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SUBSTRATE PROCESSTNG APPARATUS AND SUBSTRATE PROCESSING METHOD

Abstract

A substrate processing apparatus includes a pitch converting unit that converts a pitch of a plurality of substrates between an unequal pitch at which a first interval and a second interval wider than the first interval are alternately repeated and a narrow pitch at which the first interval is repeated. The pitch converting unit includes: the plurality of holding members that hold the plurality of substrates aligned at the unequal pitch; and the moving unit configured to move the plurality of holding members in the alignment direction of the plurality of substrates so as to switch the plurality of substrates between an unequal pitch arrangement in which the plurality of substrates are aligned at the unequal pitch, and a narrow pitch arrangement in which the plurality of substrates are aligned at the narrow pitch. Each of the plurality of holding members has two holding grooves for holding two substrates, respectively. The two holding grooves are spaced apart by a first interval.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Japanese Patent Application No. 2024-018105 filed Feb. 8, 2024, the subject matter of which is incorporated herein by reference in entirety.

BACKGROUND

Technical Field

[0002] The present invention relates to a substrate processing apparatus and a substrate processing method for processing a substrate. Examples of such a substrate include a semiconductor substrate, a substrate for a flat panel display (FPD), a glass substrate for a photomask, a substrate for an optical disk, a substrate for a magnetic disk, a ceramic substrate, and a substrate for a solar cell. Examples of the FPD include a liquid crystal display device and an organic electroluminescence (EL) display device.

Related Art

[0003] Conventionally, a substrate processing apparatus that immerses and processes a batch of a plurality of substrates in a processing liquid has been known. Such a substrate processing apparatus includes an orientation converting mechanism (orientation converting unit) and a pusher (pusher mechanism) (see, for example, Japanese Patent Application Laid-Open No. 2010-093230). The orientation converting mechanism converts the orientation of the substrate to and from a horizontal orientation from and to a vertical orientation. The pusher can pass and receive a plurality of substrates in the vertical orientation to and from the orientation converting mechanism by causing a lifting holder (pusher member) to move up and down.

[0004] After the lifting holder receives twenty-five substrates from the orientation converting mechanism, the lifting holder is turned by 180 degrees about the vertical axis. By turning the lifting holder by 180 degrees, the twenty-five substrates held by the lifting holder is shifted by a half pitch. In this configuration, another twenty-five substrates are passed from the orientation converting mechanism to the lifting holder. As a result, the twenty-five substrates passed later in time are inserted between the twenty-five substrates passed earlier in time, and a substrate group including fifty substrates in total is formed on the lifting holder. At this time, two adjacent substrates are positioned face to face, in which the front surfaces (or the rear surfaces) thereof face each other. The fifty substrates held by the lifting holder are also aligned at a half pitch that is a half of a substrate holding pitch used inside a carrier.

[0005] Japanese Patent Application Laid-Open No. 2022-077177 discloses a pitch converting unit. The pitch converting unit includes a base member, twenty-five chucks (holding members) that are slidably provided to the base member, and a pitch changing mechanism that changes the interval between the chucks. Each of the chucks suctions a part of the peripheral edge of one substrate, with the vacuum.

SUMMARY

[0006] In order to reduce the amount of processing liquid (chemical liquid and cleaning liquid) used in the substrate processing apparatus, there is a demand for aligning a plurality of substrates at a pitch narrower than the half pitch, and processing the plurality of substrates aligned at the narrower pitch, as a batch. In such a case, for example, if the pitch converting unit is to use fifty holding members to hold fifty substrates, each of the holding members needs to be reduced in width in the alignment direction of the fifty substrates. Therefore, it becomes difficult to ensure the dimensional accuracy of the holding members, and for the holding members to hold the respective substrates in the vertical orientation.

[0007] The present invention has been made in view of such circumstances, and an object of the present invention is to provide a substrate processing apparatus and a substrate processing method including a pitch converting unit capable of holding each substrate in the vertical orientation, easily.

[0008] In order to achieve such an object, the present invention uses the following configurations. That is, a substrate processing apparatus according to the present invention is a substrate processing apparatus for processing a plurality of substrates, the substrate processing apparatus including: a pitch converting unit that converts a pitch between the plurality of substrates, between an unequal pitch in which a first interval and a second interval wider than the first interval are repeated alternately, and a narrow pitch in which the first interval is repeated; a substrate processing unit that processes the plurality of substrates aligned at the narrow pitch, as a batch; and a main transporting mechanism that transports the plurality of substrates aligned at the narrow pitch to the substrate processing unit, in which the pitch converting unit includes: a plurality of holding members that hold the plurality of substrates aligned at the unequal pitch; a moving unit configured to move the plurality of holding members in an alignment direction of the plurality of substrates so as to switch the plurality of substrates between an unequal pitch arrangement in which the plurality of substrate are arranged at the unequal pitch, and a narrow pitch arrangement in which the plurality of substrates are aligned at the narrow pitch; and each of the plurality of holding members has two holding grooves that hold two substrates, respectively, among the plurality of substrates, and the two holding grooves are spaced apart from each other by the first interval.

[0009] In the substrate processing apparatus according to the present invention, the pitch converting unit includes: the plurality of holding members that hold the plurality of substrates aligned at the unequal pitch; and the moving unit configured to move the plurality of holding members in the alignment direction of the plurality of substrates so as to switch the plurality of substrates between the unequal pitch arrangement in which the plurality of substrates are aligned at the unequal pitch, and the narrow pitch arrangement in which the plurality of substrates are aligned at the narrow pitch. Each of the plurality of holding members has the two holding grooves that hold two substrates, respectively, among the plurality of substrates. The two holding grooves are spaced apart from each other by the first interval (first interval<second interval). Because each of the holding members has the two holding grooves for holding two substrates, each of the holding members can be provided with a relatively large width, in the alignment direction of the plurality of substrates. With this, it is possible to ensure the dimensional accuracy of the holding members, and to allow the plurality of holding members to hold the substrates in the vertical orientation, easily.

[0010] Furthermore, in the substrate processing apparatus described above, preferably, the two holding grooves are spaced apart from each other by the first interval that is smaller than a half of the second interval. In the unequal pitch, the first interval and the second interval wider than the first interval are repeated alternately. Let us assume herein that there is a predetermined interval constituting of one first interval and one second interval. Assuming that the predetermined interval is 10 mm, for example, by setting the first interval smaller than a half of the second interval, it is possible to set the first interval smaller than ⅓ times 10 mm, and to set the length of the first interval to any length, e.g., 3 mm, without any fractional part below the decimal point.

[0011] Furthermore, in the substrate processing apparatus described above, preferably, the two holding grooves are spaced apart from each other by the first interval that is a half of the second interval. In the unequal pitch, the first interval and the second interval wider than the first interval are arranged alternately. Let us assume herein that there is a predetermined interval constituting of one first interval and one second interval. Assuming that the predetermined interval is 10 mm, for example, by setting the first interval equal to a half of the second interval, it is possible to set the first interval to a value smaller than ⅓ times 10 mm, and to set the second interval to a value ⅔ times 10 mm.

[0012] In the substrate processing apparatus described above, preferably, the moving unit includes

a guide rail that supports the plurality of holding members in a manner movable in the alignment direction; an extending/retracting mechanism that extends and retracts the plurality of holding members in the alignment direction; and a driving unit that drives the extending/retracting mechanism. The guide rail can support the plurality of holding members in a manner movable in the alignment direction. The extending/retracting mechanism driven by the driving unit can extend/retract the plurality of holding members.

[0013] In the substrate processing apparatus described above, the extending/retracting mechanism preferably includes: a housing that is provided to a first holding member, among the plurality of holding members; a protrusion that protrudes from a second holding member toward the first holding member positioned adjacently to the second holding member, among the plurality of holding members, and becomes housed in the housing when the plurality of holding members are retracted in the alignment direction; and a stopper that is provided to a tip of the protrusion, that prevents the protrusion from coming out of the housing when the plurality of holding members are extended in the alignment direction. The extending/retracting mechanism can extend/retract the plurality of holding members using the housing, the protrusion, and the stopper.

[0014] In the substrate processing apparatus described above, preferably, the extending/retracting mechanism further includes an elastic member provided between the first holding member and the second holding member. While the plurality of holding members are in between of being extended in the alignment direction and retracted in the alignment direction, the holding members are free to move from their positions. By providing the elastic member, it is possible to suppress movements of the holding members that are free to move. In this manner, it is possible to suppress shaking of the plurality of substrates held in the plurality of holding grooves in the vertical orientation. Thus, for example, it is possible to suppress a contact of two adjacently positioned substrates.

[0015] Furthermore, the substrate processing apparatus described above preferably further includes: an orientation converting mechanism that converts the plurality of substrates to and from a horizontal orientation from and to a vertical orientation; a pusher mechanism that includes a pusher member that holds the plurality of substrates aligned at the unequal pitch in the vertical orientation, and is capable of passing the plurality of substrates to and from the orientation converting mechanism; and a delivering mechanism that transports the plurality of substrates aligned at the unequal pitch, to and from the pusher member from and to the pitch converting unit.

[0016] Furthermore, preferably, the substrate processing apparatus described above further includes a control unit, in which the control unit is configured to: cause the orientation converting mechanism to convert two or more first substrates held at a reference pitch in which a reference interval that is a sum of the first interval and the second interval is repeated, from the horizontal orientation to the vertical orientation, as a batch; cause the pusher member to receive the two or more first substrates having been converted to the vertical orientation, and to hold the two or more first substrates aligned at the reference pitch in the vertical orientation; cause the pusher mechanism to move the two or more first substrates held by the pusher member by the first interval in an alignment direction of the two or more first substrates; cause the orientation converting mechanism to convert two or more second substrates held at the reference pitch, from the horizontal orientation to the vertical orientation, as a batch; cause the pusher member to receive the two or more second substrates having been converted to the vertical orientation; cause the pusher member to hold the plurality of substrates including the two or more first substrates and the two or more second substrates, the first substrates and the second substrates being arranged alternately and aligned at the unequal pitch; cause the delivering mechanism to transport the plurality of substrates aligned at the unequal pitch from the pusher member to the pitch converting unit; cause the pitch converting unit to convert a pitch of the plurality of substrates from the unequal pitch to the narrow pitch; cause the main transporting mechanism to transport the plurality of substrates aligned at the narrow pitch to the substrate processing unit; and cause the substrate processing unit to process the plurality of substrates aligned at the narrow pitch as a batch.

[0017] The two or more first substrates are aligned at the reference pitch, and the two or more second substrates are aligned at the reference pitch. The two or more second substrates are arranged in a manner offset from to the two or more respective first substrates by the first interval in the alignment direction. As a result, a plurality of substrates including the two or more first substrates and the two or more second substrates that are alternately arranged become aligned at the unequal pitch. The pitch converting unit then converts the pitch between the plurality of substrates that are aligned at the unequal pitch, to the narrow pitch. That is, a first pitch conversion is performed by aligning the two or more first substrates and the two or more second substrates at the unequal pitch, and a second pitch conversion is performed by converting the unequal pitch to the narrow pitch. By performing the pitch conversion in two stages, it becomes possible to convert the pitch of the two or more first substrates and the two or more second substrates that are aligned at the reference pitch, easily, to the narrow pitch.

[0018] In addition, preferably, the substrate processing apparatus described above further includes a carrier shelf for placing a carrier housing N substrates that are aligned at a reference pitch in which a reference interval that is a sum of the first interval and the second interval is repeated, where N is a natural number equal to or more than two, and the orientation converting mechanism includes an orientation converting unit that converts the two or more first substrates and the two or more second substrates from or to the horizontal orientation to or from the vertical orientation, and a substrate handling mechanism that transports the N substrates from and to the carrier placed on the carrier shelf, to and from the orientation converting unit.

[0019] Furthermore, preferably, the substrate processing apparatus described above further includes a control unit, in which the control unit is configured to: cause the substrate handling mechanism to transport N substrates aligned at the reference pitch in the horizontal orientation on a first carrier placed on the carrier shelf, from the first carrier to the orientation converting unit; cause the substrate handling mechanism to transport P substrates aligned at the reference pitch in the horizontal orientation, the P substrates being substrates among N substrates on a second carrier placed on the carrier shelf, from the second carrier to the orientation converting unit; cause the orientation converting unit to convert the two or more first substrates including the N substrates from the first carrier and the P substrates held at the reference pitch, from the horizontal orientation to the vertical orientation, as a batch; cause the pusher member to receive the two or more first substrates having been converted to the vertical orientation, and to hold the two or more first substrates aligned at the reference pitch; cause the pusher mechanism to move the two or more first substrates held by the pusher member by the first interval in an alignment direction of the two or more first substrates; cause the substrate handling mechanism to transport Q substrates aligned at the reference pitch in the horizontal orientation to the orientation converting unit, the Q substrates being remainder of the N substrates on the second carrier; cause the substrate handling mechanism to transport N substrates in the horizontal orientation aligned at the reference pitch on a third carrier placed on the carrier shelf, from the third carrier to the orientation converting unit; cause the orientation converting unit to convert the two or more second substrates including the Q substrates and the N substrates from the third carrier and held at the reference pitch, from the horizontal orientation to the vertical orientation, as a batch; cause the pusher member to receive the two or more second substrates having been converted to the vertical orientation; cause the pusher member to hold the plurality of substrates including the two or more first substrates and the two or more second substrates that are arranged alternately at the unequal pitch; cause the delivering mechanism to transfer the plurality of substrates that are aligned at the unequal pitch, from the pusher member to the pitch converting unit; cause the pitch converting unit to convert the pitch of the plurality of substrates from the unequal pitch to the narrow pitch; cause the main transporting mechanism to transport the plurality of substrates aligned at the narrow pitch to the substrate processing unit; and cause the substrate processing unit to process the plurality of substrates aligned at the narrow pitch, as a batch.

[0020] The first pitch conversion is performed by aligning N substrates housed in each of the three carriers at the reference pitch, to the unequal pitch, and the second pitch conversion is performed by converting the unequal pitch to the narrow pitch. By performing the pitch conversion in two stages, it is possible to convert the pitch of the N substrates that are aligned at the reference pitch inside each of the three carriers, easily, to the narrow pitch.
[0021] Furthermore, preferably, the substrate processing apparatus described above further includes a control unit, in which the control unit is configured to: cause the main transporting mechanism to transport the plurality of substrates aligned at the narrow pitch in the vertical orientation, the plurality of substrates having been processed as a batch by the substrate processing unit, to a position above the pitch converting unit; cause the pitch converting unit to hold the plurality of substrates aligned at the narrow pitch in the vertical orientation; cause the pitch converting unit to convert the pitch of the plurality of substrates from the narrow pitch to the unequal pitch; cause the delivering mechanism to transport the plurality of substrates aligned at the unequal pitch from the pitch converting unit to the pusher member; cause the pusher member to hold the plurality of substrates in the vertical orientation, the plurality of substrates being a plurality of substrates that are aligned at the unequal pitch, and in which the two or more first substrates and the two or more second substrates are arranged alternately; cause the orientation converting mechanism to receive the two or more first substrates aligned at the reference pitch, among the plurality of substrates, from the pusher member, and to convert the two or more first substrates from the vertical orientation to the horizontal orientation; and cause the orientation converting mechanism to receive the two or more second substrates aligned at the reference pitch, among the plurality of substrates, from the pusher member, and to convert the two or more second substrates from the vertical orientation to the horizontal orientation, in which in the reference pitch, a reference interval equal to a sum of the first interval and the second interval is repeated.
[0022] The first pitch conversion is performed by aligning the plurality of narrow pitch substrates having been processed as a batch by the substrate processing unit, at the unequal pitch. The plurality of substrates that are aligned at the unequal pitch and in which the two or more first substrates and the two or more second substrates are arranged alternately are decomposed into the two or more first substrates and the two or more second substrates that are arranged at the reference pitch. The second pitch conversion is thus performed. By performing the pitch conversion in two stages, the pitch of the plurality of substrates (the two or more first substrates and the two or more second substrates) aligned at the narrow pitch can be easily converted to the reference pitch.
[0023] A substrate processing method according to the present invention is a substrate processing method for processing a plurality of substrates, the substrate processing method including: a pitch converting step of causing a pitch converting unit to convert a pitch between the plurality of substrates from an unequal pitch in which a first interval and a second interval wider than the first interval are repeated alternately, to a narrow pitch in which the first interval is repeated; a substrate transporting step of causing a main transporting mechanism to transport the plurality of substrates aligned at the narrow pitch to a substrate processing unit; and a substrate processing step of causing the substrate processing unit to process the plurality of substrates aligned at the narrow pitch, as a batch, in which the pitch converting step includes: a holding step of causing a plurality of holding members to hold the plurality of substrates aligned at the unequal pitch, while holding two substrates, among the plurality of substrates, at the first interval with two holding grooves that are provided to each of the plurality of holding members and spaced apart from each other by the first interval; a pitch conversion executing step of causing a moving unit to move the plurality of holding members in an alignment direction of the plurality of substrates so as to switch the plurality of substrates from an unequal pitch arrangement in which the plurality of substrates are aligned at the unequal pitch to a narrow pitch arrangement in which the plurality of substrates are aligned at the narrow pitch.
[0024] With the substrate processing apparatus and the substrate processing method according to

the present invention, the pitch converting unit can easily hold each substrate in the vertical orientation.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0025] For the purpose of illustrating the invention, there are shown in the drawings several forms which are presently preferred, it being understood, however, that the invention is not limited to the precise arrangement and instrumentalities shown.

[0026] FIG. **1** is a plan view illustrating a schematic configuration of a substrate processing apparatus according to a first embodiment;

[0027] FIG. **2** is a plan view illustrating a configuration of a transfer block and elements therearound;

[0028] FIG. **3** is a side view illustrating a substrate handling mechanism;

[0029] FIG. **4** is a side view illustrating an orientation converting unit;

[0030] FIG. **5** is a side view illustrating a pusher mechanism;

[0031] FIG. **6** is a side view illustrating a longitudinal cross section of a pusher member;

[0032] FIG. **7** is a side view illustrating elements such as a delivering mechanism and two pitch converting units, in a view as indicated by arrows A-A in FIG. **2**;

[0033] FIG. **8** is a plan view mainly illustrating an incoming delivering mechanism and an outgoing delivering mechanism;

[0034] FIG. **9** is a plan view mainly illustrating an intermediating mechanism;

[0035] FIG. **10** is a side view illustrating a schematic configuration of a pitch converting unit that holds a plurality of substrates aligned at an unequal pitch;

[0036] FIG. **11** is a side view illustrating a schematic configuration of the pitch converting unit holding a plurality of substrates that are aligned at a narrow pitch;

[0037] FIG. **12** is a bottom view mainly illustrating an extending/retracting mechanism included in the pitch converting unit holding a plurality of substrates that are aligned at the unequal pitch;

[0038] FIG. **13** is a bottom view mainly illustrating an extending/retracting mechanism included in the pitch converting unit holding a plurality of substrates that are aligned at the narrow pitch;

[0039] FIG. **14** is a flowchart for explaining a former half of an operation of the substrate processing apparatus;

[0040] FIGS. **15**A to **15**C are side views for explaining the operation of the substrate processing apparatus;

[0041] FIGS. **16**A to **16**C are side views for explaining the operation of the substrate processing apparatus;

[0042] FIGS. **17**A to **17**C are side views for explaining the operation of the substrate processing apparatus;

[0043] FIGS. **18**A and **18**B are side views for explaining the operation of the substrate processing apparatus;

[0044] FIGS. **19**A and **19**B are side views for explaining the operation of the substrate processing apparatus;

[0045] FIGS. **20**A and **20**B are side views for explaining the operation of the substrate processing apparatus;

[0046] FIG. **21** is a flowchart for explaining a latter half of an operation of the substrate processing apparatus;

[0047] FIGS. **22**A and **22**B are side views for explaining the operation of the substrate processing apparatus;

[0048] FIGS. **23**A and **23**B are side views for explaining the operation of the substrate processing

apparatus;
[0049] FIGS. **24**A and **24**B are side views for explaining the operation of the substrate processing apparatus;
[0050] FIGS. **25**A to **25**C are side views for explaining the operation of the substrate processing apparatus;
[0051] FIGS. **26**A to **26**C are side views for explaining the operation of the substrate processing apparatus;
[0052] FIG. **27** is a bottom view mainly illustrating an extending/retracting mechanism included in a pitch converting unit holding a plurality of substrates that are aligned at an unequal pitch, in a second embodiment;
[0053] FIG. **28** is a bottom view mainly illustrating the extending/retracting mechanism included in the pitch converting unit holding a plurality of substrates that are aligned at a narrow pitch, in the second embodiment;
[0054] FIGS. **29**A and **29**B are side views for explaining an operation of a substrate processing apparatus according to a third embodiment;
[0055] FIGS. **30**A and **30**B are side views for explaining the operation of the substrate processing apparatus according to the third embodiment;
[0056] FIGS. **31**A and **31**B are side views for explaining the operation of the substrate processing apparatus according to the third embodiment; and
[0057] FIGS. **32**A and **32**B are side views for explaining the operation of the substrate processing apparatus according to the third embodiment.

DETAILED DESCRIPTION

First Embodiment

[0058] A first embodiment of the present invention will now be described with reference to drawings. FIG. **1** is a plan view illustrating a schematic configuration of a substrate processing apparatus **1** according to the first embodiment. FIG. **2** is a plan view illustrating a configuration of a transfer block **5** and elements around the transfer block **5**.
[0059] In the description herein, for the convenience, the direction in which the transfer block **5** and a processing block **7** are arranged will be referred to as a “front-back direction X”. The front-back direction X is horizontal. In the front-back direction X, a direction from the processing block **7** toward the transfer block **5**, for example, will be referred to as “frontwards”. The direction opposite to the frontward direction will be referred to as “rearwards”. The horizontal direction orthogonal to the front-back direction X will be referred to as “width directions Y”. One of the “width directions Y” will be referred to as “rightwards”, as appropriate. The direction opposite to the rightward direction will be referred to as “leftwards”. The direction perpendicular to the horizontal direction will be referred to as “vertical directions Z”. In each drawing, front, rear, right, left, top, and bottom are indicated as appropriate, for reference.

<1. Configuration of Substrate Processing Apparatus>

[0060] FIG. **1** will now be referred to. The substrate processing apparatus **1** processes a substrate W. The substrate processing apparatus **1** is a batch substrate processing apparatus that processes a plurality of (e.g., fifty, seventy-five, or a hundred) substrates W as a batch. The substrate processing apparatus **1** performs processes such as a chemical liquid process, a cleaning process, and a drying process on the substrates W. The substrate processing apparatus **1** includes a stocker **2**, a placing shelf **3**, the transfer block **5**, the processing block **7**, and a batch substrate transporting area **8**.

<1-1. Stocker>

[0061] In the stocker **2**, at least one carrier C is housed. The stocker **2** is positioned in front of the transfer block **5**, adjacently. The carrier C stores therein a plurality of (e.g., twenty-five) substrates W, in the horizontal orientation, with a predetermined interval (e.g., 10 mm) therebetween. In other words, the carrier C stores N (e.g., twenty-five) substrates W aligned at a reference pitch, in the horizontal orientation. Note that N is a natural number equal to or more than two. In the reference

pitch, a reference interval TN**9** (e.g., 10 mm (millimeters)) is repeated. That is, when the reference interval TN**9** is 10 mm, the reference pitch is 10-mm pitch. The N substrates W in the carrier C are aligned in the vertical direction Z, or a direction of the thickness of the substrates W. One example of the carrier C is a front opening unified pod (FOUP), but without limitation thereto.

[0062] The stocker **2** includes a plurality of (e.g., two) loading ports **9**. The two loading ports **9** are arranged along the width direction Y. In the present embodiment, the two loading ports **9** are used for loading and unloading a carrier C. The stocker **2** also includes at least one storage shelf **11** and a carrier transporting robot **13**. On the storage shelves **11**, carriers C are placed.

[0063] The carrier transporting robot **13** transports the carrier C to and from the two loading ports **9**, the storage shelf **11**, and the placing shelf **3**. The carrier transporting robot **13** has a gripper **15** that grips, for example, a protrusion provided on the top surface of the carrier C. The carrier transporting robot **13** can move the gripper **15** in the horizontal directions (the front-back direction X and the width direction Y) and the vertical direction Z. The carrier transporting robot **13** is driven by one or more electric motors.

[0064] The placing shelf **3** is disposed in the area of the stocker **2**. The placing shelf **3** is positioned in front of the transfer block **5**, adjacently. On the placing shelf **3**, carriers C are placed. The placing shelf **3** corresponds to a carrier shelf according to the present invention.

<1-2. Transfer Block>

[0065] FIGS. **1** and **2** will now be referred to. The transfer block **5** includes a substrate handling mechanism (robot) HTR, an orientation converting unit **19**, a pusher mechanism **21**, a delivering mechanism **23**, and two pitch converting units **25**, **26**. The orientation converting unit **19** corresponds to an orientation converting mechanism according to the present invention. One of the two pitch converting units **25**, **26** corresponds to a pitch converting unit according to the present invention.

[0066] The substrate handling mechanism HTR is disposed on the rear side of the placing shelf **3**. The substrate handling mechanism HTR transports a plurality of (e.g., twenty-five) substrates W in the horizontal orientation, between the carrier C placed on the placing shelf **3**, and the orientation converting unit **19**. As illustrated in FIG. **3**, the substrate handling mechanism HTR includes a plurality of (e.g., twenty-five or thirteen) hands **27**. Each of the hands **27** holds one substrate W. The plurality of hands **27** are arranged at the reference pitch, in the vertical direction Z. The twenty-five substrates W held by the twenty-five hands **27**, for example, therefore, are aligned at the reference pitch. In the reference pitch, the reference interval TN**9** (e.g., 10 mm) is repeated.

[0067] In FIG. **3** and the like, for the convenience of illustration, the substrate handling mechanism HTR includes five hands **27**. It is assumed that a pair of horizontal holders **37** and a pair of vertical holders **39**, to be described later, are configured to hold five substrates W. It is also assumed that a pusher member **55** (see FIG. **6**), which is to be described later, is configured to support ten substrates W.

[0068] The substrate handling mechanism HTR further includes a hand support **29**, an advancing/retracting unit **31**, and a rotating lift **33**. The hand support **29** supports the plurality of hands **27**. The advancing/retracting unit **31** advances and retracts the hand support **29** to move the plurality of hands **27**. The rotating lift **33** rotates the advancing/retracting unit **31** about a vertical axis AX**1**, to change the direction of the hands **27**. The rotating lift **33** is fixed to a floor surface. Each of the advancing/retracting unit **31** and the rotating lift **33** includes an electric motor. The substrate handling mechanism HTR may also have a movable hand (not illustrated) for transporting only one substrate W, separately from the hands **27**.

[0069] The orientation converting unit **19** converts a plurality of (e.g., twenty-five) substrates W to and from the vertical orientation from and to the horizontal orientation. The orientation converting unit **19** is disposed on the left side of the substrate handling mechanism HTR. As illustrated in FIG. **4**, the orientation converting unit **19** includes a support base **35**, the pair of horizontal holders **37**, the pair of vertical holders **39**, and a rotation driving unit **41**.

[0070] The support base **35** is rotatably supported about a horizontal axis AX**2** extending in the front-back direction X. The pair of horizontal holders **37** and the pair of vertical holders **39** are provided in a manner extending at a right angle with respect to a support surface **35**A. When the plurality of substrates W are in the horizontal orientation, the pair of horizontal holders **37** holds the plurality of substrates W. In other words, when the plurality of substrates W are in the horizontal orientation, the plurality of substrates W are placed on the pair of horizontal holders **37**. When the plurality of substrates W are in the vertical orientation, the pair of vertical holders **39** holds the plurality of substrates W.

[0071] The pair of horizontal holders **37** and the pair of vertical holders **39** are both disposed in the front-back direction X (see FIG. **2**). When the pair of horizontal holders **37** holds the plurality of substrates W in the horizontal orientation, the pair of vertical holders **39** is at a position closer to the pusher mechanism **21** than to the pair of horizontal holders **37**. The pair of horizontal holders **37** has a plurality of pairs (e.g. twenty-five pairs, thirty-eight pairs, fifty pairs) of shelves **37**A that are arranged at the reference pitch, in a direction DR**1** in which the pair of horizontal holders **37** extend. The pair of vertical holders **39** includes a plurality of pairs (e.g. twenty-five pairs, thirty-eight pairs, fifty pairs) of holding grooves **39**A that are arranged at the reference pitch, in the direction DR**1** in which the pair of vertical holders **39** extends.

[0072] The orientation converting unit **19** further includes an axial moving unit **51** and a housing moving unit **53**. The axial moving unit **51** moves the pair of horizontal holders **37** along the direction DR**1** in which the pair of horizontal holders **37** extends, by a preset extremely small distance. The housing moving unit **53** moves the pair of vertical holders **39** closer to or further away from the pair of horizontal holders **37**. For example, when the pair of horizontal holders **37** is to hold a plurality of substrates W in the horizontal orientation, the housing moving unit **53** can move the pair of vertical holders **39** in the width direction Y. The rotation driving unit **41** converts the plurality of substrates W held by the pair of horizontal holders **37** and the pair of vertical holders **39** to and from the horizontal orientation from and to the vertical orientation.

[0073] The rotation driving unit **41** includes, for example, an electric motor. Each of the axial moving unit **51** and the housing moving unit **53** includes an air cylinder or an electric actuator. The electric actuator includes an electric motor.

[0074] The pusher mechanism **21** is disposed on the left side of the orientation converting unit **19**. As illustrated in FIG. **5**, the pusher mechanism **21** includes a pusher member **55**, a rotation shaft **57**, a pusher rotating unit **59**, a pusher horizontally moving unit **61**, a lift stage **63**, and a pusher lift **65**.

[0075] As illustrated in FIG. **6**, the pusher member **55** holds a plurality of (e.g., fifty, seventy-five, or a hundred) substrates W that are aligned at the unequal pitch in which a first interval TN**1** (e.g., 3.333 mm) and a second interval TN**2** (e.g., 6.666 mm) are repeated alternately, in the vertical orientation. The second interval TN**2** is an interval larger than the first interval TN**1** (second interval TN**2**>first interval TN**1**). The first interval TN**1** is also referred to as a narrow interval, and the second interval TN**2** is also referred to as a wide interval.

[0076] As illustrated in FIG. **6**, the pusher member **55** includes a plurality of (e.g., fifty, seventy-five, or a hundred) vertical holding grooves **67** for holding a plurality of substrates W in the vertical orientation. The plurality of vertical holding grooves **67** are arranged, for example, at the unequal pitch in which the first interval TN**1** and the second interval TN**2** are repeated alternately. The sum of the first interval TN**1** (e.g., 3.333 mm) and the second interval TN**2** (e.g., 6.666 mm) equals the reference interval TN**9** (e.g., 10 mm).

[0077] FIG. **5** will now be referred to. A bottom surface of the pusher member **55** is connected to an upper end of the rotation shaft **57**. The pusher rotating unit **59** rotates the pusher member **55** and the rotation shaft **57** about the vertical axis AX**3** passing through the rotation shaft **57**. As a result, the plurality of substrates W supported in the vertical orientation on the pusher member **55** are rotated about the vertical axis AX**3**. The pusher rotating unit **59** includes an electric motor, for example. The pusher rotating unit **59** is provided under the pusher member **55**. The pusher rotating

unit **59** is also attached to the top surface of the lift stage **63** with the pusher horizontally moving unit **61** therebetween.

[0078] The pusher horizontally moving unit **61** includes two guide rails **61**A extending in the width direction Y, a slider **61**B, and an electric motor, not illustrated. The two guide rails **61**A are provided on the top surface of the lift stage **63**. The slider **61**B is caused to move in the width direction Y along the two guide rails **61**A. The slider **61**B is driven by the electric motor. The pusher lift **65** raises and lowers the lift stage **63** in the vertical direction Z. With this, the pusher member **55** is raised and lowered. The pusher lift **65** includes, for example, an electric actuator.

[0079] FIG. **2** will now be referred to. The two pitch converting units **25**, **26** are disposed on the left side of the pusher mechanism **21**. If the two pitch converting units **25**, **26** are to be arranged in the vertical direction Z, the substrate processing apparatus **1** becomes unnecessarily high. In this respect, the two pitch converting units **25**, **26** are arranged in the front-back direction X. In other words, the first pitch converting unit **25** is disposed on the rear side of the second pitch converting unit **26** in plan view. Therefore, it is possible to suppress the substrate processing apparatus **1** from becoming unnecessarily high. For example, the delivering mechanism **23** transports a plurality of substrates W aligned at the unequal pitch to and from the pusher member **55** from and to the two pitch converting units **25**, **26**.

[0080] FIGS. **2** and **7** will now be referred to. FIG. **7** is a side view illustrating elements such as the delivering mechanism **23** and two pitch converting units **25**, **26**, in a view as indicated by arrows A-A in FIG. **2**. The delivering mechanism **23** includes an incoming delivering mechanism **71**, an intermediating mechanism **73**, and an outgoing delivering mechanism **75**. The incoming delivering mechanism **71** transports the plurality of substrates W aligned at the unequal pitch, from the pusher member **55** to the first pitch converting unit **25**. The intermediating mechanism **73** transports the plurality of substrates W aligned at the narrow pitch, from the first pitch converting unit **25** to a first delivery position P**1**. The outgoing delivering mechanism **75** transports the plurality of substrates W aligned at the unequal pitch, from the second pitch converting unit **26** onto the pusher member **55**. The incoming delivering mechanism **71**, the intermediating mechanism **73**, and the outgoing delivering mechanism **75** have a chuck **77**, a chuck **78**, and a chuck **79**, respectively.

[0081] As illustrated in FIG. **7**, the incoming delivering mechanism **71** is disposed at an incoming delivery height H**1**. The incoming delivering mechanism **71** is disposed, for example, beside a lift **141** of the second pitch converting unit **26**. The chuck **78** of the intermediating mechanism **73** is provided at a position above the first pitch converting unit **25**. The chuck **78** of the intermediating mechanism **73** is disposed between the incoming delivery height H**1** and a first delivery position P**1**. The first delivery position P**1** is a position higher than the incoming delivery height H**1** and an outgoing delivery height H**2**. The outgoing delivering mechanism **75** is disposed at the outgoing delivery height H**2** higher than the incoming delivery height H**1**. Each of the incoming delivering mechanism **71** and the outgoing delivering mechanism **75** is configured in such a manner that the plurality of substrates W held by the outgoing delivering mechanism **75** and the outgoing delivering mechanism **75** do not interfere with the plurality of other substrates W held by the incoming delivering mechanism **71** and the incoming delivering mechanism **71**.

[0082] FIG. **8** is a plan view mainly illustrating the incoming delivering mechanism **71** and the outgoing delivering mechanism **75**. The incoming delivering mechanism **71** is disposed on the rear side of the outgoing delivering mechanism **75**. That is, the incoming delivering mechanism **71** is disposed on side of the processing block **7**, and the outgoing delivering mechanism **75** is disposed on the side of the stocker **2**. The incoming delivering mechanism **71** includes the chuck **77**, an opening and closing unit **81**, a front-back direction moving unit **83**, and a width direction moving unit **85**.

[0083] The chuck **77** holds a plurality of substrates W that are aligned at the unequal pitch, in the vertical orientation. The chuck **77** includes a pair of chuck members **77**A, **77**B extending in the width direction Y. The pair of chuck members **77**A, **77**B includes a plurality of pairs (e.g., fifty

pairs, seventy-five pairs, a hundred pairs) of holding grooves **87**, **88** that are arranged at the unequal pitch. In the unequal pitch, the first interval TN**1** (e.g., 3.333 mm) and the second interval TN**2** (e.g., 6.666 mm) are repeated alternately. The first chuck member **77**A has a plurality of holding grooves **87** that are arranged at the unequal pitch. The second chuck member **77**B has a plurality of holding grooves **88** that are arranged at the unequal pitch.

[0084] The opening and closing unit **81** supports the two chuck members **77**A, **77**B in a manner movable in the front-back direction X. The opening and closing unit **81** opens or closes the two chuck members **77**A, **77**B with respect to each other in the front-back direction X. Specifically, the opening and closing unit **81** brings the two chuck members **77**A, **77**B close to each other or further away from each other. When the opening and closing unit **81** closes the chuck **77**, the chuck **77** can hold the plurality of substrates W in the vertical orientation. By contrast, when the opening and closing unit **81** opens the chuck **77**, the chuck **77** can pass the plurality of substrates W in the vertical orientation between the two chuck members **77**A, **77**B, in the vertical direction Z. The opening and closing unit **81** includes an air cylinder or an electric actuator that drives the two chuck members **77**A, **77**B.

[0085] The front-back direction moving unit **83** is disposed nearer to the two pitch converting units **25**, **26** than the width direction moving unit **85**. The front-back direction moving unit **83** moves the chuck **77** and the opening and closing unit **81** horizontally in the front-back direction X. The width direction moving unit **85** moves the chuck **77**, the opening and closing unit **81**, and the front-back direction moving unit **83** horizontally in the width direction Y. That is, the front-back direction moving unit **83** and the width direction moving unit **85** can move the chuck **77** in the front-back direction X and the width direction Y (two-dimensional directions). The front-back direction moving unit **83** includes, for example, an air cylinder or an electric actuator. The width direction moving unit **85** includes an electric actuator.

[0086] The outgoing delivering mechanism **75** includes the chuck **79**, an opening and closing unit **89**, a front-back direction moving unit **91**, and a width direction moving unit **93**. The chuck **79** has the same configuration as that of the chuck **77**. Specifically, the chuck **79** includes a pair of chuck members **79**A, **79**B extending in the width direction Y. The pair of chuck members **79**A, **79**B includes a plurality of pairs (e.g., fifty pairs, seventy-five pairs, a hundred pairs) of holding grooves **95**, **96** that are arranged at the unequal pitch. The front-back direction moving unit **91** is disposed nearer to the two pitch converting units **25**, **26** than the width direction moving unit **93**. Other than the configurations described above, the opening and closing unit **89**, the front-back direction moving unit **91**, and the width direction moving unit **93** are configured in the same manner as the opening and closing unit **81**, the front-back direction moving unit **83**, and the width direction moving unit **85**, respectively.

[0087] FIG. **9** is a plan view mainly illustrating the intermediating mechanism **73**. The intermediating mechanism **73** includes the chuck **78**, an opening and closing unit **101**, an arm **103**, and a lift **105**. The chuck **78** includes a pair of chuck members **78**A, **78**B extending in the width direction Y. The pair of chuck members **78**A, **78**B includes a plurality of pairs (e.g., fifty pairs, seventy-five pairs, a hundred pairs) of holding grooves **107**, **108** arranged at the narrow pitch (e.g., 3.333-mm pitch (⅓ pitch)). Specifically, the first chuck member **78**A has a plurality of holding grooves **107** that are arranged at the narrow pitch, in the width direction Y. The second chuck member **78**B has a plurality of holding grooves **108** that are arranged at the narrow pitch.

[0088] The opening and closing unit **101** is provided on the right side (on the side of the pusher mechanism **21**) of the chuck **78**. Other than this point, the opening and closing unit **101** is configured in the same manner as the opening and closing unit **81**. More specifically, the opening and closing unit **101** supports the pair of chuck members **78**A, **78**B in a manner movable in the front-back direction X. The opening and closing unit **101** opens or closes the pair of chuck members **78**A, **78**B in the front-back direction X. When the opening and closing unit **101** closes the chuck **78**, the chuck **78** can hold a plurality of substrates W in the vertical orientation aligned at in

the narrow pitch. By contrast, when the opening and closing unit **101** opens the chuck **78**, the chuck **78** can pass the plurality of substrates W in the vertical orientation between the two chuck members **78**A, **78**B, in the vertical direction Z.

[0089] The opening and closing unit **101** is attached to the lift **105**, with the arm **103** therebetween, in a manner enabled to move up or and down. The lift **105** raises and lowers the chuck **78** and the opening and closing unit **101** in the vertical directions Z. The lift **105** includes, for example, an electric actuator. With this, the intermediating mechanism **73** can receive the plurality of substrates W aligned at the narrow pitch in the vertical orientation, from the first pitch converting unit **25**, and move the plurality of substrates W to the first delivery position P**1** (see FIG. **7**), to deliver the plurality of substrates W to the main transporting mechanism WTR.

[0090] Note that the transfer block **5** has two transporting paths for transporting a plurality of substrates W to and from the pusher member **55** (pusher mechanism **21**) from and to the main transporting mechanism WTR. That is, a first transporting path is a path passing through the incoming delivering mechanism **71**, the first pitch converting unit **25**, and the intermediating mechanism **73**. A second conveyance path is a path passing through the second pitch converting unit **26** and the outgoing delivering mechanism **75**. For example, when fifty substrates W are held by the intermediating mechanism **73**, the outgoing delivering mechanism **75** can transport the fifty substrates W having been processed in a chemical liquid processing bath BT**1**, for example, to the pusher member **55**. The fifty substrates W (processing substrate group) can therefore be transported smoothly.

<1-2-1. Pitch Converting Unit>

[0091] FIG. **7** and FIGS. **10** to **13** will now be referred to. Each of the two pitch converting units **25**, **26** converts the pitch of the plurality of substrates W to and from the unequal pitch from and to the narrow pitch. In the unequal pitch, the first interval TN**1** (e.g., 3.333 mm) and second interval TN**2** (e.g., 6.666 mm) wider than the first interval TN**1** are repeated alternately. In the narrow pitch, the first interval TN**1** is repeated.

[0092] The first pitch converting unit **25** aligns a plurality of substrates W aligned at the unequal pitch, at the narrow pitch. That is, the first pitch converting unit **25** converts the pitch of the plurality of substrates W before being processed in the processing block **7**, to the narrow pitch. By contrast, the second pitch converting unit **26** causes the plurality of substrates W aligned at the narrow pitch, to become aligned at the unequal pitch. That is, the second pitch converting unit **26** converts the pitch of the plurality of substrates W having been processed in the processing block **7**, to the unequal pitch.

[0093] Each of the two pitch converting units **25**, **26** includes a pitch converting body **111**. The pitch converting body **111** includes a plurality of (e.g., twenty-five, thirty-eight, and fifty) holding members **113** and a moving unit **115**.

[0094] The plurality of holding members **113** hold the plurality of substrates W aligned at the unequal pitch, in the vertical orientation. Each of the plurality of holding members **113** has two holding grooves **117** that hold two substrates W, respectively, among the plurality of substrates W. The two holding grooves **117** are spaced apart from each other by the first interval TN**1** (e.g., 3.333 mm). On each of the holding members **113**, the two holding grooves **117** are arranged in the width direction Y. For example, when the pitch converting unit **25** has twenty-five holding members **113**, the twenty-five holding members **113** can hold fifty substrates W in the fifty holding grooves **117**, respectively. In FIGS. **10** to **13**, for the convenience of illustration, each of the two pitch converting units **25**, **26** are illustrated as having five holding members **113** (**113**A to **113**E).

[0095] The moving unit **115** moves the plurality of holding members **113** in the alignment direction of the plurality of substrates W (width direction Y) to shift the plurality of holding members **113** between an unequal pitch arrangement in which the plurality of substrates W are aligned at the unequal pitch, and a narrow pitch arrangement in which the plurality of substrates W are aligned at the narrow pitch. The moving unit **115** includes a base member **119**, two guide rails **121**, an

extending/retracting mechanism **123**, a driving unit **125**, and a coupling portion **127**.
[0096] The two guide rails **121** support the plurality of holding members **113** in a manner movable in the alignment direction (width direction Y). Each of the two guide rails **121** extends in the width direction Y. The two guide rails **121** are attached to the top surface of the base member **119**. Among the plurality of holding members **113**, the holding member **113**C at the center is fixed to the base member **119** using a screw SW, for example. That is, the holding member **113**C at the center does not move in the width direction Y. Note that the number of the guide rails **121** is not limited to two, and may be one or three or more. That is, the moving unit **115** may include one or more guide rails **121**.
[0097] The extending/retracting mechanism **123** causes the plurality of holding members **113** to extend and to retract in the alignment direction (width direction Y). The extending/retracting mechanism **123** is connected to each of the holding members **113**. The extending/retracting mechanism **123** is provided as, for example, a link mechanism. Specifically, the extending/retracting mechanism **123** is configured as, for example, a lazy tongs mechanism, a linear zigzag mechanism, or any mechanism similar thereto. The extending/retracting mechanism **123** includes, for example, a plurality of (twenty-five; five in FIG. **10** and other drawings) link members **129**, a plurality of (twenty-five; five in FIG. **10** and other drawings) pins **131**, and a plurality of (twenty-four; four in FIG. **10** and other drawings) joints **133**. In FIGS. **12** and **13**, for example, the five pins **131** are provided to the bottom surfaces of the five holding members **113**, respectively. Each of the five link members **129** is attached to one of the five pins **131**, in a manner rotatable about a vertical axis. The five pins **131** are positioned at the five centers of the five link members **129**, respectively. Each of the four joints **133** connects ends of two adjacent link members **129**.
[0098] For example, a joint **133**A connects a first end of the link member **129**B and a second end of the link member **129**A. A joint **133**B connects a second end of the link member **129**B and a first end of the link member **129**C.
[0099] The driving unit **125** drives the extending/retracting mechanism **123**. The driving unit **125** is attached to the bottom surface of the base member **119**. The driving unit **125** causes a rod **125**A extending in the width direction Y to extend and to retract. The driving unit **125** includes an air cylinder or an electric actuator. The coupling portion **127** couples the holding member **113**E at the end of the plurality of holding members **113**, to a distal end of the rod **125**A of the driving unit **125**. The coupling portion **127** is passed through an opening **119**A of the base member **119**.
[0100] In FIGS. **10** and **12**, for example, when the rod **125**A of the driving unit **125** is extended, the extending/retracting mechanism **123** causes the holding member **113**E at the end to move away from the holding member **113**C at the center, to cause the other three holding members **113**A, **113**B, and **113**D to move away from the holding member **113**C at the center. As a result, the plurality of substrates W becomes aligned at the unequal pitch. In FIGS. **11** and **13**, for example, when the rod **125**A of the driving unit **125** is retracted, the extending/retracting mechanism **123** causes the holding member **113**E at the end to move closer to the holding member **113**C at the center, to cause the other three holding members **113**A, **113**B, and **113**D to move closer to the holding member **113**C at the center. As a result, the plurality of substrates W becomes aligned at the narrow pitch (first interval TN**1**).
[0101] As illustrated in FIG. **7**, each of the pitch converting units **25**, **26** includes a lift **141**. The lift **141** raises and lowers the pitch converting body **111** (the plurality of holding members **113** and the moving unit **115**). The lift **141** includes an air cylinder or an electric actuator.
[0102] The lift **141** of the first pitch converting unit **25** raises and lowers the plurality of holding members **113**, between an upper position higher than (the top surface of) the chuck **77** of the incoming delivering mechanism **71**, and a lower position lower than the chuck **77**. Furthermore, the lift **141** of the second pitch converting unit **26** raises and lowers the plurality of holding members **113** between an upper position higher than (the upper surface of) the chuck **79** of the outgoing

delivering mechanism **75** and a lower position lower than the chuck **79**.

<1-3. Processing Block>

[0103] FIG. **1** will now be referred to. The processing block **7** includes a plurality of (e.g., four) batch processing baths BT**1** to BT**4** and a drying unit **143**. The four batch processing baths BT**1** to BT**4** and the drying unit **143** are arranged in the front-back direction X in which the substrate processing apparatus **1** extends. In each of the four batch processing baths BT**1** to BT**4**, a plurality of (e.g. fifty, seventy-five, or a hundred) substrates W are immersed as a batch. Each of the four batch processing baths BT**1** to BT**4** stores therein a process liquid (e.g., chemical liquid or pure water) in which the plurality of substrates W are immersed.

[0104] The four batch processing baths BT**1** to BT**4** include, for example, two chemical liquid processing baths BT**1**, BT**3** and two cleaning processing baths BT**2**, BT**4**. The chemical liquid processing bath BT**1** and the cleaning processing bath BT**2** together form one set, and the chemical liquid processing bath BT**3** and the cleaning processing bath BT**4** together forms another set. The combinations of the chemical liquid processing bath and the cleaning processing bath is not limited to this example. The number of batch processing baths is not limited to four, and may be one or more. At least one of the four batch processing baths BT**1** to BT**4** corresponds to the substrate processing unit according to the present invention.

[0105] Each of the two chemical liquid processing baths BT**1**, BT**3** performs etching processing using a chemical liquid. For example, a solution of phosphoric acid is used as the chemical liquid, but the chemical liquid is not limited to the phosphoric acid solution. The chemical liquid is heated to a preset temperature. A chemical liquid ejecting pipe (not illustrated) is provided on an inner bottom surface of each of the chemical liquid processing baths BT**1**, BT**3**. Each of the chemical liquid processing baths BT**1**, BT**3** stores therein a chemical liquid supplied from the chemical liquid ejecting pipe.

[0106] Each of the two cleaning processing baths BT**2**, BT**4** performs a cleaning process, for cleaning the chemical liquid attached to the plurality of substrates W with cleaning liquid (rinsing liquid). As the cleaning liquid, pure water such as deionized water (DIW) is used, for example. Each of the cleaning processing baths BT**2**, BT**4** stores therein pure water supplied from a pure water ejection pipe, not illustrated.

[0107] The processing block **7** includes a lifter LF**1** as a dedicated transport mechanism for transferring the substrates W subjected to the chemical liquid process in the chemical liquid processing bath BT**1** to the cleaning processing bath BT**2**, and a lifter LF**2** for transferring the substrates W subjected to the chemical liquid process in the chemical liquid processing bath BT**3** to the cleaning processing bath BT**4**. Each of the two lifters LF**1**, LF**2** includes a substrate holding unit that holds a plurality of (e.g., fifty, seventy-five, a hundred) substrates W aligned in the width direction Y at the narrow pitch, in the vertical orientation, a lift that raises and lowers the substrate holding unit, and a horizontally moving unit that moves the substrate holding unit in the front-back direction X.

[0108] The drying unit **143** includes a substrate holding mechanism that holds a plurality of (e.g., fifty, seventy-five, or a hundred) substrates W aligned at the narrow pitch in the width direction Y, in the vertical orientation, and a processing chamber that houses the plurality of substrates W held by the substrate holding mechanism. The drying unit **143** dries the substrates by supplying an organic solvent (e.g., isopropyl alcohol) to the substrates W in a reduced-pressure atmosphere, or getting rid of the liquid components on the surface of the substrate W using centrifugal force.

<1-4. Batch Substrate Transporting Area>

[0109] The batch substrate transporting area **8** is positioned on the rear side of the stocker **2**, and is positioned adjacently on the left side the transfer block **5** and the processing block **7**. The batch substrate transporting area **8** extends in the front-back direction X. The batch substrate transporting area **8** includes a main transporting mechanism (main transporting robot) WTR. The main transporting mechanism WTR transports a plurality of (e.g., fifty, seventy-five, or a hundred)

substrates W aligned in the width direction Y in the vertical orientation at the narrow pitch, in the front-back direction X. The main transporting mechanism WTR transports a plurality of substrates W from and to the first delivery position P**1**, the second delivery position P**2**, a plurality of (for example, four) batch processing baths BT**1** to BT**4**, and the drying unit **143**.

[0110] The main transporting mechanism WTR includes a chuck **145**, a chuck lift (not illustrated), a chuck horizontally moving unit (not illustrated), and a guide rail **147**. The chuck **145** holds a plurality of substrates W aligned at the narrow pitch in the width direction Y, in the vertical orientation. The chuck **145** includes a pair of chuck members **145**A, **145**B that extend in the width direction Y. The pair of chuck members **145**A, **145**B includes a plurality of pairs (e.g. fifty pairs, seventy-five pairs, or a hundred pairs) of holding grooves that are arranged along the width direction Y, at the narrow pitch. The pair of chuck members **145**A, **145**B is opened and closed by a chuck opening and closing unit, not illustrated.

[0111] The chuck **145** is movable in the front-back direction X along the guide rail **147**. The chuck **145** is moved in the front-back direction X by the chuck horizontally moving unit. The chuck **145** is moved up and down in the vertical direction Z by the chuck lift. Each of the chuck horizontally moving unit and the chuck lift includes, for example, an electric actuator. The chuck opening and closing unit includes, for example, an air cylinder or an electric actuator.

<1-5. Control Unit>

[0112] The substrate processing apparatus **1** includes a control unit **151** (see FIG. **1**) and a storage unit (not illustrated). The control unit **151** controls each of the components included in the substrate processing apparatus **1**. The control unit **151** includes one or more processors such as a central processing unit (CPU). The storage unit includes at least one of a read-only memory (ROM), a random access memory (RAM), and a hard disk, for example. The storage unit stores therein a computer program required in controlling each of the components included in the substrate processing apparatus **1**.

<2. Operation of Substrate Processing Apparatus>

[0113] An operation of the substrate processing apparatus **1** will now be described with reference to the flowchart illustrated in FIGS. **14** and **21**. To begin with, a former half of the operation, from transporting the carrier C to the loading port **9** to drying will be described with reference to FIG. **14**. In the present embodiment, the substrate processing apparatus **1** processes fifty substrates W taken out from the two carriers C, as a batch.

[0114] In FIG. **15**A and the like, the reference numeral TA denotes a front surface (a device surface or a principal surface) of a substrate W (W**1**, W**2**). The rear surface of a substrate W is a surface opposite to the front surface of the substrate W. The device surface is a surface on which a device is formed, or a surface in the middle of the process of forming a device. Note that, in FIG. **15**A and the like, for the convenience of illustration, the twenty-five substrates W**1** are represented as five substrates W**1**, and the twenty-five substrates W**2** are represented as five substrates W**2**.

[Step S01] Perform Vertical Orientation Conversion of First Substrate Group

[0115] FIG. **1** will now be referred to. An external transporting robot, not illustrated, transports two carriers C onto the loading ports **9**, respectively, one after another. The carrier transporting robot **13** of the stocker **2** then transports the first carrier C from the loading port **9** onto the placing shelf **3**. It is assumed herein that the first carrier C houses the twenty-five substrates W**1** (first substrate group) that are aligned at the reference pitch (e.g., 10-mm pitch), in which the reference interval TN**9** is repeated. The substrate handling mechanism HTR in the transfer block **5** takes out the twenty-five substrates W**1** in the horizontal orientation, from the first carrier C placed on the placing shelf **3** using twenty-five hands **27**, for example. The substrate handling mechanism HTR then transports the twenty-five substrates W**1** having been taken out, to the orientation converting unit **19**. Note that the carrier transporting robot **13** moves the empty first carrier C, where the twenty-five substrates W**1** have been taken out, from the placing shelf **3** to the storage shelf **11**.

[0116] FIG. **15**A will now be referred to. The orientation converting unit **19** receives the twenty-

five substrates W**1** aligned at the reference pitch, from the substrate handling mechanism HTR. In the orientation converting unit **19**, the twenty-five substrates W**1** are held (placed) on the twenty-five pairs of shelves **37**A, respectively, provided to the pair of horizontal holders **37**. FIG. **15**B will now be referred to. The housing moving unit **53** (see FIG. **4**) of the orientation converting unit **19** brings the pair of vertical holders **39** closer to the pair of horizontal holders **37**. As a result, the peripheral edges of the twenty-five substrates W**1** are housed and held inside the twenty-five pairs of holding grooves **39**A of the pair of vertical holders **39**, respectively.

[0117] FIG. **15**C will now be referred to. The orientation converting unit **19** then converts the orientation of the twenty-five substrates W**1** (first substrate group) held at the reference pitch, from the horizontal orientation to the vertical orientation, as a batch. Specifically, the rotation driving unit **41** included in the orientation converting unit **19** converts the twenty-five substrates W**1** held by the pair of horizontal holders **37** and the pair of vertical holders **39**, from the horizontal orientation to the vertical orientation. The axial moving unit **51** (see FIG. **4**) of the orientation converting unit **19** then moves the pair of horizontal holders **37** in a direction in which the pair of horizontal holders **37** move closer to the support surface **35**A so that the twenty-five pairs of shelves **37**A on the pair of horizontal holders **37** move away from the twenty-five substrates W**1** that are in the vertical orientation.

[Step S02] Cause Pusher Member to Receive First Substrate Group

[0118] FIG. **16**A will now be referred to. The pusher lift **65** (see FIG. **5**) in the pusher mechanism **21** raises the pusher member **55** to a position higher than the pair of horizontal holders **37** and the pair of vertical holders **39**. As a result, the pusher member **55** receives the twenty-five substrates W**1** (first substrate group) having the orientation converted to the vertical orientation. The pusher member **55** holds the twenty-five substrates W**1** aligned at the reference pitch, in the vertical orientation. Note that the fifty vertical holding grooves **67** of the pusher member **55** are arranged at the unequal pitch.

[Step S03] Shift First Substrate Group by First Interval

[0119] FIG. **16**B will now be referred to. The pusher mechanism **21** shifts the twenty-five substrates W**1** held by the pusher member **55** by the first interval TN**1** (3.333 mm), in the alignment direction of the twenty-five substrates W**1**. Specifically, the pusher rotating unit **59** (see FIG. **5**) of the pusher mechanism **21** rotates the pusher member **55** by 180 degrees about the vertical axis AX**3**. As a result, the twenty-five substrates W**1** held by the pusher member **55** are shifted leftwards by the first interval TN**1**. The direction in which the front surfaces of the twenty-five substrates W**1** face is changed from the left to the right. Note that the substrates W**1** may also be moved by the first interval TN**1** by causing the pusher rotating unit **59** to rotate the pusher member **55** by 180 degrees, and by causing the pusher horizontally moving unit **61** (see FIG. **5**) to move the pusher member **55** in the width direction Y.

[0120] The orientation converting unit **19** also rotates the elements such as the pair of horizontal holders **37** by 90 degrees about the horizontal axis AX**2**. As a result, the elements such as the pair of horizontal holders **37** are raised. The axial moving unit **51** (see FIG. **4**) in the orientation converting unit **19** moves the pair of horizontal holders **37** in the direction moving the pair of horizontal holders **37** away from the support surface **35**A. The housing moving unit **53** (see FIG. **4**) in the orientation converting unit **19** moves the pair of vertical holders **39** away from the pair of horizontal holders **37**.

[Step S04] Perform Vertical Orientation Conversion of Second Substrate Group

[0121] The carrier transporting robot **13** illustrated in FIG. **1** then transports a second carrier C from the loading port **9** onto the placing shelf **3**. It is assumed herein that the second carrier C houses the twenty-five substrates W**2** that are aligned at the reference pitch (10-mm pitch), in the same manner as the first carrier C. The substrate handling mechanism HTR takes out the twenty-five substrates W**2** in the horizontal orientation, from the second carrier C placed on the placing shelf **3**, using twenty-five hands **27**. The substrate handling mechanism HTR then transports the

taken out twenty-five substrates W**2** to the orientation converting unit **19**. Note that the carrier transporting robot **13** moves the empty second carrier C from which the twenty-five substrates W**2** have been taken out, from the placing shelf **3** to the storage shelf **11**.

[0122] FIG. **16**C will now be referred to. The orientation converting unit **19** receives the twenty-five substrates W**2** aligned at the reference pitch, from the substrate handling mechanism HTR. In the orientation converting unit **19**, the twenty-five substrates W**2** are held on the twenty-five pairs of shelves **37**A, respectively, provided to the pair of horizontal holders **37**. FIG. **17**A will now be referred to. The housing moving unit **53** (see FIG. **4**) of the orientation converting unit **19** then brings the pair of vertical holders **39** closer to the pair of horizontal holders **37**.

[0123] FIG. **17**B will now be referred to. The orientation converting unit **19** then converts the orientation of the twenty-five substrates W**2** (second substrate group) held at the reference pitch, from the horizontal orientation to the vertical orientation, as a batch. The axial moving unit **51** (see FIG. **4**) of the orientation converting unit **19** then moves the pair of horizontal holders **37** in a direction in which the pair of horizontal holders **37** move closer to the support surface **35**A so that the twenty-five pairs of shelves **37**A on the pair of horizontal holders **37** move away from the twenty-five substrates W**1** that are in the vertical orientation.

[Step S05] Cause Pusher Member to Receive Second Substrate Group

[0124] FIG. **17**C will now be referred to. The pusher lift **65** (see FIG. **5**) in the pusher mechanism **21** then raises the pusher member **55** to a position higher than the pair of horizontal holders **37** and the pair of vertical holders **39**. As a result, the pusher member **55** receives the twenty-five substrates W**2** (second substrate group) having the orientation converted to the vertical orientation. The pusher member **55** holds the fifty substrates W (W**1**, W**2**) aligned at the unequal pitch. In the fifty substrates W, the twenty-five substrates W**1** and the twenty-five substrates W**2** are positioned alternately.

[0125] As illustrated in FIGS. **17**B and **17**C, the front surfaces (the device surfaces or the main surfaces) of the twenty-five substrates W**1** face a predetermined direction (rightwards). By contrast, the front surfaces of the twenty-five substrates W**2** face the direction opposite to the predetermined direction (leftwards). That is, the fifty substrates W are arranged in a manner what is called face to face.

[Step S06] Cause Incoming Delivering Mechanism to Transport Processing Substrate Group to Pitch Converting Unit

[0126] The incoming delivering mechanism **71** then transports the fifty substrates W (processing substrate group) aligned at the unequal pitch, from the pusher member **55** to the first pitch converting unit **25**. This operation will now be explained specifically. FIG. **18**A will now be referred to. To begin with, the orientation converting unit **19** rotates the elements such as the pair of horizontal holders **37** by 90 degrees about the horizontal axis AX**2**. As a result, the elements such as the pair of horizontal holders **37** are raised. The incoming delivering mechanism **71** moves the chuck **77** horizontally, from the position above the first pitch converting unit **25** to the position below the pusher member **55**. The chuck **77** is closed and is capable of holding fifty substrates W.

[0127] FIG. **18**B will now be referred to. The pusher mechanism **21** then lowers the pusher member **55** holding the fifty substrates W in the vertical orientation. As the pusher member **55** is passed between the pair of chuck members **77**A, **77**B of the chuck **77**, the fifty substrates W are delivered from the pusher member **55** to the chuck **77**. The chuck **77** then holds fifty substrates W that are aligned at the unequal pitch in the vertical orientation.

[0128] FIG. **19**A will now be referred to. The incoming delivering mechanism **71** then moves the chuck **77** from the position above the pusher member **55** to the position above the first pitch converting unit **25**. FIG. **19**B will now be referred to. The lift **141** (see FIG. **7**) of the first pitch converting unit **25** then raises the pitch converting body **111** including the twenty-five holding members **113**. As a result, the first pitch converting unit **25** receives the fifty substrates W from the incoming delivering mechanism **71**.

[Step S07] Convert Pitch of Processing Substrate Group from Unequal Pitch to Narrow Pitch

[0129] FIG. **20**A will now be referred to. The first pitch converting unit **25** then converts the pitch of the fifty substrates W from the unequal pitch to the narrow pitch (3.333-mm pitch). In other words, the first pitch converting unit **25** aligns the fifty substrates W having been aligned at the unequal pitch, at the narrow pitch. This operation will now be explained specifically.

[0130] Each of the twenty-five holding members **113** in the first pitch converting unit **25** has two holding grooves **117** that are spaced apart from each other by the first interval TN**1** (3.333 mm). The first pitch converting unit **25** holds two substrates W**1**, W**2**, among the fifty substrates W, using the two holding grooves **117** on each of the twenty-five holding members **113**, and holds the fifty substrates W aligned at the unequal pitch, using the twenty-five holding members **113**.

[0131] The moving unit **115** (see FIG. **10**) of the first pitch converting unit **25** then moves the twenty-five holding members **113** in the alignment direction of the fifty substrates W (the width direction Y) to switch the fifty substrate W from the unequal pitch arrangement in which the substrates W are aligned at the unequal pitch, to the narrow pitch arrangement in which the fifty substrates W are aligned at the narrow pitch. The intermediating mechanism **73** keeps the chuck **78** open.

[Step S08] Cause Intermediating Mechanism to Transfer Processing Substrate Group to First Delivery Position

[0132] FIG. **20**B will now be referred to. The intermediating mechanism **73** then lowers the chuck **78** as indicated by the broken line, to receive the fifty substrates W aligned at the narrow pitch held by the first pitch converting unit **25**. The intermediating mechanism **73** then closes the chuck **78**. In this manner, chucks **78** is enabled to hold fifty substrates W.

[0133] The intermediating mechanism **73** then raises the chuck **78** to the first delivery position P**1**. In this manner, the intermediating mechanism **73** can receive fifty substrates W from the first pitch converting unit **25**, and deliver the fifty substrates W to the main transporting mechanism WTR. The chuck **78** holds fifty substrates W that are aligned at the narrow pitch in the vertical orientation.

[Step S09] Perform Substrate Process and Drying Process

[0134] The main transporting mechanism WTR then receives fifty substrates W from the intermediating mechanism **73**, using the chuck **145**, and transports the fifty substrates W to one of the two chemical liquid processing baths BT**1**, BT**3**. For example, when the main transporting mechanism WTR transports fifty substrates W to the chemical liquid processing bath BT**1**, the lifter LF**1** receives the fifty substrates W that are aligned at the narrow pitch, from the main transporting mechanism WTR, at the position above the chemical liquid processing bath BT**1**. Then, by lowering the fifty substrates W, the lifter LF**1** immerses the fifty substrates W in the chemical liquid stored in the chemical liquid processing bath BT**1**. As a result, the fifty substrates W are subjected to the chemical liquid process, as a batch.

[0135] After a preset chemical liquid process time has elapsed, the lifter LF**1** pulls out the fifty substrates W from the chemical liquid in the chemical liquid processing bath BT**1** by raising the fifty substrates W. The lifter LF**1** then moves the fifty substrates W horizontally from the position above the chemical liquid processing bath BT**1** to the position above the cleaning processing bath BT**2**. Then, by lowering the fifty substrates W, the lifter LF**1** immerses the fifty substrates W in the pure water stored in the cleaning processing bath BT**2**. As a result, the fifty substrates W are cleaned as a batch. After a preset cleaning processing time has elapsed, the lifter LF**1** pulls out the fifty substrates W from the pure water in the cleaning processing bath BT**2**.

[0136] When the main transporting mechanism WTR transports the fifty substrates W to the chemical liquid processing bath BT**3**, the lifter LF**2** receives the fifty substrates W from the main transporting mechanism WTR. The lifter LF**2** then transports the fifty substrates W to the chemical liquid processing bath BT**3**, and to the cleaning processing bath BT**4**, sequentially.

[0137] After the cleaning process, the main transporting mechanism WTR receives the fifty

substrates W from one of the two lifters LF**1**, LF**2**, using the chuck **145**, and transports the fifty substrates W to the drying unit **143**. The drying unit **143** dries the fifty substrates W. The main transporting mechanism WTR then receives the fifty dried substrates W from the drying unit **143**.

[0138] The latter half of the operation from the drying process to transporting to the carrier C from the loading port **9** will be described with reference to FIG. **21**.

[Step S11] Cause Main Transporting Mechanism to Transport Processing Substrate Group to Second Delivery Position

[0139] FIGS. **2** and **22**A will now be referred to. The main transporting mechanism WTR transports the fifty substrates W in the vertical orientation having been processed in the chemical liquid processing bath BT**1**, or the like, and aligned at the narrow pitch, to a position above the second pitch converting unit **26**. In other words, the main transporting mechanism WTR transports the fifty substrates W having been subjected to the drying process by the drying unit **143**, to a position above the second pitch converting unit **26**.

[0140] The main transporting mechanism WTR then lowers the fifty substrates W being held by the chuck **145**, to the second delivery position P**2**. In this manner, the main transporting mechanism WTR transports the fifty substrates W in the vertical orientation that are aligned at the narrow pitch, to the second pitch converting unit **26**. The second pitch converting unit **26** receives the fifty substrates W in the vertical orientation that are aligned at the narrow pitch, from the main transporting mechanism WTR. Before receiving the fifty substrates W, the second pitch converting unit **26** moves the twenty-five holding members **113** in such a manner that the fifty holding grooves **117** are arranged at the narrow pitch.

[Step S12] Perform Pitch Conversion on Processing Substrate Group, from Narrow Pitch to Unequal Pitch

[0141] FIG. **22**B will now be referred to. The second pitch converting unit **26** then converts the pitch of the fifty substrates W from the narrow pitch to the unequal pitch. This operation will now be explained specifically. The second pitch converting unit **26** holds the fifty substrates W that are aligned at the narrow pitch, using the twenty-five holding members **113**, while ensuring the first interval TN**1** between two of substrates W using the two holding grooves **117** provided to each of the twenty-five holding members **113** and spaced apart from each other by the first interval TN**1**. The moving unit **115** (see FIG. **10**) then moves the twenty-five holding members **113** in the alignment direction of the fifty substrates W (in the width direction Y), so as to shift the fifty substrates W from the narrow pitch arrangement to the unequal pitch arrangement.

[Step S13] Cause Outgoing Delivering Mechanism to Transport Processing Substrate Group to Pusher Member

[0142] FIG. **23**A will now be referred to. The outgoing delivering mechanism **75** of the delivering mechanism **23** then transports the fifty substrates W that are aligned at the unequal pitch in the vertical orientation, from the second pitch converting unit **26** to the pusher member **55**. This operation will now be explained specifically. The chuck **79** of the outgoing delivering mechanism **75** is closed. To begin with, the lift **141** (see FIG. **7**) of the second pitch converting unit **26** lowers the pitch converting body **111** including the twenty-five holding members **113**. As the holding members **113** are lowered, the outgoing delivering mechanism **75** receives the fifty substrates W in the vertical orientation and aligned at the unequal pitch, and holds the substrates W, using the chuck **79**.

[0143] FIG. **23**B will now be referred to. The outgoing delivering mechanism **75** then transports the fifty substrates W being held by the chuck **79**, from the position above the second pitch converting unit **26** to the position above the pusher member **55**. The pusher mechanism **21** then raises the pusher member **55** to a position higher than the chuck **79**. As the pusher member **55** is raised, the pusher mechanism **21** receives the fifty substrates W from the chuck **79** of the outgoing delivering mechanism **75**, and holds the substrates W, using the pusher member **55**. The pusher member **55** holds the fifty substrates W that are aligned at the unequal pitch, in the vertical

orientation.
[Step S14] Cause Orientation Converting Unit to Receive Second Substrate Group
[0144] FIG. **24**A will now be referred to. The outgoing delivering mechanism **75** moves the chuck **79** to a position above the second pitch converting unit **26**. The rotation driving unit **41** in the orientation converting unit **19** then rotates the elements including the pair of horizontal holders **37** by 90 degrees about the horizontal axis AX**2** so as to enable the pair of vertical holders **39** to receive the twenty-five substrates W**2** (second substrate group). As a result, the pair of horizontal holders **37** and the pair of vertical holders **39** are laid down. The axial moving unit **51** brings the pair of horizontal holders **37** closer to the support surface **35**A, and the housing moving unit **53** brings the pair of vertical holders **39** closer to the pair of horizontal holders **37**.
[0145] FIG. **24**B will now be referred to. The pusher mechanism **21** then lowers the pusher member **55** from a position higher than the pair of vertical holders **39**, to a position lower than the pair of vertical holders **39**. As the pusher member **55** is lowered, the orientation converting unit **19** receives the twenty-five substrates W**2** (second substrate group), among the fifty substrates W (processing substrate group), from the pusher member **55**, using the pair of horizontal holders **37** and the pair of vertical holders **39**. The pair of vertical holders **39** holds the twenty-five substrates W**2** that are aligned at the reference pitch (10-mm pitch). The axial moving unit **51** then moves the pair of horizontal holders **37** away from the support surface **35**A. As a result, the twenty-five pairs of shelves **37**A on the pair of horizontal holders **37** come into contact with the rear surfaces of the twenty-five substrates W**2**, respectively.
[0146] Note that, as illustrated in FIG. **24**A, the moving unit **115** in the second pitch converting unit **26** moves twenty-five (twenty-four) holding members **113** in such a manner that the fifty holding grooves **117** are arranged at the narrow pitch. Furthermore, as illustrated in FIG. **24**B, the lift **141** in the second pitch converting unit **26** raises the pitch converting body **111** including the twenty-five holding members **113** in such a manner that the fifty holding grooves **117** are arranged at a position higher than the chuck **79**.
[Step S15] Perform Horizontal Orientation Conversion of Second Substrate Group
[0147] FIG. **25**A will now be referred to. The orientation converting unit **19** rotates the elements such as the pair of horizontal holders **37** by 90 degrees about the horizontal axis AX**2**. In this manner, the orientation converting unit **19** converts the twenty-five substrates W**2** from the vertical orientation to the horizontal orientation. The housing moving unit **53** then moves the pair of vertical holders **39** away from the pair of horizontal holders **37**. As a result, the peripheral edges of the twenty-five substrates W**2** are removed from the twenty-five pairs of holding grooves **39**A in the pair of vertical holders **39**.
[0148] The carrier transporting robot **13** illustrated in FIG. **1** transports the empty second carrier C from the storage shelf **11** to the placing shelf **3**. The substrate handling mechanism HTR takes out the twenty-five substrates W**2** having the orientation converted into the horizontal orientation by the orientation converting unit **19** and aligned at the reference pitch, from the orientation converting unit **19** (see FIG. **25**B). The substrate handling mechanism HTR then transports the twenty-five substrates W**2** into the second carrier C on the placing shelf **3**. The carrier transporting robot **13** then transports the second carrier C storing therein the processed twenty-five substrates W**2**, from the placing shelf **3** to the loading port **9**.
[Step S16] Shift First Substrate Group by First Interval
[0149] FIG. **25**B will now be referred to. After the orientation converting unit **19** changes the orientation of the twenty-five substrates W**2** to the horizontal orientation, the pusher mechanism **21** raises the pusher member **55** holding the twenty-five substrates W**1** (first substrate group).
[0150] The pusher mechanism **21** also shifts the twenty-five substrates W**1** held by the pusher member **55** by the first interval TN**1** (3.333 mm) in the alignment direction of the twenty-five substrates W**1**. Specifically, the pusher rotating unit **59** (see FIG. **5**) of the pusher mechanism **21** rotates the pusher member **55** by 180 degrees about the vertical axis AX**3**. As a result, the twenty-

five substrates W**1** held by the pusher member **55** are shifted rightwards by the first interval TN**1**. The direction in which the front surfaces of the twenty-five substrates W**1** face is also changed from the right to the left. Note that the substrates W**1** may also be moved by the first interval TN**1** by causing the pusher rotating unit **59** to rotate the pusher member **55** by 180 degrees, and by causing the pusher horizontally moving unit **61** (see FIG. **5**) to move the pusher member **55** in the width direction Y.

[Step S17] Cause Orientation Converting Unit to Receive First Substrate Group

[0151] FIG. **25**C will now be referred to. The orientation converting unit **19** lays down the pair of horizontal holders **37** and the pair of vertical holders **39**. The axial moving unit **51** then brings the pair of horizontal holders **37** closer to the support surface **35**A, and the housing moving unit **53** brings the pair of vertical holders **39** closer to the pair of horizontal holders **37**.

[0152] FIG. **26**A will now be referred to. The pusher mechanism **21** then lowers the pusher member **55** from a position higher than the pair of vertical holders **39**, to a position lower than the pair of vertical holders **39**. As the pusher member **55** is lowered, the orientation converting unit **19** receives the twenty-five remaining substrates W**1** from the pusher member **55**, using the pair of horizontal holders **37** and the pair of vertical holders **39**. The pair of vertical holders **39** holds the twenty-five substrates W**1** that are aligned at the reference pitch (e.g., 10-mm pitch). The axial moving unit **51** then brings twenty-five pairs of shelves **37**A of the pair of horizontal holders **37** into contact with the rear surfaces of the twenty-five substrates W**1**, respectively.

[Step S18] Perform Horizontal Orientation Conversion of First Substrate Group

[0153] FIG. **26**B will now be referred to. The orientation converting unit **19** rotates the elements such as the pair of horizontal holders **37** by 90 degrees about the horizontal axis AX**2**. In this manner, the orientation converting unit **19** converts the twenty-five substrates W**1** from the vertical orientation to the horizontal orientation. FIG. **26**C will now be referred to. The housing moving unit **53** then moves the pair of vertical holders **39** away from the pair of horizontal holders **37**.

[0154] The carrier transporting robot **13** illustrated in FIG. **1** transports the empty first carrier C from the storage shelf **11** to the placing shelf **3**. The substrate handling mechanism HTR takes out the twenty-five substrates W**1** having the orientation converted into the horizontal orientation by the orientation converting unit **19** and aligned at the reference pitch (10-mm pitch), from the orientation converting unit **19** (see FIG. **26**C). The substrate handling mechanism HTR then transports the twenty-five substrates W**1** into the first carrier C on the placing shelf **3**. The carrier transporting robot **13** then transports the first carrier C storing therein the processed twenty-five substrates W**1**, from the placing shelf **3** to the loading port **9**. The external transporting robot, not illustrated, transports the two carriers C from the respective loading ports **9**, to the next destination, one after another.

[0155] According to the present embodiment, each of the pitch converting units **25**, **26** includes the plurality of holding members **113** that hold the plurality of substrates W aligned at the unequal pitch, and the moving unit **115** that moves the plurality of holding members **113** in the alignment direction (width direction Y) so as to change between the unequal pitch arrangement in which the plurality of substrates W are aligned at the unequal pitch and the narrow pitch arrangement in which the plurality of substrates W are aligned at the narrow pitch. Each of the plurality of holding members **113** has two holding grooves **117** that hold two substrates W, respectively, among the plurality of substrates W. The two holding grooves **117** are spaced apart from each other by the first interval TN**1** (first interval TN**1**<second interval TN**2**). Because each of the holding members **113** has the two holding grooves **117** for holding the two substrates W, respectively, each of the holding members **113** can be provided with a relatively large width in the direction in which of the plurality of substrates W are aligned (width direction Y). With this, it becomes possible to ensure the dimensional accuracy of the holding members **113**, and to allow the plurality of holding members **113** to hold the substrates W in the vertical orientation, easily.

[0156] Furthermore, the two holding grooves **117** of each of the holding members **113** are spaced

apart from each other by the first interval TN**1** (e.g., 3.333 mm), which is an interval that is a half of the second interval TN**2** (e.g., 6.666 mm). In the unequal pitch, the first interval TN**1** and the second interval TN**2** wider than the first interval TN**1** are repeated alternately. Let us assume herein that there is a predetermined interval (reference interval TN**9**) constituting of one first interval TN**1** and one second interval TN**2**. Assuming that the predetermined interval is 10 mm, for example, by setting the first interval TN**1** equal to a half of the second interval TN**2**, it is possible to set the first interval TN**1** to a value smaller than ⅓ times 10 mm, and to set the second interval TN**2** to a value ⅔ times 10 mm.

[0157] Furthermore, two or more (e.g., twenty-five) substrates W**1** are aligned at the reference pitch (e.g., 10-mm pitch), and two or more (e.g., twenty-five) substrates W**2** are aligned at the reference pitch. Furthermore, the twenty-five substrates W**2** are arranged offset from the twenty-five substrates W**1** by the first interval TN**1** (e.g., 3.333 mm) in the alignment direction. As a result, the fifty substrates W including the twenty-five substrates W**1** and the twenty-five substrates W**2** arranged alternately are aligned at the unequal pitch. The first pitch converting unit **25** then converts the pitch of the fifty substrates W aligned at the unequal pitch, to the narrow pitch (e.g., 3.333-mm pitch). That is, the first pitch conversion is performed by aligning the twenty-five substrates W**1** and the twenty-five substrates W**2** at the unequal pitch, and the second pitch conversion is performed by converting the unequal pitch to the narrow pitch. By performing the pitch conversion in two stages, it becomes possible to convert the pitch of the twenty-five substrates W**1** and the twenty-five substrates W**2** that are aligned at the reference pitch easily to the narrow pitch.

[0158] In addition, the first pitch conversion for aligning the fifty substrates W aligned at the narrow pitch (e.g., 3.333-mm pitch), having been processed as a batch in the chemical liquid processing bath BT**1** or the like, at the unequal pitch is performed. The fifty substrates W, which are aligned at the unequal pitch and in which the twenty-five substrates W**1** and the twenty-five substrates W**2** are arranged alternately, are decomposed into the twenty-five substrates W**1** and the twenty-five substrates W**2** both of which are arranged at the reference pitch (e.g., 10-mm pitch). The second pitch conversion is thus performed. By performing the pitch conversion in two stages, fifty substrates W (twenty-five substrates W**1** and twenty-five substrates W**2**) aligned at the narrow pitch can be easily converted to the reference pitch.

Second Embodiment

[0159] A second embodiment according to the present invention will now be described with reference to drawings. Note that redundant descriptions with those in the first embodiment will be omitted. FIG. **27** is a bottom view mainly illustrating the extending/retracting mechanism **160** included in the pitch converting unit **25** holding the plurality of substrates W that are aligned at the unequal pitch. FIG. **28** is a bottom view mainly illustrating the extending/retracting mechanism **160** included in the pitch converting unit **25** holding a plurality of substrates W that are aligned at the narrow pitch.

[0160] In the first embodiment, each of the two pitch converting units **25**, **26** includes the link mechanism illustrated in FIGS. **12** and **13**, as the extending/retracting mechanism **123**. In this regard, in the second embodiment, each of the two pitch converting units **25**, **26** may include a housing **161**, a protrusion **163**, and a stopper **165**, illustrated in FIGS. **27** and **28**, as the extending/retracting mechanism **160**.

[0161] FIGS. **27** and **28** will now be referred to. The extending/retracting mechanism **160** includes a plurality of housings **161**, a plurality of protrusions **163**, and a plurality of stoppers **165**. In the configuration in which the pitch converting body **111** includes the twenty-five holding members **113**, the extending/retracting mechanism **160** includes twenty-four housings **161**, twenty-four protrusions **163**, and twenty-four stoppers **165**. For every pair of the two adjacent holding members **113**, one housing **161**, one protrusion **163**, and one stopper **165** are provided. FIGS. **27** and **28** will be described focusing on the two adjacent holding members **113**A, **113**B, as an example. The

holding member **113**A corresponds to a first holding member according to the present invention. The holding member **113**B corresponds to a second holding member according to the present invention.

[0162] The housing **161** is provided to the holding member **113**A, as an example. As illustrated in an enlarged view inside the circle in FIG. **27**, the housing **161** includes a housing body **161**A and a joint path **161**B. The joint path **161**B communicates with the housing body **161**A. The joint path **161**B opens in a manner facing the holding member **113**B.

[0163] The protrusion **163** is provided on a side surface of the holding member **113**B, the side surface being a surface facing the holding member **113**A. In other words, the protrusion **163** protrudes from the holding member **113**B toward the holding member **113**A. When the plurality of holding members **113** retract in the alignment direction (width direction Y), for example, the protrusion **163** becomes housed inside the housing **161** of the holding member **113**A, as illustrated in FIG. **28**. Furthermore, with the width WD of the holding members **113** in the width direction Y, the interval between the two holding members **113**A and **113**B is set to a preset distance. As a result, for example, the fifty holding grooves **117**, including the two holding grooves **117** of every holding member **113**, become aligned at the narrow pitch (e.g., 3.333-mm pitch).

[0164] The stopper **165** is provided at the tip of the protrusion **163**. The stopper **165** is housed inside the housing **161**. A diameter DM**1** (or the width) of the stopper **165** is larger than a diameter DM**2** of the protrusion **163**. An inner diameter DM**3** of the joint path **161**B of the housing **161** is smaller than the diameter DM**1** of the stopper **165**, and larger than the diameter DM**2** of the protrusion **163**. Therefore, the stopper **165** cannot pass through the joint path **161**B, but the protrusion **163** can pass through the joint path **161**B. When the plurality of holding members **113** extend in the alignment direction (width direction Y), for example, the stopper **165** prevents the protrusion **163** from coming out of the housing **161**, as illustrated in FIG. **27**. The interval between the two holding members **113**A and **113**B is also brought to a preset distance. As a result, the fifty holding grooves **117**, for example, are aligned at the unequal pitch.

[0165] In the description above, the housing **161** is provided to the holding member **113**A, and the protrusion **163** is provided to the holding member **113**B. In this regard, the housing **161** may be provided to the holding member **113**B, and the protrusion **163** may be provided to the holding member **113**A. In addition, as illustrated in FIGS. **27** and **28**, two protrusions **163** and two stoppers **165** may be provided to the holding member **113**C at the center fixed in the width direction Y.

[0166] The extending/retracting mechanism **160** also includes a plurality of holes **167** and a plurality of elastic members **169**. In a configuration in which the pitch converting body **111** has twenty-five holding members **113**, the extending/retracting mechanism **160** has twenty-four holes **167** and twenty-four elastic members **169**. One hole **167** and one elastic member **169** are provided, correspondingly to every pair of the two adjacent holding members **113**. The following description is made focusing on the two adjacent holding members **113**A, **113**B, as an example.

[0167] The hole **167** is provided to the holding member **113**B, for example. Specifically, the hole **167** is provided on a side surface of the holding member **113**B, the side surface being a surface facing the holding member **113**A. The hole **167** opens to a space between the two holding members **113**A and **113**B. The elastic member **169** is, for example, a spring, but may be a sponge. The elastic member **169** is provided between the two holding members **113**A and **113**B, and one end of the elastic member **169** is housed inside the hole **167**. For example, when the plurality of holding members **113** retract in the alignment direction (width direction Y), almost the entirely elastic member **169** becomes housed inside the housing **161**, as illustrated in FIG. **28**.

[0168] The elastic member **169** generates a repulsive force upon receiving an external force. For example, as illustrated in FIGS. **27** and **28**, it is preferable for the elastic member **169** to be provided between the two holding members **113**A and **113**B, in a manner exerting the repulsive force, when the plurality of holding members **113** are extended in the alignment direction (width direction Y) as well as when the plurality of holding members **113** are retracted in the alignment

direction (width direction Y).
[0169] While the plurality of holding members **113** are in between of being extended in the alignment direction (width direction Y) and retracted in the alignment direction (width direction Y) (in between of being opened and closed), the holding members **113** are free to move from their positions. By providing the plurality of elastic members **169**, it is possible to suppress movements of the holding members **113** (including the two holding members **113**A, **113**B) that are free to move. In this manner, it is possible to suppress shaking of the fifty substrates W held in the fifty holding grooves **117** in the vertical orientation, for example. Thus, it is possible to suppress a contact of two adjacently positioned substrates W, for example.
[0170] In the above description, the hole **167** is provided to the holding member **113**B. In this regard, the hole **167** may also be provided to the holding member **113**A. Furthermore, it is also possible to provide two holes **167** to the holding member **113**C at the center.
[0171] The moving unit **115** according to the second embodiment includes a second driving unit **171** and a second coupling portion **173**, in addition to the base member **119**, the two guide rails **121**, the extending/retracting mechanism **160**, the driving unit **125**, and the coupling portion **127** illustrated in FIGS. **27** and **28**. In the same manner as the driving unit **125**, the second driving unit **171** is also attached to the bottom surface of the base member **119**. The second driving unit **171** causes a rod **171**A extending in the width direction Y to extend and retract. The second driving unit **171** includes an air cylinder or an electric actuator.
[0172] The coupling portion **127** couples the holding member **113**E at a first end of the plurality of holding members **113**, to a distal end of the rod **125**A of the driving unit **125**. Similarly, the second coupling portion **173** couples the holding member **113**A at a second end of the plurality of holding members **113**, to a distal end of the rod **171**A of the second driving unit **171**. Similarly to the coupling portion **127** illustrated in FIGS. **10** and **11**, the second coupling portion **173** is passed through an opening, not illustrated, provided to the base member **119**.
[0173] The second driving unit **171** causes the rod **171**A to extend and to retract in a manner synchronized with the rod **125**A being caused to extend and to retract by the driving unit **125**. In FIGS. **27** and **28**, when the driving unit **125** causes the rod **125**A to extend, and the second driving unit **171** causes the rod **171**A to extend, the four holding members **113**A, **113**B, **113**D, and **113**E are moved away from the holding member **113**C at the center. As a result, the plurality of substrates W held by the plurality of holding members **113** become aligned at the unequal pitch. When the driving unit **125** causes the rod **125**A to retract and the second driving unit **171** causes the rod **171**A to retract, the four holding members **113**A, **113**B, **113**D, and **113**E are moved closer to the holding member **113**C at the center. As a result, the plurality of substrates W held by the plurality of holding members **113** become aligned at the narrow pitch.
[0174] According to the present embodiment, the extending/retracting mechanism **160** can extend/retract the plurality of holding members **113** using the housings **161**, the protrusions **163**, and the stoppers **165**.
[0175] A modification of the second embodiment will now be explained. In the second embodiment, the moving unit **115** in each of the pitch converting units **25**, **26** includes the extending/retracting mechanism **160** that includes the housings **161**, the protrusions **163**, and the stoppers **165**. In this regard, the moving unit **115** may include the extending/retracting mechanism **123** (e.g., a link mechanism) according to the first embodiment, in addition to the extending/retracting mechanism **160**. In such a case, it is possible not to provide the moving unit **115** with the second driving unit **171**. In this manner, the one driving unit **125** causes each of the holding members **113** to move along the guide rails **121**. In addition, with the stoppers **165** and the width WD of the holding members **113**, the interval between the two adjacent holding members **113** are set to the preset distance. In this manner, the positional precision of the two holding members **113** (two holding members **113**A, **113**E illustrated in FIGS. **12** and **27**) at both ends of the extending/retracting mechanism **123** can be further improved.

Third Embodiment

[0176] A third embodiment according to the present invention will now be described with reference to drawings. Note that redundant descriptions with those in the first and the second embodiments will be omitted.

[0177] In the first embodiment, the operation of the substrate processing apparatus **1** that processes the fifty substrates W as a batch has been described. In this regard, in the third embodiment, the operation of the substrate processing apparatus **1** that processes seventy-five substrates W as a batch will be described.

[0178] The substrate handling mechanism HTR includes, for example, twenty-five or thirteen hands **27** that are arranged at the reference pitch (e.g., 10-mm pitch) in the vertical direction Z. The pair of horizontal holders **37** provided to the orientation converting unit **19** includes, for example, thirty-eight pairs of shelves **37**A that are arranged at the reference pitch. The pair of vertical holders **39** provided to the orientation converting unit **19** includes, for example, thirty-eight pairs of holding grooves **39**A that are arranged at the reference pitch. The pusher member **55** includes seventy-five or seventy-six vertical holding grooves **67** that are arranged at the unequal pitch.

[0179] The chuck **77** of the incoming delivering mechanism **71** includes seventy-five or seventy-six pairs of holding grooves **87**, **88** that are arranged at the unequal pitch. The chuck **78** of the intermediating mechanism **73** includes seventy-five or seventy-six pairs of holding grooves **107**, **108** that are arranged at the narrow pitch (e.g., 3.333-mm pitch). The chuck **79** of the outgoing delivering mechanism **75** includes seventy-five pairs or seventy-six pairs of holding grooves **95**, **96** that are arranged the unequal pitch. Each of the two pitch converting units **25**, **26** includes thirty-eight holding members **113**. Each of the thirty-eight holding members **113** includes two holding grooves **117** that are spaced apart from each other by the first interval (e.g., 3.333 mm). That is, the thirty-eight holding members **113** have seventy-six holding grooves **117** in total. The thirty-eight holding members **113** may also have seventy-five holding grooves **117** in total.

<3. Operation of Substrate Processing Apparatus>

[0180] An operation of the substrate processing apparatus **1** will now be described with reference to the flowchart illustrated in FIG. **14**. FIGS. **29**A to **32**B are side views for explaining the operation of the substrate processing apparatus **1**. In FIGS. **29**A to **32**B, for the convenience of illustration, the pair of horizontal holders **37** provided to the orientation converting unit **19** has eight pairs of shelves **37**A. The pair of vertical holders **39** in the orientation converting unit **19** has eight pairs of holding grooves **39**A. The pusher member **55** has sixteen vertical holding grooves **67**.

[0181] FIG. **1** will now be referred to. An external transporting robot, not illustrated, transports three carriers C one after another. N (e.g., twenty-five) substrates W**1** are housed in the first carrier C. N (e.g., twenty-five) substrates W**2** are housed in the second carrier C. N (e.g., twenty-five) substrates W**3** are housed in the third carrier C. N is a natural number equal to or more than two. The carrier transporting robot **13** of the stocker **2** then transports the first carrier C from the loading port **9** onto the placing shelf **3**.

[Step S01] Perform Vertical Orientation Conversion of First Substrate Group

[0182] FIG. **29**A will now be referred to. The substrate handling mechanism HTR transports twenty-five substrates W**1** that are aligned at the reference pitch (e.g., 10-mm pitch) in the horizontal orientation, from the first carrier C placed on the placing shelf **3** to the orientation converting unit **19**. In other words, the substrate handling mechanism HTR takes out the twenty-five substrates W**1** from the first carrier C placed on the placing shelf **3**, using the twenty-five hands **27**. The substrate handling mechanism HTR then transports the twenty-five substrates W**1** having been taken out, to the orientation converting unit **19**. The orientation converting unit **19** receives the twenty-five substrates W**1** using the twenty-five pairs of shelves **37**A, out of the thirty-eight pairs of shelves **37**A. The carrier transporting robot **13** transports the empty first carrier C from the placing shelf **3** to the storage shelf **11**. The carrier transporting robot **13** then transports the second carrier C from the loading port **9** to the placing shelf **3**.

[0183] FIG. **29**B will now be referred to. The substrate handling mechanism HTR transports P (e.g., thirteen or twelve) substrates W**2** that are aligned at the reference pitch in the horizontal orientation, among twenty-five (N) substrates W**2**, from the second carrier C placed on the placing shelf **3** to the orientation converting unit **19**. Note that P is a natural number one, or two or more. In other words, the substrate handling mechanism HTR takes out twenty-five substrates W**2** from the second carrier C placed on the placing shelf **3**. Then, the substrate handling mechanism HTR transports thirteen substrates W**2**, which is almost a half of the twenty-five substrates W**2** having been taken out, to the orientation converting unit **19**.
[0184] The orientation converting unit **19** is already holding the twenty-five substrates W**1**. The orientation converting unit **19** receives thirteen substrates W**2** using thirteen pairs of shelves **37**A, out of thirty-eight pairs of shelves **37**A. As a result, the orientation converting unit **19** comes to hold thirty-eight substrates W**1**, W**2** (the twenty-five substrates W**1** and the thirteen substrates W**2**). These thirty-eight substrates W**1**, W**2** will be referred to as a first substrate group. The housing moving unit **53** (see FIG. **4**) of the orientation converting unit **19** then brings the pair of vertical holders **39** closer to the pair of horizontal holders **37**.
[0185] FIG. **30**A will now be referred to. The orientation converting unit **19** converts the thirty-eight (two or more) substrates W**1**, W**2** including the twenty-five (N) substrates W**1** and the thirteen (P) substrates W**2** that are held at the reference pitch, from the horizontal orientation to the vertical orientation. Specifically, the rotation driving unit **41** rotates the elements such as the pair of horizontal holders **37** by 90 degrees about the horizontal axis AX**2**. As a result, the thirty-eight substrates W**1**, W**2** being held by the pair of horizontal holders **37** and the pair of vertical holders **39** are converted from the horizontal orientation to the vertical orientation. The axial moving unit **51** (see FIG. **4**) then moves the pair of horizontal holders **37** in a direction in which the pair of horizontal holders **37** move closer to the support surface **35**A so that the thirty-eight pairs of shelves **37**A on the pair of horizontal holders **37** move away from the thirty-eight substrates W**1**, W**2** that are in the vertical orientation.
[0186] The substrate handling mechanism HTR waits, while holding twelve substrates W**2**. The carrier transporting robot **13** transports the empty second carrier C from the placing shelf **3** to the storage shelf **11**. After the empty second carrier C is transported from the placing shelf **3**, the carrier transporting robot **13** transports the third carrier C from the loading port **9** onto the placing shelf **3**.
[Step S02] Cause Pusher Member to Receive First Substrate Group
[0187] FIG. **30**B will now be referred to. The pusher lift **65** (see FIG. **5**) raises the pusher member **55** to a position higher than the pair of horizontal holders **37** and the pair of vertical holders **39**. As a result, the pusher member **55** receives the thirty-eight substrates W**1**, W**2** (first substrate group) having the orientation converted to the vertical orientation. The pusher member **55** also holds thirty-eight substrates W**1**, W**2** aligned at the reference pitch.
[Step S03] Shift First Substrate Group by First Interval
[0188] FIG. **31**A will now be referred to. The pusher mechanism **21** moves the thirty-eight substrates W**1**, W**2** being held by the pusher member **55** by the first interval TN**1** (e.g., 3.333 mm) in the alignment direction of the thirty-eight substrates W**1**, W**2**. Specifically, the pusher rotating unit **59** (see FIG. **5**) rotates the pusher member **55** by 180 degrees about the vertical axis AX**3**. As a result, the front surfaces of the thirty-eight substrates W**1**, W**2** come to face rightwards. Furthermore, the thirty-eight substrates W**1**, W**2** being held by the pusher member **55** are moved leftwards by the first interval TN**1**.
[0189] The orientation converting unit **19** also rotates the elements such as the pair of horizontal holders **37** by 90 degrees about the horizontal axis AX**2**. As a result, the elements such as the pair of horizontal holders **37** are raised. The axial moving unit **51** (see FIG. **4**) in the orientation converting unit **19** moves the pair of horizontal holders **37** in the direction moving the pair of horizontal holders **37** away from the support surface **35**A. The housing moving unit **53** (see FIG. **4**) in the orientation converting unit **19** moves the pair of vertical holders **39** away from the pair of

horizontal holders **37**.

[Step S04] Perform Vertical Orientation Conversion of Second Substrate Group

[0190] The substrate handling mechanism HTR then transports the remaining twelve (Q) substrates W**2** that are aligned at the reference pitch in the horizontal orientation, among the twenty-five (N) substrates W**2** from the second carrier C, to the orientation converting unit **19**. In other words, the substrate handling mechanism HTR transports twelve (Q) substrates W**2** already being held thereby, to the orientation converting unit **19**. Among the thirty-eight pairs of shelves **37**A of the horizontal holder **37**, twelve pairs of shelves **37**A receive the twelve substrates W**2**, respectively. Note that Q is a natural number one, or two or more.

[0191] FIG. **31**B will now be referred to. The substrate handling mechanism HTR transports twenty-five substrates W**3** that are aligned at the reference pitch in the horizontal orientation, from the third carrier C placed on the placing shelf **3** to the orientation converting unit **19**. Specifically, the substrate handling mechanism HTR takes out the twenty-five substrates W**3** from the third carrier C placed on the placing shelf **3**. The substrate handling mechanism HTR then transports the twenty-five substrates W**3** having been taken out, to the orientation converting unit **19**. The twenty-five pairs of shelves **37**A on the horizontal holder **37** receive the twenty-five substrates W**3**, respectively. As a result, the orientation converting unit **19** comes to hold thirty-seven substrates W**2**, W**3** (the twelve substrates W**2** and the twenty-five substrates W**3**). The thirty-seven substrates W**2**, W**3** will be referred to as a second substrate group.

[0192] The housing moving unit **53** (see FIG. **4**) brings the pair of vertical holders **39** closer to the pair of horizontal holders **37**. The pusher mechanism **21** lowers the pusher member **55** holding the thirty-eight substrates W**1**, W**2**. The carrier transporting robot **13** transports the empty third carrier C from the placing shelf **3** to the storage shelf **11**.

[0193] FIG. **32**A will now be referred to. The orientation converting unit **19** then converts the thirty-seven (two or more) substrates W**2**, W**3** including the twelve (Q) substrates W**2** and the twenty-five (N) substrates W**3** that are held at the reference pitch, from the horizontal orientation to the vertical orientation. The axial moving unit **51** (see FIG. **4**) then moves the pair of horizontal holders **37** in the direction moving the pair of horizontal holders **37** closer to the support surface **35**A.

[Step S05] Cause Pusher Member to Receive Second Substrate Group

[0194] FIG. **32**B will now be referred to. The pusher lift **65** (see FIG. **5**) then raises the pusher member **55**. As a result, the pusher member **55** comes to receive the thirty-seven substrates W**2**, W**3** (second substrate group) having the orientation converted to the vertical orientation. The pusher member **55** holds the seventy-five substrates W (W**1**, W**2**, W**3**) including the thirty-eight substrates W**1**, W**2** and thirty-seven substrates W**2**, W**3** that are arranged alternately, in the vertical orientation. The seventy-five substrates W (processing substrate group) held by the pusher member **55** are aligned at the unequal pitch, as illustrated in FIG. **32**B.

[0195] As illustrated in FIGS. **32**A and **32**B, the front surfaces of the thirty-eight substrates W**1**, W**2** face a predetermined direction (rightwards). By contrast, the front surfaces of the thirty-seven substrates W**2**, W**3** face the direction opposite to the predetermined direction (leftwards). That is, the seventy-five substrates W are aligned in a manner what is called face to face. As illustrated in FIG. **32**B, a dummy substrate DW may be held in the vertical holding groove **67** not holding the substrate W. That is, the pusher member **55** may hold seventy-five substrates W and one dummy substrate DW (seventy-six substrates in total).

[0196] The incoming delivering mechanism **71** of the delivering mechanism **23** then transports seventy-five substrates W that are aligned at the unequal pitch, from the pusher member **55** to the first pitch converting unit **25** (step S**06**). The first pitch converting unit **25** then converts the pitch of the seventy-five substrates W (processing substrate group) from the unequal pitch to the narrow pitch (step S**07**). The intermediating mechanism **73** receives the seventy-five substrates W that are aligned at the narrow pitch from the first pitch converting unit **25**. The intermediating mechanism

73 transports the seventy-five substrates W to the first delivery position P**1** (step S**08**). Note that the first delivery position P**1** is a position where the intermediating mechanism **73** can transfer the seventy-five substrates W to and from the main transporting mechanism WTR.

[0197] The main transporting mechanism WTR transports the seventy-five substrates W that are aligned at the narrow pitch to the chemical liquid processing bath BT**1**, for example. The chemical liquid processing bath BT**1** performs the chemical liquid process on the seventy-five substrates W that are aligned at the narrow pitch, as a batch (step S**09**). Specifically, the main transporting mechanism WTR transports the seventy-five substrates W to the lifter LF**1** corresponding to the chemical liquid processing bath BT**1**, for example. The lifter LF**1** then immerses the seventy-five substrates W in the chemical liquid stored in the chemical liquid processing bath BT**1**, and then immerses the seventy-five substrates W in the pure water stored in the cleaning processing bath BT**2**. The main transporting mechanism WTR then transports the seventy-five substrates W from the lifter LF**1** to the drying unit **143**. The drying unit **143** then dries the seventy-five substrates W.

[0198] The latter half of the operation of the substrate processing apparatus **1** is performed as in the flowchart illustrated in FIG. **21**. The seventy-five substrates W are subjected to processes such as the orientation conversion in the order as illustrated in FIGS. **32**B, **32**A, **31**B, **31**A, **30**B, **30**A, **29**B, and **29**A. Twenty-five substrates W**3** are stored in the third carrier C. The twenty-five substrates W**2** are stored in the second carrier C, and the twenty-five substrates W**1** are stored in the first carrier C.

[0199] According to the present embodiment, the first pitch conversion is performed by aligning N (e.g., twenty-five) substrates W**1**, W**2**, and W**3** stored at the reference pitch (e.g., 10-mm pitch) in each of the three carriers C, at the unequal pitch, and then the second pitch conversion is performed to convert the unequal pitch to the narrow pitch (e.g., 3.333-mm pitch). By performing the pitch conversion in two stages, it becomes possible to convert the pitch of N substrates W**1**, W**2**, W**3** that are aligned at the reference pitch in each of the three carriers C, respectively, easily to the narrow pitch.

[0200] The present invention is not limited to the embodiments described above, and the following modifications are still possible.

[0201] (1) In each of the embodiments described above, when the reference interval TN**9** is 10 mm, for example, the first interval TN**1** is 3.333 mm, for example, and the second interval TN**2** is 6.666 mm, for example. In this case, the first interval TN**1** was equal to a half interval of the second interval TN**2**. In this regard, the first interval TN**1** may be smaller than a half interval of the second interval TN**2** (larger than 0 (zero) mm). For example, when the reference interval TN**9** is 10 mm, for example, the first interval TN**1** may be 3 mm, and the second interval TN**2** may be 7 mm. The first interval TN**1** may be 2.5 mm, and the second interval TN**2** may be 7.5 mm. Furthermore, preferably, the second interval TN**2** is 2 to 3 times the first interval TN**1**.

[0202] For example, the two holding grooves **117** on each of the holding members **113** may be configured to be spaced apart from each other by a first interval TN**1** (e.g., 3 mm) that is smaller than a half interval of the second interval TN**2** (e.g., 7 mm), and that is larger than zero (0) mm. In the unequal pitch, the first interval TN**1** and the second interval TN**2** wider than the first interval TN**1** are repeated alternately. Let us assume herein that there is a predetermined interval (reference interval TN**9**) constituting of one first interval TN**1** and one second interval TN**2**. In a case where the predetermined interval is 10 mm, for example, if the first interval TN**1** is smaller than a half of the second interval TN**2**, the first interval TN**1** may be smaller than ⅓ times 10 mm, and the first interval TN**1** may have any length such as 3 mm, without any fractional part below the decimal point.

[0203] Furthermore, the two holding grooves **117** provided to each of the holding members **113** may be spaced apart from each other by a first interval TN**1** (e.g., 3 mm) which is an interval equal to or more than ⅓ times and equal to or less than ½ times the second interval TN**2** (e.g., 7 mm).

[0204] (2) In each of the embodiments and the modification (1), when the reference interval TN**9**

is, for example, 10 mm, the first interval TN**1** is, for example, 3.333 mm, and the second interval TN**2** is, for example, 6.666 mm. In this regard, the first interval TN**1** may be larger than the interval ⅓ times the reference interval TN**9** (e.g., 3.333 mm) and smaller than an interval ½ times the reference interval TN**9** (e.g., 5 mm).

[0205] (3) In each of the embodiments and modifications described above, the incoming delivering mechanism **71** is provided on the rear side of the outgoing delivering mechanism **75**, but the incoming delivering mechanism **71** may also be provided in front of the outgoing delivering mechanism **75**. That is, the positions of the incoming delivering mechanism **71** and the outgoing delivering mechanism **75** may be reversed. In this case, the incoming delivering mechanism **71** transports the plurality of substrates W from the pusher member **55** to the second pitch converting unit **26**, and the outgoing delivering mechanism **75** transports the plurality of substrates W from the first pitch converting unit **25** to the pusher member **55**.

[0206] (4) In each of the embodiments and modifications described above, the intermediating mechanism **73** transports the plurality of substrates W that are aligned at the narrow pitch, from the first pitch converting unit **25** to the main transporting mechanism WTR. In this regard, the intermediating mechanism **73** may transport the plurality of substrates W that are aligned at the narrow pitch, from the main transporting mechanism WTR to the second pitch converting unit **26**.

[0207] (5) In each of the embodiments and modifications described above, the chuck **77** (the pair of chuck members **77**A, **77**B) of the incoming delivering mechanism **71** is opened and closed by the opening and closing unit **81**. In this respect, it is possible for the chuck **77** not to be opened and closed.

[0208] (6) In each of the embodiments and modifications described above, the chuck **79** (the pair of chuck members **79**A, **79**B) of the outgoing delivering mechanism **75** is opened and closed by the opening and closing unit **89**. In this respect, it is possible for the chuck **79** not to be opened and closed.

[0209] (7) In each of the embodiments and modifications described above, the substrate processing apparatus **1** processes the fifty substrates W that are aligned face to face, for example, as a batch. In this regard, the substrate processing apparatus **1** may process the fifty substrates W that are aligned face to back, as a batch. The “face to back” herein is an alignment in which the twenty-five substrates W**1** of the first substrate group and the twenty-five substrates W**2** of the second substrate group face the same direction (e.g., leftwards). In such a case, in step S**03** of the flowchart illustrated in FIG. **14**, the pusher mechanism **21** does not rotate the pusher member **55** by 180 degrees about the vertical axis AX**3**, but the pusher horizontally moving unit **61** moves the pusher member **55** by the first interval TN**1** in the width direction Y (e.g., 3.333 mm).

[0210] (8) In each of the embodiments and modifications described above, the substrate processing apparatus **1** may process one hundred substrates W as a batch. In such a case, the substrate processing apparatus **1** is configured as follows.

[0211] The substrate handling mechanism HTR includes, for example, twenty-five or thirteen hands **27** that are arranged at the reference pitch (e.g., 10-mm pitch) in the vertical direction Z. The pair of horizontal holders **37** provided to the orientation converting unit **19** includes, for example, fifty pairs of shelves **37**A that are arranged at the reference pitch. The pair of vertical holders **39** provided to the orientation converting unit **19** includes, for example, fifty pairs of holding grooves **39**A that are arranged at the reference pitch. The pusher member **55** includes one hundred vertical holding grooves **67** that are arranged at the unequal pitch.

[0212] The chuck **77** of the incoming delivering mechanism **71** includes one hundred pairs of holding grooves **87**, **88** that are arranged at the unequal pitch. The chuck **78** of the intermediating mechanism **73** includes one hundred pairs of holding grooves **107**, **108** that are arranged at the narrow pitch (e.g., 3.333-mm pitch). The chuck **79** of the outgoing delivering mechanism **75** includes a hundred pairs of holding grooves **95**, **96** arranged at the unequal pitch. Each of the two pitch converting units **25**, **26** includes fifty holding members **113**. Each of the fifty holding

members **113** includes two holding grooves **117** that are spaced apart from each other by the first interval (e.g., 3.333 mm). That is, the fifty holding members **113** have one hundred holding grooves **117** in total.

[0213] Furthermore, the substrate processing apparatus **1** creates a group of one hundred processed substrates as follows. The first substrate group includes the twenty-five substrates W**1** corresponding to the first carrier C and the twenty-five substrates W**2** corresponding to the second carrier C. The second substrate group includes the twenty-five substrates W**3** corresponding to the third carrier C and the twenty-five substrates W**4** corresponding to the fourth carrier C. Note that the substrates W**4** are not illustrated. The first substrate group and the second substrate group is converted individually, from the horizontal orientation to the vertical orientation by the orientation converting unit **19**. In addition, the pusher member **55** holds the one hundred substrates W that are aligned at the unequal pitch. In the one hundred substrates W, fifty substrates W**1**, W**2** and fifty substrates W**3**, W**4** are aligned alternately, and are aligned face to face, for example.

[0214] (9) In the embodiments and modifications described above, the transfer block **5** includes the substrate handling mechanism HTR and the orientation converting unit **19**, separately. In this regard, the substrate handling mechanism HTR may also be provided with the function of the orientation converting unit **19**. In other words, the orientation converting unit **19** may be provided with the function of the substrate handling mechanism HTR. For example, the substrate handling mechanism HTR (or the orientation converting unit **19**) takes out thirteen substrates W from the carrier C placed on the placing shelf **3** using thirteen hands **27**, and converts the thirteen substrates W thus taken out, from the horizontal orientation to the vertical orientation. Then, the substrate handling mechanism HTR (or the orientation converting unit **19**) may arrange the thirteen substrates W in the vertical orientation, in the plurality of vertical holding grooves **67** in the pusher member **55**. The orientation converting unit **19** having the function of the substrate handling mechanism HTR corresponds to an orientation converting mechanism according to the present invention.

[0215] (10) In each of the embodiments and modifications described above, the delivering mechanism **23** includes the intermediating mechanism **73**, but it is also possible for the delivering mechanism **23** not to include the intermediating mechanism **73**. In such a case, the main transporting mechanism WTR receives the plurality of substrates W that are aligned at the narrow pitch directly from the first pitch converting unit **25**.

[0216] (11) In each of the embodiments and modifications described above, the transfer block **5** includes the two pitch converting units **25**, **26**, but may also include one, or three or more pitch converting units. For example, in a configuration in which the transfer block **5** includes single pitch converting unit **25**, it is possible for the transfer block **5** not to include the outgoing delivering mechanism **75**, for example. In addition, the single pitch converting unit **25** converts the pitch of the plurality of substrates W to and from the unequal pitch, from and to the narrow pitch.

[0217] (12) In each of the embodiments and modifications described above, the incoming delivering mechanism **71** includes the front-back direction moving unit **83** that moves the elements such as the chuck **77** horizontally in the front-back direction X. The outgoing delivering mechanism **75** includes the front-back direction moving unit **91** that horizontally moves the elements such as the chuck **79** in the front-back direction X. Regarding these, it is possible for the incoming delivering mechanism **71** not to include the front-back direction moving unit **83**, and for the outgoing delivering mechanism **75** not to include the front-back direction moving unit **91**. In such a case, the pusher mechanism **21** may further include a front-back direction moving unit (not illustrated) that horizontally moves the pusher member **55** in the front-back direction X. For example, when the pusher member **55** is horizontally moved in the front-back direction X and the chuck **77** of the incoming delivering mechanism **71** is moved in the width direction Y, the incoming delivering mechanism **71** may receive a plurality of substrates W that are aligned at the unequal pitch in the vertical orientation, from the pusher member **55**.

[0218] The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification, as indicating the scope of the invention.

Claims

1. A substrate processing apparatus for processing a plurality of substrates, the substrate processing apparatus comprising: a pitch converting unit that converts a pitch between the plurality of substrates, between an unequal pitch in which a first interval and a second interval wider than the first interval are repeated alternately, and a narrow pitch in which the first interval is repeated; a substrate processing unit that processes the plurality of substrates aligned at the narrow pitch, as a batch; and a main transporting mechanism that transports the plurality of substrates aligned at the narrow pitch to the substrate processing unit, in which the pitch converting unit includes: a plurality of holding members that hold the plurality of substrates aligned at the unequal pitch; a moving unit configured to move the plurality of holding members in an alignment direction of the plurality of substrates so as to switch the plurality of substrates between an unequal pitch arrangement in which the plurality of substrate are arranged at the unequal pitch, and a narrow pitch arrangement in which the plurality of substrates are aligned at the narrow pitch; and each of the plurality of holding members has two holding grooves that hold two substrates, respectively, among the plurality of substrates, and the two holding grooves are spaced apart from each other by the first interval.

2. The substrate processing apparatus according to claim 1, wherein the two holding grooves are spaced apart from each other by the first interval that is smaller than a half of the second interval.

3. The substrate processing apparatus according to claim 1, wherein the two holding grooves are spaced apart from each other by the first interval that is a half of the second interval.

4. The substrate processing apparatus according to claim 1, wherein, the moving unit includes a guide rail that supports the plurality of holding members in a manner movable in the alignment direction; an extending/retracting mechanism that extends and retracts the plurality of holding members in the alignment direction; and a driving unit that drives the extending/retracting mechanism.

5. The substrate processing apparatus according to claim 4, wherein the extending/retracting mechanism includes: a housing that is provided to a first holding member, among the plurality of holding members; a protrusion that protrudes from a second holding member toward the first holding member positioned adjacently to the second holding member, among the plurality of holding members, and becomes housed in the housing when the plurality of holding members are retracted in the alignment direction; and a stopper that is provided to a tip of the protrusion, that prevents the protrusion from coming out of the housing when the plurality of holding members are extended in the alignment direction.

6. The substrate processing apparatus according to claim 5, wherein the extending/retracting mechanism further includes an elastic member provided between the first holding member and the second holding member.

7. The substrate processing apparatus according to claim 1, further comprising: an orientation converting mechanism that converts the plurality of substrates to and from a horizontal orientation from and to a vertical orientation; a pusher mechanism that includes a pusher member that holds the plurality of substrates aligned at the unequal pitch in the vertical orientation, and is capable of passing the plurality of substrates to and from the orientation converting mechanism; and a delivering mechanism that transports the plurality of substrates aligned at the unequal pitch, to and from the pusher member from and to the pitch converting unit.

8. The substrate processing apparatus according to claim 7, further comprising a control unit, wherein the control unit is configured to: cause the orientation converting mechanism to convert

two or more first substrates held at a reference pitch in which a reference interval that is a sum of the first interval and the second interval is repeated, from the horizontal orientation to the vertical orientation, as a batch; cause the pusher member to receive the two or more first substrates having been converted to the vertical orientation, and to hold the two or more first substrates aligned at the reference pitch in the vertical orientation; cause the pusher mechanism to move the two or more first substrates held by the pusher member by the first interval in an alignment direction of the two or more first substrates; cause the orientation converting mechanism to convert two or more second substrates held at the reference pitch, from the horizontal orientation to the vertical orientation, as a batch; cause the pusher member to receive the two or more second substrates having been converted to the vertical orientation; cause the pusher member to hold the plurality of substrates including the two or more first substrates and the two or more second substrates, the first substrates and the second substrates being arranged alternately and aligned at the unequal pitch; cause the delivering mechanism to transport the plurality of substrates aligned at the unequal pitch from the pusher member to the pitch converting unit; cause the pitch converting unit to convert a pitch of the plurality of substrates from the unequal pitch to the narrow pitch; cause the main transporting mechanism to transport the plurality of substrates aligned at the narrow pitch to the substrate processing unit; and cause the substrate processing unit to process the plurality of substrates aligned at the narrow pitch as a batch.

9. The substrate processing apparatus according to claim 7, further comprising a carrier shelf for placing a carrier housing N substrates that are aligned at a reference pitch in which a reference interval that is a sum of the first interval and the second interval is repeated, where N is a natural number equal to or more than two, and the orientation converting mechanism includes: an orientation converting unit that converts the two or more first substrates and the two or more second substrates from or to the horizontal orientation to or from the vertical orientation, and a substrate handling mechanism that transports the N substrates from and to the carrier placed on the carrier shelf, to and from the orientation converting unit.

10. The substrate processing apparatus according to claim 9, further comprising a control unit, wherein the control unit is configured to: cause the substrate handling mechanism to transport N substrates aligned at the reference pitch in the horizontal orientation in a first carrier placed on the carrier shelf, from the first carrier to the orientation converting unit; cause the substrate handling mechanism to transport P substrates aligned at the reference pitch in the horizontal orientation, the P substrates being substrates among N substrates on a second carrier placed on the carrier shelf, from the second carrier to the orientation converting unit; cause the orientation converting unit to convert the two or more first substrates including the N substrates from the first carrier and the P substrates held at the reference pitch, from the horizontal orientation to the vertical orientation, as a batch; cause the pusher member to receive the two or more first substrates having been converted to the vertical orientation, and to hold the two or more first substrates aligned at the reference pitch; cause the pusher mechanism to move the two or more first substrates held by the pusher member by the first interval in an alignment direction of the two or more first substrates; cause the substrate handling mechanism to transport Q substrates aligned at the reference pitch in the horizontal orientation to the orientation converting unit, the Q substrates being remainder of the N substrates on the second carrier; cause the substrate handling mechanism to transport N substrates in the horizontal orientation aligned at the reference pitch on a third carrier placed on the carrier shelf, from the third carrier to the orientation converting unit; cause the orientation converting unit to convert the two or more second substrates including the Q substrates and the N substrates from the third carrier and held at the reference pitch, from the horizontal orientation to the vertical orientation, as a batch; cause the pusher member to receive the two or more second substrates having been converted to the vertical orientation; cause the pusher member to hold the plurality of substrates including the two or more first substrates and the two or more second substrates that are arranged alternately at the unequal pitch; cause the delivering mechanism to transfer the plurality of

substrates that are aligned at the unequal pitch, from the pusher member to the pitch converting unit; cause the pitch converting unit to convert a pitch of the plurality of substrates from the unequal pitch to the narrow pitch; cause the main transporting mechanism to transport the plurality of substrates aligned at the narrow pitch to the substrate processing unit; and cause the substrate processing unit to process the plurality of substrates aligned at the narrow pitch, as a batch.

11. The substrate processing apparatus according to claim 7, further comprising a control unit, wherein the control unit is configured to: cause the main transporting mechanism to transport the plurality of substrates aligned at the narrow pitch in the vertical orientation, the plurality of substrates having been processed as a batch by the substrate processing unit, to a position above the pitch converting unit; cause the pitch converting unit to hold the plurality of substrates aligned at the narrow pitch in the vertical orientation; cause the pitch converting unit to convert the pitch of the plurality of substrates from the narrow pitch to the unequal pitch; cause the delivering mechanism to transport the plurality of substrates aligned at the unequal pitch from the pitch converting unit to the pusher member; cause the pusher member to hold the plurality of substrates in the vertical orientation, the plurality of substrates being a plurality of substrates that are aligned at the unequal pitch, and in which the two or more first substrates and the two or more second substrates are arranged alternately; cause the orientation converting mechanism to receive the two or more first substrates aligned at the reference pitch, among the plurality of substrates, from the pusher member, and to convert the two or more first substrates from the vertical orientation to the horizontal orientation; and cause the orientation converting mechanism to receive the two or more second substrates aligned at the reference pitch, among the plurality of substrates, from the pusher member, and to convert the two or more second substrates from the vertical orientation to the horizontal orientation, wherein in the reference pitch, a reference interval equal to a sum of the first interval and the second interval is repeated.

12. A substrate processing method for processing a plurality of substrates, the substrate processing method comprising: a pitch converting step of causing a pitch converting unit to convert a pitch between the plurality of substrates from an unequal pitch in which a first interval and a second interval wider than the first interval are repeated alternately, to a narrow pitch in which the first interval is repeated; a substrate transporting step of causing a main transporting mechanism to transport the plurality of substrates aligned at the narrow pitch to a substrate processing unit; and a substrate processing step of causing the substrate processing unit to process the plurality of substrates aligned at the narrow pitch, as a batch, wherein the pitch converting step includes: a holding step of causing a plurality of holding members to hold the plurality of substrates aligned at the unequal pitch, while holding two substrates, among the plurality of substrates, at the first interval with two holding grooves that are provided to each of the plurality of holding members and spaced apart from each other by the first interval; a pitch conversion executing step of causing a moving unit to move the plurality of holding members in an alignment direction of the plurality of substrates so as to switch the plurality of substrates from an unequal pitch arrangement in which the plurality of substrates are aligned at the unequal pitch to a narrow pitch arrangement in which the plurality of substrates are aligned at the narrow pitch.