WAFER CONVEYING SYSTEM, WAFER CONVEYING METHOD, AND DEFECT DETECTION DEVICE

TECHNICAL FIELD

The present invention relates to the field of semiconductor equipment, and in particular to a wafer conveying system, a wafer conveying method and a defect detection device.

BACKGROUND

In the production and manufacturing of semiconductor integrated circuits (ICs), the wafer conveying of various machines involves the use of pre-alignment systems. Currently, the most widely used is the PU rotary table pre-alignment system, which requires the wafer to rotate one circle to obtain the complete edge information of the wafer for the detection of the center position and notch position of the wafer. Although this increases the amount of data, it does not improve the data collection accuracy itself, and it is impossible to significantly improve the accuracy of wafer pre-alignment, and it also reduces the efficiency of obtaining the center deviation and notch rotation deviation of the wafer.

At present, in the production and conveying process of wafers, the wafers need to be transferred to the pre-alignment table for pre-alignment before the manipulator transfers the wafers from the wafer library to the worktable. The existing conveying scheme requires that the pre-alignment table completes the compensation of the center deviation and notch rotation deviation of the wafer, and then the manipulator transfers the wafer to the worktable at a predetermined position according to a predetermined path. In this way, the pre-alignment table needs to have the function of position compensation for the wafer, which increases the cost.

SUMMARY

One of the objectives of the present invention is to provide a wafer conveying system that can use an existing worktable or manipulator to compensate for the wafer

loading deviation (i.e., the wafer center deviation and notch rotation deviation), without requiring a predetermined station (e.g., a pre-alignment stage) to have the function of compensating for the wafer loading deviation, thereby simplifying the complexity of the pre-alignment stage and helping to reduce costs. The present invention also provides a wafer conveying method and a defect detection device.

In order to achieve the above-mentioned object, one aspect of the present invention provides a wafer conveying system. The wafer conveying system includes:

a wafer library, configured to store a wafer;

a manipulator, configured to take out the wafer from the wafer library and convey the wafer to a predetermined station;

a wafer loading deviation detection module, configured to obtain a wafer loading deviation of the wafer at the predetermined station; and

a wafer loading deviation compensation module, configured to calculate a position deviation of the wafer at a handover station between the manipulator and a worktable based on the wafer loading deviation, the worktable moving to the handover station and adjusting a position thereof based on the position deviation, the manipulator configured to convey the wafer from the predetermined station to the handover station, and the worktable carrying the wafer from the handover station; or the wafer loading deviation compensation module configured to calculate a wafer loading path of the manipulator from the predetermined station to the handover station between the manipulator and the worktable based on the wafer loading deviation, the wafer loading path including a compensation for the wafer loading deviation, the manipulator moving to the handover station according to the wafer loading path, and conveying the wafer to the worktable.

Optionally, the wafer loading deviation detection module may be configured to obtain a first image of the wafer at the predetermined station, and calculate the wafer loading deviation of the wafer based on the first image.

Optionally, the wafer deviation detection module may include a detection light source and a camera, the detection light source configured to emit a detection light to the wafer at the predetermined station, and the camera configured to receive a reflected light or a scattered light from a surface of the wafer to obtain the first image.

Optionally, the wafer loading deviation detection module may further include a detection table, the detection table is located at the predetermined station, and the manipulator is configured to convey the wafer from the wafer library to the detection table at the predetermined station.

Optionally, the surface of the detection table for placing the wafer may have at least three pre-alignment marking points, and the first image includes images of the at least three pre-alignment marking points.

Optionally, the wafer loading deviation detection module calculating the wafer loading deviation based on the first image may include: identifying pre-alignment mark points in the first image, and obtaining a mapping transformation matrix according to an actual physical position relationship of the at least three pre-alignment mark points on the detection table; using the mapping transformation matrix, converting the first image into a top plan view, wherein a center of the top plan view coincides with a center of the detection table; and obtaining the wafer loading deviation by using a centering and orientation algorithm based on the top plan view.

Optionally, the wafer deviation detection module may further include a fork for adsorbing the wafer on the detection table, and a surface of the wafer fork for adsorbing the wafer has at least three pre-alignment mark points; the first image includes images of the at least three pre-alignment mark points.

Optionally, the wafer loading deviation detection module may further include a wafer fork driving mechanism, and the wafer fork driving mechanism is configured to drive the fork to rotate so as to perform a macro defect detection on a front side or a back side of the wafer adsorbed on the fork.

Optionally, the wafer loading deviation detection module calculating the wafer loading deviation based on the first image may include: identifying pre-alignment mark points in the first image, and obtaining a mapping transformation matrix according to an actual physical position relationship of the at least three pre-alignment mark points on the fork; converting the first image into a top plan view using the mapping transformation matrix, wherein a center of the top plan view coincides with a center of the fork; and obtaining the wafer loading deviation by using a centering and orientation

algorithm based on the top plan view.

Optionally, the wafer loading deviation detection module obtaining the wafer loading deviation of the wafer based on the top plan view by using a centering and orientation algorithm may include: automatically selecting a binarization threshold, performing a binarization process on the top plan view, and filtering out an area of the wafer in the top plan view by a connected domain area; extracting an edge information of the wafer by using a Canny algorithm, and performing circle fitting according to the edge information of the wafer to obtain a position of a center of the wafer in the top plan view; obtaining the number of deviation pixels between the center of the wafer in the top plan view and the center of the top plan view; obtaining a center deviation of the wafer according to a pixel size of the top plan view and the number of the deviation pixels; intercepting a plurality of small images at edge of the wafer according to the position of the center of the wafer in the top plan view; extracting features from each of the small images using a HOG algorithm, and classifying the small images using a SVM supervised learning algorithm, and outputting specified small images with notches; locating a notch position of the wafer in the specified small image with notches using a geometric template matching algorithm, and converting the notch position into the top plan view; and determining a notch rotation deviation of the wafer by using the position of the center of the wafer and a notch vertex position in the top plan view, wherein the wafer loading deviation comprises the center deviation and the notch rotation deviation of the wafer.

Optionally, the wafer loading deviation detection module calculating the wafer loading deviation of the wafer based on the first image may include: obtaining a reference image of a reference wafer captured at the predetermined position, and obtaining a center coordinate and a notch rotation angle of the reference wafer, and determining a reference wafer loading deviation of the reference wafer according to the center coordinate and the notch rotation angle of the reference wafer; and obtaining a center coordinate and a notch rotation angle of the wafer in the first image, calculating differences between the center coordinates and the notch rotation angles of the wafer and the reference wafer, and determining the wafer loading deviation according to the

differences and the reference wafer loading deviation.

Optionally, a coordinate system for capturing the reference image may be the same as a coordinate system for capturing the first image.

Another aspect of the present invention provides a wafer conveying method. The wafer conveying method includes:

step 1: taking out a wafer from a wafer library and conveying the wafer to a predetermined station by a manipulator;

step 2: obtaining a wafer loading deviation at the predetermined station; and

step 3: calculating a position deviation of the wafer at a handover station between the manipulator and a worktable based on the wafer loading deviation, the worktable moving to the handover station and adjusting a position thereof based on the position deviation, the manipulator conveying the wafer from the predetermined station to the handover station, and the worktable carrying the wafer from the handover station; or a loading deviation compensation module calculating a wafer loading path of the manipulator from the predetermined station to the handover station between the manipulator and the worktable based on the wafer loading deviation, the wafer loading path including a compensation for the wafer loading deviation, the manipulator moving to the handover station according to the wafer loading path, and conveying the wafer to the worktable.

The present invention also provides a defect detection device, which includes a worktable, a defect detection system and the above-mentioned wafer conveying system; wherein the wafer conveying system is configured to convey the wafer to the worktable, and the defect detection system is configured to perform a defect detection on the wafer on the worktable.

Optionally, the defect detection system may include a bright field detection light source or a dark field detection light source, and the defect detection system further includes a detector.

In the wafer conveying system, wafer conveying method and defect detection device provided by the present invention, a manipulator is first used to convey the wafer from a wafer library to a predetermined station; then, at the predetermined station, the

wafer loading deviation is obtained; after obtaining the wafer loading deviation, based on the wafer loading deviation, the position deviation of the wafer at the handover station between the manipulator and the worktable is calculated, the worktable moves to the handover station and adjusts its position based on the position deviation (i.e., moves to a position after the deviation is compensated based on the position deviation), the manipulator transfers the wafer from the predetermined station to the handover station, and the worktable carries the wafer from the handover station; or after obtaining the wafer loading deviation, based on the wafer loading deviation, the wafer loading path of the manipulator from the predetermined station to the handover station between the manipulator and the worktable is calculated, and the wafer loading path includes compensation for the wafer loading deviation. The manipulator moves to the handover station according to the wafer loading path and transfers the wafer to the worktable. In this way, there is no need for a predetermined station (such as a pre-alignment table) to have the function of compensating for the wafer loading deviation, thereby simplifying the structural complexity of the pre-alignment table and utilizing the existing worktable or manipulator to perform wafer loading deviation compensation, thereby enhancing process adaptability and anti-noise interference capability and reducing equipment costs.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a wafer conveying system according to an embodiment of the present invention.

FIG. 2 is a schematic diagram of a wafer conveying system transporting wafers according to an embodiment of the present invention.

FIG. 3 is a schematic plan view of a detection table according to an embodiment of the present invention.

FIG. 4 is a schematic diagram of a wafer conveying system transporting wafers according to another embodiment of the present invention.

FIG. 5 is a schematic plan view of a wafer fork in one embodiment of the present invention.

List of Reference Numerals

10-wafer library; 11-manipulator; 11a-fork body; 11b-manipulator body; 12-wafer loading deviation detection module; 121-detection table; 122-wafer fork; 123-wafer fork driving mechanism; 13-wafer loading deviation compensation module; 14-worktable; 14a-suction cup; 20-wafer; 30-pre-alignment mark point; 40-vacuum suction cup.

DETAILED DESCRIPTION

The wafer conveying system and defect detection device proposed in the present invention are further described in detail below in conjunction with the accompanying drawings and specific embodiments. The advantages and features of the present invention will become clearer according to the following description. It should be noted that the accompanying drawings are all in a very simplified form and are not in precise proportions, and are only used to conveniently and clearly assist in explaining the purpose of the embodiments of the present invention.

As used in the present invention, the singular forms "one", "an" and "the" include plural objects, the term "or" is generally used to include the meaning of "and/or", the term "several" is generally used to include the meaning of "at least one", and the term "at least two" is generally used to include the meaning of "two or more". In addition, the terms "first", "second" and "third" are used for descriptive purposes only and cannot be understood as indicating or implying relative importance or implicitly indicating the number of technical features indicated. Therefore, the features defined as "first", "second" and "third" may explicitly or implicitly include one or at least two of the features, "one end" and "the other end" and "the proximal end" and "the distal end" generally refer to two corresponding parts, which include not only the endpoints, and the terms "installed", "connected" and "coupled" should be understood in a broad sense, for example, it can be a fixed connection, a detachable connection, or an integral body; it can be a mechanical connection or an electrical connection; it can be directly connected or indirectly connected through an intermediate medium, it can be the internal connection of two elements or the interaction relationship between two elements. In addition, as used in the present invention, an element disposed on another element

generally only indicates that there is a connection, coupling, cooperation or conveying relationship between the two elements, and the connection, coupling, cooperation or conveying between the two elements may be direct or indirect through an intermediate element, and cannot be understood as indicating or implying the spatial position relationship between the two elements, that is, one element may be in any orientation such as inside, outside, above, below or on one side of another element, unless otherwise clearly indicated in the content. For ordinary technicians in this field, the specific meanings of the above terms in the present invention can be understood according to specific circumstances.

In order to reduce equipment costs, the present invention provides a wafer conveying system. FIG. 1 is a schematic diagram of a wafer conveying system of an embodiment of the present invention. As shown in FIG. 1, the wafer conveying system includes a wafer library 10, a manipulator 11, a wafer loading deviation detection module 12, and a wafer loading deviation compensation module 13. The wafer library 10 is used to store wafers. The manipulator 11 takes out the wafer from the wafer library 10 and transfers the wafer to a predetermined station. The wafer loading deviation detection module 12 obtains the wafer loading deviation of the wafer at the predetermined station. The wafer loading deviation compensation module 13 calculates the position deviation of the wafer at the handover station between the manipulator 11 and the worktable based on the wafer loading deviation, the worktable moves to the handover station and adjusts its position based on the position deviation (i.e., moves to the position after deviation compensation based on the position deviation), the manipulator 11 transfers the wafer from the predetermined station to the handover station, and the worktable carries the wafer from the handover station; or the wafer loading deviation compensation module 13 calculates the wafer loading path of the manipulator 11 from the predetermined station to the handover station between the manipulator 11 and the worktable based on the wafer loading deviation, the wafer loading path includes compensation for the wafer loading deviation, the manipulator 11 moves to the handover station according to the wafer loading path, and transfers the wafer to the worktable.

FIG. 2 is a schematic diagram of a wafer conveying system according to an embodiment of the present invention. Referring to FIG. 2, a wafer library 10 is used to store wafers 20. During the process of the wafer conveying system transferring wafers 20, the manipulator 11 takes out the wafer 20 from the wafer library 10 and transfers the wafer 20 to a predetermined station. The manipulator 11 may include a fork body 11a and a manipulator body 11b located at the end of the fork body 11a.

After the wafer 20 is transferred to the predetermined station, the loading deviation detection module 12 obtains the loading deviation of the wafer 20 at the predetermined station. Specifically, the loading deviation detection module 12 can obtain a first image of the wafer 20 located at the predetermined station, and based on the first image, calculate the loading deviation of the wafer 20, the loading deviation of the wafer 20 includes the center deviation and the notch rotation deviation of the wafer 20, so that the center deviation and the notch rotation deviation of the wafer 20 are obtained without the wafer 20 rotating one circle, which is conducive to improving the efficiency of obtaining the loading deviation of the wafer 20, and further improving the efficiency of transferring the wafer 20 to the worktable 14.

The wafer deviation detection module 12 may include a detection light source (not shown in the figure) and a camera (not shown in the figure), wherein the detection light source emits detection light to the wafer 20 located at the predetermined position, and the camera receives the reflected light or scattered light from the surface of the wafer 20 to obtain the first image. The wafer 20 may be a silicon wafer, but is not limited thereto.

The camera may be an area scan camera or a line scan camera. The area scan camera receives reflected light or scattered light from the surface of the wafer 20 to obtain the first image, or the line scan camera scans the wafer 20 to obtain the first image.

In some embodiments, the predetermined station may be a pre-alignment station, but is not limited thereto.

The wafer conveying system can be applied to a defect detection device, but is not limited thereto. The detection table (also referred to as a macro table) in the defect detection device does not have a rotation function. When performing defect detection, the manipulator adsorbs the wafer and moves it to the detection table, and the wafer fork

drives the wafer to rotate to achieve macro detection of the front or back of the wafer. Since the pre-alignment table is not required in the present application to compensate for the loading wafer deviation of the wafer 20. In some embodiments, as shown in Figure 2, the loading wafer deviation detection module 12 may also include a detection table 121, and the detection table 121 is located at the predetermined station. The manipulator 11 transfers the wafer 20 from the wafer library 10 to the detection table 121 located at the predetermined station, so that the detection table 121 of the defect detection device is used as the predetermined station for obtaining the first image, without the need to set an additional pre-alignment table, which is conducive to reducing costs, but is not limited thereto. In other embodiments, other tables or positions can be used as predetermined stations for obtaining the first image.

FIG. 3 is a schematic plan view of a detection table according to an embodiment of the present invention. In one embodiment, as shown in FIG. 2, the surface of the detection table 121 on which the wafer 20 is placed may have at least three pre-alignment mark points 30. At least three pre-alignment mark points 30 may be arranged around the wafer placement region of the detection table 121. In order to facilitate the subsequent calculation of the center of the detection table 121, at least three pre-alignment mark points 30 may be arranged on a circumference with the center of the detection table 121 as the center. A vacuum suction cup 40 is provided in the wafer placement region of the detection table 121 for adsorbing the wafer 20. The first image may include images of the at least three pre-alignment mark points 30 so as to subsequently determine the center of the detection table 121.

After obtaining the first image, the wafer loading deviation detection module 12 may calculate and obtain the wafer loading deviation of the wafer 20 based on the first image, which may include: identifying the pre-alignment mark points 30 in the first image, and obtaining a mapping transformation matrix according to the actual physical position relationship of the at least three pre-alignment mark points 30 on the detection table 121; converting the first image into a top plan view using the mapping transformation matrix; and based on the top plan view, obtaining the wafer loading deviation of the wafer 20 using a centering and orientation algorithm. In order to

facilitate the calculation of the center deviation and notch rotation deviation of the wafer 20, the center of the top plan view may be made to coincide with the center of the detection table 121 in the top plan view, but is not limited thereto.

FIG. 4 is a schematic diagram of a wafer conveying system according to another embodiment of the present invention transferring a wafer. In one embodiment, referring to FIG. 1 and FIG. 4, the wafer loading deviation detection module 12 may further include a fork 122 for adsorbing the wafer 20 on the detection table 121. The wafer loading deviation detection module 12 may further include a wafer fork driving mechanism 123, and the wafer fork driving mechanism 123 drives the fork 122 to rotate, so as to perform macro defect detection on the front or back of the wafer 20 adsorbed on the fork 122.

Referring to FIG. 4, in the process of the wafer conveying system transferring the wafer 20 to the worktable 14, the manipulator 11 first takes out the wafer 20 from the wafer library 10 and transfers the wafer 20 to a predetermined station. For example, the manipulator 11 can transfer the wafer 20 to the detection table 121. Then, the wafer fork 122 absorbs the wafer 20 on the predetermined station, and the camera obtains the first image of the wafer 20 located at the predetermined station. Next, the wafer loading deviation detection module 12 calculates and obtains the wafer loading deviation of the wafer 20 based on the first image.

FIG. 5 is a schematic plan view of a fork in one embodiment of the present invention. As shown in FIG. 5, the surface of the fork 122 adsorbing the wafer 20 may have at least three pre-alignment mark points 30. At least three pre-alignment mark points 30 may be arranged around the wafer placement region of the fork 122. In order to facilitate the subsequent calculation of the center of the fork 122, at least three pre-alignment mark points 30 may be arranged on a circumference with the center of the fork 122 as the center. A vacuum suction cup 40 is arranged in the wafer placement region of the fork 122 for adsorbing the wafer 20. The first image may include images of the at least three pre-alignment mark points 30.

After obtaining the first image, the wafer loading deviation detection module 12 may calculate and obtain the wafer loading deviation of the wafer 20 based on the first

image, which may include: identifying the pre-alignment mark points 30 in the first image, and obtaining a mapping conversion matrix according to the actual physical position relationship of the at least three pre-alignment mark points 30 on the fork 122; using the mapping conversion matrix to convert the first image into a top plan view; and based on the top plan view, obtaining the wafer loading deviation of the wafer 20 using a centering and orientation algorithm. In order to facilitate the calculation of the center deviation and notch rotation deviation of the wafer 20, the center of the top plan view may be made to coincide with the center of the fork 122 in the top plan view.

Before identifying the pre-alignment mark points 30 in the first image, the position parameters (i.e., coordinates) of the pre-alignment mark points 30 can be read to determine the approximate area of the pre-alignment mark points 30 in the first image, so as to narrow the detection range of the pre-alignment mark points 30 and improve the detection efficiency.

In the above-mentioned process of identifying the pre-alignment mark points 30 in the first image, in the case where the pre-alignment mark points 30 is set on the detection table 121, the position of the center of the pre-alignment mark points 30 on the detection table 121 in the first image can be identified through automatic threshold binarization and connected domain screening. In the case where the pre-alignment mark points 30 is set on the fork 122, the position of the center of the pre-alignment mark points 30 on the fork 122 in the first image can be identified through automatic threshold binarization and connected domain screening.

After the pre-alignment mark points 30 in the first image is identified, the position parameters of the pre-alignment mark points 30 may also be updated for use in subsequent reading of the position parameters of the pre-alignment mark points 30.

The above-mentioned wafer loading deviation detection module 12, based on the top plan view, uses a centering and orientation algorithm to obtain the wafer deviation of wafer 20, which may include: automatically selecting a binarization threshold, binarizing the top plan view, and filtering out the area of the wafer 20 in the top plan view by the connected domain area; extracting the edge information of the wafer 20 by using the Canny algorithm, performing circle fitting according to the edge information

of the wafer 20, and obtaining the position of the center of the wafer 20 in the top plan view, that is, obtaining the center coordinates (center position) of the wafer 20; obtaining the number of deviation pixels between the center of the wafer 20 in the top plan view and the center of the top plan view. Specifically, for the case where a pre-alignment mark points 30 is set on the detection table 121, the number of deviation pixels between the center of the wafer 20 and the center of the detection table 121 in the first image is obtained. For the case where a pre-alignment mark points 30 is set on the fork 122, the number of deviation pixels between the center of the wafer 20 and the center of the detection table 121 is obtained. Obtain the number of deviation pixels between the center of the wafer 20 and the center of the fork 122 in the first image; obtain the center deviation of the wafer 20 according to the pixel size of the top plan view and the number of deviation pixels; intercept a number of small images at the edge of the wafer 20 according to the center position of the wafer 20 in the top plan view, and perform affine transformation to keep the edge direction of the wafer 20 consistent; use the HOG algorithm to extract features in each of the small images, use the SVM supervised learning algorithm to classify, and output the small images with notches; use the geometric template matching algorithm to locate the notch position of the wafer 20 in the small image with notches, and convert the notch position to the top plan view; use the center position and the notch vertex position of the wafer 20 in the top plan view to determine the notch rotation angle of the wafer 20, wherein the notch rotation angle of the wafer 20 is determined according to the inclination angle of the line connecting the center of the wafer 20 and the notch vertex, and the notch rotation deviation of the wafer 20 is determined according to the notch rotation angle, so that the loading deviation of the wafer 20 is obtained. It should be noted that the step of obtaining the loading deviation of the wafer 20 by using the centering and orientation algorithm is not limited thereto.

In another embodiment, when the manipulator 11 transfers the wafer 20 to a predetermined station, the camera in the loading deviation detection module 12 can obtain a first image of the wafer 20. In this case, no pre-alignment mark points may be set on the detection table 121 and the fork 122. The loading deviation detection module

12 can calculate the loading deviation of the wafer 20 based on the first image including the wafer but not including the pre-alignment mark points.

Specifically, the wafer loading deviation detection module 12 calculates and obtains the wafer loading deviation of the wafer 20 based on the first image, which may include: obtaining a reference image of a reference wafer captured at the predetermined station, and obtaining the center coordinates and notch rotation angle of the reference wafer, and determining a reference wafer loading deviation of the reference wafer according to the center coordinates and notch rotation angle of the reference wafer; obtaining the center coordinates and notch rotation angle of the wafer 20 in the first image, calculating the difference between the center coordinates and notch rotation angle of the wafer 20 and the reference wafer, and determining the wafer loading deviation of the wafer 20 according to the difference and the reference wafer loading deviation, wherein the wafer loading deviation of the wafer 20 includes the center deviation and notch rotation deviation of the wafer 20.

It should be noted that since the positions of the camera, the detection light source and the predetermined station are fixed, a coordinate system for capturing an image is determined. The first image and the reference image acquired at the same predetermined station using a fixed camera and detection light source are captured in the same coordinate system, that is, the coordinate systems for capturing the reference image and the first image are the same. Therefore, the loading deviation of the wafer 20 can be obtained based on the reference loading deviation of the reference wafer and the difference between the center coordinates and the notch rotation angle of the wafer in the first image and the reference wafer in the reference image.

The deep learning target detection algorithm can be used to directly detect and locate the notch in the first image, and the center coordinates and notch vertex coordinates of the wafer 20 in the first image can be obtained. The notch rotation angle of the wafer 20 can be calculated according to the center coordinates and notch vertex position of the wafer 20, but it is not limited thereto. The center coordinates and notch vertex coordinates of the wafer 20 in the first image can also be obtained by other methods known in the art.

After obtaining the wafer loading deviation of the wafer 20, the wafer loading deviation compensation module 13 calculates the position deviation of the wafer 20 at the handover station between the manipulator 11 and the worktable 14 based on the loading deviation, the worktable moves to the handover station and adjusts the position based on the position deviation (moves to the position after the deviation compensation based on the position deviation), the manipulator 11 transfers the wafer 20 from the predetermined station to the handover station, and the worktable 14 carries the wafer 20 from the handover station. In this embodiment, a micro-motion table may be provided on the worktable 14, and after the worktable 14 moves to the handover station, as shown in FIG. 2, the micro-motion table moves in the X direction, the Y direction and the Rz direction to compensate for the position deviation, wherein the X direction and the Y direction are perpendicular to each other and parallel to the table surface of the worktable 14, the Z direction is perpendicular to the X direction and the Y direction, and the movement in the Rz direction is a rotation with the Z direction as the rotation axis.

Alternatively, after obtaining the wafer loading deviation of the wafer 20, the wafer loading deviation compensation module 13 calculates the wafer loading path of the manipulator from the predetermined station to the handover station of the manipulator 11 and the worktable 14 based on the wafer loading deviation, the wafer loading path includes compensation for the wafer loading deviation, the manipulator moves to the handover station according to the wafer loading path, and transfers the wafer 20 to the worktable 14. The wafer loading path includes the specific position where the manipulator 11 places the wafer 20 on the handover station, and the specific position is the position after compensation based on the wafer loading deviation of the wafer 20.

As shown in FIG. 2 and FIG. 4, a suction cup 14a is provided in the worktable 14 for sucking and fixing the wafer 20 placed on the worktable 14.

In the wafer conveying system of the present application, the wafer library 10 is used to store the wafer 20; the manipulator 11 transfers the wafer 20 from the wafer library 10 to the predetermined station; then the wafer loading deviation detection module 12 obtains the wafer loading deviation of the wafer 20 at the predetermined station; after obtaining the wafer loading deviation of the wafer 20, the wafer loading

deviation compensation module 13 calculates the position deviation of the wafer 20 at the handover station of the manipulator 11 and the worktable 14 based on the wafer loading deviation, the worktable 14 moves to the handover station and adjusts its position based on the position deviation, the manipulator 11 transfers the wafer 20 from the predetermined station to the handover station, and the worktable 14 carries the wafer from the handover station; or after obtaining the wafer loading deviation, the wafer loading deviation compensation module 13 calculates the position deviation of the manipulator 11 from the predetermined station to the machine based on the wafer loading deviation. The wafer loading path of the handover station between the manipulator 11 and the worktable 14 includes compensation for the wafer loading deviation. The manipulator 11 moves to the handover station according to the wafer loading path, and transfers the wafer 20 to the worktable 14. In this way, there is no need for a predetermined station (such as a pre-alignment table) to have the function of compensating for the wafer loading deviation, thereby simplifying the structural complexity of the pre-alignment table, and utilizing the existing worktable or manipulator to perform wafer loading deviation compensation, thereby enhancing process adaptability and anti-noise interference capability, and reducing equipment costs.

The present application also provides a wafer conveying method, and the wafer conveying method is executed when the above-mentioned wafer conveying system is running. Specifically, the wafer conveying method includes:

Step 1: the manipulator takes out the wafer from the wafer library and transfers the wafer to a predetermined station;

Step 2, obtaining the wafer loading deviation at the predetermined station; and

Step 3, based on the loading deviation, calculate the position deviation of the wafer at the handover station between the manipulator and the worktable, the worktable moves to the handover station and adjusts its position based on the position deviation, the manipulator transfers the wafer to the handover station, and the worktable carries the wafer from the handover station; or based on the loading deviation, calculate a wafer loading path of the manipulator from the predetermined station to the handover station between the manipulator and the worktable, the wafer loading path includes

compensation for the loading deviation, the manipulator moves to the handover station according to the wafer loading path, and transfers the wafer to the worktable.

It should be understood that at least part of the above steps one to three may include multiple steps or multiple stages, and these steps or stages are not necessarily performed at the same time, but can be performed at different times. The execution order of these steps or stages is not necessarily sequential, but can be performed in turn or alternately with other steps or at least part of the steps or stages in other steps.

At the predetermined station, the step of obtaining the wafer loading deviation may include: obtaining a first image of the wafer located at the predetermined station, and calculating the wafer loading deviation based on the first image.

The predetermined station may be a detection station of a defect detection device, but is not limited thereto.

The present application provides a defect detection device. Referring to FIG. 1, FIG. 2 and FIG. 4, the defect detection device includes a worktable 14, a defect detection system, and the above-mentioned wafer conveying system.

The wafer conveying system includes a wafer library 10, a manipulator 11, a wafer loading deviation detection module 12 and a wafer loading deviation compensation module 13.

The wafer library 10 is used to store wafers 20.

The manipulator 11 takes out the wafer 20 from the wafer library 10 and transfers the wafer 20 to a predetermined station.

The wafer loading deviation detection module 12 obtains the wafer loading deviation of the wafer 20 at the predetermined station.

Specifically, the wafer loading deviation detection module 12 may include a detection light source (not shown in the figure) and a camera (not shown in the figure), wherein the detection light source emits detection light to the wafer 20 located at the predetermined station, and the camera obtains a first image of the wafer 20 located at the predetermined station, for example, the camera may receive reflected light or scattered light from the surface of the wafer 20 to obtain the first image. After obtaining the first image, the wafer loading deviation detection module 12 calculates the wafer

loading deviation of the wafer 20 based on the first image.

The wafer deviation detection module 12 may also include a detection table 121 (also called a macro table). The detection table 121 does not have a rotation function. When performing defect detection, the manipulator 11 transfers the wafer 20 to the detection table 121, and the wafer fork 122 drives the wafer 20 to rotate to achieve macro detection of the front or back of the wafer 20.

Since the present application does not need to compensate for the wafer 20 loading deviation at the predetermined station (such as the pre-alignment station), the detection station 121 can be used as the predetermined station for acquiring the first image without setting up an additional pre-alignment station, which is beneficial to reducing costs.

The wafer loading deviation compensation module 13 calculates the position deviation of the wafer 20 at the handover station between the manipulator 11 and the worktable 14 based on the wafer loading deviation, the worktable 14 moves to the handover station and adjusts its position based on the position deviation, the manipulator 11 transfers the wafer 20 from the predetermined station to the handover station, and the worktable 14 carries the wafer 20 from the handover station; or the wafer loading deviation compensation module 13 calculates the wafer loading path of the manipulator 11 from the predetermined station to the handover station between the manipulator 11 and the worktable 14 based on the wafer loading deviation, the wafer loading path includes compensation for the wafer loading deviation, the manipulator 11 moves to the handover station according to the wafer loading path, and transfers the wafer 20 to the worktable 14.

The defect detection system (not shown in the figure) performs defect detection on the wafer 20 on the worktable 14.

Specifically, the defect detection system may include a bright field detection light source or a dark field detection light source, and the defect detection system may also include a detector. As an example, the detection light emitted by the bright field detection light source irradiates the surface of the wafer 20 and generates reflected light, and the detector detects the reflected light to detect defects on the surface of the wafer 20; or the detection light emitted by the dark field detection light source irradiates the

surface of the wafer 20 and generates scattered light, and the detector detects the scattered light to detect defects on the surface of the wafer 20.

It should be noted that this specification adopts a progressive description method, and the wafer conveying method and defect detection device described later focus on the differences from the wafer conveying system described previously, and the same and similar parts between the various parts can be referenced to each other.

References throughout the specification to "one embodiment," "another embodiment," "some embodiments," or "this embodiment" indicate that a particular component, structure, or feature described in connection with the embodiment is included in at least one embodiment. Therefore, the appearance of the phrases "one embodiment," "another embodiment," "some embodiments," or "this embodiment" in various places throughout the specification are not necessarily referring to the same embodiment.

The above description is only a description of the preferred embodiment of the present invention, and is not any limitation on the scope of rights of the present invention. Any technical personnel in this field can make possible changes and modifications to the technical solution of the present invention by using the methods and technical contents disclosed above without departing from the spirit and scope of the present invention. Therefore, any simple modifications, equivalent changes and modifications made to the above embodiments based on the technical essence of the present invention without departing from the content of the technical solution of the present invention shall fall within the protection scope of the technical solution of the present invention.

Claims

1. A wafer conveying system, wherein the wafer conveying system comprises:

a wafer library, configured to store a wafer;

a manipulator, configured to take out the wafer from the wafer library and convey the wafer to a predetermined station;

a wafer loading deviation detection module, configured to obtain a wafer loading deviation of the wafer at the predetermined station; and

a wafer loading deviation compensation module, configured to calculate a position deviation of the wafer at a handover station between the manipulator and a worktable based on the wafer loading deviation, the worktable moving to the handover station and adjusting a position thereof based on the position deviation, the manipulator configured to convey the wafer from the predetermined station to the handover station, and the worktable carrying the wafer from the handover station; or the wafer loading deviation compensation module configured to calculate a wafer loading path of the manipulator from the predetermined station to the handover station between the manipulator and the worktable based on the wafer loading deviation, the wafer loading path comprising a compensation for the wafer loading deviation, the manipulator moving to the handover station according to the wafer loading path, and conveying the wafer to the worktable.

2. The wafer conveying system according to claim 1, wherein the wafer loading deviation detection module is configured to obtain a first image of the wafer at the predetermined station, and calculate the wafer loading deviation of the wafer based on the first image.

3. The wafer conveying system according to claim 2, wherein the loading wafer deviation detection module comprises a detection light source and a camera, the detection light source configured to emit a detection light to the wafer at the predetermined station, and the camera configured to receive a reflected light or a scattered light from a surface of the wafer to obtain the first image.

4. The wafer conveying system according to claim 2, wherein the wafer loading deviation detection module further comprises a detection table, the detection table is located at the predetermined station, and the manipulator is configured to convey the wafer from the wafer library to the detection table at the predetermined station.

5. The wafer conveying system according to claim 4, wherein a surface of the detection table for placing the wafer has at least three pre-alignment mark points, and wherein the first image comprises images of the at least three pre-alignment mark points.

6. The wafer conveying system according to claim 5, wherein the wafer loading deviation detection module calculating the wafer loading deviation based on the first image comprises:

identifying pre-alignment mark points in the first image, and obtaining a mapping transformation matrix according to an actual physical position relationship of the at least three pre-alignment mark points on the detection table;

using the mapping transformation matrix, converting the first image into a top plan view, wherein a center of the top plan view coincides with a center of the detection table; and

obtaining the wafer loading deviation by using a centering and orientation algorithm based on the top plan view.

7. The wafer conveying system according to claim 4, wherein the loading wafer deviation detection module further comprises a fork for adsorbing the wafer on the detection table, and a surface of the fork for adsorbing the wafer has at least three pre-alignment mark points, the first image comprises images of the at least three pre-alignment mark points.

8. The wafer conveying system according to claim 7, wherein the loading wafer deviation detection module further comprises a fork driving mechanism, and wherein

the fork driving mechanism is configured to drive the fork to rotate so as to perform a macro defect detection on a front side or a back side of the wafer adsorbed on the fork.

9. The wafer conveying system according to claim 7, wherein the wafer loading deviation detection module calculating the wafer loading deviation based on the first image comprises:

identifying pre-alignment mark points in the first image, and obtaining a mapping transformation matrix according to an actual physical position relationship of the at least three pre-alignment mark points on the fork;

converting the first image into a top plan view using the mapping transformation matrix, wherein a center of the top plan view coincides with a center of the fork; and

obtaining the wafer loading deviation by using a centering and orientation algorithm based on the top plan view.

10. The wafer conveying system according to claim 6 or 9, wherein the wafer loading deviation detection module obtaining the wafer loading deviation of the wafer based on the top plan view by using a centering and orientation algorithm comprises:

automatically selecting a binarization threshold, performing a binarization process on the top plan view, and filtering out an area of the wafer in the top plan view by a connected domain area;

extracting an edge information of the wafer by using a Canny algorithm, and performing circle fitting according to the edge information of the wafer to obtain a position of a center of the wafer in the top plan view;

obtaining the number of deviation pixels between the center of the wafer in the top plan view and the center of the top plan view;

obtaining a center deviation of the wafer according to a pixel size of the top plan view and the number of the deviation pixels;

intercepting a plurality of small images at edge of the wafer according to the position of the center of the wafer in the top plan view;

extracting features from each of the small images using a HOG algorithm, and

classifying the small images using a SVM supervised learning algorithm, and outputting specified small images with notches;

locating a notch position of the wafer in the specified small image with notches using a geometric template matching algorithm, and converting the notch position into the top plan view; and

determining a notch rotation deviation of the wafer by using the position of the center of the wafer and a notch vertex position in the top plan view, wherein the wafer loading deviation comprises the center deviation and the notch rotation deviation of the wafer.

11. The wafer conveying system according to claim 2, wherein the wafer loading deviation detection module calculating the wafer loading deviation based on the first image comprises:

obtaining a reference image of a reference wafer captured at the predetermined position, and obtaining a center coordinate and a notch rotation angle of the reference wafer, and determining a reference wafer loading deviation of the reference wafer according to the center coordinate and the notch rotation angle of the reference wafer; and

obtaining a center coordinate and a notch rotation angle of the wafer in the first image, calculating differences between the center coordinates and the notch rotation angles of the wafer and the reference wafer, and determining the wafer loading deviation according to the differences and the reference wafer loading deviation.

12. The wafer conveying system according to claim 11, wherein a coordinate system for capturing the reference image is the same as a coordinate system for capturing the first image.

13. A wafer conveying method, comprising:

step 1: taking out a wafer from a wafer library and conveying the wafer to a predetermined station by a manipulator;

step 2: obtaining a wafer loading deviation at the predetermined station; and

step 3: calculating a position deviation of the wafer at a handover station between the manipulator and a worktable based on the wafer loading deviation, the worktable moving to the handover station and adjusting a position thereof based on the position deviation, the manipulator conveying the wafer from the predetermined station to the handover station, and the worktable carrying the wafer from the handover station; or a loading deviation compensation module calculating a wafer loading path of the manipulator from the predetermined station to the handover station between the manipulator and the worktable based on the wafer loading deviation, the wafer loading path comprising a compensation for the wafer loading deviation, the manipulator moving to the handover station according to the wafer loading path, and conveying the wafer to the worktable.

14. A defect detection device, comprising a worktable, a defect detection system and the wafer conveying system according to any one of claims 1 to 12, wherein the wafer conveying system is configured to convey the wafer to the worktable, and the defect detection system is configured to perform a defect detection on the wafer on the worktable.

15. The defect detection device according to claim 14, wherein the defect detection system comprises a bright field detection light source or a dark field detection light source, and wherein the defect detection system further comprises a detector.