

A bonding alignment system, bonding device and bonding method

Technical Field

The disclosure relates to the field of semiconductor manufacturing technology, particularly to a bonding alignment system, a bonding device, and a bonding method.

Background

In the field of semiconductor manufacturing technology, bonding technology can be used to achieve three-dimensional integration of semiconductor devices. By bonding two or more semiconductor structures with the same or different functions, the performance of the chip can be improved. Herein, the bonding process can be distinguished according to the bonding object, including wafer-to-wafer (W2W) bonding, die-to-wafer (D2W) bonding, and die-to-die (D2D) bonding.

In the alignment step of the chip-to-wafer bonding process, the optical microscopy system needs to image the targets of the chip and the wafer to calculate their alignment deviation. In the prior art, alignment is achieved by designing glass targets on the carrier head of the chip. The glass target is located on the side of the same plane as the chip. After calibrating the positions of the glass target and the chip target, the glass target can be calibrated with the target directly facing the wafer. However, due to the vertical distance between the two targets, the field depth of the microscope objective cannot cover both of them, and this distance may vary with the thickness of the chip. When adapting to bond different chips, a displacement microscope is required to image glass targets and wafer targets. Therefore, the repeatability and accuracy errors caused by the mechanical displacement will affect the bonding accuracy of the chip and the wafer.

In order to overcome the above shortcomings of the prior art, the disclosure provides a bonding alignment technique that uses a simplified device structure to quickly calibrate the alignment deviation, thereby improving the efficiency of bonding alignment.

Summary

A brief overview of one or more aspects is provided below to provide a basic understanding of these aspects. The summary is not an exhaustive overview of all aspects envisaged, and is neither intended to identify the key or decisive elements of all aspects nor to attempt to define the scope of any or all aspects. The sole purpose of the summary is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

In order to overcome the above shortcomings of the prior art, the disclosure provides a bonding alignment system, a bonding device, and a bonding method that uses a simplified device structure to quickly calibrate the alignment deviation, thereby improving the efficiency of bonding alignment.

Specifically, the bonding alignment system provided according to the first aspect of the disclosure comprises: a first target, on which a first target point is set to calibrate a first position of a wafer; a transparent second target, located between the first target and an image capture device, wherein a second target point is set on the transparent second target to calibrate a second position of a component to be bonded; the image capture device, for capturing a first image with the first target point and a second image with the second target point via an optical compensation assembly, to indicate an alignment deviation between the first position and the second position; and the optical compensation assembly, located between the second target and the image capture device, and comprising a plurality of optical path regions, wherein the optical compensation assembly moves a first optical path region thereof between the image capture device and the first target, for the image capture device to focus on the first target through the first optical path region, and moves a second optical path region thereof between the image capture device and the second target, for the image capture device to focus on the second target through the second optical path region.

Further, in some embodiments of the disclosure, the plurality of optical path regions are set on a turntable, and the optical compensation assembly switches between the first optical path region and the second optical path region by rotating the turntable.

Further, in some embodiments of the disclosure, the bonding alignment system

further comprising: a microscopic objective lens, wherein the second optical path region is an empty zone, the image capture device focuses on the second target point through the microscopic objective lens, and an optical path plate that compensates for an optical path difference between the first target and the second target is set on the first optical path region, for the image capture device to focus on the first target point through the microscopic objective lens, the optical path plate and the second target.

Further, in some embodiments of the disclosure, the optical path plate adopts a flat glass, and a relationship between a refractive index and a thickness thereof and the optical path difference is represented as: $l = d - d/n$, wherein l is the optical path difference, n is the refractive index of the optical path plate, and d is the thickness of the optical path plate.

Further, in some embodiments of the disclosure, the bonding alignment system is adapted to a plurality of components to be bonded with different thicknesses, and the turntable is provided with a plurality of first optical path regions with corresponding first optical paths.

Further, in some embodiments of the disclosure, the second target point and a first surface of the component to be bonded near the image capture device, are both maintained a second optical path corresponding to the second optical path region with the image capture device, the first target point corresponds to a position on a second surface of the component to be bonded away from the image capture device, and is maintained the corresponding first optical path with the image capture device, and the optical compensation assembly is configured to move the corresponding first optical path region between the image capture device and the first target according to the first optical path, for the image capture device to focus on the first target through the first optical path region.

Further, in some embodiments of the disclosure, the thickness of the component to be bonded is between 40 microns and 600 microns, and optical path plates in corresponding first optical path regions are divided into a plurality of groups according to their refractive indexes, wherein optical path plates from different groups have different refractive indexes, and optical path plates from a same group have a same refractive index

and different thicknesses.

Further, in some embodiments of the disclosure, the first target is provided with a plurality of first target points, the second target is provided with a plurality of corresponding second target points, and the image capture device captures a first image with the plurality of first target points and a second image with the plurality of corresponding second target points via the optical compensation assembly, to improve detection accuracy of the alignment deviation between the first position and the second position.

In addition, a bonding device provided according to the second aspect of the disclosure comprises: a bonding alignment system according to any one of the first aspect, for detecting an alignment deviation between a first position of a wafer to be bonded and a second position of a component to be bonded; a first bonding head for holding the wafer, provided with a first target of the bonding alignment system; and a second bonding head for holding the component to be bonded, provided with a second target of the bonding alignment system, and cooperating with the first bonding head to compensate for the alignment deviation and bond the first position of the wafer to the second position of the component to be bonded.

In addition, A bonding method according to the third aspect of the disclosure comprising following steps: holding a wafer to be bonded via a first bonding head of a bonding device according to the second aspect, and holding a component to be bonded via a second bonding head thereof; moving a first optical path region of an optical compensation assembly of a bonding alignment system in the bonding device, between an image capture device and a first target of the first bonding head, to control the image capture device to focus on the first target through the first optical path region, and capture a first image with a first target point thereof; moving a second optical path region of the optical compensation assembly between the image capture device and a second target of the second bonding head, to control the image capture device to focus on the second target through the second optical path region, and capture a second image with a second target point thereof; determining an alignment deviation between a first position of the wafer

and a second position of the component to be bonded, according to a position difference between the first target point and the second target point in the corresponding image; and compensating for the alignment deviation via the first bonding head and/or the second bonding head, and bonding the first position of the wafer to the second position of the component to be bonded.

Brief Description of the Drawings

The above features and advantages of the disclosure will be better understood after reading the detailed description of the embodiments of the disclosure in conjunction with the following figures. In the figures, components are not necessarily drawn to scale, and components having similar related features may have the same or similar reference numerals.

Fig. 1 shows a schematic diagram of the bonding alignment system provided according to some embodiments of the disclosure.

Fig. 2 shows a schematic diagram of the optical path principle for optical path plate imaging provided according to some embodiments of the disclosure.

Fig. 3 shows a schematic diagram of optical paths of different thickness optical path plates provided according to some embodiments of the disclosure.

Fig. 4 shows a flowchart of the bonding method provided according to some embodiments of the disclosure.

Reference signs:

10	first target
20	second target
201	component to be bonded
30	microscope objective lens
40	optical path plate
50	turntable

Detailed Description of Embodiments

The implementations of the disclosure are described below by specific embodiments. Those skilled in the art can easily understand other advantages and effects of the disclosure from the contents disclosed in the description. Although the description of the disclosure is introduced together with preferred embodiments, it does not mean that the features of the present invention are limited to the embodiments. On the contrary, the purpose of introducing the present invention in combination with the embodiments is to cover other options or modifications that may be extended based on the claims of the present invention. In order to provide a deep understanding of the present invention, the following description will contain many specific details. The present invention can also be implemented without using these details. In addition, in order to avoid confusion or ambiguity of the key points of the present invention, some specific details are omitted in the description.

In the description of the disclosure, it should be noted that, unless otherwise specified and defined, the terms "installation", "connecting" and "connection" should be understood in a broad sense. For example, they can be fixed connection, removable connection or integrated connection; mechanical connection or electrical connection; as well as direct connection, indirect connection through intermediate media or internal connection of two components. For those skilled in the art, the specific meaning of the above terms in the disclosure can be understood in specific cases.

In addition, the words "up", "down", "left", "right", "top", "bottom", "horizontal" and "vertical" used in the following description should be understood as the orientation shown in this paragraph and the relevant drawings. This relative term is only for convenience of explanation, and does not mean that the described device needs to be manufactured or operated in a specific direction, so it should not be understood as a limitation of the disclosure.

It is understood that although the terms "first", "second", "third", etc. can be used here to describe various components, regions, layers and/or parts, these components, regions, layers and/or parts should not be limited by these terms, and these terms are only

used to distinguish different components, regions, layers and/or parts. Therefore, a first component, area, layer and/or part discussed below can be referred to as a second component, area, layer and/or part without departing from some embodiments of the disclosure.

As mentioned above, in the field of semiconductor manufacturing technology, bonding technology can be used to achieve three-dimensional integration of semiconductor devices. By bonding two or more semiconductor structures with the same or different functions, the performance of the chip can be improved. Herein, the bonding process can be distinguished according to the bonding object, including wafer-to-wafer (W2W) bonding, die-to-wafer (D2W) bonding, and die-to-die (D2D) bonding.

In the alignment step of the chip-to-wafer bonding process, the optical microscopy system needs to image the target of the chip and the wafer to calculate their alignment deviation. In the prior art, alignment is achieved by designing glass targets on the carrier head of the chip. The glass target is located on the side of the same plane as the chip. After calibrating the positions of the glass target and the chip target, the glass target can be calibrated with the target directly facing the wafer. However, due to the vertical distance between the two targets, the field depth of the microscope objective cannot cover both of them, and this distance may vary with the thickness of the chip. When adapting to bond different chips, a displacement microscope is required to image glass targets and wafer targets. Therefore, the repeatability and accuracy errors caused by the mechanical displacement will affect the bonding accuracy of the chip and wafer.

In order to overcome the above shortcomings of the prior art, the disclosure provides a bonding alignment system, a bonding device, and a bonding method that uses a simplified device structure to quickly calibrate the alignment deviation, thereby improving the efficiency of bonding alignment.

In some non-limiting embodiments, the bonding alignment system provided by the first aspect of the disclosure can be configured with the bonding device provided by the second aspect of the disclosure, and the bonding method provided by the third aspect of the disclosure can be implemented according to the bonding device provided by the

second aspect of the disclosure.

Specifically, the bonding device provided according to the second aspect of the disclosure comprises a bonding alignment system, a first bonding head, and a second bonding head.

The bonding alignment system is used for detecting an alignment deviation between a first position of a wafer to be bonded and a second position of a component to be bonded. The first bonding head for holding the wafer is provided with a first target of the bonding alignment system. The second bonding head for holding the component to be bonded is provided with a second target of the bonding alignment system, and cooperating with the first bonding head to compensate for the alignment deviation and bond the first position of the wafer to the second position of the component to be bonded.

Please refer to Fig. 1, Fig. 1 shows a schematic diagram of the bonding alignment system provided according to some embodiments of the disclosure

As shown in Fig. 1, the bonding alignment system comprises the first target 10, the transparent second target 20 (e.g. glass material), an image capture device, and an optical compensation assembly.

A first target point is set on the first target 10 to calibrate the first position of a wafer. a transparent second target 20 is located between the first target 10 and the image capture device, wherein a second target point is set on the transparent second target 20 to calibrate a second position of a component to be bonded 201. The image capture device is used for capturing a first image with the first target point and a second image with the second target point via the optical compensation assembly, to indicate the alignment deviation between the first position and the second position. The optical compensation assembly is located between the second target 20 and the image capture device, and comprising a plurality of optical path regions. The optical compensation assembly moves a first optical path region thereof between the image capture device and the first target 10, for the image capture device to focus on the first target 10 through the first optical path region, and moves a second optical path region thereof between the image capture device and the second target 20, for the image capture device to focus on the second target 20 through the second

optical path region.

In some embodiments, the plurality of optical path regions are set on a turntable 50, and the optical compensation assembly switches between the first optical path region and the second optical path region by rotating the turntable 50.

In some embodiments, the bonding alignment system also comprises a microscopic objective lens 30. The second optical path region is an empty zone, the image capture device focuses on the second target point through the microscopic objective lens 30, and an optical path plate 40 that compensates for an optical path difference between the first target 10 and the second target 20 is set on the first optical path region, for the image capture device to focus on the first target point through the microscopic objective lens 30, the optical path plate 40 and the second target 20.

Please refer to Fig. 2~Fig. 3. Fig. 2 shows a schematic diagram of the optical path principle for optical path plate imaging provided according to some embodiments of the disclosure. Fig. 3 shows an optical path schematic of different thickness optical path plates provided according to some embodiments of the disclosure.

As shown in Fig. 2, the optical path plate 40 adopts a flat glass to avoid optical errors such as spherical aberration, chromatic aberration, and coma introduced by the curvature lens. A relationship between a refractive index and a thickness of the flat glass and the optical path difference is represented as:

$$l = d - d/n,$$

wherein l is the optical path difference, n is the refractive index of the optical path plate 40, and d is the thickness of the optical path plate 40.

As shown in Fig. 3, the bonding alignment system is adapted to a plurality of components to be bonded 201 with different thicknesses, and the turntable 50 is provided with a plurality of first optical path regions with corresponding first optical paths.

The second target point and a first surface of the component to be bonded 201 near the image capture device, are both maintained the second optical path corresponding to the second optical path region with the image capture device. The first target point corresponds to a position on a second surface of the component to be bonded 201 away

from the image capture device, and is maintained the corresponding first optical path with the image capture device. The optical compensation assembly is configured to move the corresponding first optical path region between the image capture device and the first target 10 according to the first optical path, for the image capture device to focus on the first target 10 through the first optical path region.

In some embodiments, the thickness of the component to be bonded 201 is between 40 microns and 600 microns, and optical path plates 40 in corresponding first optical path regions are divided into a plurality of groups according to their refractive indexes. The optical path plates 40 from different groups have different refractive indexes, and optical path plates 40 from a same group have a same refractive index and different thicknesses to adapt to a large thickness range. Specifically, this grouping method can avoid the excessive absorption of light energy by the thick optical path plate 40, which would otherwise affect the imaging quality. On the other hand, it can balance the weight differences at various positions of the turntable 50 to avoid alignment errors caused by the tilt of the turntable 50.

In some embodiments, changes in the thickness of the bonded component 201 may correspondingly result in optical path differences that cause focal drift of the microscopic objective lens 30. For example, for the component to be bonded 201 with a first thickness t_1 (e.g. 40 μm), an optical path plate 40 with a first refractive index n_1 (e.g. 1.52) and a first thickness d_1 (e.g. 117 μm) can be used. For chips with a second thickness t_2 (e.g. 600 μm), an optical path plate 40 with a second refractive index n_2 (e.g. 1.51) and a second thickness d_2 (e.g. 1776 μm) can be used.

In some embodiments, the first target 10 is provided with a plurality of first target points, the second target 20 is provided with a plurality of corresponding second target points, and the image capture device captures the first image with the plurality of first target points and the second image with the plurality of corresponding second target points via the optical compensation assembly, to improve detection accuracy of the alignment deviation between the first position and the second position.

The working principle of the above bonding alignment system and bonding device

will be described below in conjunction with some embodiments of some bonding methods. Those skilled in the art can understand that the embodiments of these bonding methods only provide some non-limiting implementations of the disclosure, which is intended to clearly display the main idea of the disclosure, and provide some specific proposals that are convenient for the public to implement, rather than limiting all working modes or all functions of the bonding alignment system and bonding device. Similarly, the bonding alignment system and the bonding device are only non-limiting embodiments provided by the disclosure, and does not limit the implementation subject to each step in these image processing methods.

Please refer to Fig.4, Fig. 4 shows a flowchart of the bonding method provided according to some embodiments of the disclosure.

As shown in Fig. 4, the bonding method first comprises holding a wafer to be bonded via a first bonding head of a bonding device, and holding a component to be bonded 201 via a second bonding head thereof.

Then, the bonding method further comprises:

moving a first optical path region of the optical compensation assembly of a bonding alignment system in the bonding device, between the image capture device and the first target 10 of the first bonding head, to control the image capture device to focus on the first target 10 through the first optical path region, and capture the first image with the first target point thereof;

moving the second optical path region of the optical compensation assembly between the image capture device and the second target 20 of the second bonding head, to control the image capture device to focus on the second target 20 through the second optical path region, and capture the second image with the second target point thereof;

determining the alignment deviation between the first position of the wafer and a second position of the component to be bonded, according to a position difference between the first target point and the second target point in the corresponding image; and

compensating for the alignment deviation via the first bonding head and/or the second bonding head, and bonding the first position of the wafer to the second position of

the component to be bonded 201.

In summary, the bonding alignment system, bonding device, and bonding method provided by the disclosure can use a simplified device structure to quickly calibrate the alignment deviation, thereby improving the efficiency of bonding alignment.

Although the above methods are illustrated and described as a series of actions in order to simplify the explanation, it should be understood and appreciated that these methods are not limited by the order of actions, because according to one or more embodiments, some actions can occur in different order and/or concurrently with other actions from the illustrations and descriptions herein or not illustrated and described herein, but can be understood by those skilled in the art.

The previous description of the disclosure is provided to enable any person skilled in the art to make or use the present invention. Various modifications to the present invention will be apparent to those skilled in the art, and the universal principles defined herein can be applied to other variants without departing from the spirit or scope of the present invention. Therefore, this present invention is not intended to be limited to the examples and designs described herein, but should be granted the widest scope consistent with the principles and novel features disclosed herein.

Claims

1. A bonding alignment system, comprising:
a first target, on which a first target point is set to calibrate a first position of a wafer;
a transparent second target, located between the first target and an image capture device, wherein a second target point is set on the transparent second target to calibrate a second position of a component to be bonded;
the image capture device, for capturing a first image with the first target point and a second image with the second target point via an optical compensation assembly, to indicate an alignment deviation between the first position and the second position; and
the optical compensation assembly, located between the second target and the image capture device, and comprising a plurality of optical path regions, wherein the optical compensation assembly moves a first optical path region thereof between the image capture device and the first target, for the image capture device to focus on the first target through the first optical path region, and moves a second optical path region thereof between the image capture device and the second target, for the image capture device to focus on the second target through the second optical path region.

2. The bonding alignment system according to claim 1, wherein the plurality of optical path regions are set on a turntable, and the optical compensation assembly switches between the first optical path region and the second optical path region by rotating the turntable.

3. The bonding alignment system according to claim 2, further comprising:
a microscopic objective lens, wherein the second optical path region is an empty zone, the image capture device focuses on the second target point through the microscopic objective lens, and an optical path plate that compensates for an optical path difference between the first target and the second target is set on the first optical path region, for the image capture device to focus on the first target point through the microscopic objective lens, the optical path plate and the second target.

4. The bonding alignment system according to claim 3, wherein the optical path plate adopts a flat glass, and a relationship between a refractive index and a thickness thereof and the optical path difference is represented as:

$$l = d - d/n,$$

wherein l is the optical path difference, n is the refractive index of the optical path

plate, and d is the thickness of the optical path plate.

5. The bonding alignment system as claimed in claim 4, wherein the bonding alignment system is adapted to a plurality of components to be bonded with different thicknesses, and the turntable is provided with a plurality of first optical path regions with corresponding first optical paths.

6. The bonding alignment system according to claim 5, wherein the second target point and a first surface of the component to be bonded near the image capture device, are both maintained a second optical path corresponding to the second optical path region with the image capture device,

the first target point corresponds to a position on a second surface of the component to be bonded away from the image capture device, and is maintained the corresponding first optical path with the image capture device, and

the optical compensation assembly is configured to move the corresponding first optical path region between the image capture device and the first target according to the first optical path, for the image capture device to focus on the first target through the first optical path region.

7. The bonding alignment system according to claim 5, wherein the thickness of the component to be bonded is between 40 microns and 600 microns, and optical path plates in corresponding first optical path regions are divided into a plurality of groups according to their refractive indexes, wherein optical path plates from different groups have different refractive indexes, and optical path plates from a same group have a same refractive index and different thicknesses.

8. The bonding alignment system according to claim 1, wherein the first target is provided with a plurality of first target points, the second target is provided with a plurality of corresponding second target points, and the image capture device captures a first image with the plurality of first target points and a second image with the plurality of corresponding second target points via the optical compensation assembly, to improve detection accuracy of the alignment deviation between the first position and the second position.

9. A bonding device, comprising:

a bonding alignment system according to any one of claims 1~8, for detecting an

alignment deviation between a first position of a wafer to be bonded and a second position of a component to be bonded;

a first bonding head for holding the wafer, provided with a first target of the bonding alignment system; and

a second bonding head for holding the component to be bonded, provided with a second target of the bonding alignment system, and cooperating with the first bonding head to compensate for the alignment deviation and bond the first position of the wafer to the second position of the component to be bonded.

10. A bonding method, comprising following steps:

holding a wafer to be bonded via a first bonding head of a bonding device according to claim 9, and holding a component to be bonded via a second bonding head thereof;

moving a first optical path region of an optical compensation assembly of a bonding alignment system in the bonding device, between an image capture device and a first target of the first bonding head, to control the image capture device to focus on the first target through the first optical path region, and capture a first image with a first target point thereof;

moving a second optical path region of the optical compensation assembly between the image capture device and a second target of the second bonding head, to control the image capture device to focus on the second target through the second optical path region, and capture a second image with a second target point thereof;

determining an alignment deviation between a first position of the wafer and a second position of the component to be bonded, according to a position difference between the first target point and the second target point in the corresponding image; and

compensating for the alignment deviation via the first bonding head and/or the second bonding head, and bonding the first position of the wafer to the second position of the component to be bonded.