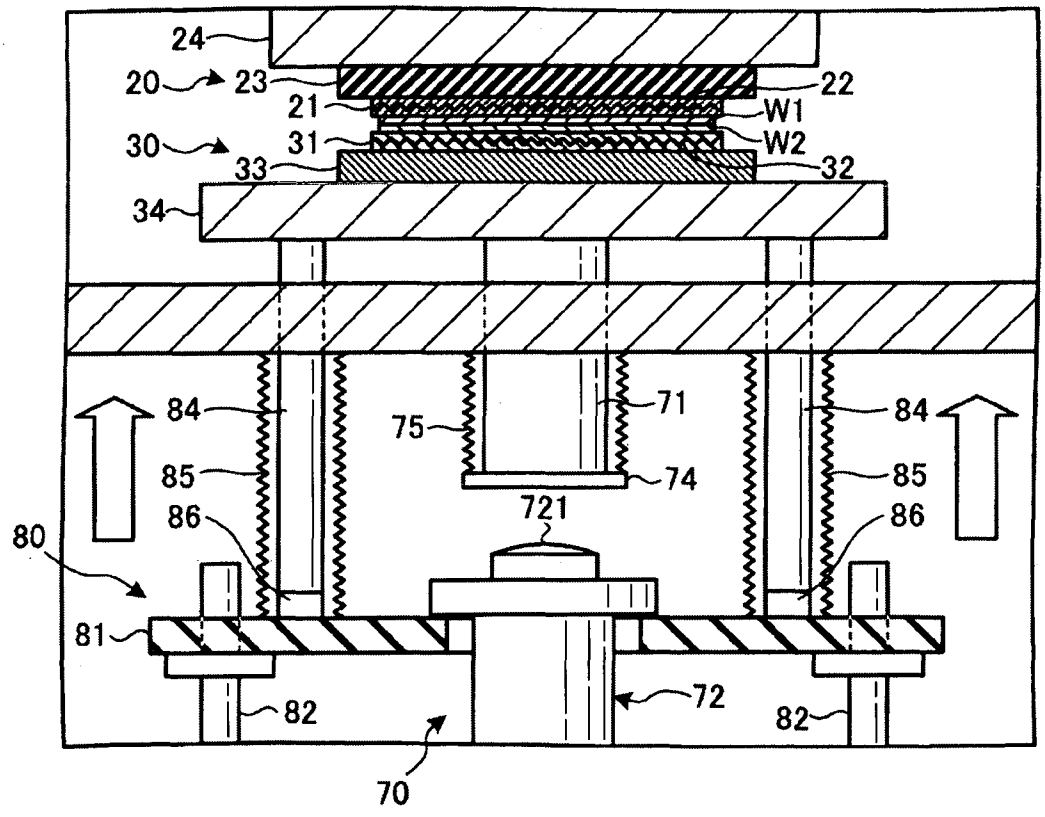

START
START TO INCREASE TEMPERATURE
S201
REDUCE PRESSURE IN CHAMBER
S202
HORIZONTAL DEGREE ADJUSTMENT PROCESSING
S203
HORIZONTAL POSITION ADJUSTMENT PROCESSING
S204
TEMPORARY PRESSURIZATION PROCESSING
S205
MAIN PRESSURIZATION PROCESSING
S206
DECREASE TEMPERATURE
S207
END

FIG.20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W1
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31
W2
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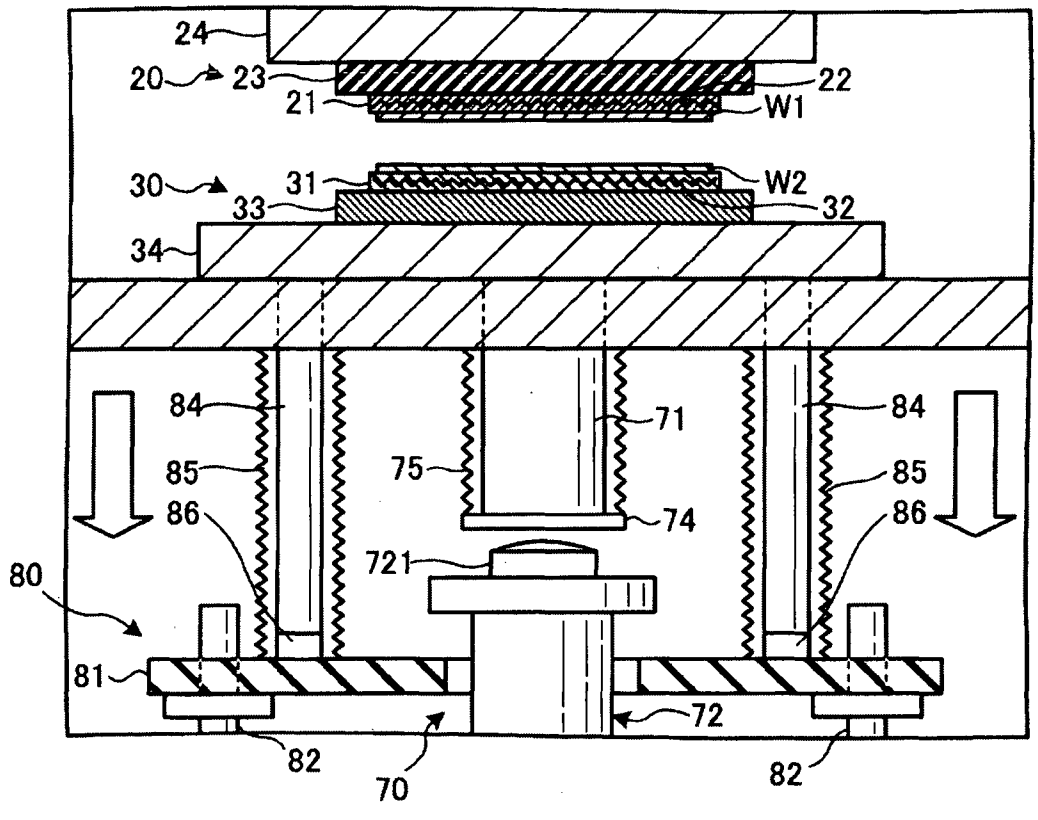
FIG.21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W1
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W2
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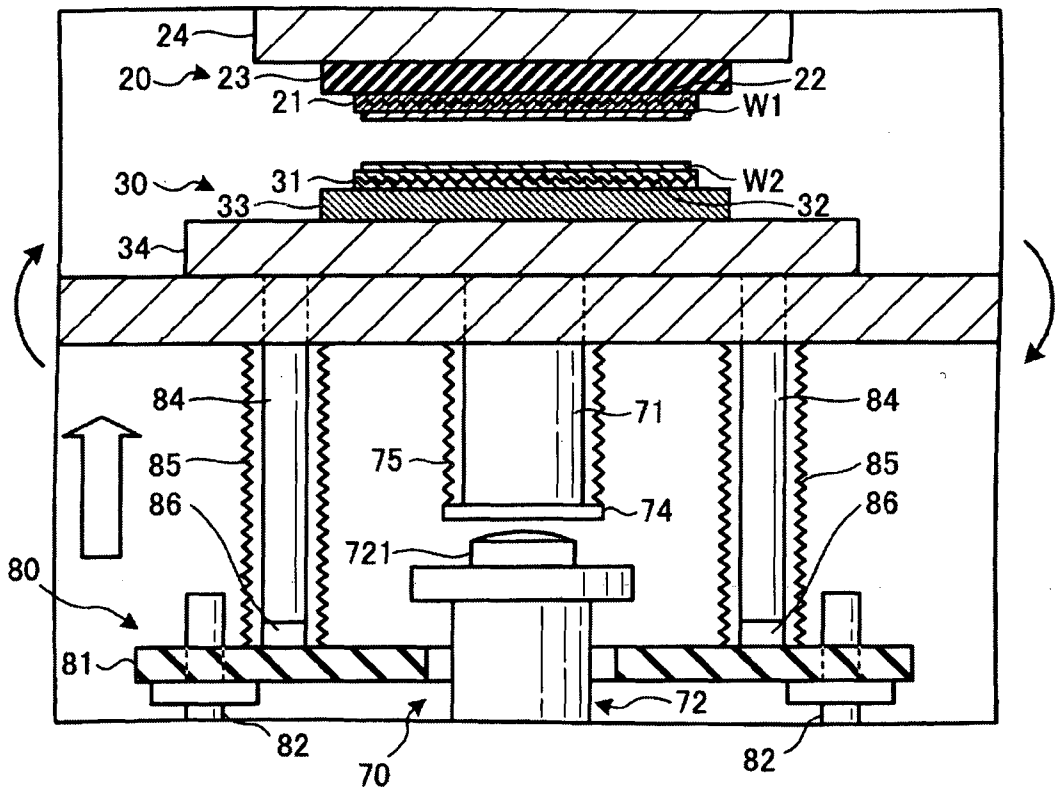
FIG.22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W1
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W2
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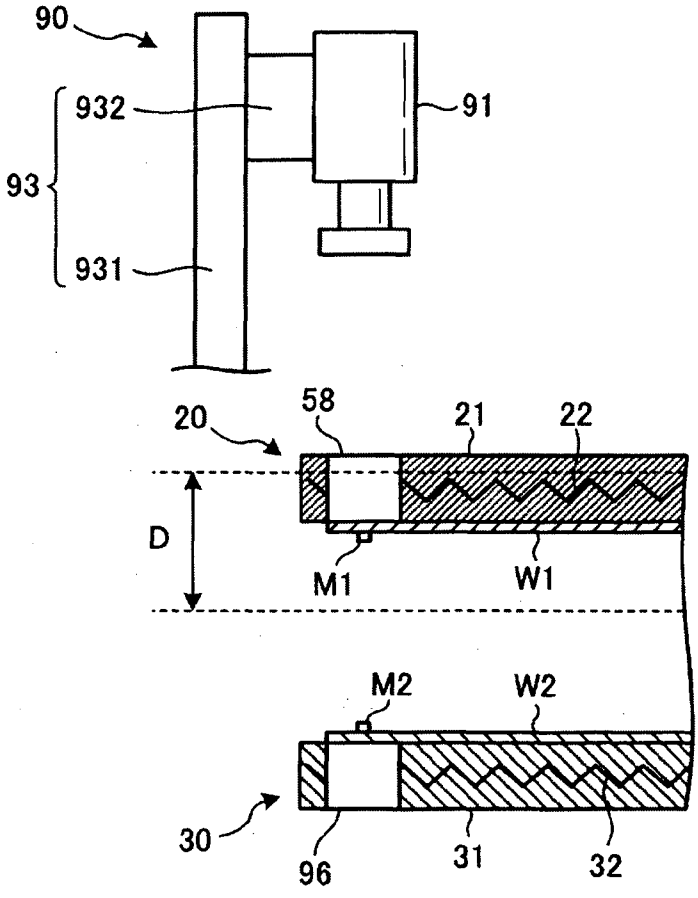
FIG.23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932
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20
58
21
22
D
M1
W1
M2
W2
30
96
31
32

FIG.24

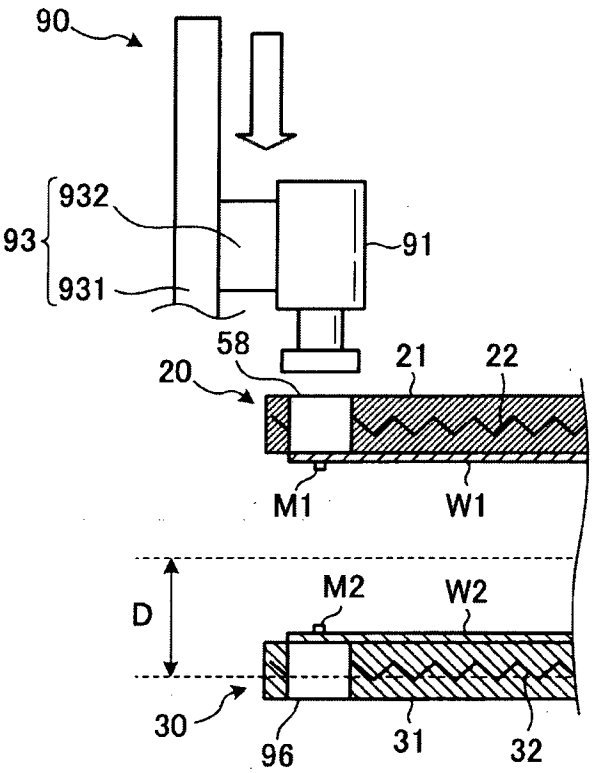

90
932
93
931
91
58
21
22
20
M1
W1
D
M2
W2
30
96
31
32

FIG.25

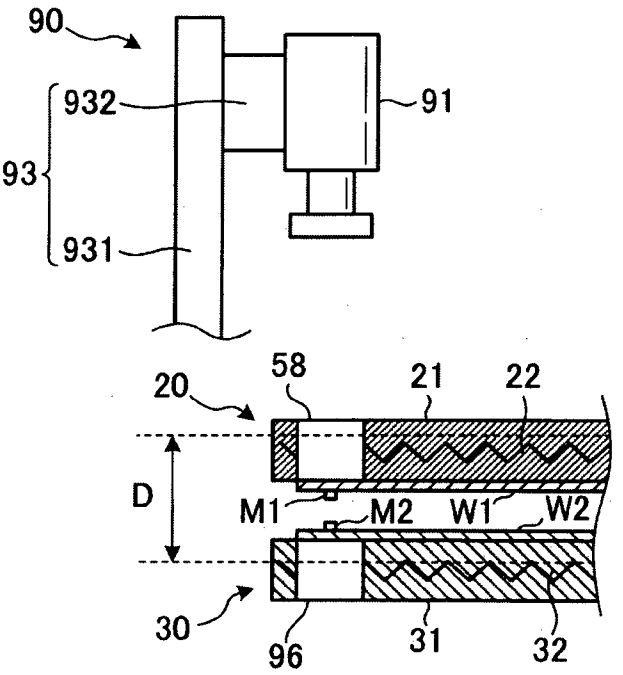
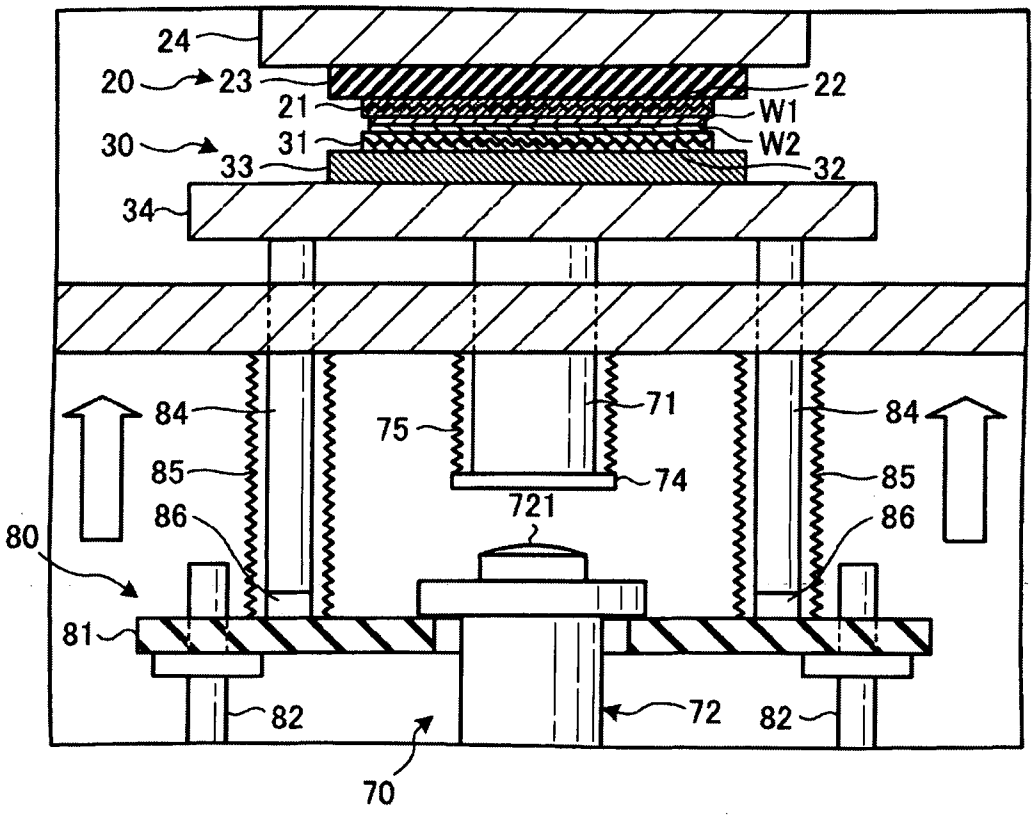

90
932
93
931
91
20
58
21
22
D
M1
M2
W1
W2
30
96
31
32

FIG.26


24
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22
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W1
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W2
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84
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86
80
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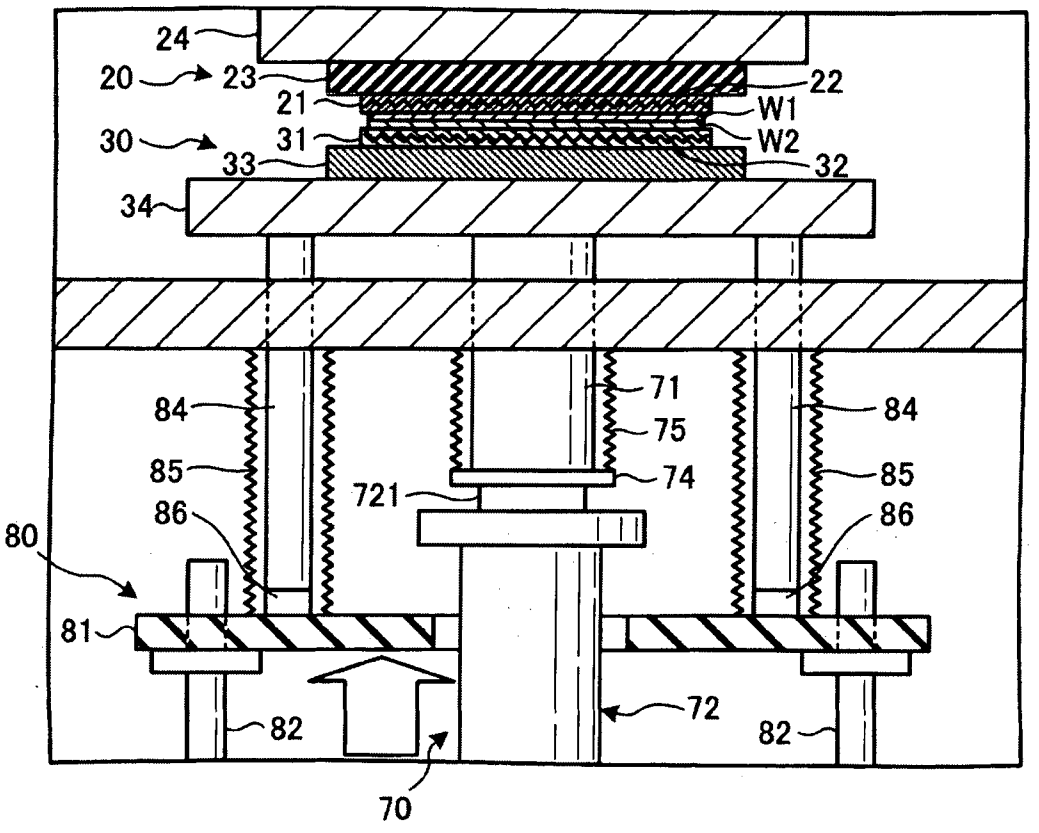
82
72
82
70

FIG.27


24
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W1
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W2
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/050893

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H01L21/02(2006.01)i, B23K20/00(2006.01)i, H01L21/683(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. H01L21/02, B23K20/00, H01L21/683

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2016
Registered utility model specifications of Japan 1996-2016
Published registered utility model applications of Japan 1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2011-119293 A (BONDTECH CO., LTD.) 2011.06.16, Paragraphs [0041]-[0055], figs. 1,2,8-11 (No Family)	1-5, 8-9 6,7
Y	JP 2010-251410 A (SHINKO ELECTRIC INDUSTRIES CO., LTD.) 2010.11.04, Paragraphs [0022]-[0056], fig.1 (No Family)	6,7
A	JP 2012-6990 A (TOKYO ELECTRON LIMITED) 2012.04.05, paragraphs [0043]-[0052], figs. 1-2 & US 2013/0153116 A1, paragraphs [0064]-[0073], figs.1-2 & WO 2012/026152 A1, pp.11-13, figs.1-2 & TW 201222695 A & KR 10-2013-0111533 A	8

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08.04.2016	19.04.2016

Name and mailing address of the ISA/JP	Authorized officer	
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