METHOD AND DEVICE FOR CHANGING THE POSITION OF A SEMICONDUCTOR WAFER

The present invention relates to the fields of the manufacture of electronic components, more especially the manufacture of integrated circuits from substrates or wafers formed from semiconductor materials such as silicon, more particularly to the mechanical methods and devices permitting a change of position of at least one semiconductor wafer provided with at least one positioning mark and placed in a support intended to house a plurality of semiconductor wafers.

Prior art teaches such methods which consist, more especially, in gripping the semiconductor wafer by one of its faces in order to change its position, more especially to move it from one place to another, the devices which permit these methods to be accomplished, comprising means which permit the wafer to be gripped by suction in the central region of one face of said wafer. Independently of the movement of the wafers from one place to another, the semiconductor wafers are orientated so as to place their positioning mark in a defined position, the latter operation possibly consisting, for example, of aligning the positioning marks of all of the wafers which are intended to be placed or which are in a common support.

The methods and devices of prior art have the disadvantage of permitting the semiconductor wafers to be contaminated because they are gripped by one of their faces which consists of a material very sensitive to various contaminations, this being the more so if the face comes into contact with an object. Furthermore, the methods and devices of prior art take a long time for the displacement and orientation operations of a semiconductor wafer or wafers to be accomplished, these operations

This Sheet Has Been Replaced



being managed independently, thereby leading to longer processing time for the semiconductor wafers, and therefore to higher processing costs.

The semiconductor wafer processing envisaged may be all processing requiring a change of position of one semiconductor wafer, a plurality of semiconductor wafers or all of the semiconductor wafers placed in a common support, for example moving wafers from one support to another, aligning the marks for the purpose of respective identification of the wafers in the support, or simply modifying the angular position of a semiconductor wafer which is in a support, for the purpose of placing the marks in a defined position.

The present invention aims to overcome the above disadvantages and to provide other advantages. One object of the present invention is to permit a change in position of at least one semiconductor wafer, while avoiding any contamination, due to gripping the wafer by one of its faces and furthermore reducing the risks of contamination.

Another object of the present invention is to permit a change in position of at least one semiconductor wafer, making it possible to modify the orientation of a wafer simultaneously with another processing operation, more especially a displacement or a transfer of the wafer.

Another object of the present invention is to save space in a semiconductor wafer processing station, by avoiding a specific installation for orientating or aligning the positioning marks of the wafers.

Another object of the present invention is to permit a plurality of semiconductor wafers to be gripped and orientated, the orientation of the wafers being effected in a simultaneous manner and, furthermore, simultaneously with another operation, more especially a displacement of the plurality of wafers.

This Sheet Has Been Replaced



More specifically, the invention comprises a mechanical method permitting a change in position of at least one semiconductor wafer provided with at least one positioning mark and placed in a support intended to house a plurality of semiconductor wafers, characterised in that it comprises the following steps:

- penetrating said support by means of a gripping arm with a first displacement of said arm in a first spatial direction,
- gripping said at least one semiconductor wafer by the peripheral part of the latter with a second displacement of said arm in a second spatial direction,
- orientating said at least one gripped semiconductor wafer so as to place said positioning mark in a defined position.

Gripping the semiconductor wafer by its peripheral part permits the contamination of this wafer to be reduced and the contamination due to gripping the semiconductor wafer by a face to be avoided, and orientating the wafer when the latter has been gripped permits this operation to be effected simultaneously with other operations, more especially a displacement of the wafer. The operation of orientating a wafer when it has been gripped permits the use of a processing station specifically for orientating the semiconductor wafers to be dispensed with, hence saving space for the processing of the wafers.

According to an advantageous feature, the method according to the invention also comprises the following steps:

- withdrawing said at least one semiconductor wafer from said support with a third displacement of said gripping arm in said first direction, opposite said first displacement,
- displacing said at least one semiconductor wafer from one place to another in space with three directions or dimensions, with displacements

This Sheet Has Been Replaced



of said arm selected from the three spatial directions, said step comprising orientating said at least one semiconductor wafer so as to place said positioning mark in a defined position, this occurring simultaneously with the displacements of said gripping arm.

The invention also relates to a mechanical method permitting a change in position of a plurality of semiconductor wafers provided with at least one positioning mark and placed in a support, characterised in that it comprises the following steps:

- penetrating said support by means of a gripping arm with a first displacement of said arm in a first spatial direction,
- gripping a plurality of semiconductor wafers by the peripheral part of said wafers with a second displacement of said arm in a second spatial direction,
- orientating said gripped semiconductor wafers so as to align said respective positioning marks of said semiconductor wafers.

According to an advantageous feature, the above method also comprises the following steps:

- withdrawing said plurality of semiconductor wafers from said support with a third displacement of said gripping arm in said first direction, opposite said first displacement,
- displacing said plurality of semiconductor wafers from one place to another in space with three directions or dimensions, with displacements of said arm selected from the three spatial directions, said step comprising orientating said gripped semiconductor wafers so as to align their respective positioning marks, this occurring simultaneously with the displacements of said gripping arm.

The invention also relates to a device permitting a change in position of at least one semiconductor wafer provided with at least one

This Sheet Has Been Replaced



positioning mark and placed in a support intended to house a plurality of semiconductor wafers, said device comprising a gripping arm for gripping said at least one semiconductor wafer and means for displacing said gripping arm, said gripping arm comprising:

- means for gripping said at least one semiconductor wafer by the peripheral part,
- means for orientating said at least one semiconductor wafer, which means co-operate with said gripping means in order to place said positioning mark in a defined position,

said device being characterised in that said displacement means for displacing said gripping arm comprise means for displacement in three spatial directions, and in that said gripping means and said orientation means are disposed on a rigid structure, said gripping means being distributed over the perimeter of the peripheral part of said at least one semiconductor wafer.

According to an advantageous feature, said gripping means comprise:

- means for gripping a plurality of semiconductor wafers by the peripheral part,
- means for orientating said gripped semiconductor wafers, which means co-operate with said gripping means in order to align said respective positioning marks of said semiconductor wafers.

The invention also relates to an arm for gripping a semiconductor wafer provided with at least one positioning mark, permitting gripping of at least one semiconductor wafer placed in a support intended for housing a plurality of semiconductor wafers, said arm comprising:

- means for gripping said at least one semiconductor wafer by the peripheral part,

This Sheet Has Been Replaced



- means for orientating said at least one semiconductor wafer, which means co-operate with said gripping means in order to place said positioning mark in a defined position,

said arm being characterised in that said gripping means and said orientation means are disposed on a rigid structure, said gripping means being distributed over the perimeter of the peripheral part of said at least one semiconductor wafer.

According to an advantageous feature, said means comprise at least three stops provided respectively with a degree of rotational freedom and distributed around the perimeter of the peripheral part of said at least one semiconductor wafer, and said orientation means comprise a driving roller for driving said at least one semiconductor wafer by friction.

According to another advantageous feature, said driving roller is formed by one of said three stops which is made at least partially drivable.

According to another advantageous feature, said positioning mark is a notch placed on the peripheral part of said at least one semiconductor wafer, and said three stops comprise respectively two adjacent and rotationally free driven rollers.

According to another advantageous feature, said driven rollers comprise, respectively, at least one first frustoconical contact surface, in order to permit said at least one semiconductor wafer to be supported by means of a peripheral edge thereof.

According to another advantageous feature, a generatrix of said at least one first frustoconical contact surface forms an angle of between 5° and 45° with a perpendicular to said at least one semiconductor wafer.

According to another advantageous feature, said driven rollers comprise, respectively, a second frustoconical surface, the top of which

This Sheet Has Been Replaced



is connected to the base of said first frustoconical surface, and the generatrix of which forms an angle with a perpendicular to said at least one semiconductor wafer greater than the angle of the generatrix of said first frustoconical surface.

According to another advantageous feature, said orientation means comprise a first beam, capable of being cut when said notch is not opposite said first beam, and a detector which detects that said first beam has been cut.

According to another advantageous feature, the gripping arm according to the invention comprises locating means for locating the position of said at least one semiconductor wafer when it is placed in said support.

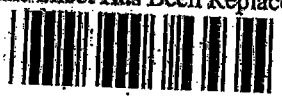
According to another advantageous feature, said marking means comprise a second beam which co-operates with said first beam and a characteristic dimension of said at least one semiconductor wafer in order to permit the position of said at least one semiconductor wafer in said support to be established.

According to another advantageous feature, said locating means comprise a third beam which interacts with said first beam or said second beam and a characteristic dimension of said at least one semiconductor wafer in order to permit the position of said at least one semiconductor wafer in said support to be established when said first or second beam is placed opposite said notch.

According to another advantageous feature, the gripping arm according to the invention comprises:

- means for gripping a plurality of semiconductor wafers by their peripheral part,

This Sheet Has Been Replaced



- means for orientating said gripped semiconductor wafers, which means co-operate with said gripping means in order to align said respective positioning marks of said semiconductor wafers.

The invention will be more clearly understood, and further features and advantages will appear, on reading the following description of examples of embodiments of methods, devices and gripping arms according to the invention, together with the accompanying drawings, the examples being given by way of illustration and without any restrictive interpretation of the invention being able to be drawn therefrom.

Figure 1A illustrates, in perspective, one embodiment of a device according to the invention, permitting the position of at least one semiconductor wafer to be changed.

Figure 1B illustrates, in perspective, an enlarged detail of Figure 1A.

Figure 2 illustrates, in perspective, a first embodiment of a gripping arm according to the invention.

Figure 3 is a plan view of the example in Figure 2.

Figure 4 is a side elevational view of the example in Figure 2.

Figure 5 is a side elevational view of a first enlarged detail of the example in Figure 2.

Figure 6 illustrates a second enlarged detail of the example in Figure 2, in partial cross-section.

Figure 7 illustrates, in perspective, a second embodiment of a gripping arm according to the invention;

The device 100 illustrated in Figure 1A and, partially, in Figure 1B, permitting a change in position of the semiconductor wafers provided, respectively, with a positioning mark and placed in a support (not illustrated) intended to house a plurality of semiconductor wafers,

This Sheet Has Been Replaced



comprises means 110 for gripping a semiconductor wafer, and means 120 for displacing the gripping means 110. The gripping means 110 will be explained in detail later, with the aid of Figures 2 to 6, and comprise means 5 for gripping the semiconductor wafer by its peripheral part and means 6 for orientating the semiconductor wafer, which means co-operate with the gripping means 5 in order to place the positioning mark in a defined position.

The device 100 comprises a frame 101 onto which fit two semiconductor wafer supports (not illustrated). The two supports fit respectively onto receiving trays (not illustrated), said receiving trays being placed, for example, beside one another and vertically in line with the doors 102 and 103, and have wafers superimposed in respective housings in the support, in a horizontal position. The device 100 permits semiconductor wafers to be transferred from one support to another while enabling the respective marks on these wafers to be placed in a defined position. For this purpose, the gripping means 110 are connected to displacement means 120, so that they can be displaced in the three spatial dimensions X, Y and Z, as illustrated in Figure 1A and, partially, in Figure 1B.

The gripping means 110 placed opposite a first support, fixed, for example, vertically in line with the door 103, thus permit the selection of the semiconductor wafer to be gripped in this support, by means of the Z displacement, then to enter the support by means of the Y displacement, to grip the wafer by means of the upward Z displacement without striking the wafer possibly placed thereabove, to remove the wafer from the support by means of a reverse Y displacement and to use the X and Z displacements to position the gripping means 110 opposite the second support placed vertically in line with the door 102 and the appropriate

This Sheet Has Been Replaced



housing in this support for the gripped wafer. During these displacements, the semiconductor wafer will advantageously be orientated in a defined position, for example so that all the semiconductor wafers have their respective marks aligned. It should be noted that, depending on the requirements, the device illustrated in Figure 1A permits the wafers in one support to be orientated without moving them into the other support; to do this, all that is required is to place the gripping means 110 in a position for gripping a wafer in its support, i.e. to place the means 110 beneath the wafer to be gripped, to grip the wafer by means of the upward Z displacement, without striking the wafer possibly placed thereabove, to orientate the wafer into the selected position, before depositing it again in the same housing, and then to remove the gripping means 110.

Figure 1B shows the gripping means 110 connected to a first part 121 of the displacement means 120, so as to permit the gripping means to be displaced with a degree of translational freedom in the Z direction. This first part 121 of the displacement means is connected, with a degree of translational freedom in the Y direction, to a second part 122 of the displacement means 120, said second part itself being connected, with a degree of translational freedom in the X direction, to the frame 101 of the device 100, as illustrated in Figure 1A.

According to an alternative, not illustrated, the gripping means may comprise means for gripping a plurality of semiconductor wafers by their peripheral part and means for orientating the gripped semiconductor wafers, which means co-operate with the gripping means in order to align the respective positioning marks of said semiconductor wafers. This alternative may be obtained, on the device 100 illustrated, by replacing

This Sheet Has Been Replaced



the gripping means 110 with the gripping arm illustrated in Figure 7 and described later.

It should be noted that the gripping arm 1 illustrated in Figures 2 to 4 constitutes the gripping means 110 of the device 100 illustrated in Figure 1A and, partially, in Figure 1B.

The gripping arm 1 illustrated in Figures 2 to 4 makes it possible to grip a semiconductor wafer 2, in the form of a disk, placed in a support (not illustrated) intended to house a plurality of similar semiconductor wafers. The semiconductor wafers 2 are respectively provided with a positioning mark 3 which is substantially in the form of a notch 3 formed on the peripheral part 4 of the wafer 2. The surface formed by the end face of the semiconductor wafer 2, including the two end edges of this surface, is called the peripheral part 4 of the wafer. This surface formed by the end face may, for example, be cylindrical or it may have substantially the shape of an external circular half-torus. The peripheral part of the wafer may, alternatively, comprise the upper and lower annular surfaces of the ends of the wafer, in the form of a thin crown.

The gripping arm 1 illustrated in Figures 2 to 4 comprises means 5 for gripping the semiconductor wafer 2 by its peripheral part 4 and means 6 for orientating the semiconductor wafer 2, which means co-operate with the gripping means 5 in order to place the positioning mark 3 in a defined position, as will be explained later.

The gripping means 5 and orientation means 6 are disposed on a rigid structure 7, permitting it to be inserted, at least partially, between two successive wafers placed in a support, for example as illustrated in Figure 4 between wafers 2 and 2B illustrated by the dot-dash lines. The upper wafer 2A, in dot-dash lines, represents the semiconductor wafer placed in the support (not illustrated) and which is not to be struck when

This Sheet Has Been Replaced



the wafer 2 is gripped. Advantageously, the gripping means comprise three stops 8, provided respectively with a degree of rotational freedom and distributed around the perimeter of the peripheral part 4 of the wafer 2, and the orientation means 6 comprise a roller 9 for driving the wafer 2 by friction.

The rigid structure 7 may, for example, be in the form of a U-shaped profile, at the base of which there are two of the three stops 8, the third stop 8 being disposed on one branch 10 of the U and the driving roller 9 being disposed on the other branch 11 of the U, as illustrated in Figure 3. A reinforcing bar 12 may connect the branches of the U at mid-height, as illustrated in Figure 3. The shape of the rigid structure 7 may vary widely, said structure having to be able to be partly inserted between two successive wafers so that the gripping means 5 can grip a wafer by its peripheral part. The rigid structure must also permit the gripped wafer to be orientated without excessive deformation of the thin end part which has to be inserted between two wafers. In order to obtain a high-performance gripping arm, a structure 7 offering excellent strength for minimum weight will be selected. The branches 10 and 11 of the U, which are intended to be able to penetrate between two successive wafers, may advantageously be made of a metallic material, and the parts 12 and 13 joining the branches, as well as the ends 14 and 15 of the branches of the U which do not penetrate between the semiconductor wafers, may be made of a rigid plastics material.

The friction driving roller 9 has a friction driving band capable of acting on the peripheral part of the semiconductor wafer 2 in order to drive the latter in an angular displacement, preferably by adhesion to at least a part or the whole of a generatrix of the surface which forms the peripheral part 4 of the wafer 2, in order to obtain a good coefficient of

This Sheet Has Been Replaced.



adhesion. The driving band 27 of the roller 9 may, for example, be formed by means of an 0-ring 25 made of a resilient material, preferably a hard resilient material, for example one having a Shore hardness in the order of 70 to 80, mounted on a drive wheel 26, as illustrated in Figure 6. The 0-ring 25 will preferably be machined in order to have a cylindrical driving surface.

The driving roller 9 is rotationally driven by a motor 20 placed on a rigid part of the arm, for example on the reinforcing bar 12, as illustrated in Figures 2 to 4. Transmission of the rotational motion between the motor 20 and the roller 9 may be effected by a belt, gears or similar means.

Alternatively, the driving roller may comprise one of the three stops 8, which would then be made at least partially drivable. In this case (not illustrated), the drivable stop fulfils the function of permitting angular displacement of the semiconductor wafer, a rotation in the case illustrated, and the function of participating, in conjunction with the other two stops, in gripping the semiconductor wafer and ensuring that the latter is in static equilibrium. The stop 8 made drivable must have an appropriate driving band, for example as described above for the driving roller 9.

The three stops 8 advantageously and respectively comprise two adjacent and rotationally free driven rollers 8A and 8B, as illustrated in Figure 3. This is in order to prevent the notch 3, constituting the positioning mark of the wafer 2, from disturbing the driving function of the driving roller or the static equilibrium of the wafer when the notch 3 passes at the level of a stop 8 while the wafer is being rotated, or when the notch is opposite a stop 8 when the wafer is gripped in the support (not illustrated). The driven rollers are positioned so that their respective

This Sheet Has Been Replaced



surfaces in contact with the wafer 2 are tangential to the surface of the end face of the wafer. Thus, if the notch 3 is opposite one of the three stops 8A or 8B, the adjacent stop, 8B or 8A respectively, will ensure that the wafer is in static and dynamic equilibrium. In the case mentioned above, of one of the stops 8 being made drivable, only one of the rollers 8A or 8B would be made drivable, the other being driven.

In the example illustrated, the rotational axes of the driven rollers 8A and 8B and of the driving roller 9 are perpendicular to the horizontal plane defined by the semiconductor wafer 2. However, it is conceivable for the axes to have another direction, depending on the contact profile of the rollers on the wafer, so that these rollers do not come into contact with one or other of the faces of the semiconductor wafer.

One driven roller 8A or 8B, as illustrated in Figure 5, advantageously has a first frustoconical contact surface 16, in order to permit contact with the semiconductor wafer 2 by means of a peripheral edge 17 thereof. In Figure 5, the roller 8A or 8B is illustrated in side view, and it is designed to grip a wafer placed substantially or exactly horizontally. Advantageously, a generatrix of the first frustoconical contact surface 16 forms an angle α of between 5° and 45° with a perpendicular to the semiconductor wafer 2. Advantageously, a driven roller 8A or 8B has a second frustoconical surface 18, the top 19 of which is connected to the base of the first frustoconical surface 16, and the generatrix of which forms an angle with a perpendicular to the semiconductor wafer 2 greater than the angle α of the generatrix of the first frustoconical surface 16. Alternatively, the top 19 of the second frustoconical surface 18 of each stop 8A, 8B may have a horizontal annular planar surface (not illustrated) adopting the shape of a crown of

This Sheet Has Been Replaced

small radial thickness, which permits the wafer to rest on the annular end of its lower surface.

It should be noted that other types of revolving surfaces may be adopted in place of the frustoconical surfaces 16 and 18 described, for example first and second revolving surfaces formed by a curved generatrix, giving rise, for example, to concave, convex or other surfaces.

The height of the first frustoconical contact surface 16 will be defined in accordance with the height available between two successive wafers, the inclination of the generatrix of the surface 16 depending on angle α, and the precision of the position of the gripping arm relative to a wafer prior to its being gripped, so that the gripped wafer is preferably supported on the first frustoconical surfaces 16, or on the first and second frustoconical surfaces 18 of the driven rollers 8A and 8B. For example, for a given height of the first frustoconical surface 16, depending on the space available between two successive wafers on the wafer support, the length of the horizontal projection of the generatrix of the first frustoconical surface must be greater than or equal to the possible radial error in the position of the arm relative to the semiconductor wafer.

Preferably, the driven rollers 8A and 8B will be made of a rigid plastics material and will have a low rotational inertia in order to be easily rotationally driven, by friction, by the semiconductor wafer. For this purpose, the rollers 8A and 8B will preferably be mounted on the structure 7 by means of bearings (not illustrated).

It should be noted that the driven rollers 8A and 8B illustrated in Figures 2 to 5 are designed to permit a wafer disposed horizontally to be gripped, as was mentioned above. It is also conceivable to grip a wafer placed in another position, for example vertically. In this case, the rollers must include means which prevent the wafer from escaping from the

This Sheet Has Been Replaced



gripping means due to the effect of gravity or of the displacement of the gripping arm, for example a third frustoconical surface (not illustrated) symmetrical with the second frustoconical surface relative to the plane of the wafer, one of the three stops 8 then being mounted, for example, so as to be displaceable on the rigid structure 7 in order to permit the wafer to cross the third frustoconical surface and to move towards the movable stop until it comes into contact with the end face of the wafer, in order to permit the wafer only a degree of rotational freedom.

The means 6 for orientating the gripping arm which is illustrated in Figures 2 to 4 advantageously comprise a first beam 21, capable of being cut when the notch 3 of the wafer 2 is not opposite the beam 21, and a detector 23, which detects that said first beam 21 has been cut. The beam 21 may, for example, be a light beam, preferably vertical, emitted by a light-emitting diode 22, and the detector may be a photosensitive cell 23 placed opposite the emitting diode. The beam 21 will be placed in such a way that, during angular displacement of the wafer 2 due to the effect of the driving roller 9, the notch 3 can let the beam 21 through to reach the photosensitive cell 23, the beam 21 being, in the opposite case, cut by the wafer 2. When the position of the notch 3 has been located by the beam 21 falling on the photosensitive cell 23, the wafer 2 is orientated by the driving roller 9 by the desired angle in order to place the mark 3 in a defined position. The operation of at least the roller 9 and the photosensitive cell 23 will advantageously be controlled and checked by a central unit (not illustrated), advantageously automated depending on the operations to be performed.

The gripping arm illustrated in Figures 2 to 4 advantageously comprises means 21, 24 for locating the position of the semiconductor wafer 2 when it is placed in a support (not illustrated). The locating

This Sheet Has Been Replaced



means have the function of permitting the gripping arm to be optimally positioned before a semiconductor wafer 2 is gripped. The locating operation consists in locating any two points on the peripheral part 4 of a wafer 2 to be gripped, for example by means of two beams 21 and 24 placed on the structure 7 of the arm and defining, respectively, the two points on a horizontal plane, as illustrated in Figure 3, in the plane of the sheet. The beam 24 may, for example, be a light beam emitted by a light-emitting diode, and the detector may be a photosensitive cell placed opposite the emitting diode. The locating means advantageously comprise the first vertical beam 21 and the second vertical beam 24 which co-operates with the first beam and a characteristic dimension of the semiconductor wafer 2, in the example the external diameter of the wafer, in order to permit the position of the semiconductor wafer in the support (not illustrated) in a horizontal plane to be established.

The two points on the peripheral part 4 of the wafer 2 are located during small approach displacements of the arm having the beams 21 and 24, for the purpose of appropriate positioning to grip the wafer. The two separate beams 21 and 24 permit the chord of an arc of the circular peripheral part of the wafer 2 to be located as soon as the beams are cut by the peripheral part of the wafer, which chord, combined with knowing the diameter of this circular part of the wafer, permits the position of the wafer to be determined and the arm to be placed in an appropriate relative position for the purpose of gripping the wafer between the stops 8, as explained above.

It should be noted that the first beam 21, used in the context of the means for orientating the wafer, is also advantageously used in the context of the locating means, in order to simplify the gripping arm.

This Sheet Has Been Replaced



Alternatively it is, of course, possible to use two separate beams for the orientation means and the locating means respectively.

Alternatively and advantageously, the locating means comprise a third beam (not illustrated), which co-operates with the first beam 21 or the second beam 24 and a characteristic dimension of the semiconductor wafer, its external diameter in the example, in order to permit the position of the semiconductor wafer in its support to be established when the first or second beam is placed opposite the notch serving as a positioning mark. For this purpose, the third beam will be placed at any position which permits the chord of an arc of the peripheral part of the wafer to be obtained, in combination with that of the first or second beam which is not placed opposite the notch, and permits the configuration of two points of a chord of an arc of the peripheral part of the wafer to be regained. In fact, the notch generally penetrates into the wafer to a not-insignificant depth, and could consequently lead to an erroneous measurement of the arc, and hence of the position of the wafer. The third beam makes it possible to ensure that at least two beams will not be opposite the notch, in order to obtain a chord. The third beam may be produced in a similar manner to the first two.

The operation of the gripping arm illustrated in Figures 2 to 4 is as follows: the arm is introduced into a support containing semiconductor wafers, the position of which it is desired to modify, for example as described above with the aid of Figures 1A and 1B. The approach of the arm beneath a wafer is accomplished by means of the locating means, as also described above, so that the arm is placed in a position such that an upward displacement of the latter results in the wafer being gripped between the rollers 8A and 8B of the arm. The wafer must, while it is gripped, rest on at least the first frustoconical surfaces 16 of a part of the

This Sheet Has Been Replaced



rollers 8A, 8B, so that it centres itself by gravity or, as soon as it is displaced angularly, by the driving roller substantially or exactly at the top 19 of the second frustoconical surface 18 of each driven roller. Thus, the wafer preferably rests on the stops 8A and 8B via its lower peripheral edge 17, as illustrated in Figure 5. Then, the wafer is displaced angularly by the driving roller 9 until the notch 3 passes over the beam 21, permitting the 23 to be actuated and thereby the angular position of the wafer to be located, the wafer then being rotated relative to this position in order to place the wafer in the defined position. During rotation of the wafer, the latter is supported on the first frustoconical surfaces 16 of a part of the rollers 8A, 8B. When the desired position is reached, the wafer is put down again in the support, as described above.

The gripping arm illustrated in Figure 7 comprises means for gripping a plurality of semiconductor wafers 2 by their peripheral part and means for orientating the gripped semiconductor wafers, which means co-operate with the gripping means in order to align the respective positioning marks of the semiconductor wafers gripped by the arm. The gripping means comprise a plurality of partial structures 7, which are capable of being respectively inserted into the free spaces between semiconductor wafers of a support (not illustrated), and they are connected by a common rigid support 30, as illustrated. Each structure carries a driving roller for rotating the wafer which this structure is intended to support, three stops 8 for supporting this wafer, and two beams 21 and 24, as described previously for a structure 7. The arm illustrated in Figure 7 makes it possible to grip, advantageously simultaneously, a plurality of wafers 2 placed in a support and to orientate, advantageously simultaneously, these wafers so as to place them in a defined position, for example so as to align their notches 3.

This Sheet Has Been Replaced



Thus the notches may be aligned, for example, while the wafers are being transferred from one place to another.

Several examples of the methods according to the invention will now be described. A first example of the method according to the invention comprises a mechanical method permitting a change in position of one or more semiconductor wafers provided with a notch and placed in a support intended to house a plurality of semiconductor wafers, consisting in gripping the semiconductor wafer or wafers by its or their peripheral part and orientating the semiconductor wafer or wafers in order to place its or their notch (or notches) in a defined position. Such a method may, for example, be implemented by a device according to the invention, as described above, permitting, more especially, an alignment of the notches of the semiconductor wafers placed in a support without removing these wafers from their support.

A second example of the method according to the invention consists in moving the semiconductor wafer or wafers from one place to another and simultaneously orientating it or them so as to place its or their notch (or notches) in a defined position, for example so as to align the notches. Such a method may, for example, be implemented by a device for transferring wafers, as described above.

This Sheet Has Been Replaced





CLAIMS

1. Mechanical method permitting a change in position of at least one semiconductor wafer (2) provided with at least one positioning mark (3) and placed in a support intended to house a plurality of semiconductor wafers, characterised in that it comprises the following steps:

- penetrating said support by means of a gripping arm (1) with a first displacement of said arm in a first spatial direction (Y),
- gripping said at least one semiconductor wafer by the peripheral part (4) of the latter with a second displacement of said arm in a second spatial direction (Z),
- orientating said at least one gripped semiconductor wafer so as to place said positioning mark in a defined position.

2. Method according to claim 1, characterised in that it also comprises the following steps:

- withdrawing said at least one semiconductor wafer from said support with a third displacement of said gripping arm (1) in said first direction (Y), opposite said first displacement,
- displacing said at least one semiconductor wafer (2) from one place to another in space with three directions or dimensions (X, Y, Z), with displacements of said arm selected from the three spatial directions (X, Y, Z), said step comprising orientating said at least one semiconductor wafer so as to place said positioning mark (3) in a defined position, this occurring simultaneously with the displacements of said gripping arm.

This Sheet Has Been Replaced



3. Mechanical method permitting a change in position of a plurality of semiconductor wafers (2) provided with at least one positioning mark (3) and placed in a support, characterised in that it comprises the following steps:

- penetrating said support by means of a gripping arm with a first displacement of said arm in a first spatial direction (Y),
- gripping a plurality of semiconductor wafers by the peripheral part (4) of said wafers with a second displacement of said arm in a second spatial direction (Z),
- orientating said gripped semiconductor wafers so as to align said respective positioning marks of said semiconductor wafers.

4. Method according to claim 3, characterised in that it also comprises the following steps:

- withdrawing said plurality of semiconductor wafers (2) from said support with a third displacement of said gripping arm in said first direction (Y), opposite said first displacement,
- displacing said plurality of semiconductor wafers from one place to another in space with three directions or dimensions (X, Y, Z), with displacements of said arm selected from the three spatial directions (X, Y, Z), said step comprising orientating said gripped semiconductor wafers so as to align their respective positioning marks, this occurring simultaneously with the displacements of said gripping arm.

5. Device permitting a change in position of at least one semiconductor wafer (2) provided with at least one positioning mark (3) and placed in a support intended to house a plurality of semiconductor wafers, said device comprising a gripping arm for gripping said at least

This Sheet Has Been Replaced



one semiconductor wafer and means for displacing said gripping arm, said gripping arm comprising:

- means for gripping said at least one semiconductor wafer by the peripheral part,
- means for orientating said at least one semiconductor wafer, which means co-operate with said gripping means in order to place said positioning mark in a defined position,

said device being characterised in that said displacement means (120) for displacing said gripping arm (1) comprise means for displacement in three spatial directions (X, Y, Z), and in that said gripping means (5) and said orientation means (6) are disposed on a rigid structure (7), said gripping means being distributed over the perimeter of the peripheral part of said at least one semiconductor wafer.

6. Device according to claim 5, characterised in that said gripping arm comprises:

- means for gripping a plurality of semiconductor wafers (2) by the peripheral part,
- means for orientating said gripped semiconductor wafers, which means co-operate with said gripping means in order to align said respective positioning marks of said semiconductor wafers.

7. Arm for gripping a semiconductor wafer (2) provided with at least one positioning mark (3), permitting gripping of at least one semiconductor wafer placed in a support intended for housing a plurality of semiconductor wafers, said arm comprising:

- means for gripping said at least one semiconductor wafer by the peripheral part

This Sheet Has Been Replaced



- means for orientating said at least one semiconductor wafer, which means co-operate with said gripping means in order to place said positioning mark in a defined position,

said arm being characterised in that said gripping means (5) and said orientation means (6) are disposed on a rigid structure (7), said gripping means being distributed over the perimeter of the peripheral part of said at least one semiconductor wafer.

8. Gripping arm according to claim 7, characterised in that said gripping means comprise at least three stops (8) provided respectively with a degree of rotational freedom and distributed around the perimeter of the peripheral part (4) of said at least one semiconductor wafer (2), and in that said orientation means comprise a driving roller (9) for driving said at least one semiconductor wafer by friction.

9. Gripping arm according to claim 8, characterised in that said driving roller (9) is formed by one of said three stops (8) which is made at least partially drivable.

10. Gripping arm according to claim 8 or 9, characterised in that said positioning mark is a notch (3) placed on the peripheral part (4) of said at least one semiconductor wafer (2), and in that said three stops (8) comprise respectively two adjacent and rotationally free driven rollers (8A, 8B).

11. Gripping arm according to claim 10, characterised in that said driven rollers (8) comprise, respectively, at least one first frustoconical

This Sheet Has Been Replaced



contact surface (16), in order to permit said at least one semiconductor wafer (2) to be supported by means of a peripheral edge (17) of the latter.

12. Gripping arm according to claim 11, characterised in that a generatrix of said at least first frustoconical contact surface forms an angle (α) of between 5° and 45° with a perpendicular to said at least one semiconductor wafer (2).

13. Gripping arm according to claim 12, characterised in that said driven rollers (8) comprise, respectively, a second frustoconical surface (18), the top (19) of which is connected to the base of said first frustoconical surface (16), and the generatrix of which forms an angle with a perpendicular to said at least one semiconductor wafer (2) which is greater than the angle (α) of the generatrix of said first frustoconical surface.

14. Gripping arm according to any one of claims 10 to 13, characterised in that said orientation means (6) comprise a first beam (21), capable of being cut when said notch (3) is not opposite said first beam, and a detector (23) which detects that said first beam has been cut.

15. Gripping arm according to any one of claims 7 to 14, characterised in that it comprises marking means (21, 24) for marking the position of said at least one semiconductor wafer (2) when it is placed in said support.

16. Gripping arm according to claims 14 and 15, characterised in that said marking means comprise a second beam (24) which co-operates

This Sheet Has Been Replaced



* C L M S *

with said first beam (21) and a feature dimension of said at least one semiconductor wafer (2) in order to permit the position of said at least one semiconductor wafer in said support to be established.

17. Gripping arm according to claims 10 and 16, characterised in that said marking means (21, 24) comprise a third beam which co-operates with said first beam (21) or said second beam (24) and a feature dimension of said at least one semiconductor wafer (2) in order to permit the position of said at least one semiconductor wafer in said support to be established when said first or second beam is placed opposite said notch (3).

18. Gripping arm according to any one of claims 7 to 17, characterised in that it comprises:

- means for gripping a plurality of semiconductor wafers (2) by the peripheral part,
- means for orientating said gripped semiconductor wafers, which means co-operate with said gripping means in order to align said respective positioning marks (3) of said semiconductor wafers.

This Sheet Has Been Replaced

ABSTRACT

Mechanical method permitting a change in position of at least one semiconductor wafer (2) provided with at least one positioning mark (3) and placed in a support intended to house a plurality of semiconductor wafers, comprising the following steps:

- penetrating the support by means of a gripping arm (1) with a first displacement of the arm in a first spatial direction (Y),
- gripping the semiconductor wafer by its peripheral part (4) with a second displacement of the arm in a second spatial direction (Z),
- orientating the gripped wafer so as to place the positioning mark in a defined position.

Device permitting a change in position of a semiconductor wafer (2) provided with a positioning mark (3) and placed in a support intended to house a plurality of semiconductor wafers, the device comprising an arm for gripping the wafer and means for displacing the arm, the latter comprising:

- means for gripping the semiconductor wafer by the peripheral part,
- means for orientating the wafer, which means co-operate with the gripping means in order to place the positioning mark in a defined position,

the displacement means (120) of the gripping arm (1) comprising means for displacement in three spatial directions (X, Y, Z), the gripping means (5) and the orientation means (6) being disposed on a rigid structure (7), the gripping means being distributed over the perimeter of the peripheral part of the semiconductor wafer.

Fig. 2

This Sheet Has Been Replaced



ABSTRACT

Mechanical method permitting a change in position of at least one semiconductor wafer (2) provided with at least one positioning mark (3) and placed in a support intended to house a plurality of semiconductor wafers, comprising the following steps:

- penetrating the support by means of a gripping arm (1) with a first displacement of the arm in a first spatial direction (Y),
- gripping the semiconductor wafer by its peripheral part (4) with a second displacement of the arm in a second spatial direction (Z),
- orientating the gripped wafer so as to place the positioning mark in a defined position.

Device permitting a change in position of a semiconductor wafer (2) provided with a positioning mark (3) and placed in a support intended to house a plurality of semiconductor wafers, the device comprising an arm for gripping the wafer and means for displacing the arm, the latter comprising:

- means for gripping the semiconductor wafer by the peripheral part,
- means for orientating the wafer, which means co-operate with the gripping means in order to place the positioning mark in a defined position,

the displacement means (120) of the gripping arm (1) comprising means for displacement in three spatial directions (X, Y, Z), the gripping means (5) and the orientation means (6) being disposed on a rigid structure (7), the gripping means being distributed over the perimeter of the peripheral part of the semiconductor wafer.

Fig. 2

METHOD AND DEVICE FOR CHANGING THE POSITION OF A SEMICONDUCTOR WAFER

The present invention relates to the fields of the manufacture of electronic components, more especially the manufacture of integrated circuits from substrates or wafers formed from semiconductor materials such as silicon, more particularly to the mechanical methods and devices permitting a change of position of at least one semiconductor wafer provided with at least one positioning mark and placed in a support intended to house a plurality of semiconductor wafers.

Prior art teaches such methods which consist, more especially, in gripping the semiconductor wafer by one of its faces in order to change its position, more especially to move it from one place to another, the devices which permit these methods to be accomplished, comprising means which permit the wafer to be gripped by suction in the central region of one face of said wafer. Independently of the movement of the wafers from one place to another, the semiconductor wafers are orientated so as to place their positioning mark in a defined position, the latter operation possibly consisting, for example, of aligning the positioning marks of all of the wafers which are intended to be placed or which are in a common support.

The methods and devices of prior art have the disadvantage of permitting the semiconductor wafers to be contaminated because they are gripped by one of their faces which consists of a material very sensitive to various contaminations, this being the more so if the face comes into contact with an object. Furthermore, the methods and devices of prior art take a long time for the displacement and orientation operations of a semiconductor wafer or wafers to be accomplished, these operations

being managed independently, thereby leading to longer processing time for the semiconductor wafers, and therefore to higher processing costs.

The document US 5,102,291 is known, which relates to a method and a machine for orientating a silicon wafer situated in a support by gripping it by its peripheral part in order to minimise possible contamination to which it could be subject by direct contact with its faces. The wafers are gripped one by one between two gripping arms which are displaceable relative to each other along an upright, and which are brought close to each other according to the displaceable guidance direction until the two arms come to press against the peripheral part of the wafer to be gripped by means of four pressure rollers which raise the wafer before the rollers come into contact with the peripheral part of the latter, the gripped silicon wafer being able to be to be rotationally orientated into a particular position relative to the support by means of pressure rollers which turn in the plane of the wafer and of which at least one may be motorised. The machine also permits a displacement of the gripped wafer limited to one upright by virtue of the two gripping arms. Detection of the desired orientation of the wafer may be effected by a mechanical sensor means, an electrical optical system or some other means. For wafers provided with a notch, the document specifies a spindle smaller than the notch which would penetrate the notch when the wafer is in the desired position.

The document US 5,445,486 is also known, which relates to a machine for transferring silicon wafers from one support to another, by means of a gripping arm inserted between the wafers in a support, the arm gripping one or more wafers by the peripheral part of their lower surface. The machine does not have a means for orientating the transferred wafers.

The semiconductor wafer processing envisaged may be all processing requiring a change of position of one semiconductor wafer, a plurality of semiconductor wafers or all of the semiconductor wafers placed in a common support, for example moving wafers from one support to another, aligning the marks for the purpose of respective identification of the wafers in the support, or simply modifying the angular position of a semiconductor wafer which is in a support, for the purpose of placing the marks in a defined position.

The present invention aims to overcome the above disadvantages and to provide other advantages. One object of the present invention is to permit a change in position of at least one semiconductor wafer, while avoiding any contamination, due to gripping the wafer by one of its faces and furthermore reducing the risks of contamination.

Another object of the present invention is to permit a change in position of at least one semiconductor wafer, making it possible to modify the orientation of a wafer simultaneously with another processing operation, more especially a displacement or a transfer of the wafer.

Another object of the present invention is to save space in a semiconductor wafer processing station, by avoiding a specific installation for orientating or aligning the positioning marks of the wafers.

Another object of the present invention is to permit a plurality of semiconductor wafers to be gripped and orientated, the orientation of the wafers being effected in a simultaneous manner and, furthermore, simultaneously with another operation, more especially a displacement of the plurality of wafers.

More specifically, the invention comprises a mechanical method permitting a change in position of at least one semiconductor wafer provided with at least one positioning mark and placed in a support intended to house a plurality of semiconductor wafers, characterised in that it comprises the following steps:

- penetrating said support by means of a gripping arm with a first displacement of said arm in a first spatial direction,
- gripping said at least one semiconductor wafer by the peripheral part of the latter with a second displacement of said arm in a second spatial direction,
- orientating said at least one gripped semiconductor wafer so as to place said positioning mark in a defined position.

Gripping the semiconductor wafer by its peripheral part permits the contamination of this wafer to be reduced and the contamination due to gripping the semiconductor wafer by a face to be avoided, and orientating the wafer when the latter has been gripped permits this operation to be effected simultaneously with other operations, more especially a displacement of the wafer. The operation of orientating a wafer when it has been gripped permits the use of a processing station specifically for orientating the semiconductor wafers to be dispensed with, hence saving space for the processing of the wafers.

According to an advantageous feature, the method according to the invention also comprises the following steps:

- withdrawing said at least one semiconductor wafer from said support with a third displacement of said gripping arm in said first direction, opposite said first displacement,
- displacing said at least one semiconductor wafer from one place to another in space with three directions or dimensions, with displacements

of said arm selected from the three spatial directions, said step comprising orientating said at least one semiconductor wafer so as to place said positioning mark in a defined position, this occurring simultaneously with the displacements of said gripping arm.

According to an advantageous feature, the method according to the invention comprises:

- penetrating said support by means of a gripping arm with a first displacement of said arm in a first spatial direction,
- gripping a plurality of semiconductor wafers by the peripheral part of said wafers with a second displacement of said arm in a second spatial direction,
- orientating said gripped semiconductor wafers so as to align said respective positioning marks of said semiconductor wafers.

According to an advantageous feature, the above method also comprises the following steps:

- withdrawing said plurality of semiconductor wafers from said support with a third displacement of said gripping arm in said first direction, opposite said first displacement,
- displacing said plurality of semiconductor wafers from one place to another in space with three directions or dimensions, with displacements of said arm selected from the three spatial directions, said step comprising orientating said gripped semiconductor wafers so as to align their respective positioning marks, this occurring simultaneously with the displacements of said gripping arm.

The invention also relates to a device permitting a change in position of at least one semiconductor wafer provided with at least one positioning mark and placed in a support intended to house a plurality of semiconductor wafers, said device comprising a gripping arm for

gripping said at least one semiconductor wafer and means for displacing said gripping arm, characterised in that said gripping arm comprises:

- means for gripping said at least one semiconductor wafer by the peripheral part,
- means for orientating said at least one semiconductor wafer, which means co-operate with said gripping means in order to place said positioning mark in a defined position,

said gripping means and said orientation means being disposed on a rigid structure, said gripping means being distributed over the perimeter of the peripheral part of said at least one semiconductor wafer, and in that said means for displacing said gripping arm comprise means for displacement in three spatial directions.

According to an advantageous feature, said gripping means comprise:

- means for gripping a plurality of semiconductor wafers by the peripheral part,
- means for orientating said gripped semiconductor wafers, which means co-operate with said gripping means in order to align said respective positioning marks of said semiconductor wafers.

The invention also relates to an arm for gripping a semiconductor wafer provided with at least one positioning mark, permitting gripping of at least one semiconductor wafer placed in a support intended for housing a plurality of semiconductor wafers, characterised in that said arm comprises:

- means for gripping said at least one semiconductor wafer by the peripheral part,

- means for orientating said at least one semiconductor wafer, which means co-operate with said gripping means in order to place said positioning mark in a defined position,

said gripping means and said orientation means being disposed on a rigid structure, said gripping means being distributed over the perimeter of the peripheral part of said at least one semiconductor wafer.

According to an advantageous feature, said means comprise at least three stops provided respectively with a degree of rotational freedom and distributed around the perimeter of the peripheral part of said at least one semiconductor wafer, and said orientation means comprise a driving roller for driving said at least one semiconductor wafer by friction.

According to another advantageous feature, said driving roller is formed by one of said three stops which is made at least partially drivable.

According to another advantageous feature, said positioning mark is a notch placed on the peripheral part of said at least one semiconductor wafer, and said three stops comprise respectively two adjacent and rotationally free driven rollers.

According to another advantageous feature, said driven rollers comprise, respectively, at least one first frustoconical contact surface, in order to permit said at least one semiconductor wafer to be supported by means of a peripheral edge thereof.

According to another advantageous feature, a generatrix of said at least one first frustoconical contact surface forms an angle of between 5° and 45° with a perpendicular to said at least one semiconductor wafer.

According to another advantageous feature, said driven rollers comprise, respectively, a second frustoconical surface, the top of which is connected to the base of said first frustoconical surface, and the

generatrix of which forms an angle with a perpendicular to said at least one semiconductor wafer greater than the angle of the generatrix of said first frustoconical surface.

According to another advantageous feature, said orientation means comprise a first beam, capable of being cut when said notch is not opposite said first beam, and a detector which detects that said first beam has been cut.

According to another advantageous feature, the gripping arm according to the invention comprises locating means for locating the position of said at least one semiconductor wafer when it is placed in said support.

According to another advantageous feature, said marking means comprise a second beam which co-operates with said first beam and a characteristic dimension of said at least one semiconductor wafer in order to permit the position of said at least one semiconductor wafer in said support to be established.

According to another advantageous feature, said locating means comprise a third beam which interacts with said first beam or said second beam and a characteristic dimension of said at least one semiconductor wafer in order to permit the position of said at least one semiconductor wafer in said support to be established when said first or second beam is placed opposite said notch.

According to another advantageous feature, the gripping arm according to the invention comprises:

- means for gripping a plurality of semiconductor wafers by their peripheral part,

- means for orientating said gripped semiconductor wafers, which means co-operate with said gripping means in order to align said respective positioning marks of said semiconductor wafers.

The invention will be more clearly understood, and further features and advantages will appear, on reading the following description of examples of embodiments of methods, devices and gripping arms according to the invention, together with the accompanying drawings, the examples being given by way of illustration and without any restrictive interpretation of the invention being able to be drawn therefrom.

Figure 1A illustrates, in perspective, one embodiment of a device according to the invention, permitting the position of at least one semiconductor wafer to be changed.

Figure 1B illustrates, in perspective, an enlarged detail of Figure 1A.

Figure 2 illustrates, in perspective, a first embodiment of a gripping arm according to the invention.

Figure 3 is a plan view of the example in Figure 2.

Figure 4 is a side elevational view of the example in Figure 2.

Figure 5 is a side elevational view of a first enlarged detail of the example in Figure 2.

Figure 6 illustrates a second enlarged detail of the example in Figure 2, in partial cross-section.

Figure 7 illustrates, in perspective, a second embodiment of a gripping arm according to the invention;

The device 100 illustrated in Figure 1A and, partially, in Figure 1B, permitting a change in position of the semiconductor wafers provided, respectively, with a positioning mark and placed in a support (not illustrated) intended to house a plurality of semiconductor wafers,

comprises means 110 for gripping a semiconductor wafer, and means 120 for displacing the gripping means 110. The gripping means 110 will be explained in detail later, with the aid of Figures 2 to 6, and comprise means 5 for gripping the semiconductor wafer by its peripheral part and means 6 for orientating the semiconductor wafer, which means co-operate with the gripping means 5 in order to place the positioning mark in a defined position.

The device 100 comprises a frame 101 onto which fit two semiconductor wafer supports (not illustrated). The two supports fit respectively onto receiving trays (not illustrated), said receiving trays being placed, for example, beside one another and vertically in line with the doors 102 and 103, and have wafers superimposed in respective housings in the support, in a horizontal position. The device 100 permits semiconductor wafers to be transferred from one support to another while enabling the respective marks on these wafers to be placed in a defined position. For this purpose, the gripping means 110 are connected to displacement means 120, so that they can be displaced in the three spatial dimensions X, Y and Z, as illustrated in Figure 1A and, partially, in Figure 1B.

The gripping means 110 placed opposite a first support, fixed, for example, vertically in line with the door 103, thus permit the selection of the semiconductor wafer to be gripped in this support, by means of the Z displacement, then to enter the support by means of the Y displacement, to grip the wafer by means of the upward Z displacement without striking the wafer possibly placed thereabove, to remove the wafer from the support by means of a reverse Y displacement and to use the X and Z displacements to position the gripping means 110 opposite the second support placed vertically in line with the door 102 and the appropriate

housing in this support for the gripped wafer. During these displacements, the semiconductor wafer will advantageously be orientated in a defined position, for example so that all the semiconductor wafers have their respective marks aligned. It should be noted that, depending on the requirements, the device illustrated in Figure 1A permits the wafers in one support to be orientated without moving them into the other support; to do this, all that is required is to place the gripping means 110 in a position for gripping a wafer in its support, i.e. to place the means 110 beneath the wafer to be gripped, to grip the wafer by means of the upward Z displacement, without striking the wafer possibly placed thereabove, to orientate the wafer into the selected position, before depositing it again in the same housing, and then to remove the gripping means 110.

Figure 1B shows the gripping means 110 connected to a first part 121 of the displacement means 120, so as to permit the gripping means to be displaced with a degree of translational freedom in the Z direction. This first part 121 of the displacement means is connected, with a degree of translational freedom in the Y direction, to a second part 122 of the displacement means 120, said second part itself being connected, with a degree of translational freedom in the X direction, to the frame 101 of the device 100, as illustrated in Figure 1A.

According to an alternative, not illustrated, the gripping means may comprise means for gripping a plurality of semiconductor wafers by their peripheral part and means for orientating the gripped semiconductor wafers, which means co-operate with the gripping means in order to align the respective positioning marks of said semiconductor wafers. This alternative may be obtained, on the device 100 illustrated, by replacing

the gripping means 110 with the gripping arm illustrated in Figure 7 and described later.

It should be noted that the gripping arm 1 illustrated in Figures 2 to 4 constitutes the gripping means 110 of the device 100 illustrated in Figure 1A and, partially, in Figure 1B.

The gripping arm 1 illustrated in Figures 2 to 4 makes it possible to grip a semiconductor wafer 2, in the form of a disk, placed in a support (not illustrated) intended to house a plurality of similar semiconductor wafers. The semiconductor wafers 2 are respectively provided with a positioning mark 3 which is substantially in the form of a notch 3 formed on the peripheral part 4 of the wafer 2. The surface formed by the end face of the semiconductor wafer 2, including the two end edges of this surface, is called the peripheral part 4 of the wafer. This surface formed by the end face may, for example, be cylindrical or it may have substantially the shape of an external circular half-torus. The peripheral part of the wafer may, alternatively, comprise the upper and lower annular surfaces of the ends of the wafer, in the form of a thin crown.

The gripping arm 1 illustrated in Figures 2 to 4 comprises means 5 for gripping the semiconductor wafer 2 by its peripheral part 4 and means 6 for orientating the semiconductor wafer 2, which means co-operate with the gripping means 5 in order to place the positioning mark 3 in a defined position, as will be explained later.

The gripping means 5 and orientation means 6 are disposed on a rigid structure 7, permitting it to be inserted, at least partially, between two successive wafers placed in a support, for example as illustrated in Figure 4 between wafers 2 and 2B illustrated by the dot-dash lines. The upper wafer 2A, in dot-dash lines, represents the semiconductor wafer placed in the support (not illustrated) and which is not to be struck when

the wafer 2 is gripped. Advantageously, the gripping means comprise three stops 8, provided respectively with a degree of rotational freedom and distributed around the perimeter of the peripheral part 4 of the wafer 2, and the orientation means 6 comprise a roller 9 for driving the wafer 2 by friction.

The rigid structure 7 may, for example, be in the form of a U-shaped profile, at the base of which there are two of the three stops 8, the third stop 8 being disposed on one branch 10 of the U and the driving roller 9 being disposed on the other branch 11 of the U, as illustrated in Figure 3. A reinforcing bar 12 may connect the branches of the U at mid-height, as illustrated in Figure 3. The shape of the rigid structure 7 may vary widely, said structure having to be able to be partly inserted between two successive wafers so that the gripping means 5 can grip a wafer by its peripheral part. The rigid structure must also permit the gripped wafer to be orientated without excessive deformation of the thin end part which has to be inserted between two wafers. In order to obtain a high-performance gripping arm, a structure 7 offering excellent strength for minimum weight will be selected. The branches 10 and 11 of the U, which are intended to be able to penetrate between two successive wafers, may advantageously be made of a metallic material, and the parts 12 and 13 joining the branches, as well as the ends 14 and 15 of the branches of the U which do not penetrate between the semiconductor wafers, may be made of a rigid plastics material.

The friction driving roller 9 has a friction driving band capable of acting on the peripheral part of the semiconductor wafer 2 in order to drive the latter in an angular displacement, preferably by adhesion to at least a part or the whole of a generatrix of the surface which forms the peripheral part 4 of the wafer 2, in order to obtain a good coefficient of

adhesion. The driving band 27 of the roller 9 may, for example, be formed by means of an 0-ring 25 made of a resilient material, preferably a hard resilient material, for example one having a Shore hardness in the order of 70 to 80, mounted on a drive wheel 26, as illustrated in Figure 6. The 0-ring 25 will preferably be machined in order to have a cylindrical driving surface.

The driving roller 9 is rotationally driven by a motor 20 placed on a rigid part of the arm, for example on the reinforcing bar 12, as illustrated in Figures 2 to 4. Transmission of the rotational motion between the motor 20 and the roller 9 may be effected by a belt, gears or similar means.

Alternatively, the driving roller may comprise one of the three stops 8, which would then be made at least partially drivable. In this case (not illustrated), the drivable stop fulfils the function of permitting angular displacement of the semiconductor wafer, a rotation in the case illustrated, and the function of participating, in conjunction with the other two stops, in gripping the semiconductor wafer and ensuring that the latter is in static equilibrium. The stop 8 made drivable must have an appropriate driving band, for example as described above for the driving roller 9.

The three stops 8 advantageously and respectively comprise two adjacent and rotationally free driven rollers 8A and 8B, as illustrated in Figure 3. This is in order to prevent the notch 3, constituting the positioning mark of the wafer 2, from disturbing the driving function of the driving roller or the static equilibrium of the wafer when the notch 3 passes at the level of a stop 8 while the wafer is being rotated, or when the notch is opposite a stop 8 when the wafer is gripped in the support (not illustrated). The driven rollers are positioned so that their respective

surfaces in contact with the wafer 2 are tangential to the surface of the end face of the wafer. Thus, if the notch 3 is opposite one of the three stops 8A or 8B, the adjacent stop, 8B or 8A respectively, will ensure that the wafer is in static and dynamic equilibrium. In the case mentioned above, of one of the stops 8 being made drivable, only one of the rollers 8A or 8B would be made drivable, the other being driven.

In the example illustrated, the rotational axes of the driven rollers 8A and 8B and of the driving roller 9 are perpendicular to the horizontal plane defined by the semiconductor wafer 2. However, it is conceivable for the axes to have another direction, depending on the contact profile of the rollers on the wafer, so that these rollers do not come into contact with one or other of the faces of the semiconductor wafer.

One driven roller 8A or 8B, as illustrated in Figure 5, advantageously has a first frustoconical contact surface 16, in order to permit contact with the semiconductor wafer 2 by means of a peripheral edge 17 thereof. In Figure 5, the roller 8A or 8B is illustrated in side view, and it is designed to grip a wafer placed substantially or exactly horizontally. Advantageously, a generatrix of the first frustoconical contact surface 16 forms an angle α of between 5° and 45° with a perpendicular to the semiconductor wafer 2. Advantageously, a driven roller 8A or 8B has a second frustoconical surface 18, the top 19 of which is connected to the base of the first frustoconical surface 16, and the generatrix of which forms an angle with a perpendicular to the semiconductor wafer 2 greater than the angle α of the generatrix of the first frustoconical surface 16. Alternatively, the top 19 of the second frustoconical surface 18 of each stop 8A, 8B may have a horizontal annular planar surface (not illustrated) adopting the shape of a crown of

small radial thickness, which permits the wafer to rest on the annular end of its lower surface.

It should be noted that other types of revolving surfaces may be adopted in place of the frustoconical surfaces 16 and 18 described, for example first and second revolving surfaces formed by a curved generatrix, giving rise, for example, to concave, convex or other surfaces.

The height of the first frustoconical contact surface 16 will be defined in accordance with the height available between two successive wafers, the inclination of the generatrix of the surface 16 depending on angle α, and the precision of the position of the gripping arm relative to a wafer prior to its being gripped, so that the gripped wafer is preferably supported on the first frustoconical surfaces 16, or on the first and second frustoconical surfaces 18 of the driven rollers 8A and 8B. For example, for a given height of the first frustoconical surface 16, depending on the space available between two successive wafers on the wafer support, the length of the horizontal projection of the generatrix of the first frustoconical surface must be greater than or equal to the possible radial error in the position of the arm relative to the semiconductor wafer.

Preferably, the driven rollers 8A and 8B will be made of a rigid plastics material and will have a low rotational inertia in order to be easily rotationally driven, by friction, by the semiconductor wafer. For this purpose, the rollers 8A and 8B will preferably be mounted on the structure 7 by means of bearings (not illustrated).

It should be noted that the driven rollers 8A and 8B illustrated in Figures 2 to 5 are designed to permit a wafer disposed horizontally to be gripped, as was mentioned above. It is also conceivable to grip a wafer placed in another position, for example vertically. In this case, the rollers must include means which prevent the wafer from escaping from the

gripping means due to the effect of gravity or of the displacement of the gripping arm, for example a third frustoconical surface (not illustrated) symmetrical with the second frustoconical surface relative to the plane of the wafer, one of the three stops 8 then being mounted, for example, so as to be displaceable on the rigid structure 7 in order to permit the wafer to cross the third frustoconical surface and to move towards the movable stop until it comes into contact with the end face of the wafer, in order to permit the wafer only a degree of rotational freedom.

The means 6 for orientating the gripping arm which is illustrated in Figures 2 to 4 advantageously comprise a first beam 21, capable of being cut when the notch 3 of the wafer 2 is not opposite the beam 21, and a detector 23, which detects that said first beam 21 has been cut. The beam 21 may, for example, be a light beam, preferably vertical, emitted by a light-emitting diode 22, and the detector may be a photosensitive cell 23 placed opposite the emitting diode. The beam 21 will be placed in such a way that, during angular displacement of the wafer 2 due to the effect of the driving roller 9, the notch 3 can let the beam 21 through to reach the photosensitive cell 23, the beam 21 being, in the opposite case, cut by the wafer 2. When the position of the notch 3 has been located by the beam 21 falling on the photosensitive cell 23, the wafer 2 is orientated by the driving roller 9 by the desired angle in order to place the mark 3 in a defined position. The operation of at least the roller 9 and the photosensitive cell 23 will advantageously be controlled and checked by a central unit (not illustrated), advantageously automated depending on the operations to be performed.

The gripping arm illustrated in Figures 2 to 4 advantageously comprises means 21, 24 for locating the position of the semiconductor wafer 2 when it is placed in a support (not illustrated). The locating

means have the function of permitting the gripping arm to be optimally positioned before a semiconductor wafer 2 is gripped. The locating operation consists in locating any two points on the peripheral part 4 of a wafer 2 to be gripped, for example by means of two beams 21 and 24 placed on the structure 7 of the arm and defining, respectively, the two points on a horizontal plane, as illustrated in Figure 3, in the plane of the sheet. The beam 24 may, for example, be a light beam emitted by a light-emitting diode, and the detector may be a photosensitive cell placed opposite the emitting diode. The locating means advantageously comprise the first vertical beam 21 and the second vertical beam 24 which co-operates with the first beam and a characteristic dimension of the semiconductor wafer 2, in the example the external diameter of the wafer, in order to permit the position of the semiconductor wafer in the support (not illustrated) in a horizontal plane to be established.

The two points on the peripheral part 4 of the wafer 2 are located during small approach displacements of the arm having the beams 21 and 24, for the purpose of appropriate positioning to grip the wafer. The two separate beams 21 and 24 permit the chord of an arc of the circular peripheral part of the wafer 2 to be located as soon as the beams are cut by the peripheral part of the wafer, which chord, combined with knowing the diameter of this circular part of the wafer, permits the position of the wafer to be determined and the arm to be placed in an appropriate relative position for the purpose of gripping the wafer between the stops 8, as explained above.

It should be noted that the first beam 21, used in the context of the means for orientating the wafer, is also advantageously used in the context of the locating means, in order to simplify the gripping arm.

Alternatively it is, of course, possible to use two separate beams for the orientation means and the locating means respectively.

Alternatively and advantageously, the locating means comprise a third beam (not illustrated), which co-operates with the first beam 21 or the second beam 24 and a characteristic dimension of the semiconductor wafer, its external diameter in the example, in order to permit the position of the semiconductor wafer in its support to be established when the first or second beam is placed opposite the notch serving as a positioning mark. For this purpose, the third beam will be placed at any position which permits the chord of an arc of the peripheral part of the wafer to be obtained, in combination with that of the first or second beam which is not placed opposite the notch, and permits the configuration of two points of a chord of an arc of the peripheral part of the wafer to be regained. In fact, the notch generally penetrates into the wafer to a not-insignificant depth, and could consequently lead to an erroneous measurement of the arc, and hence of the position of the wafer. The third beam makes it possible to ensure that at least two beams will not be opposite the notch, in order to obtain a chord. The third beam may be produced in a similar manner to the first two.

The operation of the gripping arm illustrated in Figures 2 to 4 is as follows: the arm is introduced into a support containing semiconductor wafers, the position of which it is desired to modify, for example as described above with the aid of Figures 1A and 1B. The approach of the arm beneath a wafer is accomplished by means of the locating means, as also described above, so that the arm is placed in a position such that an upward displacement of the latter results in the wafer being gripped between the rollers 8A and 8B of the arm. The wafer must, while it is gripped, rest on at least the first frustoconical surfaces 16 of a part of the

rollers 8A, 8B, so that it centres itself by gravity or, as soon as it is displaced angularly, by the driving roller substantially or exactly at the top 19 of the second frustoconical surface 18 of each driven roller. Thus, the wafer preferably rests on the stops 8A and 8B via its lower peripheral edge 17, as illustrated in Figure 5. Then, the wafer is displaced angularly by the driving roller 9 until the notch 3 passes over the beam 21, permitting the 23 to be actuated and thereby the angular position of the wafer to be located, the wafer then being rotated relative to this position in order to place the wafer in the defined position. During rotation of the wafer, the latter is supported on the first frustoconical surfaces 16 of a part of the rollers 8A, 8B. When the desired position is reached, the wafer is put down again in the support, as described above.

The gripping arm illustrated in Figure 7 comprises means for gripping a plurality of semiconductor wafers 2 by their peripheral part and means for orientating the gripped semiconductor wafers, which means co-operate with the gripping means in order to align the respective positioning marks of the semiconductor wafers gripped by the arm. The gripping means comprise a plurality of partial structures 7, which are capable of being respectively inserted into the free spaces between semiconductor wafers of a support (not illustrated), and they are connected by a common rigid support 30, as illustrated. Each structure carries a driving roller for rotating the wafer which this structure is intended to support, three stops 8 for supporting this wafer, and two beams 21 and 24, as described previously for a structure 7. The arm illustrated in Figure 7 makes it possible to grip, advantageously simultaneously, a plurality of wafers 2 placed in a support and to orientate, advantageously simultaneously, these wafers so as to place them in a defined position, for example so as to align their notches 3.

Thus the notches may be aligned, for example, while the wafers are being transferred from one place to another.

Several examples of the methods according to the invention will now be described. A first example of the method according to the invention comprises a mechanical method permitting a change in position of one or more semiconductor wafers provided with a notch and placed in a support intended to house a plurality of semiconductor wafers, consisting in gripping the semiconductor wafer or wafers by its or their peripheral part and orientating the semiconductor wafer or wafers in order to place its or their notch (or notches) in a defined position. Such a method may, for example, be implemented by a device according to the invention, as described above, permitting, more especially, an alignment of the notches of the semiconductor wafers placed in a support without removing these wafers from their support.

A second example of the method according to the invention consists in moving the semiconductor wafer or wafers from one place to another and simultaneously orientating it or them so as to place its or their notch (or notches) in a defined position, for example so as to align the notches. Such a method may, for example, be implemented by a device for transferring wafers, as described above.



CLAIMS

1. Mechanical method permitting a change in position of at least one semiconductor wafer (2) provided with at least one positioning mark (3) and placed in a support intended to house a plurality of semiconductor wafers, characterised in that it comprises the following steps:

- penetrating said support by means of a gripping arm (1) with a first displacement of said arm in a first spatial direction (Y),
- gripping said at least one semiconductor wafer by the peripheral part (4) of the latter with a second displacement of said arm in a second spatial direction (Z),
- orientating said at least one gripped semiconductor wafer so as to place said positioning mark in a defined position.

2. Method according to claim 1, characterised in that it also comprises the following steps:

- withdrawing said at least one semiconductor wafer from said support with a third displacement of said gripping arm (1) in said first direction (Y), opposite said first displacement,
- displacing said at least one semiconductor wafer (2) from one place to another in space with three directions or dimensions (X, Y, Z), with displacements of said arm selected from the three spatial directions (X, Y, Z), said step comprising orientating said at least one semiconductor wafer so as to place said positioning mark (3) in a defined position, this occurring simultaneously with the displacements of said gripping arm.

3. Method according to claim 1, characterised in that it comprises:

- penetrating said support by means of a gripping arm with a first displacement of said arm in a first spatial direction (Y),
- gripping a plurality of semiconductor wafers by the peripheral part (4) of said wafers with a second displacement of said arm in a second spatial direction (Z),
- orientating said gripped semiconductor wafers so as to align said respective positioning marks of said semiconductor wafers.

4. Method according to claim 3, characterised in that it also comprises the following steps:
- withdrawing said plurality of semiconductor wafers (2) from said support with a third displacement of said gripping arm in said first direction (Y), opposite said first displacement,
- displacing said plurality of semiconductor wafers from one place to another in space with three directions or dimensions (X, Y, Z), with displacements of said arm selected from the three spatial directions (X, Y, Z), said step comprising orientating said gripped semiconductor wafers so as to align their respective positioning marks, this occurring simultaneously with the displacements of said gripping arm.

5. Device permitting a change in position of at least one semiconductor wafer (2) provided with at least one positioning mark (3) and placed in a support intended to house a plurality of semiconductor wafers, said device comprising a gripping arm for gripping said at least one semiconductor wafer and means for displacing said gripping arm, characterised in that said gripping arm comprises:
- means for gripping said at least one semiconductor wafer by the peripheral part,

- means for orientating said at least one semiconductor wafer, which means co-operate with said gripping means in order to place said positioning mark in a defined position,

said gripping means (5) and said orientation means (6) being disposed on a rigid structure (7), said gripping means being distributed over the perimeter of the peripheral part of said at least one semiconductor wafer, and in that said displacement means (120) for displacing said gripping arm (1) comprise means for displacement in three spatial directions (X, Y, Z).

6. Device according to claim 5, characterised in that said gripping arm comprises:

- means for gripping a plurality of semiconductor wafers (2) by the peripheral part,
- means for orientating said gripped semiconductor wafers, which means co-operate with said gripping means in order to align said respective positioning marks of said semiconductor wafers.

7. Arm for gripping a semiconductor wafer (2) provided with at least one positioning mark (3), permitting gripping of at least one semiconductor wafer placed in a support intended for housing a plurality of semiconductor wafers, characterised in that said arm comprises:

- means for gripping said at least one semiconductor wafer by the peripheral part,
- means for orientating said at least one semiconductor wafer, which means co-operate with said gripping means in order to place said positioning mark in a defined position,

said gripping means (5) and said orientation means (6) being disposed on a rigid structure (7), said gripping means being distributed over the perimeter of the peripheral part of said at least one semiconductor wafer.

8. Gripping arm according to claim 7, characterised in that said gripping means comprise at least three stops (8) provided respectively with a degree of rotational freedom and distributed around the perimeter of the peripheral part (4) of said at least one semiconductor wafer (2), and in that said orientation means comprise a driving roller (9) for driving said at least one semiconductor wafer by friction.

9. Gripping arm according to claim 8, characterised in that said driving roller (9) is formed by one of said three stops (8) which is made at least partially drivable.

10. Gripping arm according to claim 8 or 9, characterised in that said positioning mark is a notch (3) placed on the peripheral part (4) of said at least one semiconductor wafer (2), and in that said three stops (8) comprise respectively two adjacent and rotationally free driven rollers (8A, 8B).

11. Gripping arm according to claim 10, characterised in that said driven rollers (8) comprise, respectively, at least one first frustoconical contact surface (16), in order to permit said at least one semiconductor wafer (2) to be supported by means of a peripheral edge (17) of the latter.

12. Gripping arm according to claim 11, characterised in that a generatrix of said at least first frustoconical contact surface forms an

angle (α) of between 5° and 45° with a perpendicular to said at least one semiconductor wafer (2).

13. Gripping arm according to claim 12, characterised in that said driven rollers (8) comprise, respectively, a second frustoconical surface (18), the top (19) of which is connected to the base of said first frustoconical surface (16), and the generatrix of which forms an angle with a perpendicular to said at least one semiconductor wafer (2) which is greater than the angle (α) of the generatrix of said first frustoconical surface.

14. Gripping arm according to any one of claims 10 to 13, characterised in that said orientation means (6) comprise a first beam (21), capable of being cut when said notch (3) is not opposite said first beam, and a detector (23) which detects that said first beam has been cut.

15. Gripping arm according to any one of claims 7 to 14, characterised in that it comprises marking means (21, 24) for marking the position of said at least one semiconductor wafer (2) when it is placed in said support.

16. Gripping arm according to claims 14 and 15, characterised in that said marking means comprise a second beam (24) which co-operates with said first beam (21) and a feature dimension of said at least one semiconductor wafer (2) in order to permit the position of said at least one semiconductor wafer in said support to be established.

17. Gripping arm according to claims 10 and 16, characterised in that said marking means (21, 24) comprise a third beam which co-operates with said first beam (21) or said second beam (24) and a feature dimension of said at least one semiconductor wafer (2) in order to permit the position of said at least one semiconductor wafer in said support to be established when said first or second beam is placed opposite said notch (3).

18. Gripping arm according to any one of claims 7 to 17, characterised in that it comprises:

- means for gripping a plurality of semiconductor wafers (2) by the peripheral part,
- means for orientating said gripped semiconductor wafers, which means co-operate with said gripping means in order to align said respective positioning marks (3) of said semiconductor wafers.