

TITLE: WAFER CASSETTE NIGHT VISION DEVICE

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a wafer cassette night vision device that can be set up in a simple way, has a relatively low structural cost, can
5 perform recognition in an efficient way, and can detect the storage status of wafers deeply inside a wafer cassette to prevent wafer breaking caused by accidental contact by a robotic arm.

DESCRIPTION OF THE PRIOR ART

Generally, wafers are stored in wafer boxes until the handling
10 equipment takes the wafers out of the wafer boxes for subsequent procedures such as cutting and testing. Before the wafers are taken out, it is necessary to confirm whether the wafers arranged in the wafer box have any bad configurations such as missing, overlapping, skewed or warped, so as to avoid damaging the wafers during the process of picking and placing.
15 Therefore, when all the wafers in the wafer box have not been taken out, a detection operation of the storage status of the wafers in the wafer box will be conducted first. When a wafer is in a bad configuration state, picking and placing will be suspended until a user resolve the error state.

Known detection measures include manual detection, infrared
20 interception sensing, proximity sensors, or complicated optical image recognition systems, which are applied to carry out detection. However,

the above detection measures have the following problems and deficiencies when used and need to be improved:

Firstly, the system includes a large number of devices and the detection process is complicated, making the comparison efficiency of the optical image recognition system poor.

Secondly, a large number of sensors must be set up, making the installation cost very high or the size bulky that is not conducive to the spatial configuration of the overall facility.

Thirdly, only the wafer storage status can be determined for the part that is visible to the naked eyes on the outside of the wafer box. However, the thickness of the wafer is extremely thin, so that even if the storage status seems normal externally, there may still be warping inside. The abnormal storage status inside cannot be detected by any of the above detection measures. Therefore, the operations of the handling equipment for picking and placing wafers still has a high risk of damaging the wafers.

SUMMARY OF THE INVENTION

Thus, in view of the above-mentioned deficiencies, the Applicant has collected relevant information, conducted multiple evaluations and considerations, and based on many years of experience in this industry, 5 through continuous trials and modifications, has finally designed the present invention of a wafer cassette night vision device that is simple in configuration, has a low structural cost, provides efficient recognition, and can deeply detect the storage status of wafers inside the wafer cassette to avoid accidental contact by a robotic arm to cause wafer breakage.

10 The primary objective of the present invention is to use a night vision device to deeply detect the storage status of wafers inside a wafer cassette in order to control operation of a robotic arm to avoid accidental contact by the robotic arm to cause wafer breakage.

To achieve the above objective, a structure of the present invention 15 comprises: a wafer cassette, a plurality of the wafers, a plurality of gap portions, a wafer transfer apparatus, a robotic arm, and a night vision device. The night vision device comprises an infrared emitting element, a radiation detecting element, and an image converting element that generates a visible light image. A status detection module and a control 20 module are also included. The wafers are arranged in a side-by-side manner inside the wafer cassette. Each of the gap portions is defined between the wafers or between the wafers and a wall surface of the wafer

cassette. The wafer transfer apparatus is arranged at one side of the wafer cassette. The robotic arm is rotatably mounted on the wafer transfer apparatus. The night vision device is mounted on the robotic arm. The infrared emitting element has an emitting direction that is consistent with a gripping direction of the robotic arm for projection into the gap portion. The radiation detecting element is arranged at one side of the infrared emitting element to receive reflected light of the infrared emitting element for conversion into an electrical signal. The image converting element is in information connection with the radiation detecting element for

10 subjecting the electrical signal to calculation processing to generate a visible light image. The status detection module is in information connection with the night vision device to determine storage status of each of the wafers according to the visible light image. The control module is in information connection with the status detection module to drive the

15 robotic arm to move into the gap portion when the storage status is read to be not abnormal.

When the wafer transfer apparatus attempts to grip the wafers inside the wafer cassette, the infrared emitting element of the night vision device is first operated to project infrared into the gap portion, and the radiation

20 detecting element receives the reflected light, and the image converting element converts the reflected light into an electrical signal for subsequently generating a visible light image, and then the status detection

module determines the storage status of the wafers at a deep site of the gap portion according to the visible light image. Finally, the control module determines the action of the robotic arm to avoid wafer breaking resulting from accidental contact by the robotic arm caused by abnormal storage status of the wafers.

By using the above technology, the problems of poor comparison efficiency, high cost, and inability to detect the storage status inside the wafer cassette in the prior art wafer storage status detection measures can be overcome, thereby achieving the practical progress of the above advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a see-through perspective view of a preferred embodiment of the present invention.

FIG. 2 is a schematic view showing status of use of the preferred
5 embodiment of the present invention.

FIG. 3 is a schematic view illustrating detecting according to the preferred embodiment of the present invention.

FIG. 3A is a cross-sectional view of a wafer cassette of FIG. 3.

FIG. 4 is a schematic view showing implementation of the preferred
10 embodiment of the present invention.

FIG. 4A is a cross-sectional view of a wafer cassette of FIG. 4.

FIG. 5 is a block diagram of operation of the preferred embodiment of the present invention.

FIG. 6 is a perspective view showing another preferred embodiment of
15 the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1 and 2, which are a see-through perspective view of a preferred embodiment of the present invention and a schematic view showing status of use of the preferred embodiment of the present invention,

5 it can be clearly seen from the drawings that the present invention comprises:

a wafer cassette 1, which receives a plurality of wafers 11 arranged side by side therein, a gap portion 111 being formed between the wafers 11, or between the wafers 11 and a wall surface of the wafer cassette 1;

10 a wafer transfer apparatus 2, which is arranged at one side of the wafer cassette 1;

a robotic arm 21, which is rotatably mounted on the wafer transfer apparatus 2;

15 a night vision device 3, which is arranged on the robotic arm 21 and comprises:

an infrared emitting element 31, which has an emitting direction consistent with a gripping direction of the robotic arm 21 and projecting into the gap portion 111;

20 a radiation detecting element 32, which is arranged at one side of the infrared emitting element 31 to receive reflected light of the infrared emitting element 31 for conversion into an electrical signal;

an image converting element 33, which is in information connection with the radiation detecting element 32 for subjecting the electrical signal to calculation processing to generate a visible light image;

5 a status detection module 4, which is in information connection with the night vision device 3 to determine storage status of each of the wafers 11 according to the visible light image, wherein the status detection module 4 is in information connection with a status database 41;

a comparison module 42, which is arranged at one side of the status database 41 to carry out comparison of the visible light image with the
10 status database 41 in order to determine whether the storage status is normal or not; and

a control module 5, which is in information connection with the status detection module 4 to drive the robotic arm 21 to move into the gap portion 111 when the storage status is read to be not abnormal.

15 The wafer 11 refer to a circular plate of semiconductor crystal. An equipment front end module (EFEM) is taken as an example for illustrating the wafer transfer apparatus 2. The interior of the gap portion 111 is a non-visible space to naked eyes inside the wafer cassette 1, such as a low light source space or a dark space. Infrared LED lighting is provided as
20 an example of the infrared emitting element 31 for supplying visible or invisible infrared light to illuminate a target area. The radiation detecting element 32 is an image sensor and uses one of complementary

metal-oxide-semiconductor (CMOS) technology and charge-coupled device (CCD) technology to carry out detecting. A signal processor is taken as an example of the image converting element 33, which converts the electrical signal into a digital signal and then calculates and processes it to generate an image. The status detection module 4 can be a cloud processor or a processor disposed in the wafer transfer apparatus 2, and the latter is taken as an example in the instant embodiment, and the comparison module 42 is one of the chips of the processor; the status database 41 is a storage medium such as a memory or a hard disk drive; and the control module 5 is another cloud processor or another processor disposed in the wafer transfer apparatus 2, all being indicated by dotted boxes in the drawings. However, the corresponding types of the above-mentioned components are only examples of preferred embodiments, and all types with the same functions belong to the scope of the present invention and are not limited to the above-mentioned examples.

Through the above description, the structure of the present technology can be understood. According to the corresponding coordination of this structure, it can achieve simple installation, relatively low structural cost, and efficient recognition operation, and can deeply detect the storage status of the wafers 11 inside the wafer cassette 1, and has the advantages of avoiding accidental contact by the robotic arm 21 to cause wafer breakage. The detailed explanation will be described below.

Referring to FIGS. 1-5, which are a see-through perspective view to a block diagram of operation of the preferred embodiment of the present invention, through assembly of the above components, it can be clearly seen from the drawings that in terms of the configuration of the equipment

5 mechanism, it is only necessary to set a night vision device 3 on an existing robotic arm 21 and to make signal transmission between the night vision device 3 and the wafer transfer apparatus 2 through wired or wireless means to complete setting up. The structure is relatively simple and there is no need to provide an extra space for setup and the cost is relatively low.

10 When setting up, the emitting direction of the infrared emitting element 31 must be set to be consistent with the gripping direction of the robotic arm 21 to allow infrared light to project into the interior of the gap portion 111. As such, regardless of the direction or height of the wafer 11 that the robot arm 21 is about to grip, the night vision device 3 will move and swing

15 synchronously, so that the storage status of the wafer can be easily recognized by setting up a single set of night vision device 3.

Particularly, the recognition light source used in the present invention is an infrared emitting element 31, which provides infrared light with a wavelength of, for example, 850nm-940nm, preferably 850nm infrared

20 light. Although this band is visible light, there is no need to hide the light in the semiconductor process, and this band can provide a stronger lighting effect, and most image sensors (including the radiation detecting element

32 used in the present invention) are also more sensitive to light in this band. Infrared light in this band is used for low light source space or dark space. A target object will reflect infrared light under the irradiation of infrared light, and under this condition, the radiation detecting element 32
5 can receive the reflected infrared light to convert the light signal or radiation signal of the reflected infrared light into an electrical signal, which is then transmitted to the image converting element 33 for processing. The image converting element 33 can then perform steps such as denoising, contrast adjustment, gamma correction, and color
10 processing to convert the electrical signal into a color-like image, which is a visible light image that can be recognized by the naked eyes.

In other words, the visible light image acquired through the night vision device 3 can clearly shows the storage status of the wafers located deep in the gap portion 111, solving the problem that various conventional
15 detection methods cannot detect the storage condition inside the wafer cassette 1. Of course, after the acquisition of the visible light image, it is necessary to further identify and confirm the storage status of each wafer 11 with the status detection module 4, and thus, the comparison module 42 is used to compare the visible light image with images in the status
20 database 41. The source of the image in the status database 41 can be such that storage status of multiple wafers 11 that have been confirmed to be not abnormal are stored for recognition purposes, and comparison data

of the standard storage status are first supplied to the status database 41, for comparing each visible light image to determine whether the storage status of the wafer at the corresponding location is normal.

The control module 5 reads the result of determination of the status
5 detection module 4. When a normal storage status of wafer is read, the robotic arm 21 is driven to get into the gap portion 111 corresponding thereto to carry out picking and placing of the wafer 11. Oppositely, if an abnormal storage status of wafer is read, such as one of tilting, wafer overlapping, wafer missing, or warping, the movement of the robotic arm
10 21 for entering this gap portion 111 is stopped, and the wafer transfer apparatus 2 drives the robotic arm 21 toward the next gap portion 111. In this way, each time before the robotic arm 21 carries out picking and placing of wafers 11, the night vision device 3 will be operated first to acquire the visible light image of the deep site of the gap portion 111.
15 Only when the status detection module 4 determines that there is no abnormality, the control module 5 will allow the robotic arm 21 to execute the operation of picking and placing. Such a recognition operation is not only simple and efficient, but also can effectively avoid the blind spot that the external storage status of the wafer cassette 1 looks normal, but the
20 internal storage status is abnormal, effectively improving the safety of the operation of picking and placing performed by the robot arm 21 and avoiding damage to the wafers 11.

Referring to FIG. 6, which is a perspective view showing another preferred embodiment of the present invention, it is clearly seen from the drawing that the instant embodiment is similar to the previous embodiment, except that the night vision device 3 includes at least one angle adjustment member 6 for adjusting the emitting angle of the infrared emitting element 31 to ensure that the infrared light can project into a deep site of the gap portion. The angle adjustment member 6 can be rotary knob adjustment, slide rail adjustment, or electric adjustment, wherein the rotary knob adjustment is to set a rotary knob on the outside of the night vision device 3 to be connected through a screw rod to the infrared emitting element 31 located inside, so that adjustment of angle can be fulfilled through simply turning the rotary knob. Such a solution involves a simple structure and easy operation. Since it is not necessary to have the infrared emitting element 31 synchronized and aligned with other light sources, there will be no concern about recognition rate problem caused by ghosting. The slide rail adjustment utilizes a housing having a hollowed arc track 61, in combination with a screw 62 that is slidable in the arc track 61 and is mounted to the infrared light emitting element 31 to carry out angle adjustment. This solution can be set on both sides of the infrared emitting element 31 to increase the mounting strength and avoid angular position deviation after the robotic arm 21 operates for a long time. The electric adjustment is similar to the rotary knob adjustment, but the rotary knob is

replaced with a motor, and as such, precise angle adjustment can be performed semi-automatically. The instant embodiment is only shown with the slide rail adjustment.

I CLAIM:

1. A wafer cassette night vision device, comprising:

a wafer cassette, which receives a plurality of wafers arranged side by side therein, a gap portion being present between the wafers or between the wafers and a wall surface of the wafer cassette;

a wafer transfer apparatus, which is arranged at one side of the wafer cassette;

a robotic arm, which is rotatably mounted on the wafer transfer apparatus;

a night vision device, which is arranged on the robotic arm and comprises:

an infrared emitting element, which has an emitting direction that is consistent with a gripping direction of the robotic arm and projecting into the gap portion;

a radiation detecting element, which is arranged at one side of the infrared emitting element to receive reflected light of the infrared emitting element for conversion into an electrical signal;

an image converting element, which is in information connection with the radiation detecting element for subjecting the electrical signal to calculation processing to generate a visible light image;

a status detection module, which is in information connection with the night vision device to determine storage status of each of the wafers according to the visible light image; and

5 a control module, which is in information connection with the status detection module to drive the robotic arm to move into the gap portion when the storage status is read to be not abnormal.

2. The wafer cassette night vision device according to claim 1,
10 wherein the radiation detecting element comprises an image sensor and uses one of complementary metal-oxide-semiconductor (CMOS) technology or charge-coupled device (CCD) technology to carry out detecting.
3. The wafer cassette night vision device according to claim 1,
15 wherein the status detection module is in information connection with a status database.
4. The wafer cassette night vision device according to claim 3,
 wherein a comparison module is arranged at one side of the status database to carry out comparison of the visible light image with
20 the status database in order to determine whether the storage status is normal or not.

5. The wafer cassette night vision device according to claim 1,
wherein the storage status comprises one of normal, tilting, wafer
overlapping, wafer missing, and warping.
6. The wafer cassette night vision device according to claim 1,
5 wherein interior of the gap portion forms a low light source space
or a dark space that is a space not visible to naked eyes.
7. The wafer cassette night vision device according to claim 1,
wherein the night vision device comprises at least one angle
adjustment member arranged thereon for adjusting an emitting
10 angle of the infrared emitting element.