

DESCRIPTION

Title of Invention

SEMICONDUCTOR MANUFACTURING APPARATUS AND METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE

Technical Field

[0001]

The present invention relates to a structure of a semiconductor manufacturing apparatus, and a method of manufacturing semiconductor devices. In particular, the present invention relates to a structure of an apparatus for picking up a semiconductor die, and a method of picking up a semiconductor die.

Background Art

[0002]

Semiconductor dies are manufactured by cutting a 6-inch or 8-inch wafer into dies of a predetermined size. When cutting, in order to prevent the diced semiconductor dies from falling apart, an adhesive wafer tape is applied to a back surface of the wafer, which is then cut from its front surface using a dicing saw or the like. At this time, the wafer tape applied to the back surface is slightly but not completely cut, and holds the semiconductor dies. Then, the diced semiconductor dies are

picked up one by one from the wafer tape and transferred to the next step such as die bonding.

[0003]

One Example of a method used to pick up a semiconductor die from a wafer tape is a method including the steps of capturing an image of an individual semiconductor die using a camera; outputting an imaging signal of the captured image to an image processor unit; determining whether or not a quality of a semiconductor die in a field of view of the camera is good based on image processing using the image processor unit; detecting a position of the semiconductor die if the quality is good; aligning a position of a pick-up jig such as a collet and a plunge-up needle with the detected position of the semiconductor die; plunging up the semiconductor die from a side of the wafer tape by the plunge-up needle; and vacuum suctioning the semiconductor die at a tip of the collet, thereby picking up the semiconductor die from the wafer tape. Another example of such a method is a method in which position data of semiconductor dies on the wafer is created by an inspection apparatus prior to placement of the wafer on a pick-up apparatus, and a wafer table is moved based on the position data, thereby picking up the semiconductor dies (e.g., PTL 1).

[0004]

According to these methods, there are problems that it takes time to performing recognition and position detection,

and that it is not possible to correctly pick up a die as the position of the chip changes due to deformation of the wafer tape. Therefore, there is proposed a method in which an image around a semiconductor die to be picked up is taken using a camera with a wide field of view to determine whether or not there is another semiconductor die around and to record a semiconductor die without a bad mark as a pick-up candidate semiconductor die, and a wafer table is moved to pick up the semiconductor die after detecting a position of the pick-up candidate semiconductor die using a camera of high power and determining whether or not there is a problem in appearance (e.g., PTL 1).

[0005]

Alternatively, there is proposed a method for reducing time required for die recognition and performing a pick-up operation efficiently, in which when positions of semiconductor dies on a wafer tape are detected row by row in a predetermined order, method a position in a next adjacent row at which no semiconductor die exists is detected and recorded in recording means, and a pick-up unit is moved based on a closest position at which no semiconductor die exists in the next row obtained from the recording means after completing position detection for semiconductor dies in one row on the wafer tape (e.g., PTL 2).

Citation List

Patent Literatures

[0006]

PTL 1: Japanese Unexamined Patent Application

Publication No. 2004-140084

PTL 2: Japanese Unexamined Patent Application

Publication No. 2002-231789

Summary of Invention

Technical Problem

[0007]

In the meantime, as illustrated in Fig. 25, when semiconductor dies arranged on the wafer tape in a grid pattern are picked up, a method in which a cutting gap 14 between semiconductor dies 15 is widened by expanding a circumference of a wafer tape 12 radially outward as indicated by arrows 51-53, and then the semiconductor dies 15 are picked up row by row (line by line) as indicated by arrows 54-55 using a collet is employed. At first, the semiconductor dies 15 are tightly arranged in order in a grid pattern as indicated by a dashed line in Fig. 25. However, after the semiconductor dies 15 in a few upper rows (lines) are picked up, the wafer tape 12 of a region in which the semiconductor dies 15 have been picked up is expanded, and therefore the semiconductor dies 15 in lower rows are moved to a lower side (in a negative Y direction) from their original positions. Amount of lower-side movement becomes larger near the center of the wafer tape 12 in an X direction, and smaller

near its circumference. Accordingly, as indicated by a solid line in Fig. 25, once the semiconductor dies 15 in a few upper rows (lines) are picked up, the semiconductor dies 15 on the wafer tape 12 that have been tightly arranged in order in a grid pattern are moved to positions along a lower-side convex curve 55 centering the center of the wafer tape 12 in the X direction.

[0008]

With a pick-up apparatus for semiconductor dies, by detecting and recording an absolute position of the center of each of the semiconductor dies 15 with respect to a reference point of the pick-up apparatus based on image recognition of the semiconductor dies 15, a field of view of a camera is moved in a downward right direction as indicated by the arrow 55 in Fig. 25, for example, to recognize a next one of the semiconductor dies 15, the field of view of the camera is adjusted with the center of this semiconductor die 15 to detect the absolute position of the semiconductor die 15, and this semiconductor die 15 is picked up using a collet.

[0009]

However, there is often a position on the wafer tape 12 at which the semiconductor die 15 is not disposed. For example, there is a case in which a TEG die 60 or the like that is used as a target for position confirmation in positioning of the wafer tape 12 as a whole is disposed, or a case in which only the semiconductor dies 15 in good state are re-arranged on the

wafer tape 12, and there is a position at which the semiconductor die 15 is not disposed. The TEG die 60 has a shape that is different from the semiconductor dies 15, and the pick-up apparatus does not recognize the TEG die 60 as the semiconductor die 15, and handles in the same manner as the case in which the semiconductor die 15 is not disposed.

[0010]

As illustrated in Fig. 25, in a case in which a position at which the TEG die 60 is disposed or a position at which the semiconductor die 15 is not disposed is located near the center of the wafer tape 12 in the X direction, and a position of the semiconductor die 15 is to be recognized and detected by moving a field of view of a camera in a downward left direction as indicated by an arrow 57 in Fig. 25, the position is treated as nothing is disposed even if there is a TEG die 60b captured in the field of view of the camera, and the pick-up apparatus moves the field of view of the camera downward according to the current moving direction (downward left) as indicated by an arrow 58 in Fig. 25. Then, the semiconductor die 15 in a row (line) next to a row (line) to which pick up is currently performed is captured in the field of view of the camera, the field of view of camera is adjusted to the center of this semiconductor die 15, and the semiconductor die 15 in one row (line) under the TEG die 60b shall be pick up. Thereafter, as indicated by an arrow 59 in Fig. 25, the pick-up apparatus

sequentially picks up the semiconductor dies 15 disposed in one row (line) under the TEG die 60b. Therefore, the pick-up apparatus completes the pick-up operation without picking up the semiconductor dies 15 that are in the row (line) of the TEG die 60 and on a left side (to a pick-up direction) of the TEG die 60.

[0011]

As described above, there is a problem that the pick-up apparatus leaves a semiconductor die unpicked when there is the TEG die 60 or there is a space where the semiconductor die 15 is not disposed on the wafer tape 12.

[0012]

An object of the present invention is to provide a semiconductor manufacturing apparatus capable of effectively preventing a semiconductor die from being left unpicked when pick-up of semiconductor dies is performed.

Solution to Problem

[0013]

A semiconductor manufacturing apparatus according to the present invention is a semiconductor manufacturing apparatus capable of picking up a plurality of semiconductor dies row by row, the semiconductor dies being arranged on a wafer tape in a grid pattern, the apparatus including: a camera configured to take an image of each of the semiconductor dies; a pick-up mechanism configured to pick up each of the semiconductor dies

from the wafer tape; and a controller unit configured to detect a position of each of the semiconductor dies based on the image of the each of the semiconductor dies taken by the camera, wherein the controller unit includes: a memory for storing the position of each of the semiconductor dies; and executable means including: detection means configured to move a field of view of the camera, so that a plurality of first semiconductor dies disposed in a first row sequentially come in a center of the field of view of the camera, and detect an absolute position of each of the first semiconductor dies in the first row with respect to a reference point of the pick-up apparatus; pick-up means configured to cause the pick-up mechanism to sequentially pick up each of the first semiconductor dies whose absolute position has been detected by the detection means; estimated position calculation and storage means configured to calculate an estimated absolute position of each of second semiconductor dies based on the absolute position of each of the first semiconductor dies that has been detected by the detection means, and store the estimated absolute position in the memory, the second semiconductor dies being in a second row and disposed near positions corresponding to the first semiconductor dies; and view field movement means configured to move the field of view of the camera, so that the estimated absolute position of each of the second semiconductor dies stored in the memory

sequentially come in the center of the field of view of the camera.

[0014]

In the semiconductor manufacturing apparatus according to the present invention, it is preferable that the camera takes an image of a plurality of rows of the semiconductor dies, the controller unit further includes: recognition means configured to, when the field of view of the camera is sequentially moved, recognize whether or not a second semiconductor die is present in the second row and disposed near a position corresponding to each of the first semiconductor dies, and the estimated position calculation and storage means: calculates, when the recognition means fails to recognize the second semiconductor die, an estimated absolute position of the second semiconductor die based on the absolute position of the each first semiconductor die that has been detected by the detection means, and stores the calculated estimated absolute position in the memory; and detects, when the recognition means recognizes the second semiconductor die, an absolute position of the second semiconductor die with respect to the reference point of the pick-up apparatus, and stores the detected absolute position as the estimated absolute position of the second semiconductor die.

[0015]

In the semiconductor manufacturing apparatus according to the present invention, it is preferable that as the estimated absolute position of each of the second semiconductor dies, the estimated position calculation and storage means takes a position displaced from the absolute position of each of the first semiconductor dies that has been detected by the detection means by a column-direction pitch between the first semiconductor dies and the second semiconductor dies.

[0016]

A method of manufacturing a semiconductor device according to the present invention is a method of manufacturing a semiconductor device capable of picking up a plurality of semiconductor dies row by row, the semiconductor dies being arranged on a wafer tape in a grid pattern, the method including: a step of preparing a semiconductor manufacturing apparatus including: a camera configured to take an image of each of the semiconductor dies; a pick-up mechanism configured to pick up each of the semiconductor dies from the wafer tape; and a controller unit configured to detect a position of each of the semiconductor dies based on the image of the each of the semiconductor dies taken by the camera, the controller unit including a memory for storing the position of each of the semiconductor dies; a detecting step of moving a field of view of the camera, so that a plurality of first semiconductor dies disposed in a first row sequentially come in a center of the

field of view of the camera, and detect an absolute position of each of the first semiconductor dies in the first row with respect to a reference point of the pick-up apparatus; a pick-up step of causing the pick-up mechanism to sequentially pick up each of the first semiconductor dies whose absolute position has been detected by the detection means; an estimated position calculating and storing step of calculating an estimated absolute position of each of second semiconductor dies based on the absolute position of each of the first semiconductor dies that has been detected by the detection means, and storing the estimated absolute position in the memory, the second semiconductor dies being in a second row and disposed near positions corresponding to the first semiconductor dies; and a view field moving step of moving the field of view of the camera, so that the estimated absolute position of each of the second semiconductor dies stored in the memory sequentially come in the center of the field of view of the camera.

[0017]

The method of manufacturing semiconductor devices according to the present invention, it is preferable that the camera takes an image of a plurality of rows of the semiconductor dies, the method further includes: a recognizing step of, when the field of view of the camera is sequentially moved, recognizing whether or not a second semiconductor die is present in the second row and disposed near a position corresponding

to each of the first semiconductor dies, and in the estimated position calculating and storing step: when the second semiconductor die fails to be recognized in the recognizing step, an estimated absolute position of the second semiconductor die is calculated based on the absolute position of the each first semiconductor die that has been detected by the detection means, and the calculated estimated absolute position is stored in the memory; and when the second semiconductor die is recognized in the recognizing step, an absolute position of the second semiconductor die with respect to the reference point of the pick-up apparatus is detected, and the detected absolute position is stored as the estimated absolute position of the second semiconductor die.

[0018]

The method of manufacturing semiconductor devices according to the present invention, it is preferable that in the estimated position calculating and storing step, a position displaced from the absolute position of each of the first semiconductor dies that has been detected in the detecting step by a column-direction pitch between the first semiconductor dies and the second semiconductor dies is taken as the estimated absolute position of each of the second semiconductor dies.

Advantageous Effect of Invention

[0019]

The present invention has an advantageous effect of providing a semiconductor manufacturing apparatus capable of effectively preventing a semiconductor die from being left unpicked when pick-up of semiconductor dies is performed.

Brief Description of Drawings

[0020]

Fig. 1 is a system diagram illustrating a system configuration of a semiconductor manufacturing apparatus according to embodiments of the present invention.

Fig. 2 is a sectional elevational view illustrating a wafer applied to a wafer tape.

Fig. 3 is a sectional elevational view illustrating a state in which the wafer applied to the wafer tape has been diced.

Fig. 4 is a view illustrating attachment of the diced wafer to a wafer holder.

Fig. 5 is a plan view illustrating arrangement of semiconductor dies and the wafer tape attached to the wafer holder of the semiconductor manufacturing apparatus according to the embodiment of the present invention.

Fig. 6 is a plan view illustrating an order of semiconductor dies to be picked up on the wafer tape on the semiconductor manufacturing apparatus according to the embodiment of the present invention, and a change in positions

of the wafer tape and the semiconductor dies after the semiconductor dies are picked up.

Fig. 7 is a flowchart showing a pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the embodiment of the present invention.

Fig. 8 is a flowchart showing the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the embodiment of the present invention.

Fig. 9 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the embodiment of the present invention.

Fig. 10 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the embodiment of the present invention.

Fig. 11 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the embodiment of the present invention.

Fig. 12 is a flowchart showing a pick-up operation of semiconductor dies by a semiconductor manufacturing apparatus according to a different embodiment of the present invention.

Fig. 13 is a flowchart showing the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 14 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 15 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 16 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 17 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 18 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 19 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 20 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 21 is a view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 22 is a different view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 23 is a different view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 24 is a different view illustrating the pick-up operation of semiconductor dies by the semiconductor manufacturing apparatus according to the different embodiment of the present invention.

Fig. 25 is a plan view illustrating an order of semiconductor dies to be picked up on the wafer tape in a conventional technique, and a change in positions of the wafer tape and the semiconductor dies after the semiconductor dies are picked up.

Description of Embodiments

[0021]

Hereinafter, embodiments of the present invention will be described with reference to the drawings. Referring to Fig. 1, a semiconductor manufacturing apparatus 100 according to the embodiments is provided with: a wafer holder 10 for fixing a wafer tape 12 having a surface on which a plurality of semiconductor dies 15 are applied; a wafer holder driving unit 18 for moving the wafer holder 10 horizontally (in XY direction); a camera 22 for taking images of the semiconductor dies 15 on the wafer tape 12; a collet 19 for picking the semiconductor dies 15 from the wafer tape 12; a collet driving unit 20 for moving the collet 19 vertically (Z direction); a plunge-up mechanism 21 for plunging up the wafer tape 12 from its lower surface (a surface on a negative Z side) to an upward direction (a positive Z side); and a controller unit 30 for controlling operations of the wafer holder driving unit 18, the collet driving unit 20, and the plunge-up mechanism 21, for processing images of the semiconductor dies 15 taken by the camera 22, and for performing recognition and position detection of the semiconductor dies 15. The collet 19, the collet driving unit 20, and the plunge-up mechanism 21 constitute a pick-up mechanism for picking up the semiconductor dies 15. In Fig. 1, a description is given taking a traverse

direction in the figure as an X direction, a direction orthogonal to a plane of figure (a direction orthogonal to the X direction) as a Y direction, and a longitudinal direction as the Z direction. Details of the wafer holder 10 will be described later.

[0022]

The controller unit 30 is a computer including: a CPU 31 that performs signal processing and calculation; a memory 32 storing a control program 33, control data 34, position data 35 of the semiconductor dies 15, a detection program 36, an estimated position calculation and storage program 37, a pick up program 38, a view field movement program 39, and a recognition program 40; a collet driving unit interface 41, a camera interface 42, a plunge-up mechanism interface 43, and a wafer holder driving unit interface 44 through which signals and data are transmitted to and received from the collet driving unit 20, the camera 22, the plunge-up mechanism 21, and the wafer holder driving unit 18, respectively. The CPU 31, the memory 32, and the interfaces 41-44 are connected via a data bus 45. The collet driving unit 20, the camera 22, the plunge-up mechanism 21, and the wafer holder driving unit 18 perform drive control and data transmission and reception based on a command from the CPU 31.

[0023]

Next, a pick-up operation for picking the semiconductor dies 15 from the wafer tape 12 by the semiconductor manufacturing apparatus 100 according to this embodiment will be described with reference to Fig. 2 through Fig. 11. Before describing an entire operation, a step of fixing the wafer tape 12 to which the semiconductor dies 15 are applied to the wafer holder 10 will be described with reference to Fig. 2 through Fig. 5.

[0024]

As illustrated in Fig. 2, an adhesive wafer tape 12 is applied to a back surface of a wafer 11, and the wafer tape 12 is attached to a metallic ring 13. The wafer 11 is handled in a state in which the wafer is attached to the metallic ring 13 via the wafer tape 12 in this manner. Then, in a cutting step, the wafer 11 is cut from its surface using a dicing saw or the like into the semiconductor dies 15 as illustrated in Fig. 3. Between the semiconductor dies 15, a cutting gap 14 is produced by dicing. A depth of the cutting gap 14 is such that it reaches a part of the wafer tape 12 through the semiconductor die 15. However, the wafer tape 12 is not completely cut, and the semiconductor dies 15 are held by the wafer tape 12.

[0025]

The semiconductor dies 15 attached to the wafer tape 12 and the ring 13 are attached to the wafer holder 10 as illustrated in Fig. 4(a) and Fig. 4(b). The wafer holder 10 includes an

annular expanded ring 16 having a flanged section, and a ring retainer 17 for fixing the ring 13 onto the flange of the expanded ring 16. The ring retainer 17 is driven in a direction approaching and retreating the flange of the expanded ring 16 by a ring retainer driving unit that is not shown. An inner diameter of the expanded ring 16 is larger than a diameter of the wafer on which the semiconductor dies 15 are arranged. The expanded ring 16 has a predetermined thickness, and is provided with the flange extending outwardly from one end surface on a side distant from the wafer tape 12. Further, an outer circumference of the other end surface of the expanded ring 16 on a side of the wafer tape 12 is curved, so that the wafer tape 12 may be smoothly expanded when the wafer tape 12 is attached to the expanded ring 16. Moreover, as illustrated in Fig. 1, the wafer holder 10 is configured to be movable by the wafer holder driving unit 18 along a surface of the wafer tape 12 (XY direction).

[0026]

As illustrated in Fig. 4(b), the wafer tape 12 to which the semiconductor dies 15 are applied is substantially planar before the tape is set to the expanded ring 16. There is a step between the upper end surface and a surface of the flange of the expanded ring 16 with both of which the wafer tape 12 is brought into contact. Accordingly, by moving the ring retainer 17 down onto the ring 13 to hold the ring 13 between the ring

retainer 17 and the flange of the expanded ring 16 as illustrated in Fig. 1, the ring 13 is pressed against the surface of the flange to expand the wafer tape 12 by an amount of the step between the upper end surface and the surface of the flange of the expanded ring 16 along the upper curved portion of the expanded ring 16. Then, a tensile force in a radial direction outwardly from the center of the wafer tape 12 as indicated by an arrow 50 in Fig. 5 is exerted on the wafer tape 12 fixed on the expanded ring 16. Further, as the wafer tape 12 is expanded by the tensile force, the cutting gap 14 between the semiconductor dies 15 applied to the wafer tape 12 is also expanded, and the semiconductor dies 15 are arranged on the wafer tape 12 in a grid pattern at an X-direction pitch P_x (row-direction pitch) and a Y-direction pitch (column-direction pitch) P_y . Moreover, at the substantial center of the wafer tape 12, two TEG dies 60a, 60b are disposed. [0027]

After fixing the wafer tape 12 in the state shown in Fig. 5, the semiconductor manufacturing apparatus 100 starts picking up the semiconductor dies 15. In the following direction, lines in the X direction are referred to as rows and lines in the Y direction are referred to as columns, and as illustrated in Fig. 6 and Fig. 9, an example in which semiconductor dies are picked up leftward (to a negative X side) as indicated by an arrow 54 in Fig. 6 and Fig. 9 from a semiconductor die 77 at a position

of $N=1$, $M=7$ (1st row, 7th column) is described. In Fig. 9, circled numbers 1 to 7 are numbers for seven columns of semiconductor dies at a central portion on the wafer tape 12, and numbers 1 to 3 in squares are numbers for rows of semiconductor dies.

[0028]

As in Step S101 of Fig. 7, the CPU 31 initializes a row number N and a column number M_{start} to values at a pick-up starting position. Here, the CPU 31 sets $N=1$, $M=7$. Next, as in Step S102 of Fig. 7, the CPU 31 reads data for position of the semiconductor die 77 illustrated in Fig. 9 as a reference position from the control data 34 illustrated in Fig. 1. Then, as illustrated in Fig. 9 and shown in Step S103 of Fig. 7, the CPU 31 outputs a command for driving the wafer holder driving unit 18 such that a center of a field of view 71 of the camera 22 comes at the reference position of the semiconductor die 77 disposed at $N=1$, $M=7$ (1st row, 7th column) that has been previously read, that is, a semiconductor die at the starting position illustrated in Fig. 6. The command is input as a control signal to the wafer holder driving unit 18 via the wafer holder driving unit interface 44, and the wafer holder driving unit 18 moves the wafer holder 10 in the XY direction.

[0029]

As in Steps S104 and S105 of Fig. 7, the CPU 31 executes the detection program 36, and obtains an image taken by the

camera 22 via the camera interface 42 to detect a central position of the semiconductor die 77 from the taken image. Then, a position of the wafer holder 10 in the XY direction is adjusted by the wafer holder driving unit 18, so that the central position of the detected semiconductor die 77 matches the center of the field of view 71 of the camera 22. When the central position of the semiconductor die 77 at (1st row, 7th column) and the center of the field of view 71 of the camera 22 match, this position is detected as an absolute position of the semiconductor die 77 (first semiconductor die) at (1st row, 7th column) with respect to a reference point (not shown) of the semiconductor manufacturing apparatus 100 (detecting step). [0030]

Next, as in Step S106 of Fig. 7, the CPU 31 executes the pick up program 38, and adjusts the position of the wafer holder 10 in the XY direction using the wafer holder driving unit 18, so that the plunge-up mechanism 21 and the collet 19 illustrated in Fig. 1 come at the absolute position of the semiconductor die 77 at (1st row, 7th column). When the adjustment of the position is completed, the CPU 31 outputs a command for picking up the semiconductor die 77. In response to this command, the plunge-up mechanism 21 moves upward to plunge up the semiconductor die 77 at (1st row, 7th column), and at the same time, the collet driving unit 20 moves the collet 19 downward

to vacuum suction the semiconductor die 77 to pick up the semiconductor die 77 from the wafer tape 12 (pick-up step).
[0031]

Subsequently, as in Steps S107 and S108 of Fig. 7, the CPU 31 executes the estimated position calculation and storage program 37, and stores a position obtained by subtracting the Y-direction pitch (column-direction pitch) P_y from the absolute position of the semiconductor die 77 at (1st row, 7th column) detected in Step S105 of Fig. 7 as an estimated absolute position of a semiconductor die 87 positioned at (2nd row ((N+1)th row), 7th column (M_{start} column) (a semiconductor die that is in a next row and in the column for the semiconductor die 77 (7th column); a second semiconductor die) in the position data 35 in the memory 32 (estimated position calculating and storing step).

[0032]

Next, as in Step S109 of Fig. 7, the CPU 31 determines whether or not the picked semiconductor die 77 is in a last column M_{end} in the N-th row. If the picked semiconductor die is not in the last column, the CPU 31 moves the wafer holder 10 to the negative side by the X-direction pitch P_x (row-direction pitch) as in Step S110 of Fig. 7, decrements M by 1 as in Step S111 of Fig. 7, moves the central position of the field of view of the camera 22 to a reference position of a semiconductor die 76 (first semiconductor die) in the same row (1st row) and in a next column (1st row, 6th column), repeats Steps S103 to S108

(the detecting step, the pick-up step, and the estimated position calculating and storing step) in Fig. 7, picks up M semiconductor dies (first semiconductor dies) disposed in the 1st row sequentially in the negative X direction as indicated by the arrow 54 in Fig. 6 and Fig. 9, estimates absolute positions of semiconductor dies (second semiconductor dies) in a next row (N=2), and stores the absolute positions as estimated absolute positions in the position data in the memory 32 sequentially as indicated by a dashed arrow E0. Then, as in Step S109 of Fig. 7, in the last column M_{end} in the 1st row (N=1), the operation moves to a connecting terminal 2 (represented by circled 2 in the figure; the same applies in the following) illustrated in Fig. 7 and then jumps to Step S112 of Fig. 8, the wafer holder 10 is moved by the Y-direction pitch P_y (column-direction pitch). Then, as in Step S113 of Fig. 8, N is incremented by 1, M is re-set to M_{start} in a 2nd row (N=2), and semiconductor dies in the 2nd row are picked up to a positive X side as illustrated in Fig. 6.

[0033]

As pick-up of semiconductor dies in the 2nd row and thereafter is performed in the same routine, in the following description, an example of a pick-up routine for semiconductor dies 111-117 in a 4th row, and for semiconductor dies 211-217 in a 5th row in which the TEG dies 60a, 60b are disposed will be described with reference to Fig. 10 and Fig. 11. Pick-up

of semiconductor dies in the 2nd row and thereafter is different from the pick-up of semiconductor dies in the 1st row described above in that while the pick-up of semiconductor dies in the 1st row is performed by reading position data for semiconductor dies as reference positions from the control data 34, moving the field of view of the camera 22 based on the data by the X-direction pitch P_x (row-direction pitch), capturing a semiconductor die in the field of view of the camera 22, adjusting the center of the field of view of the camera 22 with a central position of this semiconductor die, and sequentially detecting absolute positions of semiconductor dies to be picked up, pick-up of semiconductor dies in the 2nd row is performed by performing calculation based on the absolute positions of the semiconductor dies whose positions have been detected, reading an estimated absolute position stored in the position data 35 in the memory 32, and moving the field of view of the camera 22 toward the estimated absolute position.

[0034]

In Fig. 10 and Fig. 11, circled numbers 1 to 7 are numbers for seven columns of semiconductor dies at a central portion on the wafer tape 12, and numbers 4 to 75 in squares are numbers for rows of semiconductor dies. Pick-up of the semiconductor dies 111 to 117 in the 4th row is performed sequentially from left to right in the figure (to the positive X side) along a lower-side convex curve 55 in Fig. 6.

[0035]

Hereinafter, a step for performing a pick-up operation sequentially from the semiconductor die 111 at 4th row, 1st column to the semiconductor die 117 at 4th row, 7th column illustrated in Fig. 10 will be described. As in Step S113 of Fig. 8, the CPU 31 sets $N=4$, $M=1$. Then, as in Step S114 of Fig. 8, the CPU 31 executes the view field movement program 39 shown in Fig. 1. First, the CPU 31 reads an estimated absolute position for the semiconductor die 111 at (4th row, 1st column) stored in the position data 35 in the memory 32 when picking up semiconductor dies in a row of $N=3$. Next, the CPU 31 outputs a command for driving the wafer holder driving unit 18 such that a center of a field of view 151 of the camera 22 comes at the previously read estimated absolute position of the semiconductor die 111 disposed at $N=4$, $M=1$ (4th row, 1st column). The command is input to the wafer holder driving unit 18 as a control signal via the wafer holder driving unit interface 44, and the wafer holder driving unit 18 moves the wafer holder 10 in the XY direction (view field moving step).

[0036]

As in Steps S115 and S116 of Fig. 8, the CPU 31 executes the detection program 36 shown in Fig. 1, and obtains an image taken by the camera 22 via the camera interface 42 to detect a central position of the semiconductor die 111 at (4th row, 1st column) from the taken image. Then, a position of the wafer

holder 10 in the XY direction is adjusted by the wafer holder driving unit 18, so that the central position of the detected semiconductor die 111 matches the center of the field of view 151 of the camera 22. Further, when the central position of the semiconductor die 111 at (4th row, 1st column) and the center of the field of view 151 of the camera 22 match, this position is detected as an absolute position of the semiconductor die 111 (first semiconductor die) at (4th row, 1st column) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 (detecting step).

[0037]

Next, as in Step S117 of Fig. 8, the CPU 31 executes the pick up program 38, and adjusts the position of the wafer holder 10 in the XY direction using the wafer holder driving unit 18, so that the plunge-up mechanism 21 and the collet 19 come at the absolute position of the semiconductor die 111 at (4th row, 1st column) to which position detection is performed. When the adjustment of the position is completed, the CPU 31 outputs a command for picking up the semiconductor die 111. In response to this command, the plunge-up mechanism 21 moves upward to plunge up the semiconductor die 111 at (4th row, 1st column), and at the same time the collet driving unit 20 moves the collet 19 downward to vacuum suction the semiconductor die 111 to pick up the semiconductor die 111 from the wafer tape 12 (pick-up step).

[0038]

Subsequently, as in Steps S118 and S119 of Fig. 8, the CPU 31 executes the estimated position calculation and storage program 37 shown in Fig. 1, and a position obtained by subtracting the Y-direction pitch (column-direction pitch) P_Y from the absolute position of the semiconductor die 111 at (4th row, 1st column) detected in Step S117 of Fig. 8 is stored in the position data 35 in the memory 32 as an estimated absolute position of the semiconductor die 211 (a second semiconductor die) positioned at 5th row ((N+1)th row), 1st column (M-th column) (estimated position calculating and storing step).

[0039]

Next, as in Step S120 of Fig. 8, the CPU 31 determines whether or not the picked semiconductor die 111 is in the last column M_{end} in the 4th row. If the picked semiconductor die 111 is not in the last column, the CPU 31 increments the column number M by 1 as in Step S121 of Fig. 8, and sets the column number M to 2.

[0040]

Then, the operation returns to Step S114 of Fig. 8. The CPU 31 executes the view field movement program 39 shown in Fig. 1, and reads an estimated absolute position for the semiconductor die 112 at (4th row, 2nd column) stored in the position data 35 in the memory 32 when picking up the semiconductor dies in a row of $N=3$. Thereafter, as illustrated

in Fig. 10, a center of a field of view 152 of the camera 22 is moved by the X-direction pitch P_x (row-direction pitch) and by ΔP_{Y1} in the Y direction as shown in Fig. 10 from the field of view 151 to, as indicated by an arrow 55a in Fig. 10, an estimated absolute position of the semiconductor die 112 (first semiconductor die) in the same row (4th row) and in a next column (4th row, 2nd column) (view field moving step).

[0041]

As in Step S115 through Step S119 of Fig. 8, the CPU 31 executes the detection program 36, the pick up program 38, and the estimated position calculation and storage program 37 shown in Fig. 1, calculates an absolute position of the semiconductor die 212 in a next row (5th row), and stores the calculated absolute position as an estimated absolute position in the position data 35 in the memory 32 (estimated position calculating and storing step).

[0042]

As in Step S121 of Fig. 8, the CPU 31 increments the column M by 1, moves the operation to Step S114 in Fig. 8, and continues picking up the semiconductor die 113 in a next column (4th row, 3rd column). The CPU 31 executes Step S114 through Step S119 of Fig. 8, and moves the field of view of the camera 22 by the X-direction pitch P_x (row-direction pitch) as indicated by an arrow 55a in Fig. 10 and by ΔP_{Y2} in the Y direction as illustrated in Fig. 10, so that a central position of a field of view 153

of the camera 22 moves to an estimated absolute position of the semiconductor die 113 in the same row (4th row) and in the next column (4th row, 3rd column) (view field moving step). Then, as shown in Step S115 through Step S119 of Fig. 8, position detection and pick-up of the semiconductor die 113 are performed (detecting step, pick-up step), an absolute position of the semiconductor die 213 in a next row (5th row) is calculated and stored as an estimated absolute position in the position data 35 in the memory 32 (estimated position calculating and storing step). In the next row (5th row), the semiconductor die 213 is not disposed, but the TEG die 60a is disposed. However, it is assumed that the semiconductor die 213 is disposed in the next row, and its estimated absolute position is calculated and stored in the position data 35 in the memory 32.

[0043]

Then, as in Step S121 of Fig. 8, the CPU 31 increments the column M by 1. As in the same manner described above, the CPU 31 executes Step S114 through Step S119 in Fig. 8, and moves the field of view of the camera 22 by the X-direction pitch P_x (row-direction pitch) as indicated by an arrow 55b in Fig. 10, so that a central position of a field of view 154 of the camera 22 moves to an estimated absolute position of the semiconductor die 114 in the same row (4th row) and in a next column (4th row, 4th column) (view field moving step). Thereafter, as shown in Step S115 through Step S119 in Fig. 8, position detection and

pick-up of the semiconductor die 114 are performed (detecting step, pick-up step), an absolute position of the semiconductor die 214 in the next row (5th row) is calculated and stored as an estimated absolute position in the position data 35 in the memory 32 (estimated position calculating and storing step). Similarly to the 3rd column, in the next row (5th row), the semiconductor die 214 is not disposed, but the TEG die 60b is disposed. However, it is assumed that the semiconductor die 214 is disposed in the next row, and its estimated absolute position is calculated and stored in the position data 35 in the memory 32.

[0044]

Then, Steps S114 through S121 in Fig. 8 are repeated in the same manner, so that the semiconductor dies 115 to 117 are picked up as indicated by an arrow 55c in Fig. 10, and estimated absolute positions of the semiconductor dies 215 to 217 disposed in the next row (5th row) are calculated and stored in the position data 35 in the memory 32.

[0045]

By the above pick-up operation, the semiconductor dies 111 to 117 disposed in the 4th row are picked up as indicated by the arrows 55a to 55c, and as indicated by a dashed arrow E1 that is substantially parallel to the arrows 55a-55c in Fig. 10 and displaced by the Y-direction pitch P_y (column-direction pitch) in the Y direction, the estimated absolute positions of

the semiconductor dies 211 to 217 assumed to be disposed in the next 5th row are stored in the position data 35 in the memory 32.

[0046]

When all of the semiconductor dies in the 4th row are picked up, as shown in Step S122 of Fig. 8, the CPU 31 determines whether or not the pick-up has been completed to a the last row N_{end} . In the above description, pick-up of the semiconductor dies in the 4th row has just been completed, and pick-up to the last row has not yet been completed. Therefore, as shown in Step S113 of Fig. 8, the CPU 31 increments N by 1, and sets M to an initial value M_{start} for the next row.

[0047]

Hereinafter, a step for performing a pick-up operation from the semiconductor die 217 disposed at (5th row, 7th column) to the semiconductor die 211 disposed at (5th row, 1st column) illustrated in Fig. 11 will be described. As previously described with reference to Fig. 10, the semiconductor dies 111-117 disposed in the 4th row are indicated by dashed lines, as all of these semiconductor dies have been picked up. Here, for steps similar to those described previously relating to pick-up of the semiconductor dies 111-117 in the 4th row, only the steps names are shown and detailed description shall be omitted. Similarly to pick-up of the semiconductor dies 111-117 in the 4th row, the CPU 31 executes Step S114 through

Step S119 of Fig. 8, and moves, as indicated by an arrow 56 in Fig. 11, a central position of a field of view 157 of the camera 22 to the estimated absolute position of the semiconductor die 217 stored in the position data 35 in the memory 32 during pick-up of the semiconductor die 117 at (4th row, 7th column) (view field moving step). Then, as shown in Step S115 through Step S119 of Fig. 8, position detection and pick-up of the semiconductor die 217 are performed (detecting step, pick-up step), an absolute position of a semiconductor die 317 in a next row (6th row) is calculated and stored as an estimated absolute position in the position data 35 in the memory 32 (estimated position calculating and storing step). As the pick-up operation here is directed to the negative X direction, the CPU decrements M by 1 as in Step S121 of Fig. 8, and moves the operation back to Step S114 in Fig. 8, and Steps S114 through S119 in Fig. 8 are repeated as described previously; the semiconductor dies 216, 215 in the 5th row are sequentially picked up, and as indicated as indicated by E2 in Fig. 11, absolute positions of semiconductor dies 316, 315 in the next row (6th row) are calculated and stored as estimated absolute positions in the position data 35 in the memory 32.

[0048]

The CPU 31 executes Step S114 of Fig. 8, and moves, as indicated by an arrow 56 in Fig. 11, the central position of the field of view 154 of the camera 22 to the estimated absolute

position of the semiconductor die 214 stored in the position data 35 in the memory 32 during pick-up of the semiconductor die 114 at (4th row, 4th column) (view field moving step).
[0049]

As in Steps S115, S116 of Fig. 8, the CPU 31 obtains an image taken by the camera 22 via the camera interface 42, to detect a central position of the semiconductor die 214 assumed to be positioned at (5th row, 4th column) from the taken image. However, at this position, a semiconductor die is not disposed, but the TEG die 60b is disposed. Therefore, the CPU 31 is not able to detect a semiconductor die from the image taken by the camera 22. In this case, the CPU 31 does not perform the detecting step and the pick-up step, and stores a position obtained by subtracting a value twice as large as the Y-direction pitch (column-direction pitch) P_y from the absolute position of the semiconductor die 114 at (4th row, 4th column) to which position detection has been previously performed as an estimated absolute position of a semiconductor die 314 at (6th row, 4th column) (second semiconductor die) in the position data 35 in the memory 32 (estimated position calculating and storing step). Then, the CPU 31 decrements M by 1 as in S121 of Fig. 8, moves the operation to Step S114 in Fig. 8, and moves the central position of the field of view of the camera 22 to the estimated absolute position of the semiconductor die 213 stored in the position data 35 in the memory 32 during pick-up

of the semiconductor die 113 at (4th row, 3rd column) (view field moving step).

[0050]

However, similarly to the case of the semiconductor die 214, a semiconductor die is not disposed, but the TEG die 60a is disposed at this position. Therefore, the CPU 31 is not able to detect a semiconductor die from the image taken by the camera 22. Accordingly, in the same manner as described above, the CPU 31 does not perform the detecting step and the pick-up step, and stores a position obtained by subtracting a value twice as large as the Y-direction pitch (column-direction pitch) P_y from the absolute position of the semiconductor die 113 at (4th row, 3rd column) to which position detection has been previously performed as an estimated absolute position of a semiconductor die 313 at (6th row, 3rd column) (second semiconductor die) in the position data 35 in the memory 32 (estimated position calculating and storing step). Then, the CPU 31 decrements M by 1 as in S121 of Fig. 8, moves the operation to Step S114 in Fig. 8, and moves the central position of the field of view of the camera 22 to the estimated absolute position of the semiconductor die 212 stored in the position data 35 in the memory 32 during pick-up of the semiconductor die 112 at (4th row, 2nd column) (view field moving step).

[0051]

As the semiconductor die 212 is disposed at this position, as in Step S115 through Step S119 of Fig. 8, the CPU 31 performs position detection and pick-up of the semiconductor die 212 (detecting step, pick-up step), and calculates an absolute position of a semiconductor die 312 in the next row (6th row), and stores the calculated absolute position as an estimated absolute position in the position data 35 in the memory 32 (estimated position calculating and storing step). Then, the semiconductor die 211 is picked up in the same manner.

[0052]

As described above, when picking up a semiconductor die (first semiconductor die) disposed in one row, the semiconductor manufacturing apparatus 100 according to this embodiment calculates an absolute position of a semiconductor die (second semiconductor die) in a row next to the current row, and stores the calculated absolute position as an estimated absolute position in a memory, and then the semiconductor manufacturing apparatus 100 moves the field of view of the camera 22 along the next row based on the stored estimated absolute position to pick up a semiconductor die. In other words, based on a semiconductor die that has been the actually picked up, a position of a semiconductor die in the next row is estimated, and the central position of the field of view of the camera 22 is moved toward the estimated position.

Accordingly, it is possible to effectively prevent the field

of view from skipping to a row next to a row to which picking is currently performed even if there is no semiconductor die in a next column, and to effectively prevent a semiconductor die in the row to which picking is currently performed from being left unpicked.

[0053]

Next, a pick-up operation by the semiconductor manufacturing apparatus 100 according to a different embodiment of the present invention will be described with reference to Fig. 11 to Fig. 23. The semiconductor manufacturing apparatus 100 according to this embodiment is different from the previously described embodiment in that as illustrated in Figs. 14 through 23, the field of views 71, 171-276 of the camera 22 are of a size containing semiconductor dies (a plurality of semiconductor dies) in three rows and three columns. Similarly to the above description, in Figs. 14 to 23, circled numbers 1 to 7 are numbers for seven columns of semiconductor dies, and numbers 1 to 3 and 4 to 7 in squares are numbers for rows of semiconductor dies.

[0054]

As in Step S201 of Fig. 12, the CPU 31 initializes a row number N and a column number M_{start} as data at a pick-up starting position. As illustrated in Fig. 14, in the following description, pick-up is performed leftward from the semiconductor die 77 disposed at (1st row, 7th column) as

indicated by the arrow 54 in Fig. 14, the CPU 31 sets $N=1$, and $M=7$. Next, as in Step S202 of Fig. 12, the CPU 31 reads data for position of the semiconductor die 77 at (1st row, 7th column) as a reference position from the control data 34. Then, as shown in Step S203 of Fig. 11, the CPU 31 outputs a command for driving the wafer holder driving unit 18 such that the center of the field of view 71 of the camera 22 comes at the reference position of the semiconductor die 77 disposed at $N=1$, $M=7$ (1st row, 7th column) that has been previously read, that is, a semiconductor die at the starting position illustrated in Fig. 6. The command is input as a control signal to the wafer holder driving unit 18 via the wafer holder driving unit interface 44, and the wafer holder driving unit 18 moves the wafer holder 10 in the XY direction.

[0055]

As illustrated in Fig. 14, the field of view 71 of the camera 22 contains the semiconductor die 77 to which the central position is adjusted, the semiconductor die 76 in the 1st row, and semiconductor dies 88, 87, 86 in the 2nd row. First, as in Step S204 of Fig. 12, the CPU 31 takes and obtains an image including the semiconductor die 77 to which the center of the field of view 71 is adjusted, and the semiconductor die 76, the semiconductor die 87 (2nd row, 7th column) that is in the row next to the row for the semiconductor die 77 and that is on a side in a pick-up direction indicated by the arrow 54 in Fig.

14. Here, the semiconductor dies 86, 88 contained in the field of view 71 may or may not be included in the image at the same time.

[0056]

Next, as in Step S205 of Fig. 12, the CPU 31 executes the detection program 36 shown in Fig. 1, and detects the central position of the semiconductor die 77 from the image taken by the camera 22 via the camera interface 42. Then, as illustrated in Fig. 14, the position of the wafer holder 10 in the XY direction is adjusted by the wafer holder driving unit 18, so that the central position of the detected semiconductor die 77 matches the center of the field of view 71 of the camera 22. When the central position of the semiconductor die 77 at (1st row, 7th column) and the center of the field of view 71 of the camera 22 match, this position is detected as an absolute position of the semiconductor die 77 (first semiconductor die) at (1st row, 7th column) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 (detecting step).

[0057]

Next, as in Step S206 of Fig. 12, the CPU 31 executes the pick up program 38 shown in Fig. 1, and adjusts the position of the wafer holder 10 in the XY direction using the wafer holder driving unit 18, so that the plunge-up mechanism 21 and the collet 19 illustrated in Fig. 1 come at the absolute position

of the semiconductor die 77 at (1st row, 7th column). When the adjustment of the position is completed, the CPU 31 outputs a command for picking up the semiconductor die 77. In response to this command, the plunge-up mechanism 21 moves upward to plunge up the semiconductor die 77 at (1st row, 7th column), and at the same time, the collet driving unit 20 moves the collet 19 downward to vacuum suction the semiconductor die 77 to pick up the semiconductor die 77 from the wafer tape 12 (pick-up step).

[0058]

Next, as in Steps S207 and S208 of Fig. 12, the CPU 31 executes the recognition program 40 shown in Fig. 1. The CPU 31 determines whether there is a semiconductor die under the semiconductor die 77 (in the 2nd row) in the center of the image taken by the camera 22, or there is nothing that can be recognized as a semiconductor die, like a case in which there is the TEG die 60 or only the wafer tape 12. Then, if a semiconductor die is recognized under the semiconductor die 77 (in the 2nd row) in the image, the CPU 31 detects as in Step S209 of Fig. 12 an absolute position of the semiconductor die 87 (second semiconductor die) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from the image. Then, as in Step S211 of Fig. 12, the CPU 31 stores the detected absolute position in the position data 35 in the

memory 32 as an estimated absolute position of the semiconductor die 87 disposed in the next row (2nd row, 7th column).

[0059]

Further, if there is no semiconductor die recognized under the semiconductor die 77 (in the 2nd row), like a case in which there is nothing like a semiconductor die but the TEG die 60 having no characteristic shape or mark of a semiconductor die or only the surface of the wafer tape 12, as in Step S210 of Fig. 12, a position obtained by subtracting the Y-direction pitch (column-direction pitch) P_y from the absolute position of the semiconductor die 77 at (1st row, 7th column) (first semiconductor die) detected in Step S205 of Fig. 12 is stored in the position data 35 in the memory 32 as an estimated absolute position of the semiconductor die 87 (second semiconductor die) that is assumed to be positioned at (2nd row (N+1 row), 7th column (M_{start} column)) as in Step S211 of Fig. 12.

[0060]

As illustrated in Fig. 14, as the semiconductor die 87 is disposed at (2nd row, 7th column (in the next row of the semiconductor die 77 in the same column)) under the semiconductor die 77 at (1st row, 7th column), the CPU 31 recognizes the semiconductor die 87 in the image as a semiconductor die, detects as in Step S209 of Fig. 12 an absolute position of the semiconductor die 87 (second semiconductor die) with respect to the reference point (not shown) of the

semiconductor manufacturing apparatus 100 from the image, and as in Step S211 of Fig. 12, stores the detected absolute position in the position data 35 in the memory 32 as an estimated absolute position of the semiconductor die 87 at (2nd row, 7th column) in the next row (estimated position calculating and storing step).

[0061]

Next, as in Step S212 of Fig. 12, the CPU 31 determines whether or not the picking has been completed to the last the column M_{end} in this row. If, not, the CPU 31 moves the operation to Step S213 of Fig. 13, from a connecting terminal 1 (indicated by a circled number 1 in the figure; the same applies in the following) in Fig. 12 to a connecting terminal 1 in Fig. 13, and executes the recognition program 40 shown in Fig. 1. The CPU 31 determines whether there is a semiconductor die on a side in the pick-up direction of the semiconductor die 77 in the center of the image taken by the camera 22 (image on the negative X side), or there is nothing that can be recognized as a semiconductor die, like a case in which there is the TEG die 60 or only the wafer tape 12. If a semiconductor die is recognized on the side in the pick-up direction of the semiconductor die 77 (image on the negative X side), the CPU 31 detects an absolute position of the semiconductor die with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from the image as in Step S214 of

Fig. 13. Then, as in Step S215 of Fig. 13, the CPU 31 moves the central position of the field of view 71 of the camera 22 to the detected absolute position, decrements the column M by 1 as in Step S216 of Fig. 13, moves the operation to S204 of Fig. 12 from a connecting terminal 3 (indicated by the circled number 3 in the figure; the same applies in the following) in Fig. 13 to a connecting terminal 3 in Fig. 12, takes an image of a semiconductor die at (1st row, 6th column), detects an absolute position of this semiconductor die, and picks up this semiconductor die.

[0062]

Further, if there is no semiconductor die recognized on the side in the pick-up direction of the semiconductor die 77 (image on the negative X side), like a case in which there is nothing like a semiconductor die but the TEG die 60 having no characteristic shape or mark of a semiconductor die or only the surface of the wafer tape 12, the operation moves to Step S217 of Fig. 13, and it is determined whether or not a semiconductor die in the first row is to be picked up. When a semiconductor die in the first row is to be picked up, there is no data of picking for a previous row. Therefore, the CPU 31 moves the wafer holder 10 by the X-direction pitch (column-direction pitch) P_x to move the field of view of the camera 22 as in Step S219 of Fig. 13, decrements the column M by 1 as in Step S220 of Fig. 13, moves the operation back to Step S204 of Fig. 12

from the connecting terminal 3 in Fig. 13 to the connecting terminal 3 in Fig. 12, takes an image around a semiconductor die that is assumed to be disposed at (1st row, 6th column), and moves the operation to Step S207 of Fig. 12 skipping the position detection step and the pick-up step.

[0063]

As illustrated in Fig. 14, in this embodiment, there is the semiconductor die 76 disposed at (1st row, 6th column) on the side in the pick-up direction (negative X side) of the semiconductor die 77 at (1st row, 7th column). Therefore, the CPU 31 recognizes in the image that the semiconductor die 76 is on the side in the pick-up direction (on the negative X side) of the semiconductor die 77, and detects an absolute position of the semiconductor die 76 with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from this image as in Step S214 of Fig. 13. Then, as in Step S215 of Fig. 13, the CPU 31 moves the central position of the field of view 71 of the camera 22 to the detected absolute position, decrements the column M by 1 as in Step S216 of Fig. 13, moves the operation to S204 of Fig. 12 from the connecting terminal 3 in Fig. 13 to the connecting terminal 3 in Fig. 12, takes an image of the semiconductor die 76 at (1st row, 6th column), detects an absolute position of the semiconductor die 76, and picks up this semiconductor die.

[0064]

Thereafter, in the same manner, the semiconductor dies disposed in the 1st row are sequentially picked up to the negative X side as indicated by the arrow 54 in Fig. 14. In addition, as indicated by a dashed arrow E0 in Fig. 14, absolute positions of semiconductor dies in the 2nd row are detected or calculated, and stored as estimated absolute positions in the position data 35 in the memory 32. Then, if it is determined that the picking has been completed to a semiconductor die in the last the column M_{end} ($M=M_{\text{end}}$) in Step S212 of Fig. 12, the CPU 31 moves the operation to Step S221 of Fig. 13 from a connecting terminal 2 in Fig. 12 and a connecting terminal 2 in Fig. 13, and determines whether or not a semiconductor die at a last row N_{end} has been picked up. Now, as it is $N=1$, and not the last row N_{end} , the CPU 31 moves the operation to Step S222 of Fig. 13, increments N by 1 to set N to be 2, and sets M to be M_{start} as a first column in the 2nd row. Then, in Step S211 of Fig. 12, the CPU 31 moves the central position of the field of view of the camera 22 to the estimated absolute position of a semiconductor die at (2nd ((N+1)th) row, M_{start} -th column) stored in the position data 35 in the memory 32, and moves the operation to Step S204 of Fig. 12 from a connecting terminal 4 (indicated by the circled number 4 in the figure; the same applies in the following) in Fig. 13, and a connecting terminal 4 in Fig. 12.

[0065]

As illustrated in Fig. 6, there are a larger number of column numbers in the 2nd row than in the 1st row. If an estimated absolute position of a pick-up starting position in the 2nd row at (2nd ((N+1)th) row, M_{start} -th column) is not stored in pick-up of semiconductor dies in the 1st row, the operation returns to Step S203 of Fig. 12, and the CPU 31 may read a reference position of a semiconductor die at the pick-up starting position (2nd ((N+1)th) row, M_{start} -th column) from data for semiconductor die arrangement, and may move the central position of the field of view of the camera 22 to this position.

[0066]

As pick-up of semiconductor dies in the 2nd row and thereafter is performed in the same routine, in the following description, an example of a pick-up routine for the semiconductor dies 111-115 in the 4th row, and for the semiconductor dies 212-216 in the 5th row in which the TEG dies 60a, 60b are disposed will be described with reference to Fig. 15 to Fig. 24. Pick-up of semiconductor dies in the 2nd row and thereafter is different from the pick-up of semiconductor dies in the 1st row described above in that while the pick-up of semiconductor dies in the 1st row when a semiconductor die is not recognized on the side of the pick-up direction is performed by moving the field of view of the camera 22 of the semiconductor die, capturing a semiconductor die in the field of view of the camera 22, adjusting the center of the field of

view of the camera 22 with a central position of this semiconductor die, and sequentially detecting absolute positions of semiconductor dies to be picked up, pick-up of semiconductor dies in the 2nd row when a semiconductor die is not recognized on the side of the pick-up direction is performed by performing calculation based on the absolute positions of the semiconductor dies whose positions have been detected, reading an estimated absolute position stored in the position data 35 in the memory 32, and moving the field of view of the camera 22 toward the estimated absolute position.

[0067]

Hereinafter, a step for performing a pick-up operation sequentially from the semiconductor die 111 at (4th row, 1st column) to the semiconductor die 115 at (4th row, 5th column) illustrated in Figs. 15 to 19 will be described. As $N=4$, $M_{start}=1$ in this example, the CPU 31 sets $N=4$, $M=1$ in Step S222 of Fig. 13, and executes the view field movement program 39 shown in Fig. 1 as in Step S223 of Fig. 13. First, the CPU 31 reads an estimated absolute position for the semiconductor die 111 at (4th row, 1st column) stored in the position data 35 in the memory 32 when picking up semiconductor dies in a row of $N=3$. Next, the CPU 31 outputs a command for driving the wafer holder driving unit 18 such that a center of a field of view 151 of the camera 22 comes at the previously read estimated absolute position of the semiconductor die 111 disposed at $N=4$, $M=1$ (4th row, 1st

column). The command is input as a control signal to the wafer holder driving unit 18 via the wafer holder driving unit interface 44, and the wafer holder driving unit 18 moves the wafer holder 10 in the XY direction (view field moving step). Then, the operation returns to S204 of Fig. 12.

[0068]

As in Steps S204 and S205 of Fig. 12, the CPU 31 executes the detection program 36 shown in Fig. 1, takes an image of the semiconductor dies 111, 112, 211 contained in a range of the field of view 171 by the camera 22 via the camera interface 42, and detects a central position of the semiconductor die 111 at (4th row, 1st column) from the taken image. Then, a position of the wafer holder 10 in the XY direction is adjusted by the wafer holder driving unit 18, so that the central position of the detected semiconductor die 111 matches the center of the field of view 171 of the camera 22. Further, when the central position of the semiconductor die 111 at (4th row, 1st column) and the center of the field of view 171 of the camera 22 match, this position is detected as an absolute position of the semiconductor die 111 (first semiconductor die) at (4th row, 1st column) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 (detecting step).

[0069]

Next, as in Step S206 of Fig. 12, the CPU 31 executes the pick up program 38 shown in Fig. 1, and adjusts the position of the wafer holder 10 in the XY direction using the wafer holder driving unit 18, so that the plunge-up mechanism 21 and the collet 19 come at the absolute position of the semiconductor die 111 at (4th row, 1st column) to which position detection is performed. When the adjustment of the position is completed, the CPU 31 outputs a command for picking up the semiconductor die 111. In response to this command, the plunge-up mechanism 21 moves upward to plunge up the semiconductor die 111 at (4th row, 1st column), and at the same time the collet driving unit 20 moves the collet 19 downward to vacuum suction the semiconductor die 111 to pick up the semiconductor die 111 from the wafer tape 12 (pick-up step).

[0070]

Next, as in Steps S207 and S208 of Fig. 12, the CPU 31 executes the recognition program 40 shown in Fig. 1. The CPU 31 determines whether there is a semiconductor die under the semiconductor die 111 in the center of the image taken by the camera 22 (in the 5th row), or there is nothing that can be recognized as a semiconductor die, like a case in which there is the TEG die 60 or only the wafer tape 12. As illustrated in Fig. 15, as the semiconductor die 211 is disposed under the semiconductor die 111 (in the 5th row), the CPU 31 recognizes the semiconductor die in the image, executes the estimated

position calculation and storage program 37 as in Step S209 of Fig. 12, detects an absolute position of the semiconductor die 211 (second semiconductor die) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from the image, and as in Step S211 of Fig. 12, stores the detected absolute position in the position data 35 in the memory 32 as an estimated absolute position of the semiconductor die 211 at (5th row, 1st column) in the next row (estimated absolute position calculating and storing step).

[0071]

Next, as in Step S212 of Fig. 12, the CPU 31 determines whether or not the picking has been completed to the last the column M_{end} in this row. If, not, the CPU 31 moves the operation to Step S213 of Fig. 13, from a connecting terminal 1 (indicated by a circled number 1 in the figure; the same applies in the following) in Fig. 12 to a connecting terminal 1 in Fig. 13, and executes the recognition program 40. The CPU 31 determines whether there is a semiconductor die on a side in the pick-up direction (positive X side) of the semiconductor die 111 in the center of the image taken by the camera 22, or there is nothing that can be recognized as a semiconductor die, like a case in which there is the TEG die 60 or only the wafer tape 12. As illustrated in Fig. 15, there is the semiconductor die 112 disposed on the side in the pick-up direction (positive X side) of the semiconductor die 111. Therefore, the CPU 31 detects

an absolute position of the semiconductor die 112 with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from this image as in Step S214 of Fig. 13. Then, as in Step S215 of Fig. 13, the CPU 31 moves the central position of the field of view 172 of the camera 22 illustrated in Fig. 16 to the detected absolute position of the semiconductor die 112, increments the column M by 1 as in Step S216 of Fig. 13, and moves the operation to S204 of Fig. 12 from the connecting terminal 3 in Fig. 13 to the connecting terminal 3 in Fig. 12.

[0072]

As in Steps S204 and S205 of Fig. 12, the CPU 31 executes the detection program 36 shown in Fig. 1, takes an image of the semiconductor dies 112, 212, 113 contained in a range of the field of view 172 illustrated in Fig. 16 by the camera 22 via the camera interface 42, and detects a central position of the semiconductor die 112 at (4th row, 2nd column) from the taken image. Then, a position of the wafer holder 10 in the XY direction is adjusted by the wafer holder driving unit 18, so that the central position of the detected semiconductor die 112 matches the center of the field of view 172 of the camera 22. Further, when the central position of the semiconductor die 112 at (4th row, 2nd column) and the center of the field of view 172 of the camera 22 match, this position is detected as an absolute position of the semiconductor die 112 (first

semiconductor die) at (4th row, 2nd column) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 (detecting step).

[0073]

Next, similarly to the above description, as in Step S206 of Fig. 12, the CPU 31 executes the pick up program 38, and picks up the semiconductor die 112 at (4th row, 2nd column) to which position detection has been performed (pick-up step).

[0074]

Next, similarly to the above description, as in Steps S207 and S208 of Fig. 12, the CPU 31 executes the recognition program 40. The CPU 31 executes the estimated position calculation and storage program 37, detects an absolute position of the semiconductor die 212 (second semiconductor die) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 as in Step S209 of Fig. 12, and as in Step S211 of Fig. 12, stores the detected absolute position in the position data 35 in the memory 32 as an estimated absolute position of the semiconductor die 212 at (5th row, 2nd column) in the next row (estimated absolute position calculating and storing step).

[0075]

Next, similarly to the above description, the CPU 31 moves the operation from Step S212 of Fig. 12 to Step S213 of Fig. 13, and executes the recognition program 40. The CPU 31 detects

an absolute position of the semiconductor die 113 with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 as in Step S214 of Fig. 13. Then, as in Step S215 of Fig. 13, the CPU 31 moves a central position of a field of view 173 illustrated in Fig. 17 to the detected absolute position of the semiconductor die 113, increments the column M by 1, and moves the operation to S204 of Fig. 12 from the connecting terminal 3 in Fig. 13 to the connecting terminal 3 in Fig. 12.

[0076]

Similarly to the above description, as in Steps S204 and S205 of Fig. 12, the CPU 31 executes the detection program 36 shown in Fig. 1, takes an image of the semiconductor dies 113, 114, and the TEG die 60a contained in a range of the field of view 173 illustrated in Fig. 17 by the camera 22 via the camera interface 42, and detects a central position of the semiconductor die 113 at (4th row, 3rd column) from the taken image. Then, the CPU 31 has the central position of the semiconductor die 113 at (4th row, 3rd column) match the center of the field of view 173 of the camera 22, and detects this position as an absolute position of the semiconductor die 113 (first semiconductor die) at (4th row, 3rd column) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 (detecting step).

[0077]

Next, similarly to the above description, as in Step S206 of Fig. 12, the CPU 31 executes the pick up program 38 shown in Fig. 1, and picks up the semiconductor die 113 at (4th row, 3rd column) to which position detection has been performed (pick-up step).

[0078]

Then, as in Step S207 to Step S211 of Fig. 12, the CPU 31 executes the recognition program 40 and the estimated position calculation and storage program 37 shown in Fig. 1. As illustrated in Fig. 17, as there is the TEG die 60a having no characteristic shape or mark of a semiconductor die under the semiconductor die 113 (in the 5th row) in the image, the CPU 31 determines that this position in the image may not be recognized as a semiconductor die. Then, as in Step S210 of Fig. 12, the CPU 31 stores a position obtained by subtracting the Y-direction pitch (column-direction pitch) P_y from the absolute position of the semiconductor die 113 (first semiconductor die) at (4th row, 3rd column) detected in Step S205 of Fig. 12 in the position data 35 in the memory 32 as an estimated absolute position of the semiconductor die 213 (second semiconductor die) that is assumed to be positioned at (5th row (N+1 row), 3rd column) as in Step S211 of Fig. 12 (estimated position calculating and storing step).

[0079]

Next, similarly to the above description, the CPU 31 moves the operation from Step S212 of Fig. 12 to Step S213 of Fig. 13, and executes the recognition program 40. The CPU 31 detects an absolute position of the semiconductor die 114 with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 as in Step S214 of Fig. 13. Then, as in Step S215 of Fig. 13, the CPU 31 moves a central position of a field of view 174 illustrated in Fig. 18 to the detected absolute position of the semiconductor die 114, increments the column M by 1 as in Step S216 of Fig. 13, and moves the operation to S204 of Fig. 12 from the connecting terminal 3 in Fig. 13 to the connecting terminal 3 in Fig. 12.

[0080]

Thereafter, in the same manner, as illustrated in Fig. 18 and Fig. 19, the recognition program 40, the estimated position calculation and storage program 37, the detection program 36, the pick up program 38, and the view field movement program 39 are executed to pick up the semiconductor dies 114, 115 sequentially, and an estimated absolute position of the semiconductor die 214 (second semiconductor die) that is assumed to be positioned at (5th row, 4th column) and the absolute position of the semiconductor die 215 positioned at (5th row, 5th column) are stored in the position data 35 in the memory 32 as respective estimated absolute positions (estimated absolute position calculating and storing step).

[0081]

As described above, the semiconductor dies disposed in the 4th row are sequentially picked up to the positive X side as indicated by an arrow 55 in Fig. 15 through Fig. 19. In addition, as indicated by a dashed arrow E5 in Fig. 15 through Fig. 19, absolute positions of semiconductor dies in the 5th row are detected or calculated and stored as estimated absolute positions in the position data 35 in the memory 32.

[0082]

When all of the semiconductor dies in the 4th row are picked up, as shown in Step S221 of Fig. 13, the CPU 31 determines whether or not the picking has been completed to a the last row N_{end} . In the above description, picking up to the last row has not yet been completed. Therefore, as shown in Step S223 of Fig. 8, the CPU 31 increments N by 1, and sets M to an initial value M_{start} for the next row.

[0083]

Hereinafter, a step for performing a pick-up operation from the semiconductor die 216 disposed at (5th row, 6th column) to the semiconductor die 212 disposed at (5th row, 2nd column) illustrated in Fig. 20 through Fig. 24 will be described. As previously described with reference to Figs. 15 through 19, the semiconductor dies disposed in the 4th row are indicated by dashed lines, as all of these semiconductor dies have been picked up. Here, for steps similar to those described

previously relating to pick-up of the semiconductor dies 111-115 in the 4th row, only the steps names are shown and detailed description shall be omitted.

[0084]

As in Steps S204 and S205 of Fig. 12, the CPU 31 executes the detection program 36 shown in Fig. 1, takes an image of the semiconductor dies 216, 316, 215 contained in a range of a field of view 276, and detects a central position of the semiconductor die 216 at (5th row, 6th column) from the taken image. Then, the CPU 31 makes the central position of the detected semiconductor die 216 match the center of the field of view 276 of the camera 22, and detects this position as an absolute position of the semiconductor die 216 (first semiconductor die) at (5th row, 6th column) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 (detecting step). Further, as in Step S206 of Fig. 12, the CPU 31 executes the pick up program 38 shown in Fig. 1, and picks up the semiconductor die 216 at (5th row, 6th column) to which position detection has been performed from the wafer tape 12 (pick-up step).

[0085]

Next, as in Steps S207 and S208 of Fig. 12, the CPU 31 executes the recognition program 40 shown in Fig. 1. As the semiconductor die 316 is disposed under the semiconductor die 216 in the center of the image taken by the camera 22, the CPU

31 recognizes the semiconductor die in the image, executes the estimated position calculation and storage program 37 as in Step S209 of Fig. 12, detects an absolute position of the semiconductor die 316 (second semiconductor die) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from the image, and as in Step S211 of Fig. 12, stores the detected absolute position in the position data 35 in the memory 32 as an estimated absolute position of the semiconductor die 316 at (6th row, 6th column) in the next row (estimated absolute position calculating and storing step).

[0086]

Then, the CPU 31 moves the operation to Step S213 of Fig. 13 and executes the recognition program 40 shown in Fig. 1. As the semiconductor die 215 is disposed on the side in the pick-up direction (negative X side) of the semiconductor die 216 in the center of the image taken by the camera 22, the CPU 31 detects an absolute position of the semiconductor die 215 with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from this image as in Step S214 of Fig. 13. Then, as in Step S215 of Fig. 13, the CPU 31 moves a central position of a field of view 275 illustrated in Fig. 21 to the detected absolute position of the semiconductor die 215, decrements the column M by 1 as in Step S216 of Fig. 13,

and moves the operation to S204 of Fig. 12 from the connecting terminal 3 in Fig. 13 to the connecting terminal 3 in Fig. 12.

[0087]

As in Steps S204 and S205 of Fig. 12, the CPU 31 takes an image of the semiconductor dies 215, 315 and the TEG die 60b contained in a range of the field of view 275 shown in Fig. 21, and detects a central position of the semiconductor die 215 at (5th row, 5th column) from the taken image. Then, the CPU 31 makes the central position of the detected semiconductor die 215 match the center of the field of view 275 of the camera 22, and detects this position as an absolute position of the semiconductor die 215 (first semiconductor die) at (5th row, 5th column) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 (detecting step). Further, similarly to the above description, as in Step S206 of Fig. 12, the CPU 31 executes the pick up program 38, and picks up the semiconductor die 215 at (5th row, 5th column) to which position detection has been performed (pick-up step).

[0088]

Next, as in Steps S207 and S208 of Fig. 12, the CPU 31 executes the recognition program 40 shown in Fig. 1. As the semiconductor die 315 is disposed under the semiconductor die 215 in the center of the image taken by the camera 22, the CPU 31 recognizes the semiconductor die in the image, executes the estimated position calculation and storage program 37 as in Step

S209 of Fig. 12, detects an absolute position of the semiconductor die 315 (second semiconductor die) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from the image, and as in Step S211 of Fig. 12, stores the detected absolute position in the position data 35 in the memory 32 as an estimated absolute position of the semiconductor die 315 at (6th row, 5th column) in the next row (estimated absolute position calculating and storing step).

[0089]

Then, the CPU 31 moves the operation to Step S213 of Fig. 13 and executes the recognition program 40. As the TEG die 60b, instead of the semiconductor die 214, is disposed on the side in the pick-up direction (negative X side) of the semiconductor die 215 in the center of the image taken by the camera 22, a semiconductor die is not recognized in the image, and the operation moves from Step S217 to Step S218 in Fig. 13. As in Step S218 of Fig. 13, the CPU 31 reads the estimated absolute position of the semiconductor die 214 stored in the position data 35 in the memory 32 when picking up the semiconductor die 114 in the previous row (4th row), moves the central position of the field of view 274 of the camera 22 illustrated in Fig. 22 to this estimated absolute position, decrements the column M by 1, and moves the operation to S204 of Fig. 12 from the

connecting terminal 3 in Fig. 13 to the connecting terminal 3 in Fig. 12.

[0090]

As in Steps S204 and S205 of Fig. 12, the CPU 31 takes an image of the TEG dies 60a, 60b, and the semiconductor die 314 contained in a range of the field of view 274 shown in Fig. 22. However, as the TEG die 60b is disposed at a position where the semiconductor die 214 is assumed to be positioned, the CPU 31 skips the detecting step and the pick-up step.

[0091]

Then, as in Steps S207 and S208 of Fig. 12, the CPU 31 executes the recognition program 40. As the semiconductor die 314 is disposed under the TEG die 60b in the center of the image taken by the camera 22, the CPU 31 recognizes the semiconductor die in the image, executes the estimated position calculation and storage program 37 as in Step S209 of Fig. 12, detects an absolute position of the semiconductor die 314 (second semiconductor die) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from the image, and as in Step S211 of Fig. 12, stores the detected absolute position in the position data 35 in the memory 32 as an estimated absolute position of the semiconductor die 314 at (6th row, 4th column) in the next row (estimated absolute position calculating and storing step).

[0092]

Next, the CPU 31 moves the operation to Step S213 of Fig. 13 and executes the recognition program 40. As the TEG die 60a, instead of the semiconductor die 213, is disposed on the side in the pick-up direction (negative X side) of the TEG die 60b in the center of the image taken by the camera 22, a semiconductor die is not recognized in the image. Therefore, the CPU 31 moves the operation from Step S217 to Step S218 in Fig. 13, and as in Step S218 of Fig. 13, reads the estimated absolute position of the semiconductor die 213 stored in the position data 35 in the memory 32 when picking up the semiconductor die 113 in the previous row (4th row), moves a central position of a field of view 273 illustrated in Fig. 23 to this estimated absolute position, decrements the column M by 1, and moves the operation to S204 of Fig. 12 from the connecting terminal 3 in Fig. 13 to the connecting terminal 3 in Fig. 12.

[0093]

As in Steps S204 and S205 of Fig. 12, the CPU 31 takes an image of the TEG die 60a, and the semiconductor dies 212, 313 contained in a range of the field of view 273 shown in Fig. 23. However, as the TEG die 60a is disposed at a position where the semiconductor die 213 is assumed to be positioned, the CPU 31 skips the detecting step and the pick-up step.

[0094]

Then, as in Steps S207 and S208 of Fig. 12, the CPU 31 executes the recognition program 40. As the semiconductor die

313 is disposed under the TEG die 60a in the center of the image taken by the camera 22, the CPU 31 recognizes the semiconductor die in the image, executes the estimated position calculation and storage program 37 as in Step S209 of Fig. 12, detects an absolute position of the semiconductor die 313 (second semiconductor die) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from the image, and as in Step S211 of Fig. 12, stores the detected absolute position in the position data 35 in the memory 32 as an estimated absolute position of the semiconductor die 313 at (6th row, 3rd column) in the next row (estimated absolute position calculating and storing step).

[0095]

Next, the CPU 31 moves the operation to Step S213 of Fig. 13 and executes the recognition program 40. As the semiconductor die 212 is disposed on the side in the pick-up direction (negative X side) of the TEG die 60a in the center of the image taken by the camera 22, the CPU 31 recognizes the semiconductor die in the image. Then, the CPU 31 detects an absolute position of the semiconductor die 212 with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 from this image as in Step S214 of Fig. 13, and as in Step S215 of Fig. 13, the CPU 31 moves the central position of the field of view 272 illustrated in Fig. 24 to the detected absolute position, decrements the column M

by 1 as in Step S216 of Fig. 13, and moves the operation to S204 of Fig. 12 from the connecting terminal 3 in Fig. 13 to the connecting terminal 3 in Fig. 12.

[0096]

Thereafter, as in Steps S204 and S205 of Fig. 12, the CPU 31 takes an image of the semiconductor dies 212, 211, 312 contained in a range of the field of view 272 shown in Fig. 24, and detects a central position of the semiconductor die 212 at (5th row, 2nd column) from the taken image. Then, the CPU 31 makes the central position of the detected semiconductor die 212 match the center of the field of view 272 of the camera 22, and detects this position as an absolute position of the semiconductor die 212 (first semiconductor die) at (5th row, 2nd column) with respect to the reference point (not shown) of the semiconductor manufacturing apparatus 100 (detecting step). Further, similarly to the above description, as in Step S206 of Fig. 12, the CPU 31 executes the pick up program 38, and picks up the semiconductor die 212 at (5th row, 2nd column) (pick-up step).

[0097]

As described above, the semiconductor dies disposed in the 5th row are sequentially picked up to the negative X side as indicated by an arrow 56 in Fig. 20 through Fig. 24. In addition, as indicated by a dashed arrow E6 in Fig. 20 through Fig. 24, absolute positions of semiconductor dies in the 6th

row are detected or calculated and stored as estimated absolute positions in the position data 35 in the memory 32.

[0098]

In this embodiment, similarly to the embodiment described previously with reference to Fig. 1 through Fig. 11, when picking up a semiconductor die (first semiconductor die) disposed in one row, an absolute position of a semiconductor die (second semiconductor die) in a row next to the current row is calculated, the calculated absolute position is stored as an estimated absolute position in a memory, and then the field of view of the camera 22 is moved along the next row based on the stored estimated absolute position to pick up a semiconductor die. In other words, based on a semiconductor die that has been the actually picked up, a position of a semiconductor die in the next row is estimated, and the central position of the field of view of the camera 22 is moved toward the estimated position. Accordingly, it is possible to effectively prevent the field of view from skipping to a row next to a row to which picking is currently performed even if there is no semiconductor die in a next column, and to effectively prevent a semiconductor die in the row to which picking is currently performed from being left unpicked.

[0099]

In the above embodiments, the example in which the semiconductor die 15 is picked from the wafer tape 12 by plunging

the semiconductor die 15 by the plunge-up mechanism 21 and vacuum-suctioning the semiconductor die 15 by the collet 19 is described. However, the pick-up mechanism for picking the semiconductor die 15 is not limited to such an example, and may be such that a stage to which a cover for an upper surface is openably attached is pressed against a lower surface of the wafer tape 12, and the cover is opened to suction the wafer tape 12 and at the same time the semiconductor die 15 is vacuum suctioned by the collet 19.

[0100]

In the above embodiments, the example in which, the semiconductor dies 15 are picked up row by row in a direction horizontal to the figure is described. However, the semiconductor dies 15 may be picked up column by column.

[0101]

The present invention is not limited to the embodiments described above, and may include any alterations and modifications without departing from the technical scope and the spirit of the present invention as defined in the appended claims.

Reference Signs List

[0102]

10: wafer holder

11: wafer

12: wafer tape

13: ring

14: cutting gap

15, 76, 77, 86-88, 111-117, 211-217, 312-317:

semiconductor die

16: expanded ring

18: wafer holder driving unit

19: collet

20: collet driving unit

21: plunge-up mechanism

22: camera

30: controller unit

32: memory

33: control program

34: control data

35: position data

36: detection program

37: estimated position calculation and storage program

38: pick up program

39: view field movement program

40: recognition program

41: collet driving unit interface

42: camera interface

43: plunge-up mechanism interface

44: wafer holder driving unit interface

45: data bus

60, 60a, 60b: TEG die

71, 151-154, 171-174, 272-276: field of view

100: semiconductor manufacturing apparatus

CLAIMS

1. A semiconductor manufacturing apparatus capable of picking up a plurality of semiconductor dies row by row, the semiconductor dies being arranged on a wafer tape in a grid pattern, the apparatus comprising:

a camera configured to take an image of each of the semiconductor dies;

a pick-up mechanism configured to pick up each of the semiconductor dies from the wafer tape; and

a controller unit configured to detect a position of each of the semiconductor dies based on the image of the each of the semiconductor dies taken by the camera, wherein

the controller unit includes:

a memory for storing the position of each of the semiconductor dies; and

executable means including:

detection means configured to move a field of view of the camera, so that a plurality of first semiconductor dies disposed in a first row sequentially come in a center of the field of view of the camera, and detect an absolute position of each of the first semiconductor dies in the first row with respect to a reference point of the pick-up apparatus;

pick-up means configured to cause the pick-up mechanism to sequentially pick up each of the first

semiconductor dies whose absolute position has been detected by the detection means;

estimated position calculation and storage means configured to calculate an estimated absolute position of each of second semiconductor dies based on the absolute position of each of the first semiconductor dies that has been detected by the detection means, and store the estimated absolute position in the memory, the second semiconductor dies being in a second row and disposed near positions corresponding to the first semiconductor dies; and

view field movement means configured to move the field of view of the camera, so that the estimated absolute position of each of the second semiconductor dies stored in the memory sequentially come in the center of the field of view of the camera.

2. The semiconductor manufacturing apparatus according to claim 1, wherein

the camera takes an image of a plurality of rows of the semiconductor dies,

the controller unit further includes:

recognition means configured to, when the field of view of the camera is sequentially moved, recognize whether or not a second semiconductor die is present in the second row and

disposed near a position corresponding to each of the first semiconductor dies, and

the estimated position calculation and storage means: calculates, when the recognition means fails to recognize the second semiconductor die, an estimated absolute position of the second semiconductor die based on the absolute position of the each first semiconductor die that has been detected by the detection means, and stores the calculated estimated absolute position in the memory; and detects, when the recognition means recognizes the second semiconductor die, an absolute position of the second semiconductor die with respect to the reference point of the pick-up apparatus, and stores the detected absolute position as the estimated absolute position of the second semiconductor die.

3. The semiconductor manufacturing apparatus according to claim 1 or 2, wherein

as the estimated absolute position of each of the second semiconductor dies, the estimated position calculation and storage means takes a position displaced from the absolute position of each of the first semiconductor dies that has been detected by the detection means by a column-direction pitch between the first semiconductor dies and the second semiconductor dies.

4. A method of manufacturing a semiconductor device capable of picking up a plurality of semiconductor dies row by row, the semiconductor dies being arranged on a wafer tape in a grid pattern, the method comprising:

a step of preparing a semiconductor manufacturing apparatus including: a camera configured to take an image of each of the semiconductor dies; a pick-up mechanism configured to pick up each of the semiconductor dies from the wafer tape; and a controller unit configured to detect a position of each of the semiconductor dies based on the image of the each of the semiconductor dies taken by the camera, the controller unit including a memory for storing the position of each of the semiconductor dies;

a detecting step of moving a field of view of the camera, so that a plurality of first semiconductor dies disposed in a first row sequentially come in a center of the field of view of the camera, and detect an absolute position of each of the first semiconductor dies in the first row with respect to a reference point of the pick-up apparatus;

a pick-up step of causing the pick-up mechanism to sequentially pick up each of the first semiconductor dies whose absolute position has been detected by the detection means;

an estimated position calculating and storing step of calculating an estimated absolute position of each of second semiconductor dies based on the absolute position of each of

the first semiconductor dies that has been detected by the detection means, and storing the estimated absolute position in the memory, the second semiconductor dies being in a second row and disposed near positions corresponding to the first semiconductor dies; and

a view field moving step of moving the field of view of the camera, so that the estimated absolute position of each of the second semiconductor dies stored in the memory sequentially comes in the center of the field of view of the camera.

5. The method of manufacturing a semiconductor device according to claim 4, wherein

the camera takes an image of a plurality of rows of the semiconductor dies,

the method further comprises: a recognizing step of, when the field of view of the camera is sequentially moved, recognizing whether or not a second semiconductor die is present in the second row and disposed near a position corresponding to each of the first semiconductor dies, and

in the estimated position calculating and storing step: when the second semiconductor die fails to be recognized in the recognizing step, an estimated absolute position of the second semiconductor die is calculated based on the absolute position of the each first semiconductor die that has been detected by the detection means, and the calculated estimated absolute

position is stored in the memory; and when the second semiconductor die is recognized in the recognizing step, an absolute position of the second semiconductor die with respect to the reference point of the pick-up apparatus is detected, and the detected absolute position is stored as the estimated absolute position of the second semiconductor die.

6. The method of manufacturing a semiconductor device according to claim 4 or 5, wherein

in the estimated position calculating and storing step, a position displaced from the absolute position of each of the first semiconductor dies that has been detected in the detecting step by a column-direction pitch between the first semiconductor dies and the second semiconductor dies is taken as the estimated absolute position of each of the second semiconductor dies.