Mounting Apparatus for Mounting of a Structured Wafer

Specification

The invention relates to a mounting apparatus for mounting of a substrate, especially of a wafer, on one structure side of the substrate, which side has structures, according to Claim 1.

These mounting apparatus are used as "chucks" in the semiconductor industry, especially for handling of wafers in the production of electrical components in various process steps. The wafers which are provided with individual component groups (structures) are also called product wafers. In each process step what is important is that the wafers are quickly, reliably and easily detachably fixed on the mounting apparatus so that handling of the wafers is not a disruption factor for the processing of the wafers. The fixing of the product wafers which have structures is more difficult the thinner they are and the more pronounced and higher the topography of the components on the product wafers. Any stress in the wafer is to be avoided as much as possible so that to some extent the very expensive structures which are present on the product wafer are not damaged. While there are different approaches to fixing of a product wafer on the unstructured, therefore flat side, in the fixing of a product wafer on its structured side there are a host of technical problems. Thus for example electrostatic fixing is problematic since the electrical circuits of the structures can be destroyed by possible voltage peaks.

Furthermore it is to be possible to handle the electrical structures as free of contamination as possible and without impurity (for example by adhesive).

The object of this invention is therefore to provide a mounting apparatus for mounting and handling as well as fixing of a substrate in which rapid, safe and careful as well as reversible and easily controllable mounting and fixing of the substrate are enabled.

This object is achieved with the features of Claim 1. Advantageous developments of the invention are given in the dependent claims. All combinations of at least two of the features given in the specification, the claims and/or the figures also fall within the framework of the invention. At the given value ranges values which lie within the indicated limits are also to be considered disclosed and claimed in any combination.

The invention is based on the idea of developing known vacuum chucks such that structures of the substrate are incorporated at the same time into the fluid flow which suctions the substrates such that a uniform suction action (suction pressure) as homogeneous as possible over the entire structure side of the substrate is enabled. In other words, the mounting apparatus as claimed in the invention enables an especially linearly variable, homogeneous surface force on the product wafer so that the substrate can be mounted on the vacuum sample holder (mounting apparatus) with the desired surface force. Preferably the surface force acting on the substrate can be controlled by changing the suction pressure in a linear relationship. The surface force is defined by the suction area F_2.

In contrast to vacuum chucks from the prior art, in this invention there is no blanket pressure application along the substrate, but suction applies only in the region of an outer ring surface of the mounting surface of the mounting apparatus. It has been ascertained that the configuration as claimed in the invention yields an extremely homogenous pressure distribution along the mounting

surface of the mounting apparatus, especially also outside of the suction area.

According to one advantageous embodiment of the invention it is provided that the outer ring surface which is made especially as a circular ring extends from one peripheral edge of the mounting surface in the direction of one middle M of the mounting surface and an especially maximum or average ring width R of the outer ring surface is less than 1/2, especially 1/5, preferably less than 1/10, even more preferably less than 1/100 of a diameter D_3 of the mounting surface. The thinner the ring width R relative to the diameter D_3 or the remaining mounting surface and/or the farther the suction surface acting on the peripheral edge of the mounting surface or on the periphery of the substrate, surprisingly the more homogeneous the pressure distribution along the (entire) mounting surface.

Hereinafter F_i is the i-th surface which results from the surface parameters for a round surface F_i especially from the circle diameter D_i. If there is a number of j=1..N bores, F_i is the sum of the areas of the $F_{i,j}$ bores.

Advantageously the fluid flow is formed by a flow channel which has the following sections:

- in the mounting element a host of suction channels which are made especially as through holes and which end in the suction area F_2,

- a fluid chamber which is connected to the suction channels on their channel ends opposite the suction area F_2 and

- at least one pressure connection which is provided on the fluid chamber for connection of a controllable aspiration apparatus.

The fluid chamber 6 is used here especially as a buffer and at the same time as a distributor

for uniform suction along the suction area F_2 so that advantageously only a single pressure connection and a single pump are required to operate the mounting apparatus.

To the extent the suction area F_2 is adjustable, especially by at least partially closing a part of the suction channels, the mounting apparatus can be used for different product substrates with different structures/dimensions (especially the height H of the structures is relevant). The suction channels can be closed especially by preferably individually triggerable valves on/in the suction channels. Alternatively it is conceivable as claimed in the invention to provide a rotating disk with openings in the region of the suction channels (corresponding to the outer ring surface) on the end of the suction channels which is facing away from the suction area F_2. In this way the suction channels can be adjusted continuously from fully open to fully closed by rotating the rotary disk. In this way all suction channels can be continuously adjusted at the same time.

Here it is moreover advantageous if the fluid chamber is formed by a fluid chamber element which is sealed to the mounting element, and by the mounting element. Thus the fluid chamber can be easily produced, especially by milling of a trough shape into the fluid chamber element. The trough shape encompasses an especially round cylinder-shaped recess with a diameter which is larger than the maximum distance between the suction channels on their end facing the fluid chamber. The fluid chamber element thus consists especially of a ring-shaped peripheral wall and an upper wall which border the fluid chamber. The fluid chamber element is sealed to the mounting element by connecting elements, especially screws. The seal is preferably a circular ring-shaped seal with a diameter which is larger than the diameter of the fluid chamber on the periphery of the fluid chamber between the fluid chamber element and the mounting element.

In another advantageous embodiment of the invention it is provided that the flow channel in the region of the fluid chamber has a flow cross section of at least the same size, which is especially

at least 5 times, preferably 10 times, even more preferably at least 20 times larger than the suction area F_2 and/or of the flow cross section F_1 of the pressure connection. The fluid chamber is thus used at the same time as a buffer and collecting space for the fluid which is flowing in from the suction channels.

It is furthermore advantageously provided that the suction area F_2 is chosen or can be adjusted such that it corresponds essentially to an inflow surface Z of a ring gap which has been formed between the mounting surface and the substrate which is mounted on the mounting surface. The ring gap has a height H which is defined by the height of the structures of the substrate and runs on the periphery of the mounting surface or on the periphery of the substrate essentially in the shape of a circular cylinder so that the inflow surface Z can be at least roughly computed from the periphery of the substrate or of the mounting surface and the height H.

According to another advantageous embodiment it is provided that the mounting surface is provided on a projection of the mounting element whose contour is chosen such that it corresponds essentially to the surface contour of the substrates which are to be processed, especially with a diameter D_3 of the mounting surface between 200 mm and 450 mm, preferable exactly 200 mm or 300 mm or 450 mm. This measure more sharply defines the inflow surface Z since it corresponds to the more or less common outer contour between the mounting surface and the substrate surface which has the contours.

To the extent the mounting surface, especially the projection, is coated with an especially elastic layer, the structures which are present on the substrate are on the one hand mounted carefully on the mounting surface and on the other contamination (for example with metal shavings) is avoided.

By a first group of especially at least 10, preferably at least 50, even more preferably at least 100, suction channels on a common first circle on the outer ring surface lying especially equidistantly to one another, the suction is further homogenized. This is because a uniform fluid flow, especially between the mounting surface and the substrate as far as to the middle M of the mounting surface, is effected by a concentric arrangement of the suction channels to the middle M of the suction surface or rotationally symmetrically to the mounting element.

According to another aspect of this invention the distance between the suction channels is smaller than 1 mm, especially smaller than 500 μm, preferably smaller than 250 μm, even more preferably smaller than 150 μm.

Here it is especially advantageous if there is a second group of especially at least 10, preferably at least 20 suction channels, especially offset to the suction channels of the first group, on a common second circle with a smaller radius than the first circle on the outer ring surface, especially concentrically to the middle M and/or equidistantly to one another. In this way, on the outer ring surface more suction channels can be accommodated and the more suction channels there are, the smaller they can be made and the more uniformly and more carefully suction of the substrate takes place. At the same time, arranging at least two groups on the outer ring surface yields higher stability of the mounting element. The number of suction channels is consequently limited only

upward by the minimum diameter of the suction channels and the dimensions of the mounting element. The offset bores are thus a replacement for a slot which would act disadvantageously on the mechanical stability of the wafer on the edge.

According to another aspect of this invention the inflow surface Z is conceivable by changing, especially controlling, the diameter D_{2i} of each suction channel.

To the extent method features have been disclosed, they are to be considered and claimed as disclosed as the method as claimed in the invention.

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

Figure 1a shows a plan view of a mounting apparatus as claimed in the invention from underneath with a cutting line A-A,

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

Figure 2a shows a view according to Figure 1b with a structured substrate which is mounted on the mounting apparatus,

Figure 2b shows a detailed view from Figure 2a and

Figures 2c shows a detailed view from Figure 2a.

Figure 3 shows a contour plot view of the pressure distribution of the surface 3o, computed with a fluid simulation program

Figure 4 shows an enlargement of the contour plot view of the pressure distribution of the surface 3o, computed with a fluid simulation program.

The same components or components with the same action are identified with the same

reference numbers in the figures.

Figure 1a shows a mounting apparatus 1 which consists of a fluid chamber element 2 and a mounting element 3. The fluid chamber 2 consists of a ring-shaped peripheral wall 2w which is formed by out-milling a circular cylinder and an upper wall 2o which covers the ring-shaped peripheral wall 2w. The upper wall 2o at the same time forms the bottom of the milled-out cylinder. For fixing of the mounting element 3 on the fluid chamber element 2, in the production of the fluid chamber element 2 internal threads 4i are cut into the peripheral wall 2w, distributed on the periphery of the peripheral wall 2w equidistantly to one another. In the production of the fluid chamber element 2 there is furthermore at least one seal groove 2n on the connecting surface between the fluid chamber element 2 and the mounting element 3. In the production of the fluid chamber element 2 there is furthermore a pressure connection 13 in the upper wall 2o. A connection element 9 is sealed or can be sealed to the pressure connection 13 and the connection element is used to connect an intake pipe 14 which is connected to a pump 16. In the intake pipe 14 there can be one or more measurement apparatus 15 for pressure measurement. The pressure can also be measured in the pump 16 and/or at another position in the flow channel.

The pressure connection 13 has a flow cross section F_1, especially as a bore with a diameter D_1. The pressure connection 13 is part of a flow channel which runs through the mounting apparatus 1. The pressure connection 13 (and thus the flow channel) leads to a fluid chamber 6 which is formed by the upper wall 2o and the peripheral wall 2w and an attachment side 3b of the mounting element 3.

The mounting element 3 has essentially a cylinder shape with an outer periphery which

corresponds to the fluid chamber element 2, especially to the peripheral wall 2w so that the mounting element 3 can be sealed with its especially planar attachment side 3b on one contact surface to the fluid chamber element 2. For this purpose there are screw receivers 4a which are arranged corresponding to the internal threads 4i for accommodating connecting elements 4 which are made as screws. The mounting element 3 can be fixed by the connecting elements 4 on the fluid chamber element 2 on their common contact surface, there being a seal 5 which is made as a ring seal in the seal groove 2n and optionally a corresponding seal groove 3n of the mounting element 4 for sealing the fluid chamber 6 relative to the environment.

The fluid chamber 6 forms another section of the flow channel. Proceeding from the fluid chamber 6 the flow channel is divided or branched in another section of the flow channel which is formed by a plurality of suction channels 7 which are provided in the mounting element 3.

The suction channels are made as through bores which run especially parallel to one another and whose ends 7e all end on or within the fluid chamber 6. The opposite end of the suction channels ends in the region of one outer ring surface 8 of a mounting surface 3o for mounting of a substrate 10. The mounting surface 3o is provided on a projection 3e which is made as a circular ring with a diameter D_3 and an obliquely running shoulder 3a. The diameter D_3 corresponds essentially to the diameter of the substrate 10.

A first group of suction channels 7 is located on a circle and within the outer ring surface 8, while a second group of suction channels is located on a second circle which is located farther inside and likewise within the outer ring surface 8. Thus as many suction channels 7 as possible with a diameter D_2 as small as possible are accommodated as near as possible to one peripheral edge U of

the mounting surface 3o. Due to the thickness of the mounting element 3 a support section of the mounting surface 3o provided within the outer ring surface 8 remains stable. In the support section there are no suction channels 7 and the support section and the entire mounting surface 3o are made flat.

The surface of the mounting element 3 can be at least partially coated with a coating 12 of soft material especially in the region of the mounting surface 3o. Preferably it is a polymer, preferably an elastomer. The coating 12 is used to protect sensitive structures 11 provided on the substrate 10 and to prevent contamination of the substrate 10 which is made as a product substrate.

The suction channels 7 which are produced by drilling are arranged concentrically to a middle M of the especially rotationally symmetrical mounting element 3.

A ring width R of the outer ring surface 8 is made as small as possible and is located as far as possible on the peripheral edge U and is especially between 1 mm and 50 mm, preferably between 1 mm and 10 mm. The diameter D_3 is especially between 200 mm and 450 mm, preferably exactly 200 mm, 300 mm or 450 mm.

By continuously exposing the fluid chamber 6 to a negative pressure via the pressure connection 13 and the pump 16, a suction action arises on a suction area F_2 which is formed by the sum of the flow cross sections of the suction channels 7 on the mounting surface 3o. In this way the substrate 10 with its structure side10s can be sucked onto the mounting surface 3o and fixed. Although there are suction channels 7 only on the outer ring surface 8 (circular ring), the area is also evacuated or negatively pressurized which is penetrated by structures 11, which lies within the outer ring surface 8 and between the mounting surface 3o and the substrate 10, and which is surprisingly

homogeneous. The homogeneous pressure distribution is most easily explained by the statistical multiparticle system in this region being understood as a large canonical ensemble. An ensemble is a set of replicas of a statistical multiparticle system which differ in their microstates but have equivalent macrostates. A large canonical ensemble is an ensemble which is subject to fluctuations of particles and energy. Although the embodiment as claimed in the invention continuously sucks particles on the edge, some particles always find the path into the interior region, likewise particles will also leave this region again. Therefore an absolute vacuum or even only a high vacuum will never be attainable. Still the number of particles can on average be kept constant with constant starts and boundary conditions. Since there are no potentials which make the statistical distribution function locally dependent (aside from gravitation potential whose effects on the distribution function are negligible for the short height of the examined region) the pressure distribution must likewise be a homogeneous function of the site. Thus the substrate 10 with the structures 11 is fixed very uniformly on the mounting surface 3o. The force acting on the substrate 10 is defined by controlling the negative pressure on the pump 16 and by means of the flow cross sections of the individual sections of the flow channel.

It has been found to be optimum as claimed in the invention if the cross sectional area F_1 of the pressure connection 13 corresponds roughly to the sum of the cross sectional areas of the suction channels, therefore roughly the suction area F_2. The ratio of the areas F_1 to F_2 is especially between 1 to 10 and 10 to 1, preferably between 2 to 7 and 7 to 2, more preferably between 3 to 5 and 5 to 3, most preferably between 4 to 5 and 5 to 4.

The suction area F_2 is moreover advantageously chosen such that it corresponds roughly to

an inflow surface Z which is formed by a ring gap 17 between the peripheral edge U of the mounting surface 3o and the substrate 10 due to the height of the structures 11 during suction. The inflow surface Z corresponds to the periphery of the ring gap 17 multiplied by the height H of the ring gap 17, especially a ratio of the suction area F_2 to the inflow surface Z being between 4 to 5 and 5 to 4.

As long as the substrate 10 is to be held on the mounting apparatus 1, the pump 16 must provide for a continuous fluid flow along the flow channel. It is provided by the above described flow cross section of the flow channel as claimed in the invention that the amount of gas which flows through the suction channels 7 per unit of time is equal to the amount of gas which leaves the fluid chamber 6 through the pressure connection 13 or the connection element 9.

The topographical structures 11 keep the substrate 10 (wafer) separated at a distance H (corresponds to height H of the ring gap 17) from the projection 3e, specifically the mounting surface 3o. The space between the substrate and the mounting surface 3o at the start of the suction process is automatically lowered to a certain pressure level somewhat above the suction pressure on the suction area F_2 and subsequently remains constant for further continuous pressurization of the fluid chamber 6. At this instant there is an especially steady-state pressure distribution along the flow profile from the inflow surface Z to the pump 16.

Thus, as claimed in the invention it can be controlled by the suction performance, especially the volumetric flow or any other easily accessible and measurable physical quantity, of the pump 16, how large the surface force acting on the substrate 10 on the mounting surface 3o is, by changing the suction performance a preferably linear change of the surface force taking place. According to another embodiment of the invention it is provided that the elastic coating 12 is elastic such that the

structures 11 penetrate at least partially, especially at least by one third of the height H, preferably by half of the height H, even more preferably by three fourths of the height H, into the elastic coating 12. In this way the height H' of the ring gap 17 is reduced so that the inflow surface Z' becomes correspondingly smaller. This could result in a reinforcing effect. A smaller inflow surface Z' at the same volumetric flow would mean a higher force and thus would press the wafer farther into the coating 12; this in turn would result in a reduction of the inflow surface Z'.

According to another advantageous embodiment of the invention, especially in combination with the embodiment described in the preceding paragraph, it is conceivable as claimed in the invention to make the suction channels 7 at least partially sealable. In this way there would be a dynamic matching possibility for the inflow surface Z'.

Reference number list

1	mounting apparatus
2	fluid chamber element
2w	peripheral wall
2o	upper wall
2n	seal groove
3	mounting element
3o	mounting surface
3e	projection
3b	attachment side
3n	seal groove

4	connecting elements
4i	internal thread
4a	screw receiver
5	seal
6	fluid chamber
7	suction channel
7e	ends
8	outer ring surface
9	connection element
10	substrate
10s	structure side
11	structures
12	coating
13	pressure connection
14	intake pipe
15	measurement apparatus
16	pump
17	ring gap
F_1	flow cross section
F_2	suction surface
U	peripheral wall

M middle

R ring width

D_1 diameter

D_2 diameter

D_3 diameter

Z inflow surface

H height

Claims

1. A mounting apparatus for mounting and fixing of a substrate (10) on one structure side (10s) of the substrate (10), which side has structures (11) with a mounting element (3) with a flat mounting surface (3o) for supporting the structures (11) and a suction area (F_2) which penetrates the mounting surface (3o) solely in an outer ring surface (8) for effecting a fluid flow which suctions the substrate (10).

2. The mounting apparatus as claimed in Claim 1, wherein the outer ring surface (8) which is made especially as a circular ring extends from one peripheral edge (U) of the mounting surface (3o) in the direction of one middle (M) of the mounting surface (3o) and an especially maximum or average ring width (R) of the outer ring surface (8) is less than 1/2, especially less than 1/5, preferably less than 1/10, even more preferably less than 1/100 of a diameter (D_3) of the mounting surface (3o).

3. The mounting apparatus as claimed in one of the preceding claims, wherein the fluid flow is formed by a flow channel which has the following sections:

- in the mounting element (3) a host of suction channels (7) which are made especially as through openings, preferably bores, and which end in the suction area (F_2),

- a fluid chamber (6) which is connected to the suction channels (7) on their channel ends (7e) opposite the suction area (F_2) and

- at least one pressure connection (13) which is provided on the fluid chamber (6) for connection of a controllable aspiration apparatus (14, 15, 16).

4. The mounting apparatus as claimed in one or more of the preceding claims, wherein the suction area (F_2) is adjustable, especially by at least partially closing a part of the suction channels (7).

5. The mounting apparatus as claimed in Claim 3, wherein the fluid chamber 6 is formed by a fluid chamber element 2 which is sealed to the mounting element 3, and by the mounting element 3.

6. The mounting apparatus as claimed in Claim 2, wherein the flow channel in the region of the fluid chamber (6) has a flow cross section which is especially at least 5 times, especially at least 10 times, preferably at least 20 times larger than the suction area (F_2) and/or of the flow cross section (F_1) of the pressure connection (13).

7. The mounting apparatus as claimed in one or more of the preceding claims, wherein the suction area (F_2) is chosen or can be adjusted such that it corresponds essentially to an inflow surface (Z) of a ring gap (17) which has been formed between the mounting surface (3o) and the substrate which is mounted on the mounting surface (3o).

8. The mounting apparatus as claimed in one or more of the preceding claims, wherein the mounting surface (3o) is provided on a projection (3e) of the mounting element (3) whose contour is chosen such that it corresponds essentially the surface contour of the substrates (10) which are to be processed, especially with a diameter (D_3) of the mounting surface (3o) between 200 mm and 450 mm, preferably exactly 200 mm or exactly 300 mm or exactly 450 mm.

9. The mounting apparatus as claimed in one or more of the preceding claims, wherein the mounting surface (3o), especially the projection (3e), is coated with an especially elastic coating

(12).

10. The mounting apparatus as claimed in one or more of the preceding claims, wherein a first group of especially at least 10, preferably at least 20, more preferably at least 100, suction channels (7) on a common first circle on the outer ring surface (8) lie especially equidistantly to one another,

11. The mounting apparatus as claimed in Claim 10, wherein a second group of especially at least 10, preferably at least 20 suction channels (7), especially offset to the suction channels (7) of the first group, lies on a common second circle with a smaller radius than the first circle on the outer ring surface (8).