

SUBSTRATE DETECTION DEVICE

FIELD OF THE INVENTION

The present invention relates to the technical field of semiconductor manufacturing, and in particular, to a substrate detection device.

BACKGROUND

FIG. 1 shows a schematic structural view of a flipping device and a material receiving device; FIG. 2 shows a schematic top view of a material receiving device. In FIG. 1, a flipping device 200' flips a plurality of substrates 100 from a horizontal posture to a vertical posture. According to FIGS. 1 and 2, when the plurality of substrates 100 are conveyed in semiconductor equipment, a robot first takes out the plurality of substrates 100 in the horizontal posture from a cassette in a loading area, and conveys the plurality of substrates 100 to the flipping device 200'. Then, the flipping device 200' rotates to flip the plurality of substrates 100 from the horizontal posture to the vertical posture, and transfers the plurality of substrates 100 in the vertical posture to a material receiving device 300', and the material receiving device 300' is movable up and down. According to FIG. 2, the material receiving device 300' comprises a substrate holder 310' having a plurality of holding slots 312'. Each holding slot 312' includes a pair of clamping slots 311' arranged opposite to each other. Each substrate 100 is inserted into a corresponding pair of clamping slots 311' by the side surface, so as to hold the plurality of substrates 100 in the vertical posture. Finally, the robot takes the plurality of substrates 100 away from the substrate holder 310' and conveys the plurality of substrates 100 to a process tank, so that the plurality of substrates 100 are immersed together in a chemical solution in the process tank, thereby performing batch wet processing on the plurality of substrates 100 in the vertical posture.

However, during repeated conveyance of the plurality of substrates 100, abnormalities such as missing substrates, stacked substrates, and obliquely inserted substrates may occur due to factors such as deformation of the substrates 100, leading to unsuccessful substrate conveyance or interference and breakage during conveyance.

Therefore, it is particularly important to provide a substrate detection device during substrate conveyance to promptly discover abnormal substrates.

SUMMARY

The object of the present invention is to provide a substrate detection device capable of promptly and effectively discovering abnormal substrates.

To achieve the above object, an embodiment of the present invention provides a substrate detection device, comprising:

an illumination unit, configured to irradiate an imaging region including a plurality of substrates with illumination light, wherein the plurality of substrates are inserted into a plurality of holding slots of a substrate holder and arranged along a predetermined arrangement direction;

an imaging unit, configured to capture an image of the imaging region and generate a captured image, wherein the captured image includes a plurality of pixel blocks representing side surfaces of the plurality of substrates;

a storage unit, configured to store a reference grid, a plurality of detection positions, and a reference width of a side surface of a single substrate, wherein the reference grid includes a search area and defect areas, and at least two spaced detection positions are arranged for each holding slot;

a reference grid, configured to search for the pixel blocks within the reference grid in the captured image at each detection position, and output search information of the pixel blocks in the reference grid;

a determination unit, configured to determine holding states of the plurality of substrates in the corresponding holding slots based on the search information.

In the substrate detection device of the present invention, the illumination unit irradiates the imaging region including the plurality of substrates with illumination light, the imaging unit captures an image of the imaging region and generates a captured image, the reference grid searches for the pixel blocks within the reference

grid in the captured image at each detection position and outputs search information of the pixel blocks in the reference grid, and then the determination unit determines holding states of the plurality of substrates in the corresponding holding slots based on the search information. In this way, the object of promptly discovering abnormal substrates on the substrate holder can be achieved, thereby avoiding unsuccessful substrate conveyance or interference and breakage during conveyance.

Other features and corresponding advantageous effects of the present invention are described in the following part of the specification, and it should be understood that at least part of the advantageous effects will become apparent from the description of the specification of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic structural view of a flipping device and a material receiving device;

FIG. 2 is a schematic top view of a material receiving device;

FIG. 3(a) is a schematic view of a plurality of substrates in a normal state when inserted into a plurality of holding slots of a substrate holder according to the present application;

FIGS. 3(b) to 3(e) are schematic views of a plurality of substrates in abnormal states when inserted into a plurality of holding slots of a substrate holder according to the present application;

FIG. 4 is a schematic structural view of the substrate detection device according to Embodiment 1 of the present application;

FIG. 5 is a schematic top view of the substrate holder according to Embodiment 1 of the present application;

FIG. 6 is a schematic structural view of the substrate detection device according to Embodiment 1 of the present application from another perspective;

FIG. 7 is a schematic view of the captured image and the reference grids according to Embodiment 1 of the present application;

FIG. 8 is a schematic view of the reference grid according to Embodiment 1 of the present application;

FIGS. 9(a) to 9(c) are schematic views of three arrangement modes of the reference grids and detection positions according to Embodiment 1 of the present application;

FIGS. 10(a) to 10(d) are schematic views of search information of pixel blocks in the reference grids under different holding states of substrates according to Embodiment 1 of the present application;

FIG. 11 is a schematic view of the captured image and the reference grids according to Embodiment 2 of the present application; and

FIGS. 12(a) and 12(b) are schematic views of the reference grid according to Embodiment 2 of the present application.

PREFERRED EMBODIMENTS OF THE PRESENT INVENTION

Embodiments of the present invention are described below with specific examples, and those skilled in the art can easily understand other advantages and effects of the present invention from the content disclosed in the specification. Although the description of the present invention will be introduced in conjunction with preferred embodiments, this does not mean that the features of the present invention are limited to these embodiments. On the contrary, the purpose of introducing the invention in conjunction with the embodiments is to cover other selections or modifications that may be extended based on the claims of the present invention. In order to provide a thorough understanding of the present invention, the following description will include many specific details. The present invention may also be practiced without these details. In addition, in order to avoid confusion or obscuring the key points of the present invention, some specific details will be omitted in the description. It should be noted that the embodiments in the present invention and the features in the embodiments may be combined with each other, provided no conflict arises.

It should be noted that in this specification, similar reference numerals and letters refer to similar items in the following accompanying drawings, and thus once an item is defined in one accompanying drawing, it is not necessary to further define and explain the item in the subsequent accompanying drawings.

The technical solutions of the present invention will be clearly and completely described below with reference to the accompanying drawings. Obviously, the described embodiments are part of the embodiments of the present invention, rather than all of the embodiments. Based on the embodiments of the present invention, all other embodiments obtained by those of ordinary skill in the art without making creative efforts shall fall within the protection scope of the present invention.

In the description of the present invention, it should be noted that the terms "center," "upper," "lower," "left," "right," "vertical," "horizontal," "inner," "outer," and the like indicate orientations or positional relationships based on the orientations or positional relationships shown in the accompanying drawings, which are merely for convenience of describing the present invention and simplifying the description, and do not indicate or imply that the referred device or element must have a specific orientation, be constructed and operated in a specific orientation, and thus should not be construed as limiting the present invention. In addition, the terms "first," "second," and "third" are used for descriptive purposes only and should not be construed as indicating or implying relative importance.

In the description of the present invention, it should be noted that unless otherwise expressly specified and limited, the terms "mount," "interconnect," and "connect" should be interpreted broadly, for example, the connection can be a fixed connection, a detachable connection, or an integral connection; the connection can be a mechanical connection or an electrical connection; the connection can be a direct connection, an indirect connection through an intermediate medium, or an internal connection between two elements. For those of ordinary skill in the art, the specific meanings of the above terms in the present invention can be understood according to specific circumstances.

To further clarify the objects, technical solutions, and advantages of the present invention, the embodiments of the present invention will be further described in detail

below with reference to the accompanying drawings.

The substrate detection device provided by the present application is used in semiconductor equipment to detect whether a plurality of substrates on a substrate holder have abnormalities such as missing substrates, stacked substrates, warped substrates, and obliquely inserted substrates.

FIG. 3(a) shows a schematic view of a plurality of substrates in a normal state when inserted into a plurality of holding slots of a substrate holder; FIGS. 3(b) to 3(e) show schematic views of a plurality of substrates in abnormal states when inserted into a plurality of holding slots of a substrate holder.

According to FIG. 3(a), the normal state means that the plurality of substrates 100 are held in respective holding slots 312. According to FIGS. 3(b) to 3(e), the abnormal states include the missing abnormality, the stacking abnormality, the warping abnormality, and the oblique insertion abnormality of the substrates 100. As shown in FIG. 3(b), the missing abnormality of the substrates 100 means that at least one holding slot 312 has no substrates 100, and the number of substrates 100 held in the plurality of holding slots 312 is less than a normal number. As shown in FIG. 3(c), the substrate stacking abnormality means that at least two substrates 100 are inserted into one holding slot 312. As shown in FIG. 3(d), the substrate warping abnormality means that the warpage degree of the substrate 100 inserted into one holding slot 312 does not meet a predetermined requirement. As shown in FIG. 3(e), the substrate oblique insertion abnormality means that one substrate 100 is inserted into two different holding slots 312.

Embodiment 1

FIG. 4 shows a schematic structural view of the substrate detection device according to Embodiment 1 of the present application; FIG. 5 shows a schematic top view of the substrate holder according to Embodiment 1 of the present application; FIG. 6 shows a schematic structural view of the substrate detection device according to Embodiment 1 of the present application from another perspective. For convenience, an illumination unit 400 is marked in FIG. 6.

According to FIGS. 4 to 6, the substrate detection device provided in this embodiment comprises the illumination units 400, an imaging unit 500, a storage unit, and a determination unit. With reference to FIG. 3(a), the illumination units 400 are configured to irradiate an imaging region including a plurality of substrates 100 with illumination light, wherein the plurality of substrates 100 are inserted into a plurality of holding slots 312 of a substrate holder 310 and arranged along a predetermined arrangement direction. The imaging unit 500 is configured to capture an image of the imaging region and generate a captured image.

In this embodiment, as shown in FIGS. 4 and 5, the substrate holder 310 includes a base portion 313 and the plurality of holding slots 312. The base portion 313 is substantially concave, and the plurality of holding slots 312 are disposed on the base portion 313 and arranged along the arrangement direction of the substrates 100. Each holding slot 312 includes a pair of clamping slots 311 arranged opposite to each other on two sides (left and right sides in FIG. 4) of the base portion 313. Each substrate 100 is inserted into a corresponding pair of clamping slots 311 by the side surface, so as to hold the plurality of substrates 100 in a vertical posture. In other embodiments, the substrate holder 310 may be disposed on an aforementioned material receiving device 300, on a flipping device, in a process tank, on a transfer robot, or the like.

With reference to FIGS. 4 to 7, in Embodiment 1, the illumination units 400 are disposed below the plurality of substrates 100, and the imaging unit 500 is disposed above the plurality of substrates 100. Wherein, the illumination units 400 are disposed on the side of the base portion 313 facing the substrates 100, so that the irradiation light of the illumination units 400 passes through gaps between the plurality of substrates 100. The imaging unit 500 is configured to capture an image of the imaging region and generate a captured image after the irradiation light passes through the gaps between the plurality of substrates 100. FIG. 7 shows a schematic view of a captured image and reference grids according to Embodiment 1 of the present application. As shown in FIG. 7, the captured image includes a plurality of pixel blocks 610 representing the plurality of substrates 100. In this example, the plurality of pixel blocks 610 are a plurality of dark blocks formed by blocking the illumination light by side surfaces of the plurality of substrates 100. In other embodiments, both the illumination units 400 and the imaging unit 500 are disposed above the plurality of

substrates 100. The illumination light of the illumination units 400 irradiates the side surfaces of the plurality of substrates 100, and the imaging unit 500 is configured to capture an image of the imaging region and generate a captured image after the illumination light of the illumination units 400 irradiates the side surfaces of the plurality of substrates 100. The plurality of pixel blocks 610 included in the captured image are bright blocks of reflected light at positions where the illumination light irradiates the side surfaces of the plurality of substrates 100. It should be noted that the present application does not specifically limit the number of light bars and cameras. Each illumination unit 400 may include at least one light bar, for example, two light bars, and the light bars may be LED light bars. The imaging unit 500 may include at least one camera, for example, one camera. In the following description, the example shown in FIG. 4 is used for illustration.

The storage unit is configured to store reference grids 700, a plurality of detection positions, and a reference width of a side surface of a single substrate 100. In this embodiment, the storage unit may include, but is not limited to, magnetic storage device (e.g., hard disks, floppy disks, magnetic strips), optical disks (e.g., compact discs (CDs), digital versatile discs (DVDs)), smart cards, and flash memory device (e.g., erasable programmable read-only memory (EPROM), cards, sticks, key drives).

According to FIG. 8, the reference grid 700 includes one search area 710 and two defect areas 720 respectively formed on two sides of the search area 710. The search area 710 represents an area that appears when the substrates 100 are normally held in the holding slots 312 (as shown in FIG. 3), and the defect areas 720 represent areas that appear when the substrates 100 are abnormally held in the holding slots 312. With reference to FIGS. 5 and 7, the plurality of detection positions include at least two detection positions arranged for each holding slot 312. In the captured image shown in FIG. 7, the holding slots 312 are not shown, but positions of the plurality of detection positions correspond to positions of the respective holding slots 312. For convenience, only two detection positions (a first detection position 31401 and a second detection position 31402) arranged for one holding slot 312 are schematically shown in FIG. 7, and the two detection positions are spaced apart. It should be understood that actually each holding slot 312 is provided with two detection positions. The purpose of designing the detection positions in this embodiment is to realize positioning of the

reference grids 700. Each detection position is located on the center line of a corresponding holding slot 312. When each reference grid 700 is positioned at a corresponding detection position, the center of the search area 710 of the reference grid 700 coincides with the corresponding detection position. In other embodiments, each holding slot 312 may be provided with more than two detection positions for mutual complementation to enhance the detection effect. In FIG. 7, the captured image further shows a first image capture area 601 (upper dashed box in the figure) and a second image capture area 602 (lower dashed box in the figure). Both the first image capture area 601 and the second image capture area 602 include pixel blocks representing the plurality of substrates 100. When the plurality of substrates 100 are detected in the plurality of holding slots 312, the two detection positions corresponding to each holding slot 312 are respectively located in the first image capture area 601 and the second image capture area 602 of the captured image. The search unit is configured to search for the pixel blocks 610 in a partial image of the captured image in the reference grids 700 at each detection position, and output search information of the pixel blocks 610 in the reference grids 700. The search information includes the presence or absence of the pixel blocks 610 in the search area 710, the width of the pixel blocks 610 in the search area 710, and the presence or absence of the pixel blocks 610 in the defect areas 720. The determination unit is configured to determine holding states of the plurality of substrates 100 in the holding slots 312 based on the above search information. It should be noted that the pixel blocks 610 referred to in this embodiment are pixel blocks representing side surfaces of the substrates 100. In this embodiment, the search unit and the determination unit are formed as a data processor such as a central processing unit (CPU) for performing various arithmetic processing. The processor may be one or more application-specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DAPDs), programmable logic device (PLDs), field-programmable gate arrays (FPGAs), processors, controllers, microcontrollers, microprocessors, or combinations thereof.

FIGS. 9(a) to 9(c) show schematic views of three arrangement modes of the reference grids and the detection positions according to Embodiment 1 of the present application. In FIGS. 9(a) and 9(b), only detection positions corresponding to two holding slots 312 are schematically shown, and the moved movable reference grids are indicated by dashed outlines; in FIG. 9(c), only detection positions corresponding to

four holding slots 312 are schematically shown. In FIGS. 9(a) to 9(c), each holding slot 312 is correspondingly provided with two detection positions, denoted as the first detection position 31401 and the second detection position 31402, respectively, and each detection position is located on the center line of a corresponding holding slot 312.

In some embodiments, each reference grid 700 includes at least one movable reference grid. In the example shown in FIG. 9(a), the reference grid 700 includes one movable reference grid, and the movable reference grid is movable between the first detection position 31401 and the second detection position 31402 arranged for one holding slot 312 to perform searching at the two detection positions, respectively, so as to detect the holding state of the substrate 100 in the holding slot 312. After the movable reference grid completes searching at the position of the holding slot 312, the movable reference grid moves to two detection positions corresponding to the next holding slot 312 to perform searching at the first detection position 31401 and the second detection position 31402 arranged for the next holding slot 312, respectively. In this way, the movable reference grid sequentially detects holding states of the plurality of substrates 100 in the plurality of holding slots 312.

In the example shown in FIG. 9(b), each reference grid 700 includes a pair of movable reference grids, and the pair of movable reference grids perform searching at two detection positions arranged for one holding slot 312 at the same time, and then move to the position of the next holding slot 312 to perform searching at the first detection position 31401 and the second detection position 31402 arranged for the next holding slot 312 at the same time. In this way, the movable reference grids 700 sequentially detect holding states of the plurality of substrates 100 in the plurality of holding slots 312.

In other embodiments, with reference to FIG. 9(c), each reference grid 700 includes a plurality of fixed reference grids respectively located at the plurality of detection positions. That is, each of the first detection position 31401 and the second detection position 31402 arranged for each holding slot 312 is correspondingly provided with fixed reference grids, so that the plurality of fixed reference grids simultaneously detect holding states of the plurality of substrates 100 in the plurality of holding slots 312.

With reference to FIG. 9(a), the width W1 of the search area 710 involved in this embodiment is not greater than the opening width W2 of each holding slot 312, for example, the width W1 is one half, three fifths, or three quarters of the width W2, so as to improve accuracy of detecting holding states of the substrates in corresponding holding slots 312. The overall width of the reference grids 700, i.e., the sum of the width W1 of the search area 710 and widths of the defect areas, does not exceed the distance d between center lines of two holding slots 312, so as to avoid mutual interference between detection data in the previous reference grid 700 and detection data in the next reference grid 700. It should be noted that dimensions of the width W1 of the search area 710 and the overall width of the reference grids 700 may be determined according to actual on-site processes, and the present application does not specifically limit the dimensions. FIGS. 10(a) to 10(d) respectively show schematic views of search information of the pixel blocks in the reference grids under different holding states of substrates according to Embodiment 1 of the present application. For convenience, search information of the reference grids 700 at the plurality of detection positions corresponding to the plurality of holding slots 312 is shown at the same time in FIGS. 10(a) to 10(d).

Exemplarily, the captured image shown in FIG. 7 shows the first image capture area 601 and the second image capture area 602. Each holding slot 312 is provided with the first detection position 31401 and the second detection position 31402. The first detection position 31401 is located in the first image capture area 601, and the second detection position 31402 is located in the second image capture area 602. Each reference grid 700 includes a pair of movable reference grids for simultaneously corresponding to two detection positions arranged for one holding slot 312. In such a case:

With reference to FIGS. 7 and 10(a), for the same holding slot 312, when the search information output by the reference grid 700 at the first detection position 31401 is that the pixel block 610 is present in the search area 710 of the reference grid 700, the width of the pixel block 610 conforms to the reference width, and no pixel block 610 is present in the defect areas 720 of the reference grid 700, and at the same time, the search information output by the reference grid 700 at the second detection position 31402 is that the pixel block 610 is present in the search area 710 of the reference grid

700, the width of the pixel block 610 conforms to the reference width, and no pixel block 610 is present in the defect areas 720 of the reference grid 700, the determination unit determines that the detected substrate 100 is in a normal holding state; otherwise, the determination unit determines that the detected substrate 100 is in an abnormal holding state. That is, the detected substrate 100 is normally held in a corresponding holding slot 312 without interference from an adjacent substrate 100.

With reference to FIGS. 7 and 10(b), for the same holding slot 312, when the search information output by the reference grid 700 at the first detection position 31401 is that the pixel block 610 is in the search area 710 of the reference grid 700, the width of the pixel block 610 does not conform to the reference width, and no pixel block 610 is present in the defect areas 720 of the reference grid 700, and at the same time, the search information output by the reference grid 700 at the second detection position 31402 is that the pixel block 610 is in the search area 710 of the reference grid 700, the width of the pixel block 610 does not conform to the reference width, and no pixel block 610 is present in the defect areas 720 of the reference grid 700, the determination unit determines that the detected substrate 100 has a stacking or warping abnormality. The expression that the width of the pixel block 610 in the search area 710 does not conform to the reference width referred to in this embodiment means that the width of the pixel block 610 in the search area 710 is greater than the reference width, which indicates that at least two substrates 100 are inserted into the holding slot 312 at the detection position where the reference grid 700 is located (see FIG. 3(c)), or the warpage degree of one substrate 100 in the holding slot 312 does not meet a predetermined requirement (see FIG. 3(d)). Whether a stacking abnormality or a warping abnormality is present can be confirmed by on-site manual inspection.

With reference to FIGS. 7 and 10(c), for the same holding slot 312, when the search information output by the reference grid 700 at the first detection position 31401 is that no pixel block 610 is present in the search area 710 of the reference grid 700 and no pixel block 610 is present in the defect areas 720 of the reference grid 700, and at the same time, the search information output by the reference grid 700 at the second detection position 31402 is that no pixel block 610 is present in the search area 710 of the reference grid 700 and no pixel block 610 is present in the defect areas 720 of the reference grid 700, the determination unit determines that the detected substrate 100

has a missing abnormality. That is, no substrate 100 is present in the holding slot 312 at the detection position where the reference grid 700 is located. It should be noted that the missing abnormality referred to in the present application means that no substrate 100 is detected in the holding slot 312 where the substrate 100 should be present. It can be understood that, under predetermined conditions, empty slots may be generated in the plurality of holding slots 312. For example, one hundred holding slots 312 normally hold one hundred substrates 100, or one hundred holding slots 312 normally hold fifty substrates 100, with an empty slot between any two adjacent substrates 100 among the fifty substrates 100. In this case, for the empty slot, it is a normal situation, and the determination unit should not determine that a missing abnormality occurs.

With reference to FIGS. 7 and 10(d), when the search information output by the reference grid 700 at the first detection position 31401 is that the pixel block 610 is present in the defect areas 720 of the reference grid 700, or the search information output by the reference grid 700 at the second detection position 31402 is that the pixel block 610 is present in the defect areas 720 of the reference grid 700, the determination unit determines that the detected substrate 100 has an oblique insertion abnormality. That is, at the detection position where the reference grid 700 is located, one substrate 100 appears in an area where a substrate is abnormally held. In this embodiment, at the detection position where the reference grid 700 is located, regardless of whether the substrate 100 is present in the holding slot 312, if the pixel block 610 is searched in the defect areas 720 of the reference grid 700, it can be considered that the substrate 100 corresponding to the pixel block 610 in the defect areas 720 has an oblique insertion abnormality.

In some embodiments, the substrate detection device further comprises an alarm unit configured to give an alarm when the determination unit determines that the detected substrate 100 is abnormal. The alarm unit includes, for example, at least one of a display and a speaker.

After the substrate detection device of the present application detects the plurality of substrates 100 on the substrate holder 310, the plurality of substrates 100 are sent into the process tank and immersed in the chemical solution in the process tank for wet processing. Different from the above embodiments, the substrate detection device of the present application may also detect the plurality of substrates 100 in the process

tank. In this case, the substrate holder 310 is disposed in the process tank, the illumination units 400 of the substrate detection device may be disposed outside the process tank and below the process tank, the process tank is made of a light-transmitting material, and light emitted by the illumination units 400 toward the process tank passes through gaps between the plurality of substrates 100. The imaging unit 500 is disposed above the process tank to capture an image of the imaging region including the plurality of substrates 100 in the process tank and generate a captured image. The description of the detection positions, the reference grids 700, and the determination logic of the determination unit is similar to the description described above, and will not be repeated herein.

Embodiment 2

FIG. 11 shows a schematic view of the captured image and the reference grids according to Embodiment 2 of the present application, and FIGS. 12(a) and 12(b) show schematic views of the reference grid according to Embodiment 2 of the present application. Embodiment 2 differs from Embodiment 1 in the following aspects: first, the defect areas 720 of the reference grid 700 provided in Embodiment 2 are configured such that when the pixel block 610 is present in the search area 710, the defect areas 720 are formed on two sides of the pixel block 610. That is, if no pixel block 610 is searched in the search area 710, the defect areas 720 will not be formed; second, the determination logics for the determination unit to determine that the detected substrate 100 has a missing abnormality and an oblique insertion abnormality are different. It should be noted that the pixel block 610 referred to in this embodiment is the pixel block representing the side surface of the substrate 100 in the captured image. The principle for determining the dimension of the search area of the reference grid involved in Embodiment 2 is similar to the principle for determining the dimension of the search area in Embodiment 1. The dimension of the defect areas of the reference grid involved in Embodiment 2 is determined according to an actual on-site process, and only needs to prevent interference between the substrate and a transfer mechanism (e.g., a flipping device or a material receiving device) during substrate conveyance.

The captured image shown in FIG. 11 shows the first image capture area 601 (upper dashed box in the figure) and the second image capture area 602 (lower dashed box in the figure). Each holding slot 312 is provided with the first detection position

31401 and the second detection position 31402. The first detection position 31401 is located in the first image capture area 601, and the second detection position 31402 is located in the second image capture area 602. Each reference grid 700 includes a pair of movable reference grids for simultaneously corresponding to the first detection position 31401 and the second detection position 31402 arranged for one holding slot 312. In such a case, the determination logics for the determination unit to determine that the detected substrate 100 has a missing abnormality and an oblique insertion abnormality in this embodiment are described as follows:

When the search information output by the reference grid 700 at the first detection position 31401 is that, for the same holding slot 312, no pixel block 610 is present in the search area 710 of the reference grid 700, and at the same time, the search information output by the reference grid 700 at the second detection position 31402 is that no pixel block 610 is present in the search area 710 of the reference grid 700, the determination unit determines that the detected substrate 100 has a missing abnormality. That is, no substrate 100 is present in the holding slot 312 at the detection position where the reference grid 700 is located. In this embodiment, at the first detection position 31401 and the second detection position 31402, no pixel block 610 is searched in the search area 710 of the reference grid 700, so the defect areas 720 are not formed on two sides of the pixel block 610, and thus no pixel block 610 is searched in the defect areas 720.

When the search information output by the reference grid 700 at the first detection position 31401 is that the pixel block 610 is present in the search area 710 of the reference grid 700 and the pixel block 610 is present in the defect areas 720 of the reference grid 700, or the search information output by the reference grid 700 at the second detection position 31402 is that the pixel block 610 is present in the search area 710 of the reference grid 700 and the pixel block 610 is present in the defect areas 720 of the reference grid 700, the determination unit determines that the detected substrate 100 has an oblique insertion abnormality. In this embodiment, at the first detection position 31401 or the second detection position 31402, the pixel block 610 is searched in the search area 710 of the reference grid 700, two defect areas 720 are formed on two sides of the pixel block 610, and if the pixel block 610 is searched in at least one defect area 720, it can be considered that the substrate 100 corresponding to the pixel

block 610 in the defect areas 720 has an oblique insertion abnormality. In this case, the width of the pixel block 610 searched in the search area 710 may conform to the reference width or be greater than the reference width. When the width of the pixel block 610 is greater than the reference width, the substrate 100 corresponding to the pixel block 610 may have a stacking or warping abnormality. In this case, whether to give an alarm for the stacking or warping abnormality first or for the oblique insertion abnormality first may be determined according to the priority of an actual process.

It should be noted that the embodiments of the present application only illustrate one determination condition for determining that the substrate 100 is in the above abnormal holding states (e.g., an oblique insertion abnormality). It can be understood that those skilled in the art may also determine the abnormal holding states (e.g., an oblique insertion abnormality) through another determination condition based on the substrate detection principle of the embodiments of the present application.

In addition, the embodiments of the present application illustrate substrate stacking or warping abnormalities, missing abnormalities, and oblique insertion abnormalities, but do not list all abnormalities. Various abnormality determinations can be made without departing from the spirit of the present application, which are specifically determined according to actual processes.

Finally, it should be noted that the above embodiments are merely used for illustrating the technical solutions of the present invention, rather than limiting the technical solutions. Although the present invention has been described in detail with reference to the foregoing embodiments, those of ordinary skill in the art should understand that they may still modify the technical solutions described in the foregoing embodiments, or equivalently replace some or all of the technical features of the technical solutions; and these modifications or replacements do not make the essence of the corresponding technical solutions depart from the scope of the technical solutions of the embodiments of the present invention.

What is claimed is:

1. A substrate detection device, comprising:

an illumination unit, configured to irradiate an imaging region including a plurality of substrates with illumination light, wherein the plurality of substrates are inserted into a plurality of holding slots of a substrate holder and arranged along a predetermined arrangement direction;

an imaging unit, configured to capture an image of the imaging region and generate a captured image, wherein the captured image includes a plurality of pixel blocks representing side surfaces of the plurality of substrates;

a storage unit, configured to store a reference grid, a plurality of detection positions, and a reference width of a side surface of a single substrate, wherein the reference grid includes a search area and defect areas, and the plurality of detection positions include at least two detection positions arranged for each of the holding slots;

a search unit, configured to search for the pixel blocks within the reference grid in the captured image at each of the detection positions, and output search information of the pixel blocks in the reference grid;

a determination unit, configured to determine holding states of the plurality of substrates in the corresponding holding slots based on the search information.

2. The substrate detection device according to claim 1, wherein the search information includes presence or absence of the pixel blocks in the search area, the width of the pixel blocks in the search area, and presence or absence of the pixel blocks in the defect areas.

3. The substrate detection device according to claim 2, wherein the reference grid includes one search area and two defect areas respectively formed on two sides of the search area.

4. The substrate detection device according to claim 2, wherein the reference grid includes one search area and two defect areas, and the two defect areas are configured

to be formed on the two sides of the pixel block when the pixel block is present in the search area.

5. The substrate detection device according to claim 3 or 4, wherein the at least two detection positions of each of the holding slots include a first detection position and a second detection position; when the search information output by the reference grid at the first detection position is that the pixel block is present in the search area of the reference grid, the width of the pixel block conforms to the reference width, and no pixel block is present in the defect areas of the reference grid, and at the same time, the search information output by the reference grid at the second detection position is that the pixel block is present in the search area of the reference grid, the width of the pixel block conforms to the reference width, and no pixel block is present in the defect areas of the reference grid, the determination unit determines that the detected substrate is in a normal holding state; otherwise, the determination unit determines that the detected substrate is in an abnormal holding state.

6. The substrate detection device according to claim 3 or 4, wherein the at least two detection positions of each of the holding slots include a first detection position and a second detection position; when the search information output by the reference grid at the first detection position is that the pixel block is present in the search area of the reference grid, the width of the pixel block does not conform to the reference width, and no pixel block is present in the defect areas of the reference grid, and at the same time, the search information output by the reference grid at the second detection position is that the pixel block is present in the search area of the reference grid, the width of the pixel block does not conform to the reference width, and no pixel block is present in the defect areas of the reference grid, the determination unit determines that the detected substrate has a stacking or warping abnormality.

7. The substrate detection device according to claim 3, wherein the at least two detection positions of each of the holding slots include a first detection position and a second detection position; when the search information output by the reference grid at the first detection position is that no pixel block is present in the search area of the reference grid and no pixel block is present in the defect areas of the reference grid, and at the same time, the search information output by the reference grid at the second detection position is that no pixel block is present in the search area of the reference

grid and no pixel block is present in the defect areas of the reference grid, the determination unit determines that the detected substrate has a missing abnormality.

8. The substrate detection device according to claim 4, wherein the at least two detection positions of each of the holding slots include a first detection position and a second detection position; when the search information output by the reference grid at the first detection position is that no pixel block is present in the search area of the reference grid, and at the same time, the search information output by the reference grid at the second detection position is that no pixel block is present in the search area of the reference grid, the determination unit determines that the detected substrate has a missing abnormality.

9. The substrate detection device according to claim 3, wherein the at least two detection positions of each of the holding slots include a first detection position and a second detection position; when the search information output by the reference grid at the first detection position is that the pixel block is present in the defect areas of the reference grid, or the search information output by the reference grid at the second detection position is that the pixel block is present in the defect areas of the reference grid, the determination unit determines that the detected substrate has an oblique insertion abnormality.

10. The substrate detection device according to claim 4, wherein the at least two detection positions of each of the holding slots include a first detection position and a second detection position; when the search information output by the reference grid at the first detection position is that the pixel block is present in the search area of the reference grid and the pixel block is present in the defect areas of the reference grid, or the search information output by the reference grid at the second detection position is that the pixel block is present in the search area of the reference grid and the pixel block is present in the defect areas of the reference grid, the determination unit determines that the detected substrate has an oblique insertion abnormality.

11. The substrate detection device according to claim 1, wherein the illumination unit is disposed below the plurality of substrates, so that irradiation light of the illumination unit passes through gaps between the plurality of substrates; the imaging unit is disposed above the plurality of substrates and configured to capture the image

of the imaging region and generate the captured image after the irradiation light passes through the gaps, and the plurality of pixel blocks included in the captured image are a plurality of dark blocks formed by blocking the illumination light by the side surfaces of the plurality of substrates.

12. The substrate detection device according to claim 11, wherein the illumination unit is disposed on the substrate holder.

13. The substrate detection device according to claim 1, wherein the illumination unit is disposed above the plurality of substrates, so that illumination light of the illumination unit irradiates the side surfaces of the plurality of substrates; the imaging unit is disposed above the plurality of substrates and configured to capture the image of the imaging region and generate the captured image after the illumination light of the illumination unit irradiates the side surfaces of the plurality of substrates, and the plurality of pixel blocks included in the captured image are bright blocks of reflected light at positions where the illumination light irradiates the side surfaces of the plurality of substrates.

14. The substrate detection device according to claim 1, wherein the imaging unit includes at least one camera.

15. The substrate detection device according to claim 1, wherein the illumination unit includes at least one light bar.

16. The substrate detection device according to claim 1, wherein the reference grid includes at least one movable reference grid, and the movable reference grid is movable to the plurality of detection positions.

17. The substrate detection device according to claim 1, wherein the reference grid includes a plurality of fixed reference grids respectively located at the plurality of detection positions.

18. The substrate detection device according to claim 1, wherein the substrate detection device further comprises an alarm unit configured to give an alarm when the determination unit determines that the detected substrate is abnormal.