Receiving Means for Mounting of Wafers

The invention relates to a receiving means for receiving and mounting of wafers and a device and a method for aligning a first wafer with a second wafer using the receiving means.

These receiving means or sample holders or chucks are available in diverse versions and a flat receiving surface or mounting surface is decisive for the receiving means, so that the structures which are becoming smaller and smaller can be correctly aligned and bonded on wafer surfaces which are larger and larger over the entire wafer surface. This is especially important when a so-called prebonding step which joins the wafers to one another by means of a separable interconnection is carried out before the actual bond process. High alignment accuracy of the wafers to one another is especially important as soon as an alignment accuracy or especially distortion values of < 2 μm are to be achieved for all structures located on one or both wafers. In the vicinity of the alignment marks this succeeds especially well in the indicated receiving means and devices for alignment, so-called aligners, especially bond aligners. With increasing distance from the alignment marks, controlled and perfect alignment with alignment accuracies or especially distortion values better than 2 μm, especially better than 1 μm and even more preferably better than 0.25 μm cannot be achieved.

Embodiments of this invention improve generic receiving means such that more accurate alignment can be achieved with them.

According to a first aspect, there is provided a device for alignment of a first wafer with a second wafer, the device including: a means for determining local alignment errors in form of a vector field with distortion vectors which local alignment errors have occurred due to strain or distortion of the first wafer relative to a second wafer, a receiving means for receiving and mounting of the wafers, the receiving means including: a mounting surface, mounting means for mounting of the wafer on the mounting surface, and compensation means including piezoelements for active, locally controllable, compensation of global distortions of the wafer, wherein the mounting surface can be stretched or shrunk for deforming the wafer accordingly, and alignment of the wafers with consideration of the vector field and simultaneous compensation by the compensation means.

According to a second aspect, there is provided a method for alignment of a first wafer with a second wafer, the method including the steps of: detecting a vector field with distortion vectors of the first wafer or a vector field with distortion vectors of the second wafer and evaluation of the vector field by evaluation means and determination of the local alignment errors, receiving one of the wafers on a receiving means for receiving and mounting of the wafers, the receiving means including: a mounting surface, mounting means for mounting of the wafer on the mounting surface, and compensation means including piezoelements for active, locally controllable, compensation of global distortions of the wafer, wherein the mounting surface can be stretched or shrunk for deforming the wafer accordingly, and alignment of the wafers with consideration of the vector field and simultaneous compensation by the compensation means.

Advantageous embodiments of the invention are also disclosed. All

combinations of at least two of the features given in the specification, the claims and/or the figures also fall within the framework of the invention. At the given value ranges, values within the indicated limits will also be disclosed as boundary values and will be claimed in any combination.

The invention is based on the finding of the applicant according to European patent applications EP 09012023 and EP 10 015 569, with the former a detection of the entire surface, especially the positions of the structures on the surface of each wafer as a position map of the wafer being possible. The latter invention relates to a device for determining local alignment errors which have occurred due to strain and/or distortion of the first wafer relative to a second wafer when the first wafer is joined to the second wafer, with the following:

- a first strain map of strain values along a first contact surface of the first wafer and/or
- a second strain map of strain values along a second contact surface and
- evaluation means for evaluating the first and/or second strain maps by which the local alignment errors can be determined.

The basic idea of this invention is to provide a receiving means consisting of several active control elements which are independent of one another and with which the mounting surface of the receiving means can be influenced, especially in shape and/or temperature. Here the active control elements are used by the corresponding activation such that the local alignment errors or local distortions which are known by means of the position maps and/or strain maps are compensated or for the most part minimized or reduced. Here not only are local distortions eliminated, but a macroscopic distortion or stretching of the wafer which arises from the local distortions altogether in its outside dimensions is at the same time minimized or corrected.

Thus, as claimed in the invention, especially in combination with the above described

inventions relating to the position maps, strain maps and/or stress maps and the in-situ correction of alignment faults disclosed there during contact-making and bonding of the wafers, it is possible to achieve a still better alignment result by active, especially local action on distortions of the wafer.

According to one advantageous embodiment of the invention it is provided that the temperature of the mounting surface can be locally influenced by the compensation means. A local temperature increase of the mounting surface leads to local expansion of the wafer which is held on the mounting surface at this position. The higher the temperature gradient, the more the wafer expands at this position. Based on the data of the position maps and/or strain maps, especially the vector evaluation of the alignment error, especially for each position of the position maps and/or strain maps, it is possible to act on local wafer distortions or to counteract them in a controlled manner.

In this connection vector evaluation is defined as a vector field with distortion vectors, which field has been determined especially by means of one of two versions of the invention described below.

The first version relates to applications in which only one of the two wafers is structured. In this case, it is provided as claimed in the invention that the deviation of the structures is detected, especially the deviation of the geometrical shape from the desired shape. In this case the deviation of the shape of exposure fields, especially exposure fields of a step & repeat exposure device, from the nominally expected shape which is conventionally rectangular is of special interest. These deviations, especially the vector field which describes these deviations, can take place based on the detection of a position map of the individual alignment marks which correspond to the exposure fields according to EP 09012023. Alternatively this vector field can also be determined based on

stress maps and/or strain maps which are acquired by means of EP 10 015 569.6. Advantageously this vector field can however as claimed in the invention also be determined by any other suitable measurement means and can be read in. In particular, step & repeat lithography systems which are operated for acquisition of these data with a special test mask and/or a special test routine are suitable for this measurement.

The second version relates to applications in which two wafers are structured. In this case it is provided as claimed in the invention that the vector field of the alignment deviation be computed for all positions of the position maps, especially of the first and second position maps according to EP 09012023. This vector field is to be determined especially for the alignment position which is considered ideal according to technological and/or economical criteria according to the material in EP 10 015 569.6.

In another advantageous embodiment of the invention it is provided that the strain of the mounting surface can be locally influenced by the compensation means, especially by arrangement of piezoelements which can preferably be individually activated on one back of the mounting surface. By stretching or shrinkage, therefore negative stretching, the mounting surface, also the wafer, is deformed accordingly, especially stretched or shrunk, especially by the mounting force acting from the mounting surface on the wafer so that in this way the wafer can be influenced in a controlled manner by a corresponding control means based on the values of the strain map which has been determined for this wafer. To the extent the shape of the mounting surface can be locally influenced by the compensation means, especially by preferably mechanical action in one Z direction, there is another possibility for counteracting distortions of the wafer on the mounting surface. Here it also applies that the control of the compensation means takes place by a control

means which undertakes a correspondingly dedicated local control of the compensation means based on the values of the position maps and/or strain maps.

The control means encompasses especially software for executing/computing corresponding routines.

According to another advantageous embodiment of the invention, it is provided that the mounting surface can be locally exposed to pressure from the back of the mounting surface, by the compensation means, especially hydraulically and/or pneumatically. In this way the shape of the mounting surface can likewise be influenced so that the aforementioned effects arise. Control likewise takes place again by the above described control means.

Advantageously the compensation means are provided as a plurality of active control elements in the receiving means, especially integrated, preferably embedded into the mounting surface. Thus a receiver of the receiving means can be made monolithic, as is likewise the case in the known receiving means.

Here it is especially advantageous if each control element or groups of control elements can be activated separately. Accordingly local activation means that a small extract, especially an extract smaller than half the wafer, preferably smaller than 1/4 of the wafer, preferably smaller than 1/8 of the wafer, even more preferably smaller than 1/16 of the wafer, can be locally activated by the compensation means. It is especially advantageous if the compensation means can act on each region of the wafer occupied by its own structure with at least one control element.

The device as claimed in the invention comprises the above described control means advantageously in a central control unit which is responsible for all control processes. But as claimed in the invention it is conceivable to provide the control means in the receiving means,

especially as a module of an overall device.

The method as claimed in the invention can be still further improved by there being one, especially repeated, acquisition of position maps and/or strain maps of the first and/or second wafer after the alignment. Thus as claimed in the invention after completed alignment there can be checking of the alignment success. Accordingly it is conceivable to eliminate a wafer pair with overly large alignment errors in order for example to align them again as claimed in the invention or to dispose of them. At the same time the acquired data can be used for self-calibration of the device, especially by the control means.

The inventions disclosed in European patent application EP 09012023.9 and/or the European patent application EP 10 015 569.6 will be considered as concomitantly disclosed at the same time as embodiments for this invention.

Other advantages, features and details of the invention will become apparent from the following description of preferred exemplary embodiments and using the drawings.

Figure 1a shows a plan view of a receiving means as claimed in the invention in a first embodiment,

Figure 1b shows a cross sectional view of the receiving means according to cutting line A-A from Figure 1a,

Figure 2a shows a plan view of a receiving means as claimed in the invention in a second embodiment,

Figure 2b shows a cross sectional view of the receiving means according to cutting line B-B from Figure 2a,

Figure 3a shows a plan view of a receiving means as claimed in the invention in a third

embodiment,

Figure 3b shows a cross sectional view of the receiving means according to cutting line C-C from Figure 3a,

Figure 4a shows a plan view of a receiving means as claimed in the invention in a fourth embodiment,

Figure 4b shows a cross sectional view of the receiving means according to cutting line D-D from Figure 4a.

The same components/features and components/features with the same action are identified with the same reference numbers in the figures.

All four embodiments show a monolithic receiver 1 which, as a flat, preferably circular ring-shaped plate, is provided with a flat mounting surface 1o for receiving and mounting of wafers. On the outer periphery the receiver has a ring-shaped shoulder 1a.

The mounting surface 1o forms a receiving plane for receiving the wafer, which plane extends in the X and Y direction. The Z direction, in which the mounting force acting on the water is pointed, runs perpendicular to them. Mounting of the wafer takes place through openings 2 which are arranged uniformly distributed in a plurality over the mounting surface 10 in order to be able to hold the wafer on the mounting surface 1o by applying negative pressure to the openings 2. The larger the number of openings 2 and the smaller the diameter of the openings 2, the less the negative pressure prevailing on the openings 2 for mounting of the wafer leads to distortions of the wafer on the openings 2.

The negative pressure on the openings 2 is applied via a vacuum means which is not shown and which applies negative pressure to an interior space 1i located on the back side of the mounting

surface 1o. The interior space 1i is furthermore bordered by a peripheral wall 1w of the receiver 1 and is sealed relative to the vicinity. The openings 2 extend from the mounting surface 1o as far as the interior space 1i and can thus be uniformly exposed to the negative pressure prevailing in the interior space 1i.

The interior space 1i is furthermore bordered by the back 1r located opposite the mounting surface 1o and by the bottom of the interior space 1i which is not shown, the back 1r being penetrated by openings 2.

On the back 1r the active control elements are a plurality of heating/cooling elements, especially exclusively heating elements 3. The heating elements 3 are each activated individually or in groups, control taking place by a control means which is not shown. When one of the heating elements 3 is heated, a local section of the mounting surface 1o is heated by the material with very good heat conduction, especially metal, of the receiver. This leads to local expansion of a wafer which lies on the mounting surface 1o in this region. Thus, for wafers which are held aligned accordingly on the receiving means and with a known position of possible distortions/ strains, a deformation of the wafer can be caused in a controlled manner by switching individual or several heating elements 3 in order to compensate for local distortions. Especially for a plurality of local compensations, this also yields global compensation of global distortions, especially a change of the diameter of the wafer in the X and/or Y direction.

One special advantage of influencing the distortions on the wafer by means of the heating and/or cooling elements lies in the possibility of being able to achieve this with minimum deformation, especially without deformation of the mounting surface and/or especially without deformation of the wafer in the vertical direction or Z direction. In this connection, minimum

deformation should be considered to be deformation of the mounting surface and especially of the wafer in the vertical direction or in the Z-direction relative to the support surface of < 5 µm, advantageously < 2 µm, preferably < 1 µm and even more preferably < 0.5 µm.

This is especially advantageous for production of prebonding interconnections, for example for prebonds, which are based on van-der-Waals bonds. Based on the fact that here the mounting surface and especially the wafer can be kept flat, the bond wave which is conventional in these prebonding steps is not influenced in its propagation by unevenness. Thus the risk that unbonded sites (so-called voids) remain is greatly reduced. For producing these prebonding interconnections, as claimed in the invention evenness of the mounting surface of < 5 µm, advantageously < 2 µm, preferably < 1 µm and even more preferably < 0.5 µm over the entire wafer surface is desired. These evenness values are defined as the distance between the highest and the lowest point within that part of the mounting surface which is in contact with the wafer.

The heating elements 3 are advantageously uniformly distributed under the mounting surface 1o. Advantageously there are more than 10 heating elements 3, especially more than 50 heating elements 3, preferably more than 100 heating elements 3, even more preferably more than 500 heating elements 3, in the receiving means. These heating elements form regions which can be separately activated in the mounting surface and which enable local action on the wafer. Advantageously the individual regions of the mounting surface are thermally insulated from one another with suitable means. In particular, the regions are made in a form which enables a uniform and closed arrangement of the individual segments. Advantageously the execution of the segments as triangles, squares or hexagons is suitable for this purpose.

In particular Peltier elements are suitable as heating elements 3.

In the second embodiment shown in Figures 2a and 2b, heating elements 3 are not shown and instead of or in combination with them there are piezoelements 4 on the mounting surface 1o, preferably with a greater distance to the back 1r than to the mounting surface 1o.

In this way a controlled action on the mounting surface 1o is possible. The piezoelements 4 can cause strains in the nanometer to micron range upon activation.

The number of piezoelements 4 can correspond to the aforementioned number of heating elements 3, a combination of the two embodiments being conceivable as claimed in the invention.

In the third embodiment of the invention shown in Figures 3a and 3b, instead of or in combination with the heating elements 3 and/or the piezoelements 4 there are pins 5 which end on the mounting surface 1o with an especially pointed pin end 5e. In the initial position of the pins 5 the pin end 5e is flush with the mounting surface 1o. To the extent there is a local distortion of a wafer in the region of a certain pin 5 as information of the distortion map or strain map, the control means can act locally on the wafer by activating individual or several pins 5 by the pin 5 or the pin end 5e being moved in the Z direction in the direction of the wafer. The pin end 5e thus locally exposes the wafer to a compressive force which provides for a local bulging or deflection of the wafer at this point. The pin 5 can be guided to slide either as a whole in a guide opening 7 which extends from the mounting surface 1o as far as the back 1r. Alternatively only the pin end 5e can be moved in the pin 5 and the pin 5 or the lower section of the pin is fixed relative to the guide opening 7. In this way special sealing of the pin 5 or of the pins 5 can be ensured relative to the interior space 1r.

The number of pins 5 corresponds to the number of piezoelements 4 or heating elements 3, here a combination with one or more of the aforementioned embodiments being possible.

In the embodiment shown in Figure 4, the receiver 1 has a plurality of pressure chambers 6 which with their upper wall 6o shown in Figure 4b form the mounting surface 1o. The pressure chambers 6 extend through the interior space 1i and are sealed relative to this. Each of the pressure chambers 6 or groups of pressure chambers 6 can be separately pressurized, and control by the described control means can take place. When pressure is applied the pressure chamber 6 is made at least on its upper wall 6o such that it yields when pressure is applied, therefore is made either thinner and/or softer than the other boundary walls of the pressure chambers 6. The openings 2 are connected to the interior space 1i.

As claimed in the invention a simply minimum local deflection of the mounting surface 1o takes place by the aforementioned compensation means 3, 4, 5, 6 by a maximum 3 µm, especially a maximum 1 µm, preferably a maximum 100 nm.

In order to be able to counteract the local distortions with one or more of the aforementioned embodiments, as described above it is necessary that the control means knows where and to what extent or in what direction there are distortions in the wafer. Only then is controlled action or counteraction and compensation of distortions possible. The strain map of each wafer yields information in the form of strain vectors which are distributed over the wafer and which have been determined with a corresponding measurement means according to EP 10 015 569.6. Corresponding control data can be filed in the control unit, especially empirically determined, in order to be able to undertake for each wafer an individual control according to the strain map of the wafer at the positions dictated by the position map of the wafer. Compensation can be carried out automatically in this way during alignment of the wafers.

The active control elements 3, 4, 5, 6 are shown not to scale in the figures and can also have

different sizes and shapes.

List of Reference Numbers

1	receiver
1a	ring-shaped shoulder
1i	interior space
1o	mounting surface
1w	peripheral wall
2	openings
3	heating/cooling elements
4	piezoelements
5	pins
5e	pin end
6	pressure chambers
6o	upper wall
7	guide opening

Claims:

1. A device for alignment of a first wafer with a second wafer, the device comprising:

a means for determining local alignment errors in form of a vector field with distortion vectors which local alignment errors have occurred due to strain or distortion of the first wafer relative to a second wafer,

a receiving means for receiving and mounting of the wafers, the receiving means comprising:

a mounting surface (1o),

mounting means for mounting of the wafer on the mounting surface (1o), and

compensation means (3, 4, 5, 6) comprising piezoelements (4) for active, locally controllable, compensation of global distortions of the wafer,

wherein the mounting surface (1o) can be stretched or shrunk for deforming the wafer accordingly, and alignment of the wafers with consideration of the vector field and simultaneous compensation by the compensation means.

2. The device as claimed in claim 1, wherein the strain of the mounting surface (1o) can be locally influenced by the compensation means (3, 4, 5, 6).

3. The device as claimed in claim 1 or 2, wherein the strain of the mounting surface (1o) can be locally influenced by arrangement of the piezoelements (4).

4. The device as claimed in claim 3, wherein the piezoelements (4) can be individually activated on a back side (1r) of the mounting surface (1o).

5. The device as claimed in claim 1 or 2, wherein the shape of the mounting surface (1o) can be locally influenced by the compensation means (3, 4, 5, 6).

6. The device as claimed in claim 5, wherein the shape of the mounting surface (1o) can be locally influenced by the compensation means by action in a Z direction.

7. The device as claimed in claim 6, wherein the compensation means acts mechanically.

8. The device as claimed in claim 1 or 2, wherein the mounting surface (1o) can be locally exposed to pressure from the back (1r) of the mounting surface (1o) by the compensation means (3, 4, 5, 6).

9. The device as claimed in claim 1 or 2, wherein the compensation means (3, 4, 5, 6) as a plurality of active control elements (3, 4, 5, 6) in the receiving means.

10. The device as claimed in claim 9, wherein the active control elements are integrated into the mounting surface (1o).

11. The device as claimed in claim 9, wherein the active control elements are embedded into the mounting surface (1o).

12. The receiving means as claimed in claim 9, wherein each control element (3, 4, 5, 6) or groups of control elements (3, 4, 5, 6) can be activated separately.

13. A method for alignment of a first wafer with a second wafer, the method comprising the steps of:

detecting a vector field with distortion vectors of the first wafer or a vector field with distortion vectors of the second wafer and evaluation of the vector field by evaluation means and determination of the local alignment errors,

receiving one of the wafers on a receiving means for receiving and mounting of the wafers, the receiving means comprising:

a mounting surface (1o),

mounting means for mounting of the wafer on the mounting surface (1o), and

compensation means (3, 4, 5, 6) comprising piezoelements (4) for active, locally controllable, compensation of global distortions of the wafer,

wherein the mounting surface (1o) can be stretched or shrunk for deforming the wafer accordingly, and alignment of the wafers with consideration of the vector field and simultaneous compensation by the compensation means.

14. The method as claimed in claim 13, wherein the strain of the mounting surface (1o) can be locally influenced by the compensation means (3, 4, 5, 6).

15. The method as claimed in claim 13 or 14, wherein the strain of the mounting surface (1o) can be locally influenced by arrangement of the piezoelements (4).

16. The method as claimed in claim 15, wherein the piezoelements (4) can be individually activated on a back side (1r) of the mounting surface (1o).

17. The method as claimed in claim 13 or 14, wherein the shape of the mounting surface (1o) can be locally influenced by the compensation means (3, 4, 5, 6).

18. The method as claimed in claim 17, wherein the shape of the mounting surface (1o) can be locally influenced by the compensation means by action in a Z direction.

19. The method as claimed in claim 18, wherein the compensation means act mechanically.

20. The method as claimed in claim 13 or 14, wherein the mounting surface (1o) can be locally exposed to pressure from the back (1r) of the mounting surface (1o) by the compensation means (3, 4, 5, 6).

21. The method as claimed in claim 13 or 14, wherein the compensation means (3, 4, 5, 6) as a plurality of active control elements (3, 4, 5, 6) in the receiving means.

22. The method as claimed in claim 21, wherein the active control elements are integrated into the mounting surface (1o).

23. The method as claimed in claim 21, wherein the active control elements are embedded into the mounting surface (1o).

24. The method as claimed in claim 21, wherein each control element (3, 4, 5, 6) or groups of control elements (3, 4, 5, 6) can be activated separately.