Device and Process for Aligning Substrates

Specification

This invention relates to a device for aligning and bringing a large-area substrate into contact with a carrier substrate for the further processing of the substrate as well as a corresponding process and a use.

The back-thinning of wafers is often necessary in the semiconductor industry and can be done mechanically and/or chemically. For back-thinning, the wafers are generally temporarily attached to a carrier system, whereby there are various methods of attachment. As carrier systems, for example, films or wafers made of silicon, silicon alloys such as SiC, SiN, etc., ceramics, (glass-fiber-reinforced) plastics, graphite, sapphire, metals, glasses or composite materials are used. At the end of the back-thinning process and the post-processing, the back-thinned wafers are mounted on film holders, and then the carrier is removed.

As soon as a working of the substrate that goes beyond the back-thinning is necessary, in turn rigid carrier systems, namely carrier substrates, are used. Examples of such working steps in corresponding industrial plants after back-thinning are: metallization, dry etching, wet etching, laser processing, lithography, oven processes, doping, etc.

In the case of a rigid carrier substrate, the product substrate that is to be worked is typically connected by an adhesive layer to the carrier substrate.

cause damage to products and plasma process chambers. Special advantages in plasma and sputter processes are achieved because of the possibility of using a carrier substrate that is the same as/smaller than the product substrate.

- In the case of lithographic exposure on so-called scanners and steppers, inadequately adjusted bond pairs are not loaded with sufficient accuracy. The referencing (pre-alignment) of the bond pair is done based on the outside contour. The outside contour of a (much) larger carrier substrate, however, does not correspond to the position of the passmarks on the product substrate as long as the adjustment of the two outside contours is not precise, or the outside contour of the product substrate cannot be used. The passmarks are thus not in the "capture range" of the microscope, and a laborious search must be made for them. This leads to losses in time, production throughput, and productivity in these systems.

Embodiments of this invention disclose a device and a process for aligning and bringing substrates into contact, with which a more exact and more efficient alignment and bringing substrates into contact with a carrier substrate is made possible.

According to a first aspect of the present invention, there is provided a device for aligning and bringing a large-area substrate into contact with a carrier substrate, for the further processing of the substrate with the following features: a substrate holding means for attaching the large-area substrate, a carrier substrate holding means for attaching the carrier substrate, detection means for detection, at least in sections, of a peripheral ontour of the large-area substrate attached to the substrate holding means and detection, at least in sections, of a peripheral contour of the carrier substrate attached to the carrier substrate holding means relative to a contact plane of the large-area substrate with the carrier substrate, aligning means for aligning the large-area substrate relative to the carrier substrate, whereby the aligning means are controlled by controlling means based on the peripheral contours detected by the detection means, and contacting means for bringing the large-area substrate, aligned relative to the carrier substrate, into contact with the

carrier substrate, wherein the detection means comprises a distance-measuring-system for determination of the distance from the distance-measuring-system to the peripheral contours.

According to a second aspect of the present invention, there is provided a process for aligning and bringing a large-area substrate into contact with a carrier substrate for the further processing of the large-area substrate with the following steps, in particular the following sequence: detection at least in sections of a peripheral contour of the large-area substrate attached to a substrate holding means and detection at least in sections of a peripheral contour of the carrier substrate attached to a carrier substrate holding means by vertical scanning detection means relative to a contact plane of the large-area substrate with the carrier substrate, wherein by a distance-measuring-system the distance from the distance-measuring-system to the peripheral contours is determined, alignment of the large-area substrate relative to the carrier substrate by alignment means, whereby the alignment means are controlled by control means based on the peripheral contours detected by the vertical scanning detection means, and bringing into contact the large-area substrate, aligned relative to the carrier substrate, with the carrier substrate by contacting means.

Also, all combinations that consist of at least two of the features indicated in the specification, the claims and/or the figures fall within the scope of the invention. In the indicated ranges of values, values that lie within the above-mentioned limits are also to be disclosed as boundary values and can be claimed in any combination.

Embodiments of the invention are based on the idea of achieving a more exact alignment by – in particular electronic – detection (detection means) of outside contours of the substrates to be aligned and brought into contact as well as processing (control means) of the detected outside contours in control signals for alignment (alignment means) of the substrates. In this case, it is especially possible according to embodiments of the invention that the alignment is preferably done continuously when substrates are moved on one another to bring them into contact. Moreover, it is especially conceivable according to embodiments of the invention to examine the alignment accuracy with the same detection means and optionally to perform a renewed alignment.

Substrates are defined as product or carrier substrates used in the semiconductor industry. The carrier substrate serves as an enhancement of the function substrate (product substrate) in the different working steps, in particular during back-thinning of the function substrate. Suitable substrates, in particular wafers, come either with smoothing ("flat") or grooves ("notch").

In an embodiment, a product (or a substrate-carrier substrate combination) is provided, which consists of a carrier substrate and a substrate, which have been aligned, brought into contact and prefixed with one another and/or bonded with the device according to embodiments of the invention and/or the process according to embodiments of the invention and in particular are distinguished in that the diameter d2 of the carrier substrate is minimally smaller than the diameter d1 of the product substrate. According to embodiments of the invention, it is thus ensured that the carrier substrate during the processing of the product substrate is exposed to no contamination, fouling or unintentional treatment, etc., whatsoever and therefore can be reused more frequently.

Although the embodiment is primarily suitable to align a carrier substrate, smaller in particular as far as the diameter d2 is concerned, relative to a substrate that is larger in particular as far as the diameter d1 is concerned, the device according to embodiments of the invention can also be used to align carrier substrates toward one another, which carrier substrates are larger than or the same size as the substrates that are to be bonded.

By the detection means being rotatable relative to the substrate and/or relative to the carrier substrate by rotational means and/or adjustable parallel to the contact plane relative to the substrate and/or relative to the carrier substrate by an adjustment system in the X- and/or Y-direction, the alignment can be implemented efficiently and precisely.

According to an advantageous embodiment of the invention, it is provided that the detection means are attached to a carrier unit that is designed in particular to be annular in sections and that can be arranged at least in sections on the peripheral side with respect to the substrate and/or carrier substrate.

Thus, an integration according to embodiments of the invention of the detection means is possible in an efficient way.

Advantageously, the carrier unit is attached between the carrier substrate holding means and the substrate holding means, in particular with contacting means attached in-between, preferably in the form of a Z-adjustment unit and/or with a base plate attached in-between. In this way, an especially efficient configuration of embodiments of the invention is provided.

In this case, in further embodiment of the invention, it is advantageous when the adjustment system is attached, in particular directly, between the base plate and the

carrier unit. Thus, a direct action on the carrier unit, in particular together with the substrate holding means attached thereto, is conceivable.

According to another advantageous embodiment of the invention, it is provided that the peripheral contour and the peripheral contour (both peripheral contours) are detectable, in particular at the same time, with the same, in particular one or more, detection means, preferably microscopes. In this way, the number of costly detection means can be reduced without sacrificing speed.

The alignment of a substrate can also be done according to embodiments of the invention in a substrate stack as a carrier substrate. In this case, a substrate stack is defined as an amount of already worked, for example back-thinned, substrates, which are in particular bonded with one another permanently. According to embodiments of the invention, this substrate stack, when it is thick enough, can serve as a carrier substrate.

The use of a mechanical alignment system (adjustment system and rotation means) is especially preferred both for the substrate and for the carrier substrate in connection with an optical distance-measuring system. In this connection, it is of special advantage when this alignment system is arranged integrated in a unit for bonding or prefixing the substrates.

Embodiments of the invention thus allow an exact, quick and economical alignment of two substrates (substrate and carrier substrate) with respect to one another, without having to refer to the alignment marks. According to embodiments of the invention, carrier substrates can therefore dispense with alignment marks, so that the latter can be produced more advantageously.

In addition, because of embodiments of this invention, repeated use of the carrier substrate is possible, without the latter having to be purified by labor-intensive and costly processes.

Moreover, the possibility arises of incorporating/integrating the device according to embodiments of the invention in a bonder.

With this embodiments of invention, the different diameters of the substrates at several points of the periphery (peripheral contours) are taken into consideration, and a more precise positioning is made possible, which factors are not possible in the case of other mechanical and/or optical positioning processes. At the same time, a faster alignment than in the case of (purely) mechanical alignment is made possible.

The process underlying embodiments of the invention and the device according to embodiments of the invention are able to make possible the necessary accuracies, in particular < 50 μm, and in particular to achieve a higher rotational accuracy on the periphery, which is a weak point in the case of previous mechanical processes. Very precise grooves can be assigned on the periphery of the substrate (so-called "notches") of the substrate and carrier substrate.

Especially advantageously, the grooves are located in such a position that they are detected by at least one detection means. Any detection means whose direction of measurement is parallel or almost parallel to the substrate normal can determine a rotational mis-orientation especially quickly by the position of the grooves. Similar considerations apply to substrates with flats or any other grooves or deviations from a predetermined ideal geometry of the substrate in question, which can be used for rotational alignment.

The process according to embodiments of the invention is in particular a dynamic, optical scanning process with software-controlled optimization of the detected/measured data.

In an advantageous embodiment of the invention, it is provided to attach the carrier substrate and the function substrate in each case to separate, mechanically

sectors/detection sections. For less precise adjustment requirements, rotation of the scanning units can be eliminated. It is also possible not to rotate the scanning units, but rather to rotate the two substrates in the case of stationary scanning units.

As an alternative, several scanning units can also be arranged in a stationary manner around the two substrates, in particular at least 3, in order to determine the position and the diameter of the two outside contours (or idealized circles that correspond in software). In this case, a rotation of substrates and/or scanning units can be omitted. A slight rotation of one substrate relative to the other substrate is in this case sufficient to align the notches or the flats in the rotational direction in the contact plane.

As an alternative, the scanning units can be arranged approximately at right angles to the substrate plane from above or below and can detect the edges of the peripheral contours of the substrates. In a special case, these are microscopes that provide an optical image of the two wafer edges for measurement and evaluation.

One or more of these microscopes can be arranged to be movable according to embodiments of the invention (rotating around fixed/standing substrates) or stationary (with rotating substrates).

In another special case, at least three microscopes are arranged in a stationary manner on the periphery above and/or below the substrates. Both peripheral edges are visible via the microscopes (optionally by refocusing because of the Z-distance (crosswise to the X- and Y-direction or contact plane), which could exceed the depth of focus. The substrate with the larger diameter, which could obscure the view on the peripheral edge of the smaller substrate, can be moved a certain distance by the alignment means and can thus be made visible and positionable. The image information of the two

peripheral edges is converted into a piece of positional information, and the substrates can be aligned precisely with respect to one another.

By software, the necessary calculation of the adjustment paths of the mechanical adjustment elements (alignment means) in the X- and Y-direction as well as the necessary rotation of the substrates can be calculated. This calculation and measurement can be continuously measured and corrected everywhere during the Z-movement (contacting means), i.e., the mechanical engagement of the two substrates.

Because of this online measuring process, it is possible to correct possible deviations during or after the assembly of the substrates or to ensure optimization by separating the units and providing for renewed alignment and bringing into contact.

Because of the device according to embodiments of the invention and the process according to embodiments of the invention, it is also possible to align precisely greatly different substrates, such as different diameters or different geometries, for example round substrates with respect to rectangular substrates.

According to a further embodiment of the invention, it is especially advantageous when the substrate is back-thinned after being brought into contact, whereby the diameter d1 is reduced by the shape of the cross-section of the substrate on its peripheral contour, in particular to d1 <= d2. As a result, the simple further processing of the substrate-carrier substrate combination, in particular in known and standardized units, is made possible.

In this case, it is of special advantage when the substrate has an annular shoulder that is produced in particular by providing an edge radius and/or by looping back the

peripheral contour. The latter can be produced in a simple way and contributes to the further optimization of the production process according to embodiments of the invention.

By an annular width dR of the shoulder being larger than or equal to the difference between d1 and d2, the diameter of the substrate can be reduced to the diameter d2 of the carrier wafer or smaller, so that in the further processing, an optimal support of the product substrate is ensured.

According to another advantageous embodiment of the invention, it is provided that during back-thinning, a thickness D_1 of the substrate is reduced up to or over the shoulder.

The device according to embodiments of the invention is further developed in particular in that the detection means are designed to detect the shape of the cross-section of the substrate on its peripheral contour in such a way that the back-thinning of the substrate can be controlled so that the diameter d1 is reduced, in particular to d1 <= d2. By the detection of the shape of the cross-section, in particular a profile of the cross-sectional contour viewed from the side, i.e., along the thickness D1 of the substrate, in particular an exact control of the back-thinning process can be carried out according to embodiments of the invention.

To the extent that existing device features and/or device features in the following figure description are disclosed, the latter are also to be regarded as disclosed as process features and vice versa.

Further advantages, features and details of the invention follow from the following description of preferred embodiments and based on the drawings. The latter show in:

Fig. 1a A schematic cross-sectional view of a device according to the