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Hara

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(54) **CARRIER SYSTEM, EXPOSURE APPARATUS, CARRIER METHOD, EXPOSURE METHOD, DEVICE MANUFACTURING METHOD, AND SUCTION DEVICE**

(71) Applicant: **NIKON CORPORATION**, Tokyo (JP)

(72) Inventor: **Hideaki Hara**, Kumagaya (JP)

(73) Assignee: **NIKON CORPORATION**, Tokyo (JP)

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CPC ***B25J 11/0095*** (2013.01); ***B25J 15/0616*** (2013.01); ***G03F 7/7075*** (2013.01);
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(58) **Field of Classification Search**
CPC .. G03F 7/707; G03F 7/70716; G03F 7/70708; G03F 7/7076
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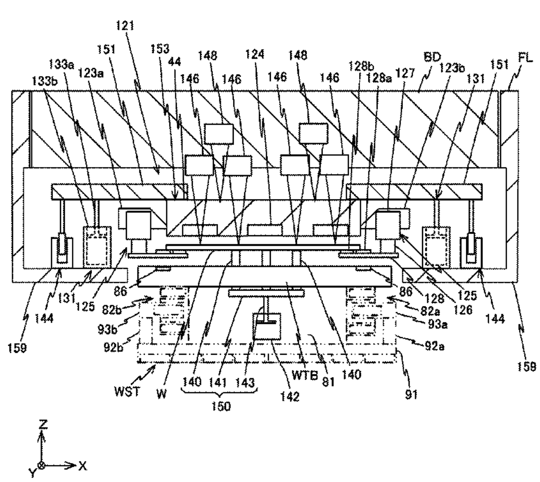
Primary Examiner — Hung Henry Nguyen
(74) *Attorney, Agent, or Firm* — Oliff PLC

(57) **ABSTRACT**

A carrier system is provided with a wafer stage which holds a mounted wafer and is also movable along an XY plane, a chuck unit which holds the wafer from above in a non-contact manner above a predetermined position and is vertically movable, and a plurality of vertical movement pins, which can support from below the wafer held by the chuck unit on the wafer stage when the wafer stage is positioned at the predetermined position above and can also move vertically. Then, flatness of the wafer is measured by a Z position detection system, and based on the measurement results, the chuck unit and the vertical movement pins that hold (support) the wafer are independently driven.

10 Claims, 11 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 61/731,892, filed on Nov. 30, 2012.

(51) **Int. Cl.**

H01L 21/67	(2006.01)
H01L 21/68	(2006.01)
H01L 21/683	(2006.01)
H01L 21/687	(2006.01)
G03F 7/20	(2006.01)
B25J 15/06	(2006.01)

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(58) **Field of Classification Search**
USPC 355/52, 55, 72–76
See application file for complete search history.

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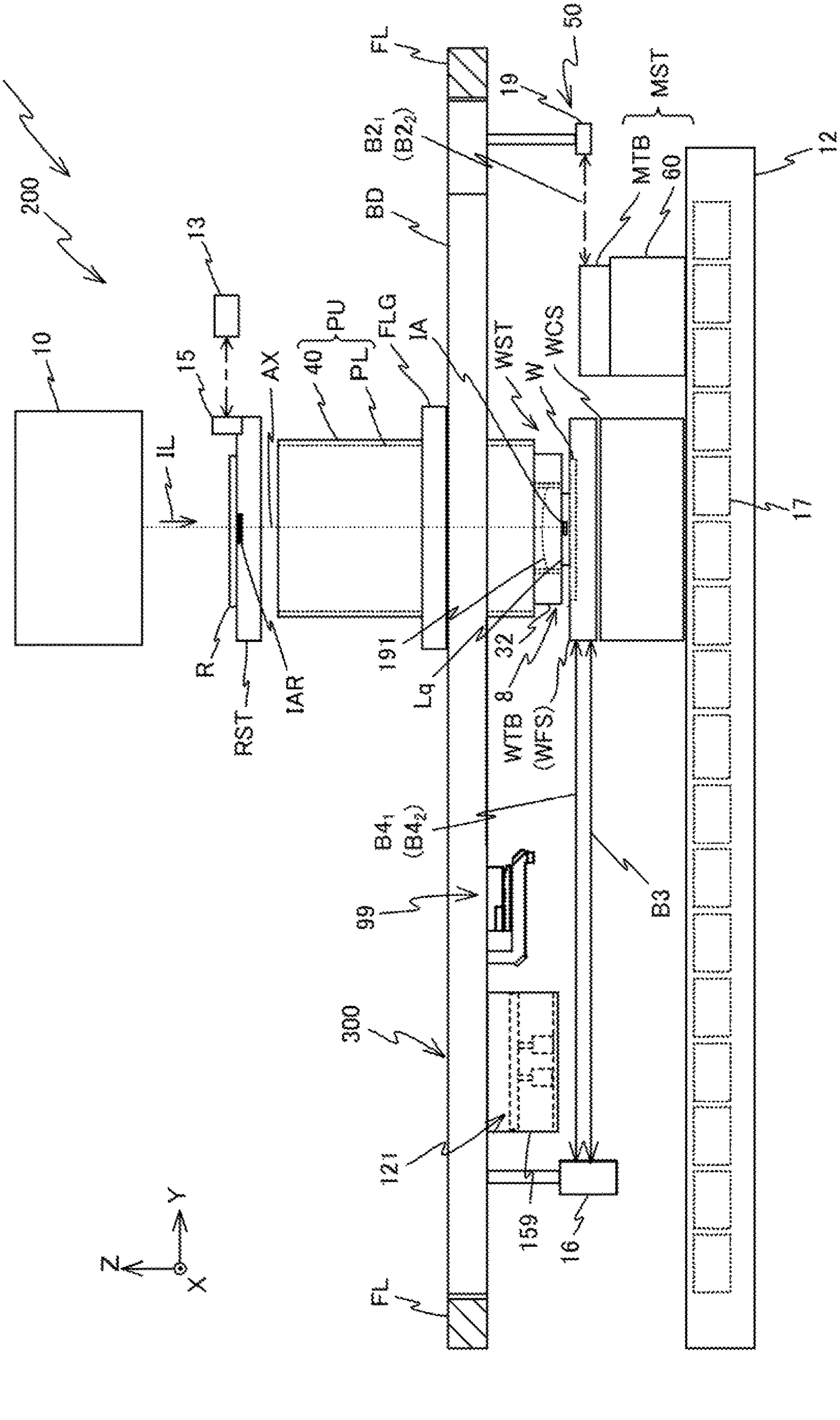
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WCS
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191
Lq
32
8
WTB
(WFS)
FL
50
19
MST
B2₁
(B2₂)
BD
MTB
60
12
17
B4₁
(B4₂)
B3
99
300
121
159
16
Z
Y
X

Fig. 1

Fig. 2A

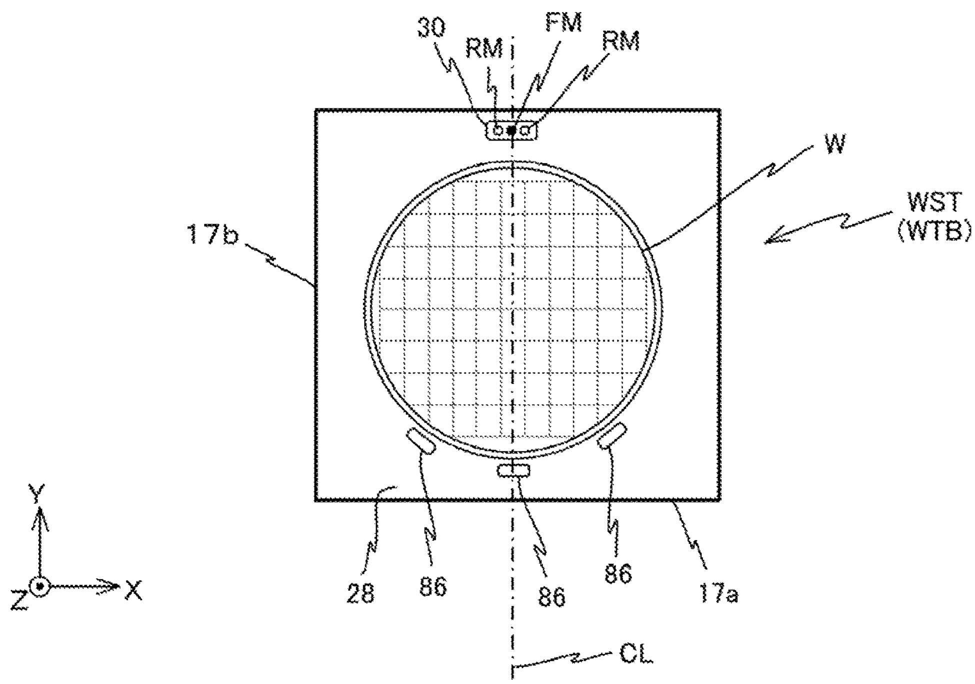
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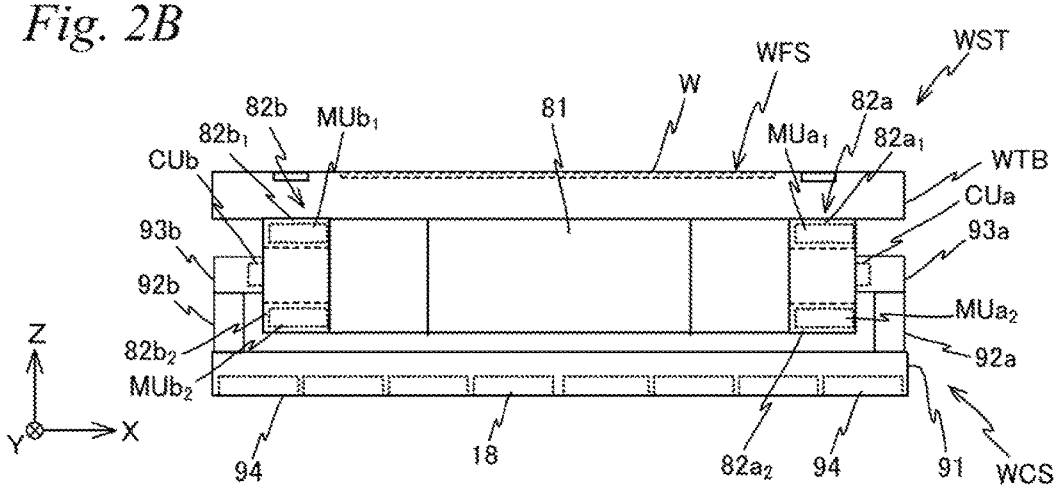
Fig. 2B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WTB
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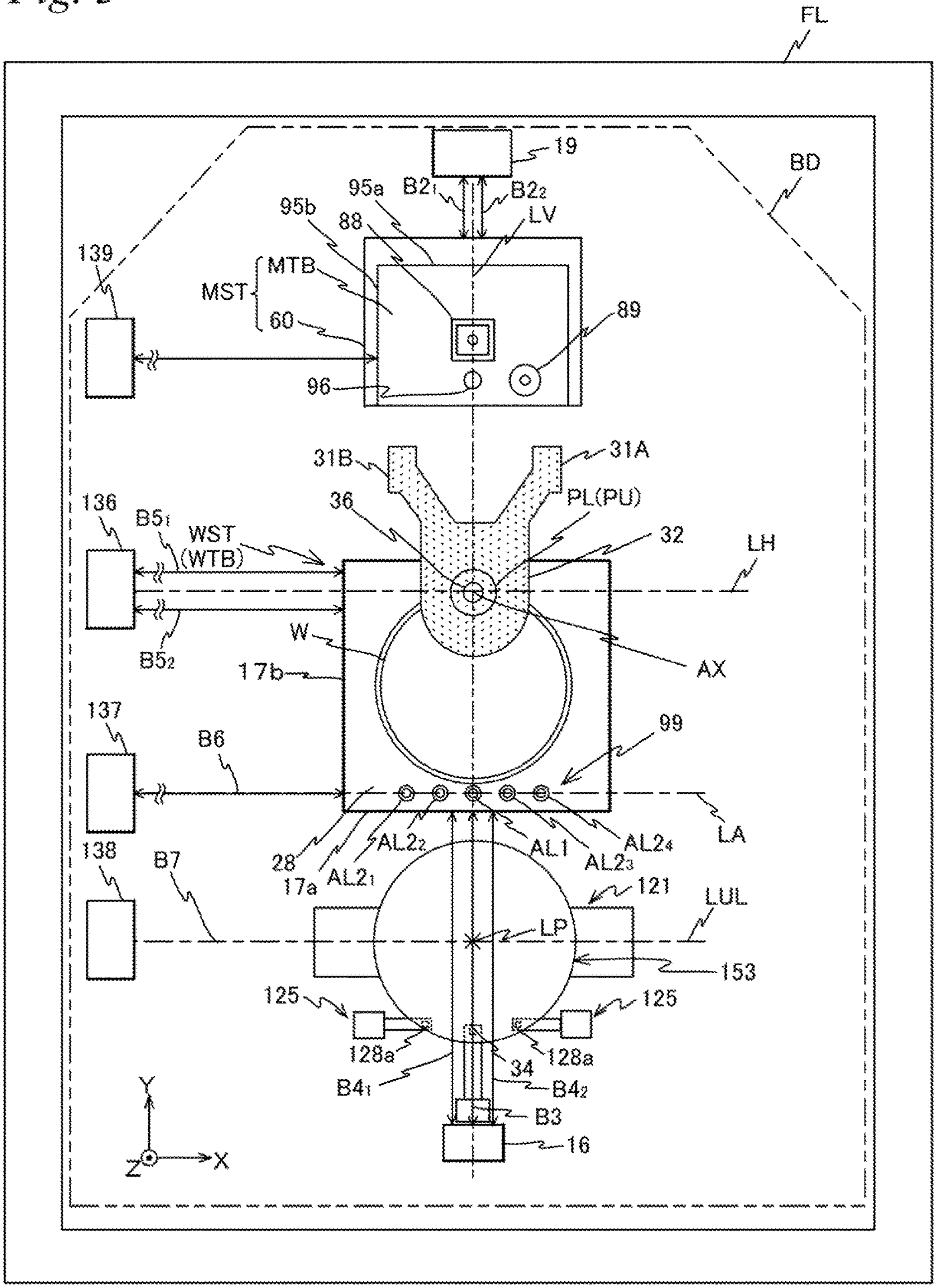
MUa2
82b2
92a
MUb2
Z
Y
X
94
18
82a2
94
91
WCS

Fig. 3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95b
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LV
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MTB
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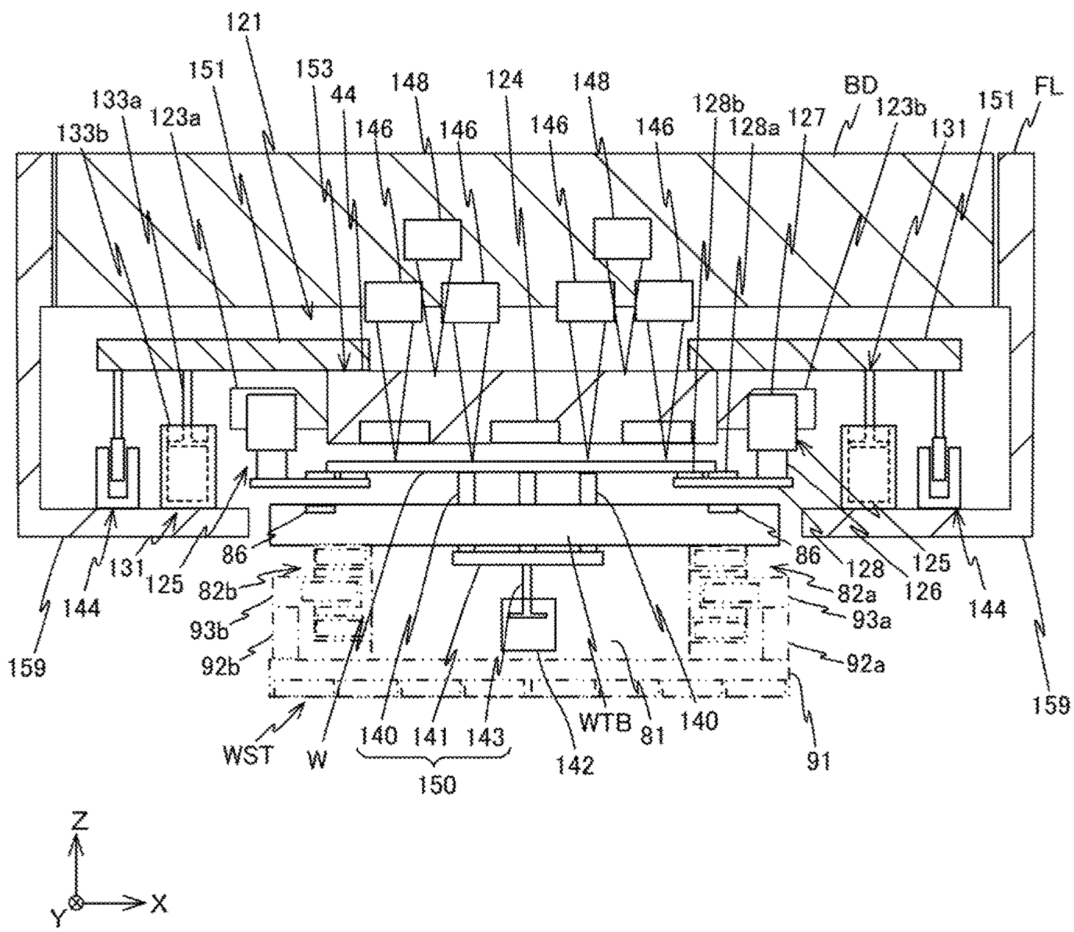
31A
36
PL(PU)
136
B5₁
WST
(WTB)
32
LH
W
AX
B5₂
17b
137
B6
99
LA
28
17a
AL2₁
AL2₂
AL1
AL2₃
AL2₄
138
B7
121
LUL
LP
153
125
125
128a
128a
34
B4₁
B4₂
B3
16
Y
X
Z

Fig. 4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133b
86
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128
125
131
125
126
144
144
82b
82a
93b
93a
92b
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159
159
WST
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143
WTB
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140
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142
150
Z
X
Y

Fig. 5

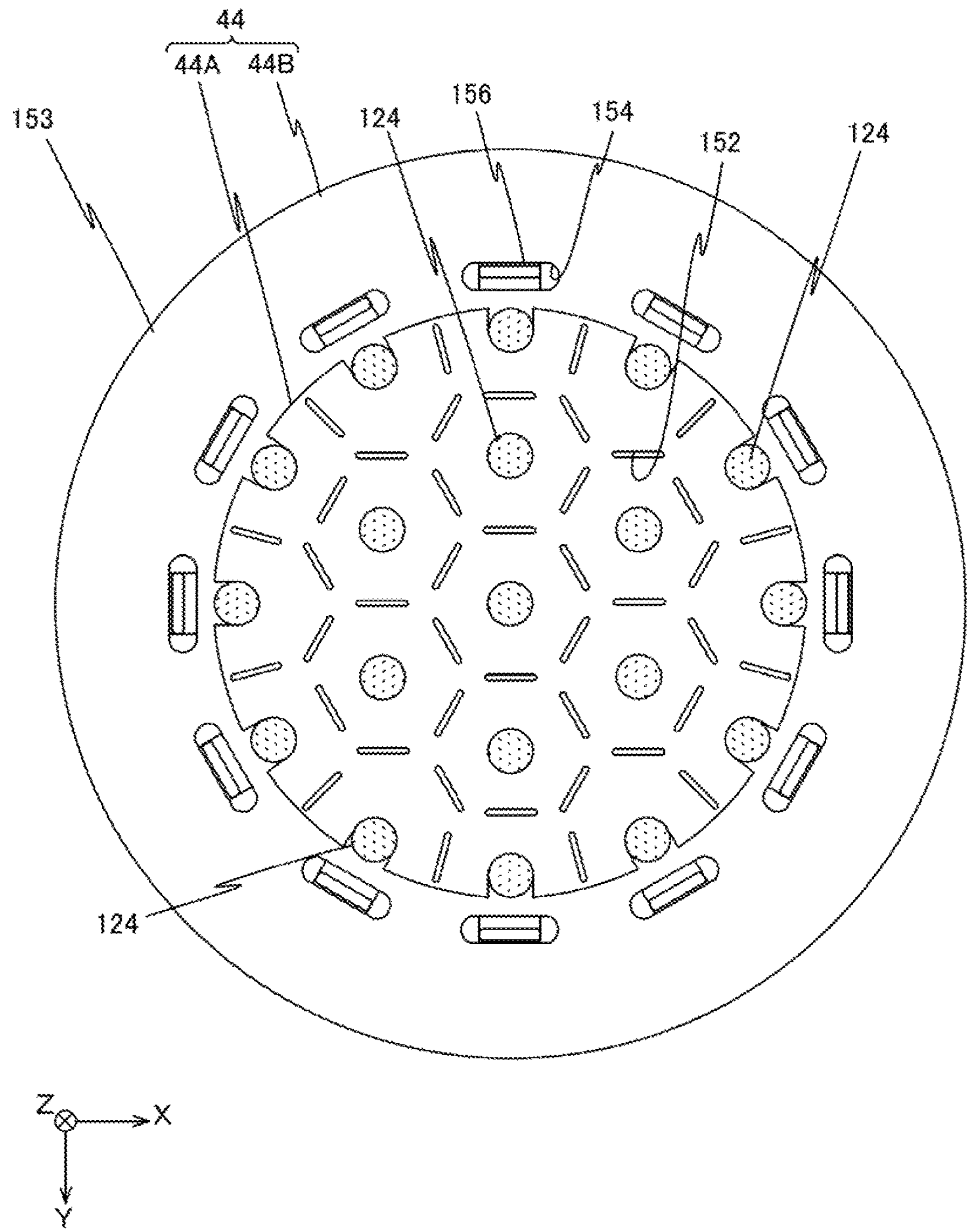
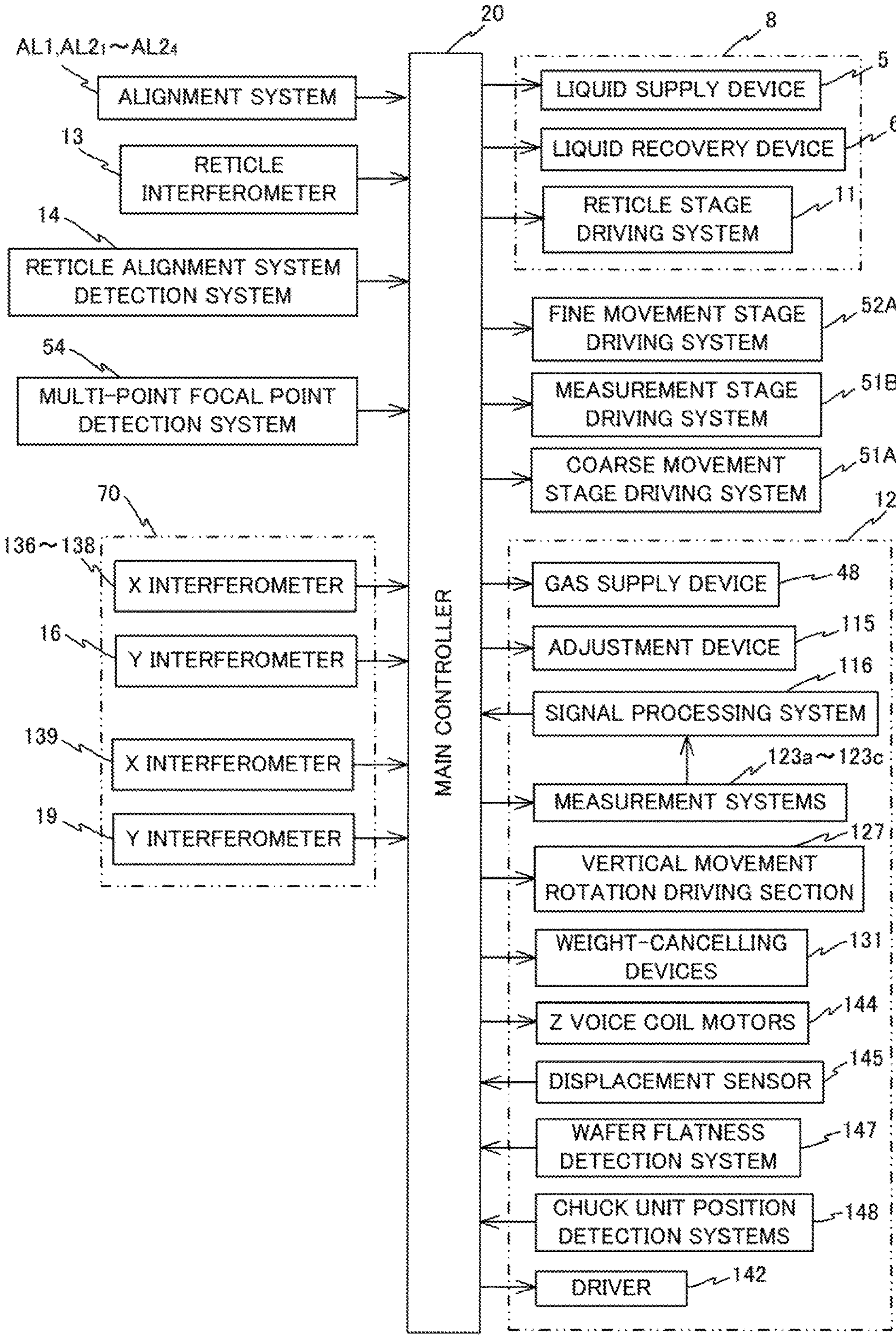


Fig. 6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8
AL1,AL2₁~AL2₄
ALIGNMENT SYSTEM
LIQUID SUPPLY DEVICE
5
LIQUID RECOVERY DEVICE
6
13
RETICLE INTERFEROMETER
RETICLE STAGE DRIVING SYSTEM
11
14
RETICLE ALIGNMENT SYSTEM DETECTION SYSTEM
FINE MOVEMENT STAGE DRIVING SYSTEM
52A
54
MULTI-POINT FOCAL POINT DETECTION SYSTEM
MEASUREMENT STAGE DRIVING SYSTEM
51B
COARSE MOVEMENT STAGE DRIVING SYSTEM
51A
70
120
136~138
X INTERFEROMETER
GAS SUPPLY DEVICE
48
16
Y INTERFEROMETER
ADJUSTMENT DEVICE
115
116
SIGNAL PROCESSING SYSTEM
MAIN CONTROLLER
139
X INTERFEROMETER
123a~123c
MEASUREMENT SYSTEMS
19
Y INTERFEROMETER
127
VERTICAL MOVEMENT ROTATION DRIVING SECTION
WEIGHT-CANCELLING DEVICES
131
Z VOICE COIL MOTORS
144
DISPLACEMENT SENSOR
145
WAFER FLATNESS DETECTION SYSTEM
147
CHUCK UNIT POSITION DETECTION SYSTEMS
148
DRIVER
142

Fig. 7A

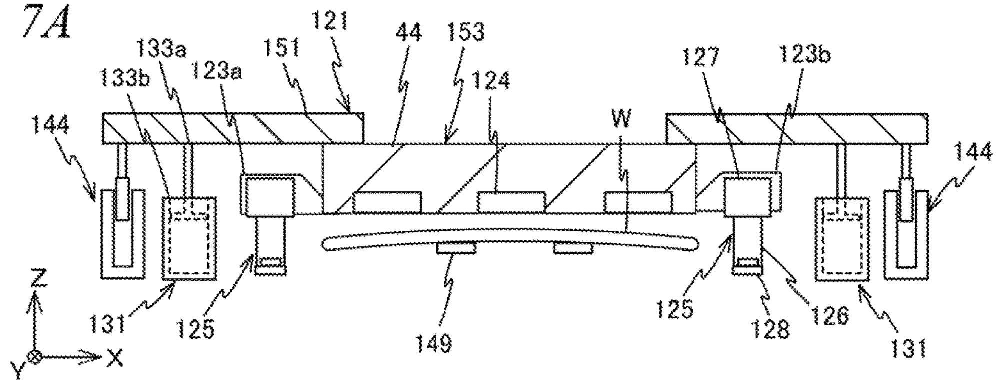


Fig. 7B

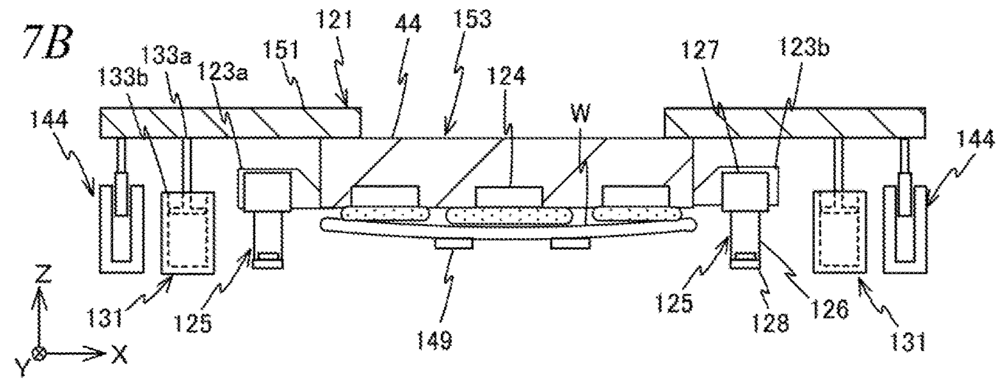


Fig. 7C

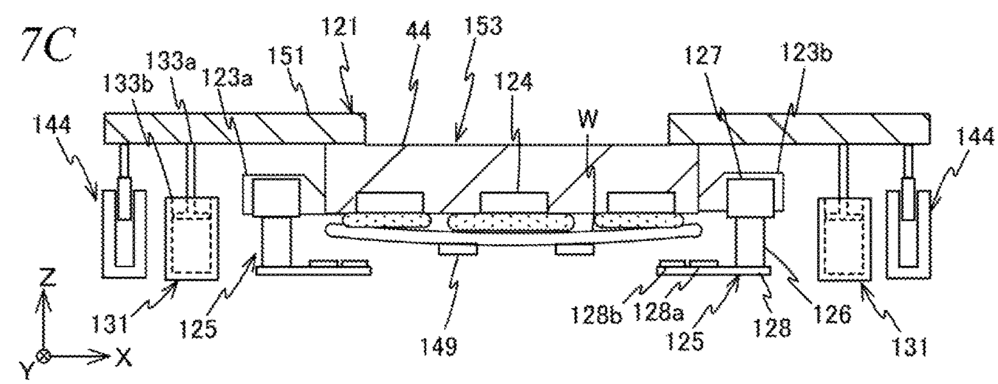


Fig. 7D

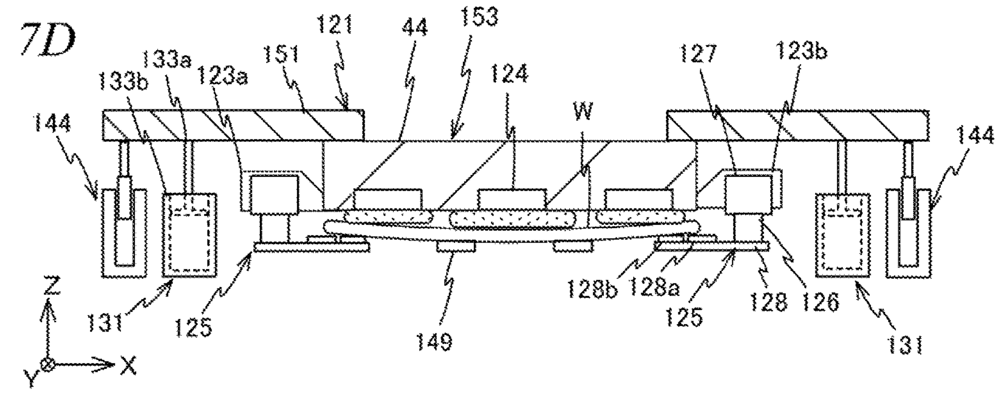


Fig. 8A

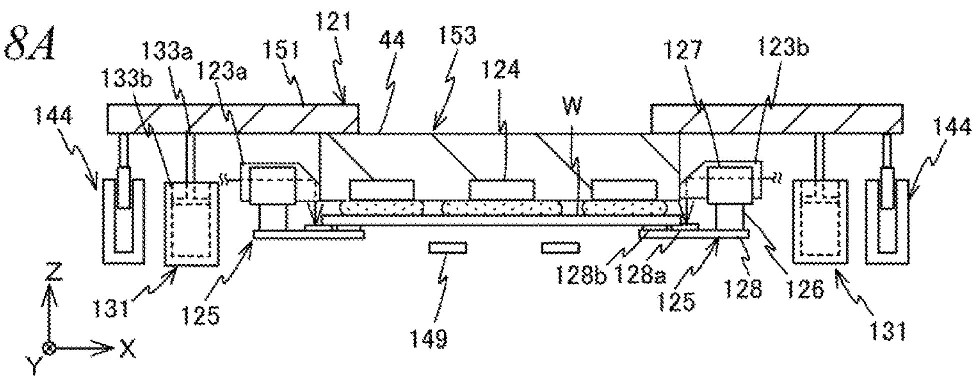


Fig. 8B

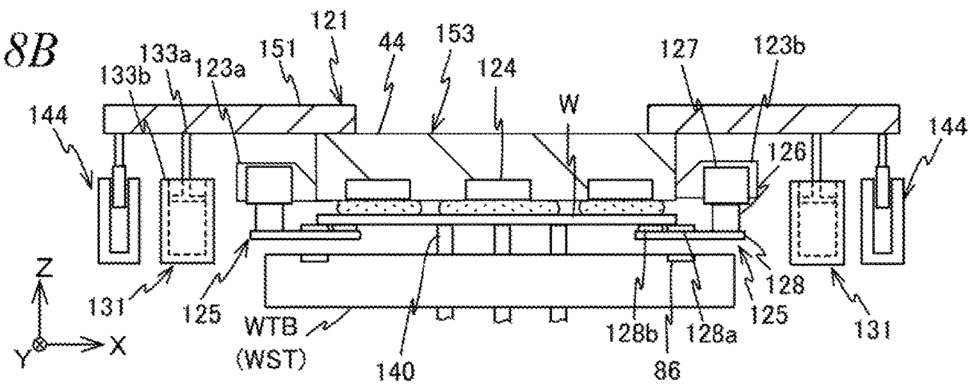


Fig. 8C

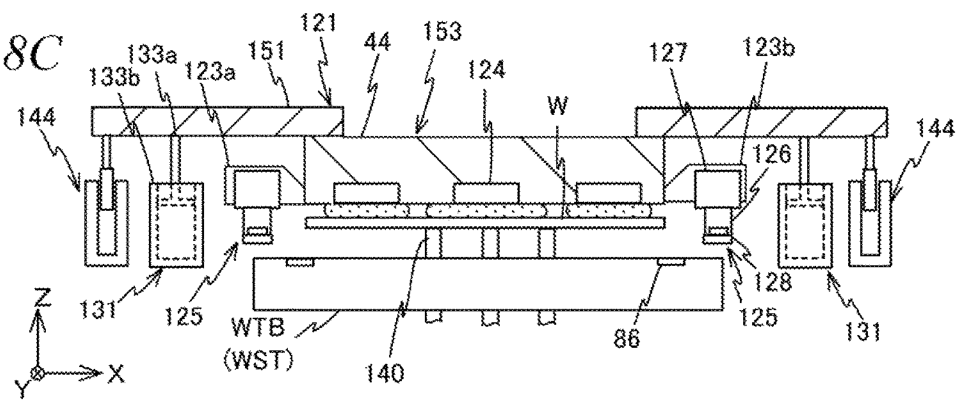


Fig. 8D

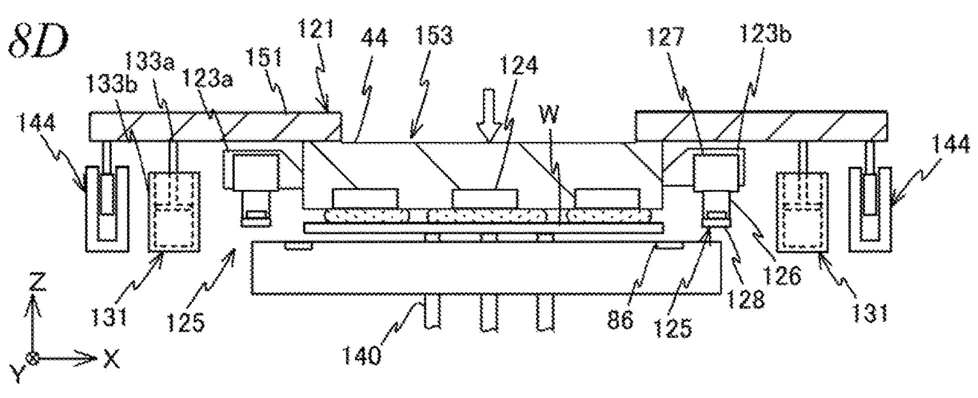
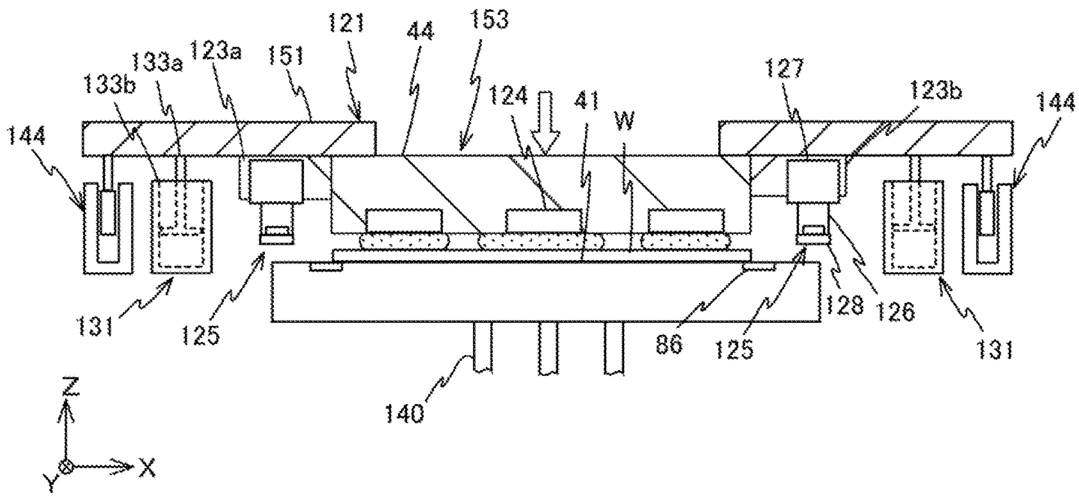


Fig. 9A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Z
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Y

Fig. 9B

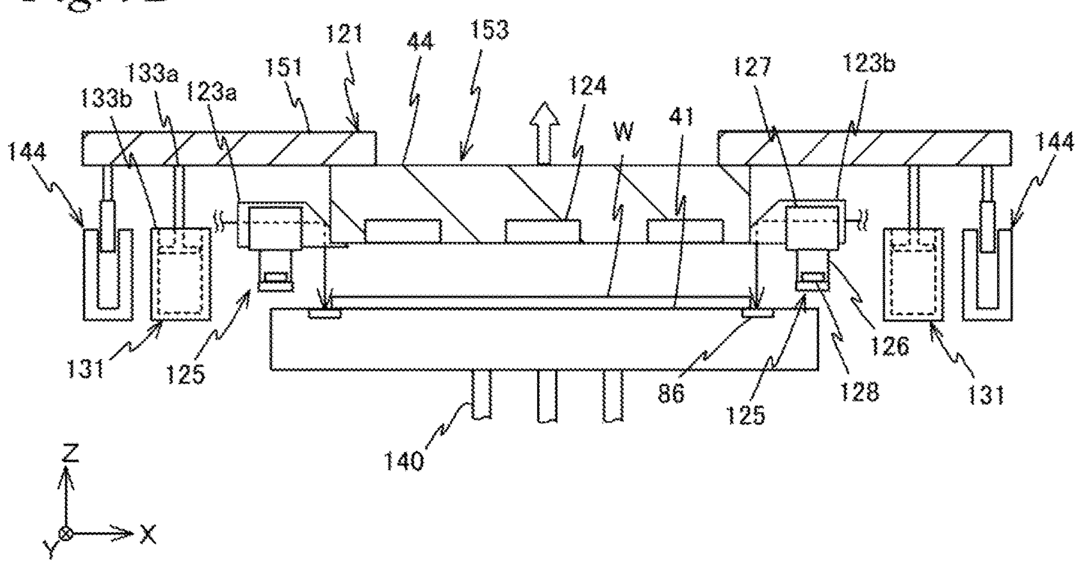
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Fig. 10

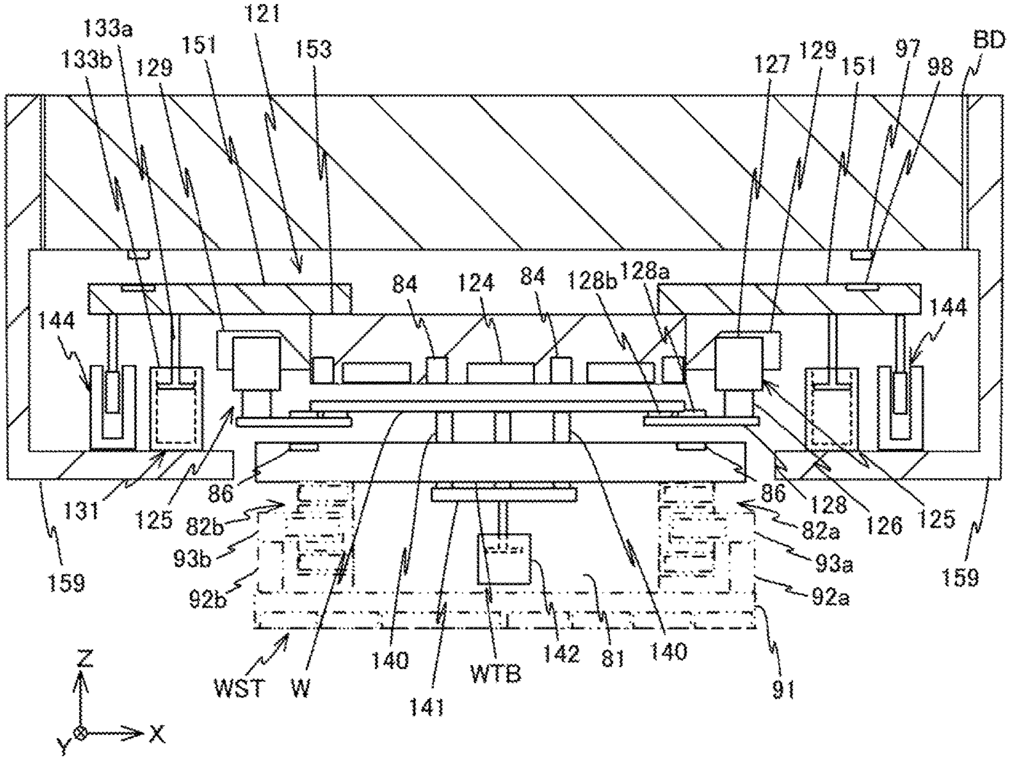
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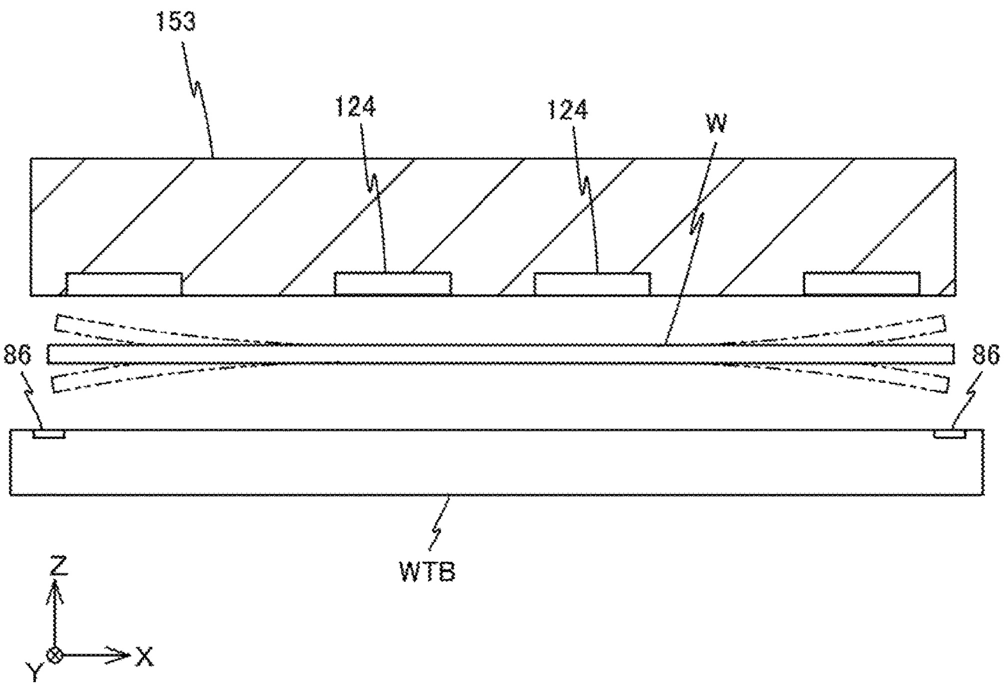
Fig. 11



CARRIER SYSTEM, EXPOSURE APPARATUS, CARRIER METHOD, EXPOSURE METHOD, DEVICE MANUFACTURING METHOD, AND SUCTION DEVICE

This is a divisional of U.S. patent application Ser. No. 14/648,280 (now U.S. Pat. No. 9,821,469), which is the U.S. National Stage of International Application No. PCT/JP2013/081852 filed Nov. 27, 2013, which claims the benefit of U.S. Provisional Application No. 61/731,892 filed Nov. 30, 2012. The disclosure of each of the above-identified prior applications is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

The present invention relates to carrier systems, exposure apparatuses, carrier methods, exposure methods, device manufacturing methods, and suction devices, and more particularly to a carrier system which carries a plate-like object, an exposure apparatus which is equipped with the carrier system, a carrier method to carry a plate-like object onto a movable body, an exposure method using the carrier method, a device manufacturing method using the exposure apparatus or the exposure method, and a suction device which suctions the plate-like object.

BACKGROUND ART

Conventionally, in a lithography process to manufacture electronic devices (microdevices) such as a semiconductor device (an integrated circuit or the like) or a liquid crystal display device, mainly, a projection exposure apparatus of a step-and-repeat method (a so-called stepper), projection exposure apparatus of a step-and-scan method (a so-called scanning stepper (also called a scanner)) or the like is mainly used.

Substrates such as a wafer, a glass plate and the like subject to exposure that are used in these types of exposure apparatuses are gradually becoming larger (for example, in the case of a wafer, in every ten years). Although a 300-mm wafer which has a diameter of 300 mm is currently the mainstream, the coming of age of a 450 mm wafer which has a diameter of 450 mm looms near. When the transition to 450 mm wafers occurs, the number of dies (chips) output from a single wafer becomes double or more than the number of chips from the current 300 mm wafer, which contributes to reducing the cost.

However, because the thickness does not necessarily increase in proportion to the size of the wafer, the 450 mm wafer is weak in intensity and rigidity when compared with the 300 mm wafer. Therefore, when focusing on a point such as a carriage of a wafer, it was considered that there was a risk of warping occurring in the wafer, which may negatively affect the exposure accuracy when a means method similar to the current 300 mm wafer was employed. Accordingly, as the carrier method of the wafer, a proposal is made of a carrier method (carry-in) or the like that can be employed even when the wafer is a 450 mm wafer in which the wafer is suctioned from above in a non-contact manner by a carrier member equipped with a Bernoulli chuck or the like to maintain the flatness degree (flatness) and performs carriage to a wafer holder (holding device) (for example, refer to PTL 1).

However, in the case of employing suction in a non-contact manner from above by the carrier member described above as a carrier method of the wafer onto the wafer stage (wafer holder), there was a risk of positional deviation (rotation deviation) in a horizontal plane of the wafer being generated at an unacceptable level, to which correction based on measurement results was difficult to perform.

CITATION LIST

Patent Literature

[PTL 1] U.S. Patent Application Publication No. 2010/0297562

SUMMARY OF INVENTION

Solution to Problem

As a method for resolving the inconvenience due to suction in a non-contact manner from above by the wafer carrier member described above, a method can be considered in which while a wafer is suctioned in a non-contact manner suction from above by a suction member such as a Bernoulli chuck or the like, the wafer is also supported from below by a support member (for example, vertical-motion pins on a wafer stage). However, according to results of experiments and the like of the inventors, in the case of performing loading of the wafer onto the wafer stage in a non-contact suction from above the wafer and support from below, it became clear that warping that is not acceptable could occur even in the case of a 300 mm wafer due to a difference in driving velocity between the suction member and the support member on the loading.

According to a first aspect of the present invention, there is provided a carrier system in which a plate-like object is carried to an object mounting member where an object mounting section is provided, the system comprising: a suction member which has an opposing section opposed to the object, the suction member forming a gas flow between the opposing section and the object to generate a suction force with respect to the object; a measurement device which obtains information related to a shape of the object suctioned by the suction member; a driver which makes the suction member relatively move in a vertical direction in an approaching or separating manner with respect to the object mounting section; and a controller which controls at least one of the suction member and the driver so that the object is mounted on the object mounting section in a predetermined shape, using the information obtained by the measurement device.

According to this system, the object can be carried onto the object mounting member, in a state maintaining high flatness.

According to a second aspect of the present invention, there is provided an exposure apparatus which forms a pattern on an object, the apparatus comprising: the carrier system described above; and a pattern generating device which exposes the object carried onto the object mounting member by the carrier system with an energy beam so as to form the pattern.

According to a third aspect of the present invention, there is provided a device manufacturing method, comprising: exposing an object using the exposure apparatus described above; and developing the object which has been exposed.

According to a fourth aspect of the present invention, there is provided a carrier method in which a plate-like object is carried to an object mounting member, the method comprising: suctioning the object from above in a non-contact manner at an area above the object mounting member by a suction member; making the suction member relatively move in a vertical direction with respect to the object mounting section by a driver; obtaining information related to a position in the vertical direction for each of a plurality of places of the object suctioned by the suction member; and controlling at least one of the suction member and the driver so that the object is mounted on the object mounting section in a predetermined shape, using the information obtained.

According to this method, the object can be carried onto the object mounting member, in a state maintaining high flatness.

According to a fifth aspect of the present invention, there is provided an exposure method, comprising: carrying the object which is plate-like onto the object mounting member by the carrier method described above; and forming a pattern on the object by exposing the object held by the object mounting member with an energy beam after carriage.

According to a sixth aspect of the present invention, there is provided a device manufacturing method, comprising: exposing an object using the exposure method described above; and developing the object which gas been exposed.

According to a seventh aspect of the present invention, there is provided a first suction device which suctions a plate-like object, the device comprising: a suction member having an opposing section which opposes the object, the suction member generating a suction force with respect to the object by blowing out gas from the opposing section; and a measurement device which obtains information related to a shape of the object suctioned by the suction member.

According to an eighth aspect of the present invention, there is provided a second suction device which makes a suction force act on a plate-like object in a non-contact manner, the device comprising: a base member; a plurality of suction sections provided at the base member, each section generating a flow of a gas in the periphery of the object so as to generate a suction force with respect to the object; and an adjustment device which deforms the object, wherein the object is deformed by the adjustment device, while the object is being suctioned by the force generated by the flow of the gas which the plurality of suction sections generated.

According to this device, it becomes possible to deform the object by the adjustment device, for example, so as to secure a desired level of flatness, while the object is being suctioned by the suction force generated by the flow of gas generated by the plurality of suction sections.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a view schematically showing a structure of an exposure apparatus according to an embodiment.

FIG. **2**A is a view (planar view) of a wafer stage in FIG. **1** when viewed from a +Z direction, and FIG. **2**B is a view (front view) of the wafer stage when viewed from a −Y direction.

FIG. **3** is a view showing a placement of an interferometer, an alignment system, a multi-point AF system and the like that the exposure apparatus is equipped with, with a projection optical system serving as a reference.

FIG. **4** is a view (front view) of a carry-in unit and the wafer stage in FIG. **1** when viewed from the −Y direction.

FIG. **5** is a view of a chuck unit in FIG. **4** when viewed from a −Z direction.

FIG. **6** is a block diagram showing an input/output relation of a main controller which mainly structures a control system of the exposure apparatus according to the embodiment.

FIG. **7**A is a view (No. **1**) used to explain a carry-in operation of a wafer, FIG. **7**B is a view (No. **2**) used to explain a carry-in operation of a wafer, FIG. **7**C is a view (No. **3**) used to explain a carry-in operation of a wafer, and FIG. **7**D is a view (No. **4**) used to explain a carry-in operation of a wafer.

FIG. **8**A is a view (No. **5**) used to explain a carry-in operation of a wafer, FIG. **8**B is a view (No. **6**) used to explain a carry-in operation of a wafer, FIG. **8**C is a view (No. **7**) used to explain a carry-in operation of a wafer, and FIG. **8**D is a view (No. **8**) used to explain a carry-in operation of a wafer.

FIG. **9**A is a view (No. **9**) used to explain a carry-in operation of a wafer, and FIG. **9**B is a view (No. **10**) used to explain a carry-in operation of a wafer.

FIG. **10** is a view used to explain an example (a modified example) of a structure of a wafer flatness detection system and a chuck unit position detection system.

FIG. **11** is a view used to explain an example of an operation immediately before the wafer is mounted on the wafer stage, of the wafer carry-in operation.

DESCRIPTION OF EMBODIMENTS

An embodiment will be described below, based on FIGS. **1** to **9**B.

FIG. **1** schematically shows a structure of an exposure apparatus **100** according to an embodiment. This exposure apparatus **100** is a projection exposure apparatus of a step and-scan method, or a so-called scanner. As it will be described later on a projection optical system PL is arranged in the present embodiment, and in the description below, a direction parallel to an optical axis AX of this projection optical system PL will be described as a Z-axis direction, a direction within a plane orthogonal to the Z-axis direction in which a reticle and a wafer are relatively scanned will be described as the Y-axis direction, a direction orthogonal to the Z-axis and the Y-axis will be described as an X-axis direction, and rotational (inclination) direction around the X-axis, the Y-axis, and the Z-axis win be described as a θx direction, a θy direction, and θz direction.

Exposure apparatus **100**, as is shown in FIG. **1**, is equipped with an exposure section **200** placed at an exposure station placed near the +Y side end on a base board **12**, a measurement section **300** placed at a measurement station a predetermined distance apart to the −Y side from exposure section **200**, a stage device **50** including a wafer stage WST and a measurement stage MST that move two-dimensionally in an XY plane independently on base board **12**, a carry-in unit **121** which structures a carry carrier system **120** (refer to FIG. **6**) that carries a wafer W along with a carry-out unit which is not shown and a wafer support member **125** which will be described later on, and a control system or the like of these parts. Here, base board **12** is supported almost horizontally (parallel to the XY plane) on a floor surface by an anti-vibration device (omitted in drawings). Base board **12** consists of a member having a plate-like outer shape. Further, inside base board **12**, a coil unit including a plurality of coils **17** placed in a matrix share with an XY two-dimensional direction serving as a row direction and a column direction is housed, which structures a stator of a planar motor (to be described later on). Incidentally, in FIG. **1**, wafer stage WST is positioned at exposure station, and wafer W is held on wafer stage WST (to be more specific, on wafer table WTB which will be described later on). Further measurement stage MST is positioned near the exposure station.

Exposure section **200** is equipped with an illumination system **10**, a reticle stage RST, a projection unit PU, a local liquid immersion device **8** and the like.

Illumination system **10**, as is disclosed in, for example, U.S. Patent Application Publication No. 2003/0025890 and the like, includes a light source, an illuminance equalizing optical system including an optical integrator and the like, and an illumination optical system that has a reticle blind and the like (none of which are shown). Illumination system **10** illuminates a slit-shaped illumination area IAR set (limited) on reticle R by the reticle blind (also called a masking system) by an illumination light (exposure light) IL, with a substantially uniform illuminance. In this case, as illumination light IL, for example, an ArF excimer laser beam (wavelength 193 nm) is used.

On reticle stage RST, reticle R on which a circuit pattern or the like is formed on its pattern surface the lower surface in FIG. **1**) is fixed, for example, by vacuum chucking, Reticle stage RST, for example, is finely drivable within the XY plane by a reticle stage driving system **11** (not shown in FIG. **1**, refer to FIG. **6**) including a linear motor, a planar motor or the like, and is also drivable in a scanning direction (the Y-axis direction which is the lateral direction of the page surface in FIG. **1**) at a predetermined scanning speed.

Position information (including rotation information in the θz direction) of reticle stage RST in the XY plane is constantly detected, for example, by a reticle laser interferometer (hereinafter, referred to as a "reticle interferometer") **13**, a movable mirror **15** (actually, a Y movable mirror (or a retroreflector) having a reflection surface orthogonal to the Y-axis direction and an X movable mirror having a reflection surface orthogonal to the X-axis direction are provided) fixed to reticle stage RST, at resolution of, for example, around 0.25 nm. Measurement values of reticle interferometer **13** are sent to a main controller **20** (not shown in FIG. **1**, refer to FIG. **6**). Main controller **20** drives reticle stage RST via reticle stage driving system **11** (refer to FIG. **6**), based on the position information of reticle stage RST. Incidentally, in the present embodiment, position information of reticle stage RST in the XY plane can be detected using an encoder, instead of the reticle interferometer described above.

Projection unit PU is placed below reticle stage RST in FIG. **1**. Projection unit PU is supported by a mainframe BD, via a flange section FLG provided at an outer circumference section of mainframe BD, which is placed horizontally above base board **12**. Mainframe BD, as is shown in FIGS. **1** and **3**, consists of a plate member having a hexagonal shape (a shape in which two corners of a rectangular shape is cut off) in a planar view whose dimension in the Y-axis direction is larger than that of the X-axis direction, and is supported on the floor surface by a support member which is not shown including an anti-vibration device which is not shown in a part thereof. As is shown in FIGS. **1** and **3**, a frame FL having a rectangular frame shape in a planar view is placed surrounding mainframe BD. Frame FL is supported at a position the same height as mainframe BD on the floor surface by a support member different from the support member supporting mainframe BD. From an end near (a Y position almost the same as a loading position LP which will be described later on) the −Y side of a pair of long sides apart in the X-axis direction of frame FL, a pair of (symmetrical) extended sections **159** that each have an L-shaped XZ section is provided in a protruding manner below (refer to FIG. **4**).

Projection unit PU includes a barrel **40**, and projection optical system PL held inside barrel **40**. Used as projection optical system PL, for example, is a dioptric system consisting of a plurality of optical elements (lens elements) arranged along optical axis AX, which is parallel to the Z-axis. Projection optical system PL, for example, is double telecentric, and has a predetermined projection magnification (for example, ¼ times, ⅕ times or ⅛ times). Therefore, when illumination area IAR on reticle R is illuminated by illumination light IL from illumination system **10**, a reduced image of the circuit pattern of reticle R (a reduced image of a part of the circuit pattern) within illumination area IAR is formed in an area (hereinafter, also called an exposure area) IA conjugate to illumination area IAR on wafer W whose surface is coated with a resist (sensitive agent) and is placed on a second surface (image plane) side of projection optical system PL, via projection optical system PL (projection unit PU), by illumination light IL having passed through reticle R placed so that its pattern surface substantially coincides with a first surface (object plane) of projection optical system PL. And, by reticle stage RST and wafer stage WST (to be more precise, fine movement stage WFS to be described later on which holds wafer W) being synchronously driven, scanning exposure of a shot area (divided area) on wafer W is performed, by reticle R being relatively moved in the scanning direction (Y-axis direction) with respect to illumination area IAR (illumination light IL) and wafer W being relatively moved in the scanning direction (Y-axis direction) with respect to exposure area IA (illumination light IL), and the pattern of reticle R is transferred onto the shot area. That is, in the present embodiment, the pattern of reticle R is generated on wafer W by illumination system **10** and projection optical system PL, and by the exposure of the sensitive layer (resist layer) on wafer W with illumination light IL the pattern is formed on wafer W.

Local liquid immersion device **8** is provided, corresponding to exposure apparatus **100** which performs exposure using a liquid immersion method. Local liquid immersion device **8** includes a liquid supply device **5**, a liquid recovery device **6** (none of which are shown in FIG. **1**, refer to FIG. **6**), nozzle unit **32** and the like. Nozzle unit **32**, as is shown in FIG. **1**, is supported in a suspended manner by mainframe BD supporting projection unit PU and the like, via a support member which is not shown surrounding the lower end periphery of barrel **40** which holds an optical element closest to the image plane side (wafer W side) structuring projection optical system PL, in this case, a lens (hereinafter also referred to as a "tip lens") **191**. Nozzle unit **32** is equipped with a supply port and a recovery port of liquid Lq, a lower surface at which the recovery port is provided and to which wafer W is placed oppositely, a supply passage connected to a liquid supply pipe **31**A (not shown in FIG. **1**, refer to FIG. **3**), and a recovery passage connected to a liquid recovery pipe **31**B (not shown in FIG. **1**, refer to FIG. **3**). To liquid supply pipe **31**A, connected is one end of a supply pipe which is not shown that has the other end connected to liquid supply device **5** (not shown in FIG. **1**, refer to FIG. **6**) and to liquid recovery pipe **31**B, connected is one end of a recovery pipe which is not shown that has the other end connected to liquid recovery device **6** (not shown in FIG. **1**, refer to FIG. **6**). In the present embodiment, main controller **20** controls liquid supply device **5** (refer to FIG. **6**), so that liquid supplied between tip lens **191** and wafer W via liquid supply pipe **31**A and nozzle unit **32**, and also controls liquid recovery device **6** (refer to FIG. **6**) so that liquid is recovered from between tip lens **191** and wafer W via nozzle unit **32** and liquid recovery pipe **31**B. On this operation, main controller **20** controls liquid supply device **5** and liquid recovery device **6** so that the amount of liquid supplied and the amount of liquid recovered are constantly equal. Accordingly, between tip lens **191** and wafer W, a fixed amount of liquid Lq (refer to FIG. **1**) is held constantly replaced. In the present embodiment, as liquid Lq described above, pure water is used through which an ArF excimer laser light (light with a wavelength of 193 nm) transmits. Incidentally, refractive index n of the pure water to the ArF excimer laser light is almost 1.44, and in the pure water, the wavelength of illumination light IL is shortened to 193 nm×1/n=around 134 nm. Incidentally, in FIG. **3**, a liquid immersion area formed by liquid Lq is shown by a reference sign **36**.

Further, in the case measurement stage MST is positioned below projection unit PU, liquid Lq can be filled in between a measurement table MTB to be described later and tip lens **191** in a manner similar to the description above.

Here, although the description goes out of sequence, stage device **50** will now be described. Stage device **50**, as is shown in FIG. **1**, is equipped with wafer stage WST and measurement stage MST placed on base board **12**, an interferometer system **70** (refer to FIG. **6**) including Y interferometers **16** and **19** that measure position information of these stages WST and MST, and the like.

Wafer stage WST, as it can be seen from FIGS. **1**, **2**B and the like, has a coarse movement stage WCS, and a fine movement stage WFS, which is supported a non-contact state by coarse movement stage and is relatively movable with respect to coarse movement stage WCS. Here, wafer stage WST (coarse movement stage WCS) is driven in predetermined strokes in the X-axis direction and the Y-axis direction, and is also finely driven in the θz direction by a coarse movement stage driving system **51**A (refer to FIG. **6**). Further, fine movement stage WFS is driven in directions of six degrees of freedom (the X-axis direction, the Y-axis direction, the Z-axis direction, the θx direction, the θy direction and the θz direction) by a fine movement stage driving system **52**A (refer to FIG. **6**), with respect to coarse movement stage WCS.

Coarse movement stage WCS, as is shown in FIG. **2**B, is equipped with a coarse movement slider section **91** having a rectangular plate-like shape whose length in the X-axis direction is slightly longer than the length in the Y-axis direction in a planar view (when viewed from the +Z direction), a pair of side wall sections **92***a*, **92***b*, each having a rectangular plate-like shape with the longitudinal direction being the Y-axis direction, and being fixed on the upper surface of one end and the other end of coarse movement slider section **91** in the longitudinal direction in a state parallel to the YZ plane, and a pair of stator sections **93***a*, **93***b* fixed on the upper surface of side wall sections **92***a*, **92***b*, respectively, at the center in the Y-axis direction facing the inner side. Incidentally, side wall sections **92***a*, **92***b* can have almost the same length in the Y-axis direction as stator sections **93***a*, **93***b*. That is, side wall sections **92***a*, **92***b* may be provided only at the center in the Y-axis direction on the upper surface of coarse movement slider section **91**, at one end and the other end in the longitudinal direction.

At the bottom surface of coarse movement stage WCS, that is, at the b base board **12** is provided, consisting of a plurality of permanent magnets **18** placed in the shape of a matrix with the XY two-dimensional directions serving as a row direction and the column direction, as is shown in FIG. **2**B. The magnet unit, along with the coil unit of base board **12**, structures coarse movement stage driving system **51**A (refer to FIG. **6**) consisting of a planar motor of an electromagnetic force (Lorentz force) driving method whose details are disclosed, for example, in U.S. Pat. No. 5,196,745 and the like. The magnitude and direction of the electric current supplied to each coil **17** (refer to FIG. **1**) structuring the coil unit are controlled by main controller **20**.

At the bottom surface of coarse movement slider section **91**, a plurality of air bearings **94** is fixed around the magnet unit described above. Coarse movement stage WCS is supported by levitation by the plurality of air bearings **94**, via a predetermined gap (clearance, gap) above base board **12**, such as for example, a gap of about several μm, and is driven in the X-axis direction, the Y-axis direction and the θz direction by coarse movement stage driving system **51**A.

Incidentally, coarse movement stage driving system **51**A is not limited to the planar motor of the electromagnetic force (Lorentz force) driving method, and for example, a planar motor of a variable magneto-resistance driving method can also be used. Other than this, coarse movement stage driving system **51**A can be structured by a magnetic levitation type planar motor, and the planar motor can driving coarse movement stage ottom surface of coarse movement slider section **91**, a magnet unit corresponding to the coil unit placed inside

WCS in directions of six degrees of freedom. In this case, the air bearings will not have to be arranged at the bottom surface of coarse movement slider section **91**.

Each of the pair of stator sections **93***a*, **93***b*, for example, consists of a member having an outer shape that is a rectangular plate shape, and inside each member, coil units CUa, CUb consisting of a plurality of coils are housed. The magnitude and direction of the electric current supplied to each coil structuring coil units CUa, CUb is controlled by main controller **20**.

Fine movement stage WFS, as is shown in FIG. **2**B, for example, is equipped with a main section **81** consisting of a low-height columnar member having an octagonal shape in a planar view, a pair of mover sections **82***a*, **82***b* each fixed to one end and the other end in the X-axis direction of a main section **81**, and a wafer table WTB consisting of a rectangular plate-shaped member when viewed from above, which is integrally fixed to the upper surface of main section **81**.

Main section **81** is preferably made of a material having a thermal expansion coefficient is the same or around the same level as that of wafer table WTB, and the material is preferably a material having a low thermal expansion coefficient.

Here, although it is omitted in the drawing in FIG. **2**B, at main section **81**, a plurality of (for example, three) vertical-motion pins **140** (refer to FIG. **4**) being vertically movable is provided, which are inserted into through holes which are not shown formed in wafer table WTB (and in a wafer holder which is not shown). At the upper surface of each of the three vertical-motion pins **140**, an exhaust opening (not shown) is formed for vacuum exhaust. Further, each of the three vertical-motion pins **140** has the lower end surface fixed to the upper surface of a platform member **141**. Each of the three vertical-motion pins **140** is placed at a position which is almost the vertex of an equilateral triangle in a planar view on the upper surface of platform member **141**. The exhaust openings formed at each of the three vertical-motion pins **140** communicates with a vacuum pump (not shown), via an exhaust pipeline formed inside vertical-motion pin **140** (and platform member **141**) and a vacuum exhaust piping which is not shown. Platform member **141** is connected to a driver **142**, via a shaft **143** fixed at the center of the lower surface. That is, the three vertical-motion pins **140** are driven in the vertical direction by driver **142**, integrally with platform member **141**. In the present embodiment, platform member **141**, the three vertical-motion pins **140** and shaft **143** structure a wafer center supporting member (hereinafter shortened to a center supporting member) **150**, which can support from below a part of a center section area of the wafer lower surface. Here, displacement in the Z-axis direction from a reference position of the three vertical-motion pins **140** (center supporting member **150**) is detected by a displacement sensor **145** (not shown in FIG. **4**, refer to FIG. **6**), such as, for example, the encoder system provided at driver **142**. Main controller **20**, based on measurement values of displacement sensor **145**, drives the three vertical-motion pins **140** (center supporting member **150**) in the vertical direction via driver **142**.

Referring back to FIG. **2**B, each of pair of mover sections **82***a*, **82***b* has a housing whose YZ section is a rectangular frame shape, which is fixed, respectively, to a surface at one end and a surface at the other end in the X-axis direction of main section **81**. Hereinafter, for the sake of convenience, the housings will be described as housings **82***a*, **82***b* using the same reference signs as mover sections **82***a*, **82***b*.

Housing **82***a* has an opening section formed whose YZ section is a rectangular shape elongate in the Y-axis direction, with the Y-axis direction dimension (length) and the Z-axis direction dimension (height) both slightly longer than stator section **93***a*. In the opening section of housings **82***a*, **82***b*, the end on the −X side of stator section **93***a* of coarse movement stage WCS is inserted in a non-contact manner. Inside an upper wall section $82a_1$ and a bottom wall section $82a_2$ of housing **82***a*, magnet units MUa_1, MUa_2 are provided.

Mover section **82***b* is structured in a similar manner, although the structure is symmetrical to mover section **82***a*. In the hollow section of housing (mover section) **82***b*, the end on the +X side of stator section **93***b* of coarse movement stage WCS is inserted in a non-contact manner. Inside an upper wall section $82b_1$ and bottom wall section $82b_2$ of housing **82***b*, magnet units MUb_1, MUb_2 are provided, which are structured similarly to magnet units MUa_1, MUa_2.

Coil units CUa, CUb described above are housed, respectively, inside stator sections **93***a* and **93***b* so that the units face magnet units MUa_1 MUa_2 and magnet units MUb_1, MUb_2.

The structure of magnet units MUa_1, MUa_2 and magnet units MUb_1, MUb_2, and coil units CUa, CUb, is disclosed in detail, for example, in U.S. Patent Application Publication No. 2010/0073652, U.S. Patent Application Publication No. 2010/0073653 and the like.

In the present embodiment, fine movement stage driving system **52**A (refer to FIG. **6**) in which fine movement stage WFS is supported by levitation in a non-contact state with respect to coarse movement stage WCS and is also driven in a non-contact manner in directions of six degrees of freedom is structured similarly to the U.S. Patent Application Publication No. 2010/0073652 and the U.S. Patent Application Publication No. 2010/0073653 described above, including the pair of magnet units MUa_1, MUa_2 that mover section **82***a* previously described has and coil unit CUa that stator section **93***a* has, and the pair of magnet units MUb_1, MUb_2 that mover section **82***b* has and coil unit CUb that stator section **93***b* has.

Incidentally, in the case of using the magnetic levitation type planar motor as coarse movement stage driving system **51**A (refer to FIG. **6**), because fine movement stage WFS can be finely driven in the Z-axis direction, the θx direction and the θy direction integrally with coarse movement stage WCS by the planar motor, fine movement stage driving system **52**A can be structured so that fine movement stage WFS is drivable in the X-axis direction, the Y-axis direction and the θz direction, or that is, in directions of three degrees of freedom in the XY plane. Other than this, for example, to each of the pair of side wall sections **92***a*, **92***b* of coarse movement stage WCS, a pair of electromagnets each can be provided facing the oblique side of the octagonal shape of fine movement stage WFS, and facing each electromagnet a magnetic body member can be provided at fine movement stage WFS. With this arrangement, since fine movement stage WFS can be driven in the XY plane by the magnetic force of the electromagnet, this allows a pair of Y-axis linear motors to be structured by mover sections **82***a*, **82***b* and stator sections **93***a*, **93***b*.

In the center on the upper surface of wafer table WTB, wafer W is fixed by vacuum suction or the like, via a wafer holder provided at a hold section of the wafer such as a pin chuck which is not shown or the like. While the wafer holder may be formed integral with wafer table WTB, in present embodiment, the wafer holder and wafer table WTB are structured separately, and the wafer holder is fixed in a recess section of wafer table WTB, for example, by vacuum chucking or the like. Further, on the upper surface of wafer table WTB, as is shown in FIG. **2**A, a plate (liquid-repellent plate) **28** is provided that has a surface (liquid-repellent surface), substantially flush to the surface of the wafer mounted on the wafer holder, to which liquid-repellent processing with respect to liquid Lq is applied, also has a rectangular outer shape (contour) with a circular opening one-size larger than the wafer holder (mounting area of the wafer) formed in the center section. Plate **28** consists of a material having a low thermal expansion coefficient, such as for example, glass or ceramics (for example, Zerodur (brand name) of Schott Corporation, Al_2O_3, TiC or the like), and to its surface, liquid-repellent processing with respect to liquid Lq is applied. To be more specific, the liquid-repellent film is formed, for example, by a fluorine-based resin material such as fluororesin material, polytetrafluoroethylene (Teflon (registered trademark)), an acrylic-based resin material, a silicon-based resin material, or the like. Incidentally, plate **28** is fixed to the upper surface of wafer table WTB, so that the entire (or a part of the) surface is flush with the surface of wafer W.

Near the end on the +Y side of plate **28**, a measurement plate **30** is provided. At this measurement plate **30**, a first fiducial mark FM is provided in the center positioned on a center line CL of wafer table WTB, and a pair or second reference marks RM used for reticle alignment is provided with the first fiducial mark FM arranged in between.

On wafer table WTB, as is shown in FIG. **2**A, a plurality of (for example, three) reflection mirrors **86** are provided near the wafer holder. The three reflection mirrors **86** are placed so that one is placed at a position near the −Y side of the wafer holder (a position where a notch of wafer faces, coinciding on center line CL, that is, a position in a six o'clock direction with respect to the center of wafer W in a planar view), and one each is placed symmetrical to center line CL, in a five o'clock direction and in a seven o'clock direction with respect to the center of wafer W in a planar view. Incidentally, in FIG. **2**A, for the sake of convenience in the drawings, while reflection mirrors **86** are illustrated on the outer side of the circular opening of the wafer plate, the mirrors are actually placed at a border section of the circular opening of plate **28** and the wafer holder, within the gap between plate **28** and wafer W. Below these reflection mirrors **86**, a porous body is provided, and liquid Lq remaining on wafer table WTB that could not be recovered by liquid recovery device **6** is recovered, via the porous body.

To each of the −Y end surface and the −X end surface of wafer table WTB, mirror polishing is applied, and a reflection surface **17***a* and a reflection surface **17***b* are formed, as is shown in FIG. **2**A.

Measurement stage MST, as is shown in FIG. **3**, is equipped with a stage main section **60**, and measurement table MTB mounted on stage main section **60**.

At the bottom surface of stage main section **60**, although it is not shown, a magnet unit consisting of a plurality of permanent magnets is provided, which structures a measurement stage driving system **51**B (refer to FIG. **6**) consisting of a planar motor that employs an electromagnetic force (Lorentz force) driving method, along with the coil unit (coil **17**) of base board **12**. At the bottom surface of stage main section **60**, a plurality of air bearings (not shown) is fixed, in the periphery of the magnet unit. Measurement stage MST, by the air bearings previously described, is supported in a levitated manner above base board **12** via a predetermined clearance gap (gap, clearance), such as for example, a clearance gap of around several μm, and is driven in the X-axis direction and the Y-axis direction by measurement stage driving system **51**B. Incidentally, measurement stage MST can be structured, having a coarse movement stage driven in directions of three degrees of freedom in the XY plane, and a fine movement stage driven in the remaining three degrees of freedom with respect to the coarse movement stage (or in six degrees of freedom). Incidentally, in the case measurement stage driving system **51**B is structured using the magnetic levitation type planar motor, for example, the measurement stage can be a single stage which is movable in directions of six degrees of freedom.

Measurement table MTB consists of a member having a rectangular shape in a planar view. At measurement table MTB, various kinds of measurement members are provided. As such measurement members, for example, an illuminance irregularity sensor **88** having a pin-hole shaped light receiving section which receives illumination light IL on the image plane of projection optical system PL, an aerial image measuring instrument **96** which measures light intensity of an aerial image projection image) of a pattern projected by projection optical system PL, and a wavefront aberration measuring instrument **89** are employed. As the illuminance irregularity sensor, a sensor having a structure similar to the one disclosed in, for example, U.S. Pat. No. 4,465,368 and the like can be used. Further, as the aerial image measuring instrument, an instrument having a structure similar to the one disclosed in, for example, U.S. Patent Application Publication No. 2002/0041377 and the like can be used. Further, as the wavefront aberration measuring instrument, an instrument having a structure similar to the one disclosed in, for example, PCT International Publication No. 03/065428 (corresponding U.S. Pat. No. 7,230,682) and the like can be used. Incidentally, adding to each sensor described above, an illuminance monitor can be employed having a light receiving section of a predetermined area which receives illumination light IL on the image plane of projection optical system PL, whose details are disclosed in, for example, U.S. Patent Application Publication No. 2002/0061469 and the like.

Incidentally, in the present embodiment, the surface of measurement table MTB (the measurement members previously described can be included) is also covered with a liquid-repellent film (water-repellent film).

Mirror polishing is applied to each of the +Y side surface and the −X surface of measurement table MTB, and a reflection surface **95***a* and a reflection surface **95***b* is formed similar to wafer table WTB described above.

Next interferometer system **70** which measures position information of wafer stage WST and measurement stage MST will be described.

Interferometer system **70** (refer to FIG. **6**) includes a plurality of interferometers that measure position information of wafer stage WST (wafer table WTB) or measurement stage MST (measurement table MTB), or to be more specific, two Y interferometers **16** and **19**, and four X interferometers **136**, **137**, **138** and **139** and the like. In the present embodiment, as each interferometer described above, a multi-axis interferometer having a plurality measurement axes is used except for a part of the interferometers.

Y interferometer **16**, as is shown in FIGS. **1** and **3**, irradiates measurement beams B4_1 and B4_2 on reflection surface **17***a* of wafer table WTB, along measurement axes in the Y-axis direction which are apart by the same distance to the −X side and the +X side from a straight line (hereinafter, called a reference axis) LV (refer to FIG. **3**) parallel to the Y-axis that passes through a projection center (optical AX, refer to FIG. **1**) of projection optical system PL, and receives the reflected lights. Further, Y interferometer **16** irradiates a measurement beam B**3** toward reflection surface **17***a*, along a measurement axis (for example, a measurement axis on reference axis LV) which is parallel to the Y-axis and is between measurement beams B4_1 and B4_2 with a predetermined spacing in the Z-axis direction, and receives measurement beam B**3** reflected off reflection surface **17***a*.

Y interferometer **19** irradiates two measurement beams B2_1 and B2_2, for example, along measurement axes in the Y-axis direction which are the same distance to the −X side and the +X side from reference axis LV, on reflection surface **95***a* of measurement table MTB, and receives each of the reflected lights.

X interferometer **136**, as is shown in FIG. **3**, irradiates measurement beams B5_1 and B5_2 along two measurement axes which are the same distance apart with respect to a straight line (reference axis) LH in the X-axis direction and passes the optical axis of projection optical system PL, on reflection surface **17***b* of wafer table WTB, and receives each of the reflected lights.

X interferometer **137**, as is shown in FIG. **3**, irradiates a measurement beam B**6** along a straight line LA, which passes through a detection center of a primary alignment system AL**1** to be described later and is parallel to the X-axis, on reflection surface **17***b* of wafer table WTB, and receives the reflected light.

X interferometer **138** irradiates a measurement beam B**7** along a straight line LUL, which passes through loading position LP where loading of the wafer is performed and is parallel to the X-axis on reflection surface **17***b* of wafer table WTB, and receives the reflected light.

X interferometer **139** irradiates a measurement beam parallel to the X-axis with respect to reflection surface **95***b*, and receives the reflected light.

Measurement values (measurement results on position information) of each interferometer of interferometer system **70** are supplied to main controller **20** (refer to FIG. **6**). Main controller **20** obtains position information related to the Y-axis direction, θx direction and the θz direction of wafer table WTB, based on the measurement values of Y interferometer **16**. Further, main controller **20** obtains position information related to the X-axis direction of wafer table WTB, based on the output of X interferometers **136**, and either **137** or **138**. Incidentally, main controller **20** can obtain the position information related to the θz direction of wafer table WTB, based on the measurement values of X interferometer **136**.

Further, main controller **20** obtains position information related to the X-axis direction, the Y-axis direction, and the θz direction of measurement table MTB (measurement stage MST), based on measurement values of Y interferometer **19** and X interferometer **139**.

Other than these sections, interferometer system **70** is equipped with a Z interferometer system, in which a pair of Z interferometers that irradiate a pair of measurement beams set apart in the Z-axis direction and parallel to the Y-axis on a pair of fixed mirrors, via a vertical pair of reflection surfaces of a movable mirror fixed to a side surface on the −Y side of coarse movement stage WCS, and receive return lights from the pair of fixed mirrors via the reflection surfaces, is placed away from reference axis LV by the same distance to the −X side and to the +X side. Based on measurement values of the Z interferometer system, main controller **20** obtains position information of wafer stage WST related to directions of at least three degrees of freedom including, the Z-axis direction, the θy direction and the θz direction.

Incidentally, a detailed structure and an example of details of a measurement method for interferometer system **70** are disclosed in detail, for example, in U.S. Patent Application Publication No. 2008/0106722 and the like.

While an interferometer system was used in the present embodiment to measure information related to the position of wafer stage WST or measurement stage MST, a different means can be used. For example, it is also possible to use an encoder system such as the one described in U.S. Patent Application Publication No. 2010/0297562.

Referring back to FIG. **1**, measurement section **300** is equipped with an alignment system device **99** attached to a lower surface of mainframe BD, and other measurement systems.

Alignment system device **99** includes five alignment systems shown in FIG. **3**, AL**1** and AL$\mathbf{2}_1$ to AL$\mathbf{2}_4$. To describe this in detail, primary alignment system AL**1** is placed in a state where its detection center is positioned passing through the center of projection unit PU (optical axis AX of projection optical system PL, also coincides with the center of exposure area IA previously described in the present embodiment) and on reference axis, at a position apart by a predetermined distance to the −Y side from optical axis AX. On one side and the other side in the X-axis direction with primary alignment system AL**1** in between, secondary alignment systems AL$\mathbf{2}_1$,AL$\mathbf{2}_2$ and AL$\mathbf{2}_3$,AL$\mathbf{2}_4$ are provided, respectively, with the detection centers placed almost symmetrically to reference axis LV. That is, the five alignment systems AL**1** and AL$\mathbf{2}_1$ to AL$\mathbf{2}_4$ are placed, with their detection centers arranged along the X-axis direction. Incidentally, in FIG. **1**, the systems are shown as alignment system device **99**, including the five alignment systems AL**1** and AL$\mathbf{2}_1$ to AL$\mathbf{2}_4$ and the holding devices that hold these systems.

As each of the five alignment systems AL**1** and AL$\mathbf{2}_1$ to AL$\mathbf{2}_4$, for example, an FIA (Field Image Alignment) system of an image processing method is used, in which a broadband detection beam that does not sensitize the resist on the wafer is irradiated on a subject mark, an image of the subject mark formed on the light-receiving plane by a reflected light from the subject mark and an image of an index (an index pattern on an index plate provided in each alignment system) which is not shown are formed using an image-forming element (CCD or the like), **99** is disclosed in, for example, U.S. Patent Application Publication No. 2009/0233234.

Carry-in unit **121** (refer to FIG. **1**) structuring a part of carrier system **120** is a unit for holding the wafer before exposure above loading position LP prior to the loading onto wafer table WTB, and for loading the wafer onto wafer table WTB. Further, the carry-out unit which is not shown is a unit for unloading the wafer after exposure from wafer table WTB.

Carry-in unit **121**, as is shown in FIGS. **3** and **4**, has a chuck unit **153** consisting of a circular plate-like member in a planar view (when viewed from above) that suctions wafer W from above in a non-contact manner, a plurality of, for example, a pair of Z voice coil motors **144** which drives chuck unit **153** in a vertical direction, a plurality of, for example, a pair of weight-cancelling devices **131** which supports the self-weight of chuck unit **153**, a pair of wafer support members **125** which supports from below wafer W suctioned by chuck unit **153**, and the like.

Chuck unit **153** as is shown in FIG. **4**, is equipped with, for example, a plate member (plate) **44** of a predetermined thickness having a circular shape in a planar view, and a plurality of chuck members **124** embedded at predetermined places at the lower surface of plate member **44**. Here, inside of plate member **44**, piping and the like are provided, and by a liquid adjusted to a predetermined temperature flowing in the piping, the plate member also serves to function as a and imaging signals are output. The imaging signals from the five alignment systems AL**1** and AL$\mathbf{2}_1$ to AL$\mathbf{2}_4$ are supplied to main controller **20** (refer to FIG. **6**). Incidentally, a detailed structure of alignment system device

cooling plate to control the temperature of the wafer to a predetermined temperature. However, plate member **44** does not necessarily have to function as a cooling plate as well.

In the present embodiment, as is shown in FIG. **5** which is a planar view of chuck unit **153** when viewed from the −Z direction, plate member **44** is two members, a disc-shaped first member **44**A and a concentric ring-shaped second member **44**B placed on the outer side of the first member, that are integrally structured. However, the two members do not necessarily have to be placed concentrically. Further, the plate member does not necessarily have to be structured by two members.

At the lower surface of the ember **44**A, chuck member **124** is placed at a plurality of (for example, nineteen) points, at a point on its center (center point), and on points spaced equally apart on a virtual double concentric circle with the point serving as the center. To describe this in detail, on the virtual circle on the inner side, chuck member **124** is placed at six points with the central angle thereof set to 60 degrees, and on the virtual circle on the outer side, chuck member **124** is placed spaced apart at twelve points with the central angle thereof set to 30 degrees, the points including six points which are on straight lines joined from the point at the center to the six points described above. The lower surface of each of the plurality of, or a total of nineteen, chuck members **124**, is embedded into the lower surface of plate member **44** (refer to FIG. **4**), in a state flush with the lower surface of plate member **44**. Incidentally, the placement of the chuck members is not limited to this, and the chuck members do not necessarily have to be equally spaced.

Each chuck member **124** consists of a so-called Bernoulli chuck. Bernoulli chuck, as is well known, is a chuck that uses the Bernoulli effect to locally increase the flow velocity of fluid (for example, air) which is blowing out to suction the target object (hold in a non-contact manner)). Here, the Bernoulli effect is an effect in which the pressure of fluid decreases when the flow velocity increases, and with the Bernoulli chuck, the suction state (holding/floating state) is decided by the weight of the target object subject to suction (hold, fix), and the flow velocity of fluid blowing out from the chuck. That is, in the case the size of the target object is known, the size of the gap between the chuck and the target object subject to hold upon the suction is decided, according to the flow velocity of the fluid blowing out from the chuck. In the present embodiment, chuck member **124** is used to suction wafer W by blowing out gas from its gas flow hole (for example, a nozzle or a blowout port) or the like to generate a flow of gas (gas flow) in the periphery of wafer W. The degree of the force of suction (that is, the flow velocity and the like of the gas blowing out) is appropriately adjustable, and by holding wafer W by suction with chuck member **124**, movement in the Z-axis direction, the θx direction and the θy direction can be restricted.

With the plurality (nineteen) chuck members **124** at least one of flow velocity, flow amount, and direction of blowout (blowout direction of the gas) or the like of the gas blowing out from each of the chuck members is controlled by main controller **20**, via an adjustment device **115** (refer to FIG. **6**). This allows the suction force of each chuck member **124** to be set individually to an arbitrary value. Incidentally, the plurality of (nineteen) chuck members **124** can be structured so that the suction can be set for each group decided in advance. Incidentally, main controller **20** can control the temperature of the gas.

In the first member **44**A, as is shown in FIG. **5**, a plurality of through holes **152** having a small width (elongated) is formed, surrounding each of the plurality of chuck members **124**. To be more specific, a part of the plurality of through holes **152** is placed so as to structure each side of a hexagon surrounding each of the seven chuck members **124** that exclude the twelve chuck members **124** positioned at the outer circumference section. The remaining parts of through holes **152** are placed surrounding half of the center section side of the twelve chuck members **124** positioned at the outer circumference section, along with some of the part of the through holes **152**. The fluid (for example, air) blown out toward wafer W from chuck members **124** when wafer W is suctioned with chuck members **124** in the manner described later on, is exhausted outside (above chuck unit **153**) via through hole **152**.

Near the inner circumference section of the second member **44**B, plurality of (for example, twelve) through holes **154** are formed on the outer side of each of the twelve chuck members **124** positioned at the outer circumference section of the first member **44**A. Inside each through hole **154**, a porous bearing **156** is provided consisting of a ceramic porous body. A plurality of (for example, twelve) porous bearings **156** are each connected to a gas supply device **48** (refer to FIG. **6**) consisting of, for example, a compressor or the like via a piping (not shown). Upon suction of wafer W to be described later on by chuck unit **153**, gas (for example, pressurized air) supplied from gas supply device **48** blows out downward (toward wafer W) from each porous bearing **156** so as to prevent wafer W from coming into contact with chuck unit **153**. The pressure, flow amount and the like of gas supplied to each porous bearing **156** are controlled by main controller **20** (refer to FIG. **6**). Incidentally, porous bearings **156** do not have to be provided in chuck unit **153** in the case there is no risk of chuck unit **153** coming into contact with wafer W.

Here, the gas supplied to chuck member **124** is clean air (for example, compressed air), in which at least the temperature is adjusted to a constant level, and dust, particles and the like are removed. That is, wafer W suctioned by chuck member **124** is maintained at a predetermined temperature by the compressed air whose temperature is controlled. Further, the temperature, the degree of cleanliness and the like of the space where wafer stage WST and the like are placed can be maintained to a set range.

To both of the ends in the X axis direction on the upper surface of chuck unit **153**, one end of each of a pair of support plates **151** extending in the X-axis direction within a horizontal plane (XY plane) is connected, as is shown in FIG. **4**.

To the upper surface of each of the pair of extended sections **159** of frame FL previously described, as is shown in FIG. **4**, Z voice coil motor **144** and weight-cancelling device **131** are fixed lined in the X-axis direction. In this case, while weight-cancelling device **131** is placed at the inner side of Z voice coil motor **144**, the arrangement is not limited to this.

And, the other end of each of the pair of support plates **151** is supported from below by weight-cancelling device **131** and Z voice coil motor **144**, which are fixed to the upper surface of each of the pair of extended sections **159**.

Each of the pair of Z voice coil motors **144** drives chuck unit **153** in the vertical direction with predetermined strokes (in a range including a first position where chuck unit **153** begins suction of wafer W, and a second position where wafer W suctioned by chuck unit **153** is mounted on the wafer holder wafer table WTB)). Each of the pair of Z voice coil motors **144** is controlled by main controller **20** (refer to FIG. **6**).

Each of the pair of weight-cancelling devices **131** is equipped with a piston member **133***a* and a cylinder **133***b* at which piston member **133***a* is provided freely slidable. The pressure of the space inside cylinder **113***b*, which is divided by the piston of piston member **133***a* and cylinder **133***b*, is set to a value according to the self-weight of chuck unit **153**. The upper end of the rod section of piston member **133***a* is joined to the lower surface of support plate **151**. Each of the pair of weight-cancelling devices **131** is type of pneumatic spring device which gives a force in an upward direction (+Z direction) to support plate **151** via piston member **133***a*, and this force allows the pair of weight-cancelling devices **131** to support all or a part of the self-weight of chuck unit **153** (and support plate **151**). The pressure, amount and the like of the pressurized gas supplied to the inside of cylinder **133***b* of weight-cancelling device **131** are controlled by main controller **20** (refer to FIG. **6**). Here, because weight-cancelling device **131** is equipped with piston member **133***a* which moves in the vertical direction along cylinder **133***b*, weight-cancelling device **131** also functions as a guide upon vertical movement of chuck unit **153***a*.

Each of the pair of wafer support members **125** is equipped with a vertical movement rotation driving sect ion **127** attached integrally via a coupling member which is not shown to each of the pair of extended sections **159** of frame FL, a drive shaft **126** which is driven in the Z-axis direction (vertical direction) and the θz direction by vertical movement rotation driving section **127**, and a support plate **128**, which has one end of its upper surface in the longitudinal direction fixed to the lower end surface of drive shaft **126**, extending in an uniaxial direction within the XY plane. Support plate **128** is driven by vertical movement rotation driving section **127**, so that the other end in the longitudinal direction is rotationally driven in the θz direction with drive shaft **126** serving as the rotation center between a first support plate position opposing a part of the outer circumference section of chuck unit **153** and a second support plate position which does not face chuck unit **153**, and is also driven in predetermined strokes in the vertical direction. A suction pad **128***b* is fixed to the upper surface of support plate **128**, near the other end. Suction pad **128***b* is joined to a vacuum device via a piping member which is not shown (the vacuum device and the piping member are each omitted in the drawings). Wafer W, when supported from below by support plate **128** (suction pad **128***b*), is vacuum chucked and held by suction pad **128***b*. That is, a frictional force between wafer W and suction pad **128***b* limits movement of wafer W in the X-axis direction, the Y-axis direction, and the θz direction. Incidentally, the frictional force between wafer W and wafer support member **125** can be used, without suction pad **128***b* being provided.

The first support plate position of each of the support plates **128** is set so that support plate **128** of one of wafer support members **125**, when at the first support plate position, faces the outer circumference edge in the five o'clock direction when viewed from the center of plate member **44** of chuck unit **153**, and support plate **128** of the other wafer support member **125**, when at the first support date position, faces the outer circumference edge in the seven o'clock direction when viewed from the center of plate member **44** of chuck unit **153** (refer to FIG. **3**). To the upper surface of each of the support plates **128**, a reflection mirror **128***a* is fixed, on the drive shaft **126** side of suction pad **128***b*.

A pair of measurement systems **123***a*, **123***b*, which employs a vertical illumination method where an illumination light can be irradiated from above to each of the reflection mirrors **128***a* on each of the support plates **128** when each of the pair of support plates **128** is at the first support plate position, is provided near the pair of wafer support members **125**. Each of the pair of measurement systems **123***a*, **123***b* is joined to mainframe BD, via a support member which is not shown.

Each of the pair of measurement systems **123***a*, **123***b* is an edge position detection system which employs an image processing method to detect position information of the edge section of wafer W, the system including an illumination light source, a plurality of optical path bending members such as reflection mirrors, lenses or the like, imaging devices such as CCDs and the like.

In carry-in unit **121**, another reflection mirror **34** is further provided (refer to FIG. **3**) at a position of a predetermined height facing the outer circumference edge in a six o'clock direction when viewed from the center of plate member **44** of chuck unit **153** (at a position which can face the notch of wafer W when wafer W is suctioned by chuck unit **153**). A measurement system **123***c* (refer to FIG. **6**) is provided, which employs a vertical illumination method in which an illumination light can be irradiated from above with respect to reflection mirror **34**. Measurement system **123***c* is structured in a similar manner as measurement systems **123***a*, **123***b*.

When edge detection of wafer W is performed by each of the three measurement systems **123***a* to **123***c*, imaging signals are to be sent to a signal processing system **116** (refer to FIG. **6**).

Carry-in unit **121** is furthermore equipped with a wafer flatness detection system **147** (refer to FIG. **6**), and a plurality of chuck unit position detection systems **148** (refer to FIGS. **4** and **6**).

Wafer flatness detection system **147** is structured by a plurality of, or in this case, four Z position detection systems **146** (refer to FIG. **4**) which detects a position (Z position) in the Z-axis direction of the wafer W surface at a plurality of places of mainframe BD each placed at, for example, three places above wafer W near the outer circumference section, and one place above the wafer near the center section vicinity. In the present embodiment, as Z position detection system **146**, a position detection system employing a triangulation method which is a type of a so-called optical displacement meter is used, which receives a reflected light of a measurement beam irradiated on a target object and detects the position (the Z position in the present embodiment) of the target object. In the present embodiment, at each Z position detection system **146**, a measurement beam is irradiated on the wafer W upper surface via through hole **152** (refer to FIG. **5**) previously described, and receives the reflected light via another through hole **152**.

Measurement values of the plurality of Z position detection systems **146** structuring wafer flatness detection system **147** are sent to main controller **20** (refer to FIG. **6**). Main controller **20**, based on the measurement values of the plurality of Z position detection systems **146**, detects the Z position at the plurality of places on the wafer W upper surface, and obtains the flatness of wafer W from the detection results.

A plurality of (for example, three) chuck unit position detection systems **148** is fixed to mainframe BD. As each of the chuck unit position detection systems **148**, a position detection system of a triangulation method similar to Z position detection system **146** is used. By the three chuck unit position detection systems **148**, the Z position of the plurality of places on the upper surface of chuck unit **153** is detected, and the detection results are sent to main controller **20** (refer to FIG. **6**).

Although it is not shown in FIG. **1**, above reticle R, a pair of reticle alignment system detection systems **14** (refer to FIG. **6**) is placed, which employs a TTR (Through The Reticle) method using an exposure wavelength to simultaneously observe a pair of reticle alignment marks on reticle R and an image via projection optical system PL of the pair of the second reference marks RM on measurement plate **30** on wafer table WTB corresponding to the reticle alignment marks. Detection signals of the pair of reticle alignment system detection systems **14** are supplied to main controller **20**.

Other than this, in exposure apparatus **100**, near projection optical system PL, an irradiation system which irradiates a plurality of measurement beams on the surface of wafer W via Lq of liquid immersion area **36**, and a multi-point focal point detection system **54** (refer to FIG. **6**) (hereinafter referred to as a multi-point AF system) consisting of a light-receiving system which receives the reflection beams of each measurement beam via liquid Lq are provided. As such a multi-point AF system **54**, a multi-point focal point detection system having a structure, in which an irradiation system and a light-receiving system each include a prism and both use the tip lens of projection optical system PL as their constituent element, as is disclosed in, for example, U.S. Patent Application Publication No. 2007/0064212, can be used.

FIG. **6** is a block diagram showing an input/output relation of main controller **20**, which mainly structures a control system of exposure apparatus **100** and has overall control of each section. Main controller **20** includes a workstation (or a microcomputer) or the like, and has overall control of each section structuring exposure apparatus **100**.

In exposure apparatus **100** related to the present embodiment structured in the manner described above, under the control of main controller **20**, similarly to the exposure apparatus disclosed in, for example, U.S. Pat. No. 8,0544,472 and the like, a parallel processing operation is performed using wafer stage WST and measurement stage MST. In exposure apparatus **100** of the present embodiment, on wafer W loaded (carry-in) on wafer stage WST as it will be described later on and held by wafer table WTB, liquid immersion area **36** is formed using local liquid immersion device **8**, and exposure operation of the wafer is performed using illumination light IL, via projection optical system PL and liquid Lq of liquid immersion area **36**. This exposure operation is performed by repeating a moving operation between shots, in which wafer stage WST is moved to a scanning starting position (acceleration starting position) for exposure of each shot area on wafer W, and a scanning exposure operation, in which the pattern of reticle R is transferred by the scanning exposure method onto each shot area, based on results of wafer alignment (EGA) by alignment systems AL**1**, and $AL2_1$ to $AL2_4$ of alignment system device **99**, the latest base line of alignment system AL**1**, and $AL2_1$ to $AL2_4$ and the like, performed in advance by the main controller. Further, on the parallel processing operation described above, the liquid immersion area is to be held on measurement stage MST during wafer exchange, and when wafer stage WST is placed right under projection unit PU on the exchange with measurement stage, the liquid immersion area on measurement stage MST is moved onto wafer stage WST.

However, in the present embodiment, different from the exposure apparatus disclosed in, U.S. Pat. No. 8,054,472 described above, position information of wafer stage WST and position information of measurement stage MST are measured using each interferometer of interferometer system **70**, during the parallel processing operation using wafer stage WST and measurement stage MST. Further, reticle alignment is performed, using the pair of reticle alignment system detection systems **14** (refer to FIG. **6**), measurement plate **30** on wafer stage WST (refer to FIG. **2**A), and the like. Furthermore, control in the Z-axis direction of wafer table WTB during exposure is performed in a real-time manner using multi-point AF system **54** previously described.

Incidentally, as is with the exposure apparatus disclosed in, U.S. Pat. No. 8,054,472 described above, a multi-point AF system consisting of an irradiation system and a light-receiving system can be placed in between alignment system device **99** and projection unit PU, instead of multi-point AF system **54**. And, the Z position of the entire surface of wafer W can be acquired using the multi-point AF system while wafer stage WST is moving on wafer alignment, and position control the Z-axis direction of wafer stage WST during exposure can be performed, based on the Z position of the entire surface of wafer W acquired during the alignment. In this case, another measurement device has to be provided for measuring the Z position of the wafer table WTB upper surface on wafer alignment and on exposure.

Next, a procedure for loading wafer W will be described based on FIGS. **7**A to **9**B. Incidentally, in FIGS. **7**A to **9**B, to simplify the drawings and to prevent complication of the drawings, wafer stage WST, wafer flatness detection system **147** and chuck unit position detection system **148** and the like are omitted, except for mainframe BD, vertical movement pin **140** and the like.

As a premise, for example, chuck unit **153**, as is shown in FIG. **7**A, is moved near a movement upper limit position (movement limit position at the +Z side) within the stroke range by the pair of Z voice coil motors **144**, or in other words, moved to the first position previously described, and is maintained at the position. Further, at this point, the pair of wafer support members **125** is to have each of their support plates **128** set to the second support plate position by main controller **20**.

In this state, first of all, carry-in of wafer W to an area below chuck unit **153** is performed, in a state where wafer W is supported from below by carrier arm **149**. Here carry-in of wafer W to loading position LP by carrier arm **149** can be performed when exposure processing on a previous wafer subject to exposure (hereinafter called a previous wafer) is being performed on wafer stage WST, or when alignment processing or the like is being performed.

Next, as is shown in FIG. **7**B, main controller **20** begins to supply fluid (air) to the plurality of chuck members **124**, and then by driving carrier arm **149** slightly upward (or by driving chuck unit **153** slightly downward), wafer W is suctioned by chuck unit **153** (chuck member **124**) in a non-contact manner while maintaining a predetermined distance (gap). Incidentally, in FIG. **7**E, to simplify the description, wafer W is to be suctioned by chuck unit **153** by a flow of air blow out indicated by blackened dots in the drawing (to be more precise, by a negative pressure caused by the flow). The same applies to each drawing in FIGS. **7**C to **9**A. However, the state of the air actually blown out is not necessarily limited to this.

Next, main controller **20** drives (rotates) support plates **128** of the pair of wafer support members **125** so as to position each support plate at its first support plate position, via vertical movement rotation driving section **127**. On this operation, as is shown FIG. **7**C, by vertical movement rotation driving section **127** of the pair of wafer support members **125**, suction pads **128***b* on the upper surface of each of the support plates **128** are moved to positions facing the lower surface (rear surface) of wafer W. Further, in the state where the support plates **128** of the pair of wafer support member **125** are positioned at each of their first support plate positions, reflection mirrors **128***a* are each facing predetermined positions at the outer circumference edge on the rear surface of wafer W. Further, at the notch position on the rear surface of wafer W, another reflection mirror **34** faces the notch position at the stage when wafer W is suctioned by chuck unit **153**.

When suction pads **128***b* on the upper surface of each of the support plates **128** face wafer W, main controller **20**, as is shown in FIG. **7**D, controls vertical movement rotation driving section **127** so as to drive support plate **128** upward. And when suction pads **128***b* on the upper surface of each of the support plates **128** and the lower surface of wafer W come into contact, main controller **20** begins vacuum suction by the pair of suction pads **128***b*, and supports the lower surface of wafer W by suction by each of the suction pads **128***b*. On this operation, movement of wafer W is restricted in directions of three degrees of freedom, which are the direction, the θx directions, and the θy direction, by the suction from above by chuck unit **153**, as well as in directions of three degrees of freedom, which are the X direction, the Y direction and the θz direction, by the suction support from below by the pair of support plates **128**, which in turn restricts the movement in directions of six degrees of freedom.

The processing sequence of exposure apparatus **100** is decided so that wafer W waits above loading position LP in this state, that is, in a state where suction hold (support) is performed by chuck unit **153** and the pair of wafer support members **125**. In exposure apparatus **100**, while wafer W waits at loading position LP, exposure processing (and alignment processing prior to the exposure processing) or the like to the previous wafer held on wafer table WTB is performed. Further, on this operation, vacuum suction of wafer W by carrier arm **149** can be moved to a state where the suction is stopped.

Then, while wafer W is waiting above loading position LP, as is shown in FIG. **8**A, the three measurement systems **123***a* to **123***c* (measurement system **123***c* is not shown. Refer to FIG. **6**) each performs edge detection of wafer W. Imaging signals of the imaging elements that the three measurement systems **123***a* to **123***c* have are sent to signal processing system **116** (refer to FIG. **6**). Signal processing system **116**, by the method disclosed in, for example, U.S. Pat. No. 6,624,433 and the like, detects position information of the wafer, of the three places at the circumferential section including the notch, and obtains positional deviation in the X-axis direction and the Y-axis direction and rotational (θz rotation) error of wafer W. Then, information on the positional deviation and the rotation error is supplied to main controller **20** (refer to FIG. **6**).

Around the beginning of the edge detection of wafer W described above, main controller **20** drives carrier arm **149** downward so as to separate carrier arm **149** and wafer W, and then makes carrier arm **149** withdraw from loading posit on LP.

When exposure processing of the previous wafer is completed, and the previous wafer is unloaded from wafer table WTB by the carry-out device which is not shown, by main controller **20**, wafer stage WST is moved to a position below (loading position LP) chuck unit **153**, via coarse movement stage driving system **51**A. Then, as is shown in FIG. **8**B, main controller **20** drives center support member **150** having the three vertical movement pins **140** upward, via driver **142**. The edge detection of wafer W by the three measurement systems **123***a* to **123***c* is still being continued at this point of time, and main controller **20** finely drives wafer stage WST by the same amount in the same direction as the deviation amount (error) of wafer W, so that wafer W is mounted on a predetermined n on wafer stage WST, based on positional deviation and rotation error information of wafer W.

Then, when the upper surface of the three vertical movement pins **140** comes into contact with the lower surface of wafer W suctioned by chuck unit **153**, main controller **20** stops the upward drive of center support member **150**. This allows wafer W to be held by suction by the three vertical movement pins **140** in a state where the positional deviation and the rotation errors are corrected.

Here, the Z position of wafer W suctioned by chuck unit **153** at the waiting position can be accurately determined to some extent. Accordingly, driving center support member **150** from the reference position by a predetermined amount, main controller **20** can make the three vertical movement pins **140** come into contact with the lower surface of wafer W auctioned by chuck unit **153**, based on measurement results of displacement sensor **145**. However, the arrangement is not limited to this, and an arrangement can be set in advance so that the three vertical movement pins **140** come into contact with the lower surface of wafer W suctioned by chuck unit **153** at the upper limit of the movement position of center support member **150** (the three vertical movement pins **140**).

Then, main controller **20** operates a vacuum pump which is not shown, and begins vacuum suction to the wafer W lower surface by the three vertical movement pins **140**. Incidentally, the suction of wafer W by chuck member **124** is being continued even in this state. By the suction by chuck member **124** and the frictional force due to the support from below of the three vertical movement pins **140**, the movement of wafer W is restricted in directions of six degrees of freedom. Accordingly, no problems occur even when the suction hold of wafer W by support plate **128** of wafer support member **125** is released in this state.

So, when wafer W is supported (held by suction) the three vertical movement pins **140**, main controller **20** separates support plates **128** of the pair of wafer support members **125** from wafer W by driving the support plates downward, after finishing vacuum suction by the pair of suction pads **128***b*, as is shown in FIG. **8**C. Then, each of the support plates **128** is set to the second support plate position, via vertical movement rotation driving section **127**.

Next, as is shown in FIG. **8**D, main controller **20** drives each of the chuck units **153** and the three vertical movement pins **140** (center support member **150**) downward that suctions and support wafer W, via the pair of Z voice coil motors **144** and driver **142**. By this operation, a downward drive of chuck unit **153** and the three vertical movement pins **140** (center support member **150**) begins, while the suction state by chuck unit **153** (chuck member **124**) and the support state by the three vertical movement pins **140** with respect to wafer W are maintained. Here, the drive of chuck unit **153** is performed by main controller **20** driving the pair of Z voice coil motors **144**, based on detection results of the plurality of chuck unit position detection systems **148**.

The drive of chuck unit **153** with the three vertical movement pins **140** (center support member **150**) described above is performed until the lower surface (rear surface) of wafer W comes into contact with a planar wafer mounting surface **41** of wafer table WTB (refer to FIG. **9**A). Here, although wafer mounting surface **41** is actually a virtual flat surface (area) formed by upper end surfaces of multiple pins that the pin chuck provided on wafer table WTB is equipped with, in FIG. **9**A and the like, the upper surface of wafer table WTB is indicated as wafer mounting surface **41**.

Before starting the downward drive and during the downward drive of chuck unit **153** with the three vertical movement pins **140** (center support member **150**) described above, main controller **20** measures the flatness of the wafer W upper surface, via wafer flatness detection system **147** (a plurality of position detection systems **146** (refer to FIG. **4**)). And, of chuck unit **153** and center support member **150**, main controller **20** controls the downward speed of one of the members this case, center support member **150**) superior in responsiveness with respect to the downward speed of the other member (in this case, chuck unit **153**), based on the measurement results of wafer flatness detection system **147**, so that the flatness of wafer W falls within a desired range.

That is, for example, in the case it is detected by wafer flatness detection system **147** that wafer W is deformed in a shape protruding downward (a shape in which the inner circumference section is recessed than the outer circumference section), main controller **20** deceases the downward speed of center support member **150** so that it becomes slower than the driving speed of chuck unit **153**, via driver **142**. When the downward speed of center support member **150** is made slower than the driving speed of chuck unit **153**, the center of the lower surface of wafer W is substantially pushed from below by the three vertical movement pins **140**. Then, when the flatness of wafer W becomes a predetermined value, main controller **20** further drives center support member **150** and chuck unit **153** downward at the same speed (synchronously). In this case, the flatness of wafer W "becomes a predetermined value" means that, for example, wafer W is not completely flat and although the inner circumference section is recessed when compared to the outer circumference section, the shape of the wafer is deformed so that the recess level becomes equal to or less than a level determined in advance.

Further, for example, in the case it is detected by wafer flatness detection system **147** that wafer W is deformed in shape protruding upward (a shape in which the inner circumference section is protruding upward than the outer circumference section), main controller **20** increases the downward speed of center support member **150** so that it becomes faster than the driving speed of chuck unit **153**, via driver **142**. When the downward speed of center support member **150** is made faster than the driving speed of chuck unit **153**, the center of the lower surface of wafer W is substantially pulled downward since the wafer is held by suction by the three vertical movement pins **140**. Then, when the flatness of wafer W becomes the predetermined value described above chuck unit **153**, main controller **20** drives center support member **150** and chuck unit further downward at the same speed (synchronously).

Incidentally, in the present embodiment, while the position in the Z direction of wafer W is detected at a plurality of points of wafer W, and information related to the shape (flatness) of wafer W is obtained from the information related to these positions, other methods can also be used. For example, an image of wafer W can be picked up by a camera or the like, and the information related to the shape (flatness) of wafer W can be obtained from the image information which has been obtained.

In the present embodiment, main controller **20** constantly measures the deformation state (flatness) of wafer W using wafer flatness detection system **147**, from the state in which wafer W is suctioned by chuck unit **153** from an upward direction and is also supported from below by vertical movement pins **140** to the state in which wafer W is held by suction on the wafer holder which is not shown. Therefore, even in the case excessive flatness correction was performed, such as when, for example, wafer W located between chuck unit **153** and the three vertical movement pins **140** has a shape protruding downward and the descending speed of vertical movement pins **140** was made slower than the descending speed of chuck unit **153** so as to adjust the flatness, and as a consequence, wafer W became a shape protruding upward, by increasing the descending speed of vertical movement pins **140** with respect to the descending speed of chuck unit **153**, the flatness of wafer W can be adjusted again to a predetermined value. However, measurement of the deformation state (flatness) of wafer W can also be performed only during a part of a time interval, the interval being from a state where wafer W is suctioned from an upward direction by chuck unit **153** and is also supported from a downward direction by vertical movement pins **140** until wafer W is held by suction on the wafer holder which is not shown (for example, just before coming into contact with wafer mounting surface **41**).

Then, when the lower surface of wafer W comes into contact with the wafer table WTB upper surface (wafer mounting surface **41**) as is shown in FIG. **9**A, main controller **20** stops the high-pressure airflow flowing out from all of the chuck members **124**, via adjustment device **115**, cancels the suction of wafer W by all of the chuck units **153**, and begins the adsorption (suction) of wafer W by the wafer holder which is not shown on wafer table WTB.

Next, as is shown in FIG. **9**B, main controller **20** moves chuck unit **153** upward to a predetermined waiting position (the first position or a position near the first position), via the pair of Z voice coil motors **144**. This completes the loading (carry-in) of wafer W onto wafer table WTB.

Here, when chuck unit **153** is driven upward and stopped (or during the upward drive), main controller **20** performs detection of edge position of wafer W, using the three measurement systems **123***a* to **123***c* previously described. In this case, edge detection of wafer W is performed by measurement beams from measurement systems **123***a*, **123***b*, **123***c* being irradiated on the three reflection mirrors **86** on wafer table WTB, and reflection beams from the reflection mirrors **86** being received by the imaging elements of measurement system **123***a*, **123***b*, **123***c*, imaging signals of the imaging elements that the three measurement systems **123***a* to **123***c* have are sent to signal processing system **116** (refer to FIG. **6**), and information on positional deviation and rotation errors of wafer W is supplied to main controller **20**. Main controller **20** stores the information on positional deviation and rotation errors in a memory as an offset amount, and on wafer alignment, on exposure or the like to be described later on, controls the position of wafer table WTB, taking into account the offset amount described above. Incidentally, because wafer W is mounted on wafer table WTB after being supported by the three vertical movement pins **140**, in a state where edge detection of wafer W is performed during the waiting previously described, and positional deviation and rotation errors obtained as a result are corrected, edge detection of wafer W after wafer W being loaded on wafer table WTB does not necessary have to be performed.

As is described so far, according to carrier system **120** related to the present embodiment exposure apparatus **100** equipped with the system, on loading wafer W onto wafer table WTB, main controller **20** can independently and vertically move chuck unit **153** which suctions wafer W from above and vertical movement pins **140** (center support member **150**) which support wafer W from below. That is, on making wafer W, in which flexure, distortion or the like has occurred, move downward for wafer stage WST to hold by suction, wafer W can be loaded on wafer stage WST in a state where the flatness of wafer W is maintained to a value within a desired range, by controlling the descending speed of center support member **150** (the three vertical movement pins **140**).

Further, in the present embodiment, while a structure was employed where three vertical movement pins **140** (center support member **150**), which were structured to vertically move in an integral manner, were used, the structure is not limited to this. For example, center support member **150** can be structured so that the three vertical movement pins move vertically in an independent manner, and the flatness of wafer W can be made to fall within a desired range by making the three vertical movement pins move vertically in an independent manner, based on measurement results of the flatness of the wafer. Incidentally, the number of vertical movement pins is not limited to three, and the pins can be equal to, less than or more than three.

Further, in carry-in unit **121** which structures a part of carrier system **120** related to the present embodiment, because the self-weight of chuck unit **153** is supported by the pair of weight-cancelling devices **131**, the force when driving chuck unit **153** in the vertical direction can be reduced, and the size of the pair of Z voice coil motors **144** can be reduced.

Further, in carrier system **120** related to the present embodiment, during the loading of wafer W onto wafer stage WST, main controller **20** measures positional deviation and rotation deviation of wafer W via measurement systems **123***a* to **123***c*, and based on the measurement results, wafer stage WST is driven so that positional deviation and rotational deviation of wafer W are corrected. Accordingly, wafer W can be loaded on wafer table WTB with good positional reproducibility.

Further, according to exposure apparatus **100** related to the present embodiment, because exposure to wafer W loaded on wafer table WTB in a state of high flatness and with good positional reproducibility is performed in a step-and-scan method, to each of a plurality of shot areas on wafer W, exposure with good overlay accuracy and without defocus becomes possible, the pattern of reticle R can be transferred on the plurality of shot areas in a favorable manner.

Incidentally, in the embodiment above, considering the point that the three vertical movement pins **140** (center support member **150**) are superior to chuck unit **153** in responsiveness at the time of driving, driver **142** was driven so as to adjust the descending speed of the three vertical movement pins **140** (center support member **150**) to make the flatness of wafer W become a value within a desired range, when wafer W is loaded on wafer stage WST. However, on the contrary, in the case chuck unit **153** is superior to the three vertical movement pins **140** (center support member **150**) in responsiveness at the time of driving, it is desirable to adjust the descending speed of chuck unit **153**. In the case responsiveness at the time of driving is about the same in the three vertical movement pins **140** (center support member **150**) and chuck unit **153**, the descending speed of one of center support member **150** and chuck unit **153**, or both center support member **150** and chuck unit **153** can be adjusted. Further, since the flatness of the wafer only has to be maintained at a predetermined level, the descending speed of one of center support member **150** and chuck unit **153**, or both center support member **150** and chuck unit **153** can be adjusted, regardless of the superiority of responsiveness.

Further, in the embodiment above, while the case has been described where wafer flatness detection system **147** was structured by the plurality of Z position detection systems **146**, the embodiment is not limited to this, and the wafer flatness detection system can be structured using a detection device that irradiates light on the entire upper surface of the wafer and can detect the surface shape. Further, in the case the wafer flatness detection system is structured by the plurality of Z position detection systems similarly to the embodiment described above, as the Z position detection system, the position detection system which employs a triangulation method does not necessarily have to be used. That is, since the wafer flatness detection system only has to be able to detect the flatness (the Z position of a plurality of places) of wafer W, for example, as is shown in FIG. **10**, instead of Z position detection system **146** previously described, a plurality of capacitance sensors **84** can be placed at the lower surface of chuck unit **153**. Because a sensor having a size smaller than Z position detection system **146** can be used for capacitance sensor **84**, capacitance sensor **84** can be placed at places more than the total of four places where the measurement points of the plurality of Z position detection systems **146** were placed, which are, for example, three places at the outer circumference section and one place at the center.

Further, because the chuck unit position detection system only has to measure the Z position of chuck unit **153**, the system is not limited to a position detection system of the triangulation method, and as is shown in FIG. **10**, for example, the chuck unit position detection system can be structured using an encoder system made up of an encoder head **97** and a scale **98**. Or, for example, in at least one of the pair of Z voice coil motors **144**, an encoder can be provided, in which the encoder measures the displacement amount in the Z-axis direction from a reference point of a mover corresponding to its stator, and the chuck unit position detection system can be structured by the encoder. Further, chuck unit position detection system **148** can be structured using the capacitance sensor.

Incidentally, in the embodiment described above, just before wafer W is loaded onto wafer table WTB, gas can be blown out from chuck member **124** toward wafer W at a blowout velocity faster than the blowout velocity so far when wafer W was being suctioned. By this operation, as is shown in FIG. **11**, the pressure between wafer W and chuck member **124** increases, and the outer circumference section of wafer W vibrates (a so-called pneumatic hammer phenomenon occurs). When wafer W is moved further downward in a state where this vibration is occurring, wafer W is mounted on wafer table WTB in a state where a contact area between the outer circumference section at the lower surface of wafer W and the wafer holder upper surface which is not shown is small. That is, because the frictional force between the wafer W lower surface and the wafer holder which is not shown is reduced, on suction hold of wafer W by the wafer holder which is not shown, wafer W is mounted on wafer table WTB in a state where generation of distortion caused by adsorption is suppressed.

Incidentally, in the embodiment described above, while wafer W is mounted on wafer mounting surface **41** of wafer table WTB by chuck unit **153** performing suction of wafer W from above, and chuck unit **153** and the three vertical movement pins **140** being driven downward in a state where the three vertical movement pins **140** perform vacuum suction of the rear surface of wafer W, the structure is not limited to this. For example, instead of the three vertical movement pins **140**, a structure that uses carrier arm **149** can be employed. In this case, carrier arm **149** is to have a structure drivable within a predetermined range also in the vertical direction, in addition to the horizontal direction. And, in a state where vacuum suction of the rear surface of wafer W is performed by carrier arm **149**, the wafer W surface is suctioned by chuck unit **153**, and main controller **20** sets each of the downward speed of chuck unit **153** and carrier arm **149** to a predetermined value, using the detection results of wafer flatness detection system **147**.

Incidentally, it is preferable to form a groove in wafer mounting surface **41** so as to fit carrier arm **149** therein so that carrier arm **149** does not interfere with wafer W when wafer W is mounted on wafer mounting surface **41**, and that wafer W and wafer mounting surface **41** can come into contact with good precision. Then, carrier arm **149** can be made to move in the horizontal direction inside the groove, so that it can be withdrawn from wafer mounting surface **41**.

Further, as another structure, wafer W can be mounted on wafer mounting surface **41** of wafer table WTB without using the three vertical movement pins **140**, after wafer W is delivered to chuck unit **153** from carrier arm **149**. In this case, for example, main controller **20** can control the descending speed of chuck unit **153**, the flow velocity (flow amount) of the fluid blowing out from chuck member **124**, and the direction of the fluid flowing, using the detection results of wafer flatness detection system **147** to preferably set each of the suction forces of chuck unit **153** to a predetermined value. On this operation, in the case the rear surface of wafer W is supported by suction using suction pad **125***b* of wafer support member **125**, similarly to the case of carrier arm **149** previously described, a cutout into which wafer support member **125** fits is preferably formed in wafer mounting surface **41**, so that wafer W and mounting surface **41** can come into contact with good precision. Further, in the case movement of wafer W in the lateral direction (a direction parallel to the mounting surface) does not have to be restricted, a structure can be employed in which wafer W is held by suction only by chuck member **124** without wafer support member **125** being provided, and wafer W is mounted on wafer mounting surface **41** of wafer table WTB. Also on this operation, for example, main controller **20** can control the descending speed of chuck unit **153**, the flow velocity (flow amount) of the fluid blowing out from chuck member **124** and the direction of the fluid flowing, using the detection results of wafer flatness detection system **147** to preferably set each of the suction forces of chuck unit **153** to a predetermined value.

Incidentally, in the embodiment described above, as an example, while liquid immersion exposure apparatus was described in which a liquid immersion space including an optical path of the illumination light was formed between the projection optical system and the wafer, and the wafer was exposed with the illumination light via the liquid between the projection optical system and the liquid immersion space, the embodiment is not limited to this, and the embodiment described above can be applied to a dry-type exposure apparatus which performs exposure of wafer W without the illumination light passing through the liquid (water).

Further, in the embodiment described above and its modified example (hereinafter referred to as the embodiment described above and the like), while the case has been described where the exposure apparatus is a scanning type exposure apparatus of the step-and-scan method or the like, the embodiment is not limited to this, and the embodiment described above can also be applied to a stationary type exposure apparatus such as a stepper. Further, the embodiment described above and the like can also be applied to a reduction projection exposure apparatus of the step-and-stitch method in which a shot area and a shot area are synthesized, an exposure apparatus of the proximity method, a mirror projection aligner or the like. Furthermore, the embodiment described above and the like can also be applied to a multi-stage type exposure apparatus equipped with a plurality of wafer stages, as is disclosed in, for example, U.S. Pat. Nos. 6,590,634, 5,969,441, 6,208,407 or the like.

Further, the projection optical system in the exposure apparatus of the embodiment described above and the like is not limited to a reduction system, and can either be an equal-magnifying or a magnifying system, and projection optical system PL is not limited to a refractive system, and can either be a reflection system or a catadioptric system, and its projection image can either be an inverted image or an erect image. Further, while the shape of the illumination area and the exposure area previously described was a rectangular shape, the embodiments are not limited to this, and for example, the shape can be an arc, a trapezoid, a parallelogram or the like.

Further, the light source of the exposure apparatus related to the embodiment described above and the like is not limited to the ArF excimer laser, and a pulse laser light source such as a KrF excimer laser (output wavelength 248 nm) an F_2 laser (output wavelength 157 nm), an Ar_2 laser (output wavelength 126 nm), or a Kr_2 laser(output wavelength 146 nm), a super high pressure mercury lamp which generates a bright line such as a g-line (wavelength 436 nm), an i-line (wavelength 365 nm), or the like can also be used. Further, a harmonic wave generating device which uses a YAG laser can also be used. As other light sources, as is disclosed in, for example, U.S. Pat. No. 7,023,610, a harmonic wave can also be used as vacuum ultraviolet light, in which a single-wavelength laser beam in the infrared range or the visible range emitted by a DFB semiconductor laser or a fiber laser is amplified by a fiber amplifier doped with, for example, erbium (or both erbium and ytterbium) and wavelength conversion into ultraviolet light is performed using a nonlinear optical crystal.

Further, in the embodiment described above and the like, as illumination light IL of the exposure apparatus, the light is not limited to light having a wavelength of 100 nm or more, and as a matter of course, light having a wavelength less than 100 nm can also be used. For example, the embodiment described above and the like can suitably be applied to an EUV exposure apparatus which uses EUV (Extreme Ultraviolet) light in the soft X-ray region (for example, a wavelength region of 5 to 15 nm). Other than this, the embodiment described above and the like can also be applied to an exposure apparatus which uses a charged particle beam such as an electron beam or an ion beam.

Furthermore, the embodiment described above and the like can also be applied to an exposure apparatus which synthesizes two reticle patterns on a wafer via the projection optical system and performs double exposure almost simultaneously on a shot area on the wafer by performing scanning exposure once, as is disclosed in, for example, U.S. Pat. No. 6,611,316.

Further, the object on which the pattern should be formed (the object subject to exposure on which the energy beam is irradiated) in the embodiment described above and the like is not limited to the wafer, and may be other objects such as a glass plate, a ceramic substrate, a film member, or a mask blank.

The usage of the exposure apparatus is not limited to the exposure apparatus for manufacturing semiconductors, and the embodiments above can be widely applied, for example, to an exposure apparatus for liquid crystals that transfers a liquid crystal display devices pattern onto a square-shaped glass plate, an exposure apparatus for manufacturing an organic EL, a thin film magnetic head, an imaging element (such as a CCD), a micromachine and a DNA chip or the like. Further, the embodiment described above and the like can also be applied to an exposure apparatus that transfers a circuit pattern onto a glass substrate or a silicon wafer for manufacturing a reticle or a mask that is used in not only microdevices such as semiconductor devices, but also used in an optical exposure apparatus, an EUV exposure apparatus, an X-ray exposure apparatus, an electron beam exposure apparatus or the like.

Electronic devices such as semiconductor devices are manufactured through the steps such as; a step for performing function/performance design of a device, a step for making a reticle based on this design step, a step for making a wafer from a silicon material, a lithography step for transferring a pattern of a mask (reticle) onto the wafer by the exposure apparatus (pattern generating device) and the exposure method related to the embodiment described above and the like, a development step for developing the wafer which has been exposed, an etching step for removing by the etching an exposed member of an area other than the area where the resist remains, a resist removing step for removing the resist that is no longer necessary since etching has been completed, a device assembly step (including a dicing process, a bonding process, and a package process), and an inspection step. In this case, in the lithography step, because the device pattern is formed on the wafer, using the exposure apparatus of the embodiment described above and the like and performing the exposure method previously described, a highly integrated device can be manufactured with good productivity.

Incidentally, the disclosures of all publications, PCT International Publications, U.S. Patent Application Publications and U.S. patents related to exposure apparatuses and the like that are cited in the description so far are each incorporated herein by reference.

The invention claimed is:

1. A suction device which suctions a plate-like object, the suction device comprising:

a suction member having an opposing section which opposes an upper surface of the object from above the object, the suction member generating a suction force with respect to the object by blowing out gas from the opposing section onto the upper surface of the object, the suction force supporting the object from above the object without the suction member contacting the upper surface of the object; and

a measurement device located above the object, which obtains information related to a shape of the upper surface of the object suctioned by the suction member.

2. The suction device according to claim **1**, wherein

the suction member makes the suction force act on the upper surface of the object, and

the measurement device obtains information related to a surface shape of the upper surface of the object.

3. The suction device according to claim **2**, wherein

the measurement device measures a spacing between the upper surface of the object and the opposing section of the suction member opposing the upper surface.

4. The suction device according to claim **3**, wherein

the measurement device includes a capacitance sensor.

5. The suction device according to claim **2**, wherein

the measurement device has a plurality of sensors which obtain information for each of a plurality of places of the upper surface of the object, related to a position in a direction intersecting the upper surface.

6. The suction device according to claim **1**, further comprising:

a controller which controls a flow of the gas using the information obtained by the measurement device.

7. The suction device according to claim **6**, wherein

the controller controls the flow of the gas so as to make the shape of the upper surface of the object into a predetermined state.

8. A suction device which makes a suction force act on a plate-like object in a non-contact manner, the suction device comprising:

a base member;

a plurality of suction sections provided at the base member, each of the suction sections generating a flow of a gas along an upper surface of the object so as to generate the suction force with respect to the object, the suction force supporting the object from above the object without the suction sections contacting the upper surface of the object; and

an adjustment device which deforms the upper surface of the object, wherein

the upper surface of the object is deformed by the adjustment device, while the object is being suctioned by the suction force generated by the flow of the gas which the plurality of suction sections generated.

9. The suction device according to claim **8**, wherein

the adjustment device includes a gas supply device which supplies the gas to the plurality of suction sections, and a controller which controls the gas supply device, wherein

the controller can control a state of the gas blowing out from each of the plurality of suction sections.

10. The suction device according to claim **8**, wherein

the adjustment device includes a gas supply device which supplies the gas to the plurality of suction sections, wherein

groups are made of the plurality of suction sections, and the gas supply device can control the gas blowing out from the suction section for each of the groups.

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