Substrate holder, method for the production of such a substrate holder and method for holding a substrate

The present invention relates to a substrate holder, a method for the production of such a substrate holder and a method for holding a substrate.

In recent years and decades, bonding technology has developed significantly. One important driving factor in the further development of bonding technology was the desire to produce individual functional units on different substrates, in particular wafers, and to bond them together in a bonding process. This allowed different manufacturers to produce various substrates with different functionalities, which could then be combined in a bonding process.

There are basically different types of bonding processes. One bonding process is a temporary bonding, in which preferably a bonding adhesive, for example a polymer, is used to bond a first substrate, the product substrate, to a second substrate, a carrier substrate. This bonding process is mostly used to enable the transportation and stabilisation of the product substrate for further method steps. Methods are performed on the product substrate that expose it to chemical, mechanical and thermal stresses. If the product substrate were not stabilised by the carrier film, it would buckle, break or crack. After the product substrate has been successfully processed, it can be separated from the carrier substrate using one of many debonding processes.

Another bonding method is direct bonding. In direct bonding, two substrates are bonded with each other directly via their substrate surfaces. In most cases, dielectric substrate surfaces are used that are hydrophilic or hydrophobic. This type of direct bonding is known as fusion bonding. If the substrate surfaces do not have a continuous dielectric surface, but are interrupted by metallic regions, for example through hole vias (TSV - through-silicon vias), then this is also referred to as a hybrid bonding surface. By far the greatest technological progress in recent years has been achieved with the help of fusion bonding processes, as they have made it possible to perform heterogeneous integration.

One of the most important tools for performing direct bonding is a substrate holder (also known as a chuck). The substrate holder has also undergone numerous further developments in recent decades.

Initially, the substrate holder consisted of a component or a component group that had a plane substrate holder surface. This substrate holder surface could have fixation elements, such as electrodes or vacuum holes, depending on whether the substrate holder was designed as an electrostatic or vacuum substrate holder. However, the characteristic feature was the plane substrate holder surface, interrupted only by fixation elements.

A first further development was to construct the substrate holder in such a way that the substrate to be fixed rests on a large number of pin elements (pins), sometimes also called knobs. Instead of a pin element substrate holder, one could also speak of a knob substrate holder. In the following text, the word pin element (instead of knob element) is used to describe this component of the substrate holder. The pin elements are generally elevations that can have different dimensions and shapes. Most of the time, the pin elements are cylindrical with a small ratio of cylinder axis length to cylinder diameter. This compact form is intended to guarantee stability. The fixation of the substrates is usually done by vacuum fixture. At the base level, where the pin elements are located, there are through holes to a vacuum system inside the substrate holder. By means of appropriate evacuation, the space between the base level and the substrate, i.e. the space between the pin elements, can be evacuated. Atmospheric pressure then presses and fixes the substrate onto the pin elements. One of the reasons for developing a pin element substrate holder was to avoid backside contamination of the substrate. The smaller the contact area, the fewer the number of particles that can be transferred from the substrate holder to the backside of the substrate.

A further development of the substrate holder consisted of the so-called zone substrate holders. The zone substrate holders are usually also pin element substrate holders, but are characterised by the fact that there are different regions on the substrate holder, which are called zones and which are separated from other zones by a sealing device. The fixation elements of such zone substrate holders are usually also vacuum fixtures. Each zone can switch its fixture, in particular its vacuum fixture, on and off independently of the fixtures of the other zones. This makes it possible to selectively fix a substrate as a function of location. It is even possible to define the fixture strength, i.e. to define the pressure with

which the substrate is pressed onto the substrate holder surface, in the case of a pin element substrate holder, the pin element surfaces, by means of the strength of the fixture, in particular the level of the vacuum created. This control option is of fundamental importance for influencing a bond wave that forms and moves between two substrates and that has been shown to have a very strong influence on the bonding result. The bonding result can be significantly improved by the option of controlling the different zones.

On this basis, it has been found that one problem with the pin element substrate holders, in particular with the zone substrate holders, is that a topography of the pin elements and/or the sealing devices affects the bonding result. The topography of the pin elements and/or sealing devices can be recognised by mechanical deformation and/or plastic deformation and/or changes to a bonding interface and/or run-out errors due to measuring systems. However, the desired bonding result would be a homogeneous, flawless bond.

One of the ways to solve this problem was to reduce the distance between the pin elements, i.e. to increase the number of pin elements per unit area, i.e. the pin element area density. The reduced distance between the pin elements means that the substrate is better supported and lies flatter on the pin elements. However, if the distance between the pin elements is too small, it is no longer possible to make appropriate sealing devices between the pin elements, which prevents the production of a zone substrate holder because different pressure levels cannot be maintained. In the prior art, the problem is solved by simply omitting the pin elements along a contour line in order to insert the sealing device. However, this in turn leads to an interruption in the homogeneity of the pin element surface density.

The object of the present invention is to provide a substrate holder that, when holding the substrate, eliminates, as far as possible, any distortion of a processing result due to the effects of pin elements and/or sealing devices, while at the same time ensuring that spatially resolved influencing of the holding is possible.

The present invention achieves the object with a substrate holder according to claim 1, a method for the production of a substrate holder according to claim 14 and a method for holding a substrate according to claim 15. Advantageous further developments of the invention are given in the sub-claims. The invention also includes all combinations of at least two features mentioned in the description, claims and/or drawings. In the case of

ranges of values given, values within the stated limits are also to be considered as limit values and can be claimed in any combination.

According to a first aspect of the present invention, a substrate holder is provided for holding a substrate during a treatment process, for example during a bonding process, lithography process, coating process and/or cleaning process, the substrate holder having a separating area for separating areas with different pressure levels that arise between the substrate holder and the substrate when holding, the separating area having at least a sealing device and a pin element and/or a further pin element, wherein the pin element and/or the further pin element and the sealing device are designed in such a way that, in order to form a non-contact sealing area, the pin element and/or the further pin element prevent contact in the separating area between the sealing device and the substrate at least in sections when the substrate is held.

In contrast to the substrate holders known from the prior art, the invention provides that the sealing device in the separating area, at least in sections, preferably over the entire separating area or over more than 30%, preferably more than 50% and most preferably more than 70% of the separating area, does not establish any contact with the substrate, by the pin elements and/or further pin elements keeping the substrate at a distance from the sealing device when holding. At the same time, the sealing device ensures that different pressure levels can be created in the regions adjacent to the separating area, forming a non-contact sealing area. A sealing device or a sealing element is therefore to be understood as a structural or physical measure, which, in particular by filling the volume, serves to form a sealing labyrinth or a gap seal, i.e. to increase a flow resistance in the separating area. In particular, a flow resistance is increased by the arrangement of the pin element, further pin element and/or sealing device. To this end, for example, the arrangement of the sealing device is used to influence the length of the flow path and/or the shape of the flow path. The separating area is thus to be understood in particular as one that is suitable for maintaining different pressure levels without, for example, realising a complete hermetic sealing device. Rather, the separating area serves to ensure that an intended pressure level can be maintained, supported and/or realised in the respective regions adjacent to the separating area. It is therefore not a matter of completely hermetically sealing two regions using the separating area.

By deliberately spacing the substrate from the sealing devices or the sealing device, it is advantageously possible to prevent the substrate from making flat contact, in particular

comparatively large-area contact, with the sealing device. This advantageously further reduces the influence of the substrate holder on the substrate, which means that the treatment process is less influenced by the sealing device. At the same time, pin elements, further pin elements and the sealing device interact in such a way that the flow resistance between the areas with different pressure levels increases, resulting in a desired sealing effect. The advantage of this is that the sealing devices themselves no longer have a mechanical effect on the substrate. A sealing surface is recessed in contrast to a pin surface, i.e. a contact surface for the pin element or further pin element, and does not come into contact with the substrate. Measurements have shown that the comparatively wide sealing devices in particular act on a bond interface during the bonding process in such a way that the effect becomes visible afterwards through measuring equipment. The recessed sealing devices do not come into contact with the substrate in the first place.

In particular, it is provided that the substrate holder essentially extends along a main extension plane and that the sealing device, the pin element and/or the further pin element is designed as a raised element that protrudes in a direction perpendicular to the main extension plane. In particular, it is preferably provided that the substrate holder has a preferably imaginary base plane that extends essentially parallel to the main extension plane, from which in turn the pin elements, the further pin elements and/or sealing devices project in a direction perpendicular to the main extension plane. The contact surfaces of the pin element or the further pin element preferably run parallel to the base plane or main extension plane. It is conceivable that one side of the sealing device facing the substrate when holding it runs at an angle to the main extension plane and/or has an uneven course. This results in more freedom in the design of the sealing devices, since no parallel alignment is required for them to rest on. In the regions designed between the substrate and the base plane when holding the substrate, a kind of sealing labyrinth or labyrinth seal or gap seal, which is particularly suitable for ensuring different pressure levels in the regions adjacent to the sealing area or separating area. It is thus provided to dispense with direct contact of the sealing devices with the substrate and to construct a combination of pin elements and sealing devices as a labyrinth seal.

The substrate holder described is preferably used for a bonding process, in particular a fusion bonding, and most preferably for a hybrid bonding. However, the use of the substrate holder is by no means limited to bonding. The substrate holder can also be used as

a fixture for a substrate that is provided for lithography, in particular photo or imprint lithography. Applications for coating processes, cleaning processes and/or similar are conceivable.

It is conceivable that the sealing device is inserted between the pin elements without removing pin elements. This allows a pin element surface density, i.e. a number of pin elements per unit area, to be obtained. The sealing device is preferably set back. It is conceivable, for example, that a sealing device could be integrated into an already existing arrangement, for example retrospectively. This makes it possible to increase a seal and/or to separate individual zones, even at a later date. This means that holding devices can be retrofitted accordingly.

Preferably, it is provided that the pin element and/or the further pin element projects relative to the sealing device. This ensures with comparatively simple means that no contact is caused between the substrate and the sealing device. In particular, the contact surfaces of the pin elements and/or further pin elements lie in a common plane parallel to the main extension plane.

It is preferably provided that the further pin element is integrated into the sealing device. This has the advantage that, when designing the separating area, i.e. the arrangement of the pin elements and the sealing device, there is no need to choose between the pin elements and the sealing devices for their positioning. It is therefore possible to construct both in any number, distribution and size. The pin elements are preferably arranged on a hexagonal grid. However, square, centred-rectangular, rectangular and oblique-angled grids are also conceivable. These grid types are known from crystallography and group theory. A non-symmetrical, i.e. statistical, distribution of the pin elements is also conceivable, although not preferred. The hexagonal grid is preferred because it ensures that each pin element is at an equal distance from all its nearest neighbours. This makes it possible to increase the density of the pin elements or additional pin elements in the separating area in a beneficial way, since the region or an area of the sealing device is also used. Thus, the homogeneity can be increased with a distribution of contact surfaces provided by the pin elements and further pin elements, since the sealing devices no are in the way of placing the pin element or further pin element in this area. This means that a homogenous pin element density can be achieved and it is possible to manufacture sealing devices in any shape, in any position and in any number.

In this context, integration is to be understood as meaning, in particular, that the further pin element is arranged, for example, on the sealing device or that the further pin element is surrounded by the sealing device and is preferably embedded in a recess, more preferably in a blind bore, in the sealing device. For example, it is conceivable that the sealing device is designed in the form of a strip or an annular strip. Preferably, a plurality of strip-shaped sealing devices extend parallel to one another in the separating area. Therein, it is most preferably possible to arrange one or more rows of pin elements between the sealing devices, which extends or extend essentially parallel to the sealing device. The further pin elements are, for example, embedded in this strip-shaped or ring-strip-shaped sealing device. This makes it possible to advantageously use the area in which the sealing device itself is arranged as the position for a pin element, namely the other pin element.

Preferably, it is provided that the substrate holder has a first zone and a second zone, wherein the first zone is separated from the second zone by the separating area. This makes it possible, for example, to realise different pressure levels in the regions associated with the first and second zones, the separating area between the first zone and the second zone ensuring that at least the pressure level between the regions separated by the separating area is not immediately equalised again. In this case, it is conceivable that, in order to maintain the pressure level during the holding process, corresponding vacuum sources or compressors ensure that the zones are subjected to a corresponding vacuum, in particular different vacuums, in order to create and/or maintain different pressure levels. The separating area essentially supports the different pressure levels in order to fulfil the desired purpose of fixing or releasing specific areas of the substrates.

It is preferably provided that the separating area has several sealing devices, in particular each with at least one further pin element, to form a sealing labyrinth, wherein the sealing devices are arranged one behind the other along a direction running from the first zone to the second zone. The substrate holder will therefore generally have vacuum leaks between the individual zones, which can, however, preferably be reduced to such an extent by connecting multiple sealing devices in series that it is possible to perform or simplify the targeted and controlled suction of the substrate. It is conceivable that different sealing devices and/or further pin elements are realised. This can help to maintain the different pressure levels. It has proven to be particularly advantageous to implement or arrange at least three sealing devices, preferably at least five sealing devices and most preferably at least eight sealing devices, between the first and second zone along the given direction. It

is conceivable that there are different sealing devices between different zones. For example, one could imagine that, in a radial direction from a centre of the substrate holder, the number of sealing devices, pin elements and/or further pin elements per separating area increases and/or decreases.

The substrate holder thus preferably has several zones. The zones can be of any shape and can be separated by the sealing devices or separating areas described in this disclosure. Zone substrate holders are known in the art and will not be described in detail here. Some substrate holders with zones are disclosed and described in the documents WO 2022 002 345 A1, WO 2019 057 286 A1, WO 2018 028 801 A1, the content of which is explicitly referred to in this regard.

In particular, it is provided that the separating area has a closed contour, for example a frame-shaped contour. For example, an arcuate, (partially) segment-shaped or circular shape is preferable. Preferably, the sealing device extends essentially along the separating area. This makes it possible, for example, to separate zones or areas with different pressure levels that are arranged concentrically to a centre of the substrate holder. This makes it possible, for example, to control a bonding wave in radial direction, in particular if it starts in the centre of the substrate holder. It would also be conceivable for the separating area to surround a zone that forms a segment in an arrangement of segments arranged in a checkerboard pattern. Therein, for example, the checkerboard-like arrangement in a row can follow a certain path, for example a circular path. This makes it possible, for example, to achieve different effects on the bond wave at the same radial distance from the centre of the substrate age, but at different positions in the circumferential direction. This allows even more precise corrections when holding the substrate, in particular in the frame of a bonding process in which a bond wave is created.

Preferably, it is provided that a lateral extent of the sealing device is greater than a lateral extent of the further pin element. In particular, the lateral extent is measured, for example, as a cross-section, i.e. cross-sectional area, in a direction and/or plane parallel to the main extension plane. This can ensure that a contact surface associated with the further pin element in the region of the sealing device is smaller than the extent of the sealing device. The lateral extent is preferably more than three times, more than ten times or even more than twenty times as large as the lateral extent of the pin element.

Preferably, it is provided that the pin element and/or the further pin element and the sealing device or preferably the substrate holder are monolithically designed, in particular to more than 50%, preferably more than 70%, and most preferably essentially completely. In particular, the term monolithically is also understood to mean the single-piece or integral design of the substrate holder. The component of the substrate holder that fixes the substrate is thus preferably of monolithic construction. The term substrate holder is understood to include in particular the structural measures, without, for example, vacuum sources that are connected to the substrate holder. The substrate holder can be referred to as a fixing component. In general, a substrate holder should be thought of as a component group with several associated components. However, since most of the other components of the substrate holder do not provide any significant added value for the inventive concept, the word fixing component can also be used synonymously for substrate holder. Monolithic means that the pin elements and the sealing devices are not inserted but are machined out of a solid component. In particular, monolithically, integrally or in one piece designed means that no further disassembly of the substrate holder is possible without destroying it. Any type of manufacturing technology can be used for this purpose. Although the monolithic design is preferably used, the substrate holder can also be designed so that the pin elements and/or the sealing devices can be inserted, for example in the sense of a kit. This design particularly allows the pin elements and/or the sealing devices to be made of a different material from the fixing component or a base body.

It is particularly preferably provided that multiple further pin elements are integrated in a common sealing device. This allows a common sealing device to be used for multiple further pin elements. This proves advantageous, for example, for the production of the substrate holder, since additional individual elements do not have to be realised. This also contributes to the stability of the substrate holder. The multiple of further pin elements are preferably arranged in the common sealing device along a row, which most preferably essentially follows the direction of the sealing device, in particular if it is a strip-shaped sealing device. It is also conceivable that multiple rows of further pin elements are integrated into the sealing device. It is also conceivable that in radial direction or in a direction perpendicular to the course of the separating area, the further pin element is arranged in the centre or offset to the centre of the sealing device.

Furthermore, it is preferably provided that the respective pin spacings between adjacent pin elements or further pin elements, on the one hand, and further pin elements or pin elements, on the other hand, are substantially constant along a predetermined direction. This

allows a homogeneous distribution of the contact surfaces, provided by the pin elements and/or further pin elements, to be realised, at least in the predetermined direction. Most preferably, the predetermined direction extends along a direction that extends parallel to the planned bonding direction or perpendicular to the course of the bond wave. This simplifies control, for example in a bonding process. The pin element spacing is preferably the variable to be reduced. In particular, the contact surfaces provided by the pin element and/or further pin elements are arranged uniformly, in particular equidistantly, to one another along the given direction.

The pin elements and/or further pin elements have at least three geometric parameters, a pin element diameter or a pin element cross-section, a pin element height and a pin element spacing (pin pitch).

It is preferably provided that a pin element spacing is between 0.1 mm and 10 mm, preferably between 0.2 mm and 5 mm, more preferably between 0.5 mm and 2.5 mm, most preferably between 1.0 mm and 2.0 mm, and utmost preferably approximately 1.5 mm. The advantage of this is that substrates fixed by means of a pressure difference are bent less locally when the pin spacing on the substrate holder is reduced in this way. So, with decreasing pin spacing, one approaches more and more an ideal, even plane surface. This has a positive influence on the treatment process.

The substrate holder is designed so that the smallest possible pin element spacing can be realised. The pin element spacing is interpreted in particular with regard to the grid used to generate the pin elements.

If the pin elements are manufactured along a square grid, the pin element spacing is preferably understood to be the distance between the pin elements along the sides of the square that are perpendicular to each other. The pin element spacing is therefore preferably not interpreted as the distance between two pin elements along the diagonals of a square.

If the pin elements are arranged along a hexagonal grid, which is the preferred design, the pin element spacing is the distance between a pin element and its six nearest neighbours. In this case, the highest possible symmetry is present.

If the pin elements are arranged in a centred rectangular, rectangular or oblique-angled grid, or if the pin elements are even distributed at random positions, then only a statistical interpretation of the pin element spacing is of concern.

The pin element spacing is preferably approximately the same in all directions. In particular, a skilled person understands ‘approximately’ to mean that the difference between two pin element spacings is less than 10%, preferably less than 5%, more preferably less than 1%, most preferably less than 0.1%, and utmost preferably less than 0.01%. It is also conceivable that the pin element spacing between pin elements in tangential or circumferential direction differs from the pin element spacing of the pin elements in radial direction. In particular, it is conceivable that the pin element positions are distributed along a hexagonal grid, which would result in a high degree of symmetry.

In the case of a pin element deviating from cylindrical symmetry, the term pin element diameter is used synonymously for a typical geometric size of the pin element cross-section. If, for example, the pin element has a square cross-section, the pin element diameter can be understood to mean either the diagonal length or the side length. The same applies to other geometric cross-sections. It is also possible that the pin elements have a pin element diameter that decreases from bottom to top if, for example, the pin elements are made as cones. The pin element diameter or cross-section is a measure of its width.

The pin element height refers to the distance from the base plane to the pin element surface, i.e. the contact area. The ratio between the pin element height and the pin element diameter should not be too large in order not to exceed an Euler buckling load.

The pin element diameter is between 0.01 mm and 5.0 mm, preferably between 0.05 mm and 1.0 mm, more preferably between 0.075 mm and 0.75 mm, most preferably between 0.1 mm and 0.5 mm, and utmost preferably approximately 0.3 mm.

The pin element height is between 0.01 mm and 2 mm, preferably between 0.02 mm and 1.5 mm, more preferably between 0.025 mm and 1.0 mm, most preferably between 0.03 mm and 0.5 mm, utmost preferably between 0.1 mm and 0.15 mm.

The sealing device has at least three geometrical parameters, a sealing device width, a sealing device height and a sealing device recess. The sealing device width describes the width of the sealing device.

The sealing width describes the width of the sealing device, in particular measured in a radial direction from the centre of the substrate holder. The seal device width is between 0.01 mm and 10 mm, preferably between 0.05 mm and 7.5 mm, more preferably between 0.075 mm and 5.0 mm, most preferably between 0.1 mm and 1.0 mm, utmost preferably approximately 0.5 mm. The sealing device width can be so wide that it comprises several pin element rows. It can therefore be greater than a pin element spacing.

The sealing device height indicates the distance from the substrate holder base plane to the sealing device surface. It must be smaller than the pin element height to ensure that the further pin element does not protrude.

The sealing device recess indicates the distance from the pin element surface to the sealing device surface. It is the distance that a tool, preferably a cutting tool, in particular a milling cutter, removes in relation to the pin element height to create the sealing device height. The sum of the sealing device height and the sealing device recess is equal to the pin element height. This would make either the sealing device height or the sealing device recess redundant. However, both are used, the former to get a quick estimate of the height and the latter to know how far a tool has to remove material to create the sealing device surface.

The sealing device recess is less than 100 µm, preferably less than 10 µm, more preferably less than 1 µm, most preferably less than 100 nm, and utmost preferably less than 10 nm. The sealing device should therefore be in the vicinity of the substrate, but not in contact with it.

The most preferred embodiment provides that all pin elements, regardless of their position on the substrate holder, i.e. pin elements and further pin elements, have the same pin element height. This ensures that a substrate always rests at the same height along the entire surface.

It is also conceivable that the pin element height changes as the position of the pin element changes. For example, it is conceivable that the elastic behaviour of a pin element on a sealing device differs from the elastic behaviour of a pin element outside of a sealing device due to the underlying sealing device. In this case, it may be expedient to provide

the pin element on a sealing device slightly larger or slightly smaller than the other pin elements in order to take account of the changed elastic behaviour.

Furthermore, embodiments are described that can be used to achieve a correspondingly high pin element density.

In a first exemplary embodiment of the present invention, the sealing devices are constructed in such a way that they are located between the pin elements without removing a single pin element.

In a second exemplary embodiment of the present invention, the sealing devices are constructed in such a way that pin elements are located on them. The pin elements that are directly bonded to the base plane are referred to simply as pin elements, and the pin elements that are located on the sealing devices are referred to as further pin elements or sealing device pin elements. The height of the pin elements is preferably identical to the sum of the height of the sealing device and the height of a further pin element. In other words, the tips of the pin elements and the further pin elements are preferably located in the same plane. The further pin elements create a vacuum leak on the sealing devices. Therefore, preferably, the height of the further pin elements must be as low as possible and/or multiple of further pin elements must be created one behind the other so that a separating area is obtained which acts as a zone separator.

In a third exemplary embodiment of the present invention, all pin elements have the same height, but some pin elements are surrounded by a sealing device, i.e. they also end at the base level of the substrate holder. Preferably, the pin elements in the sealing devices are created by circular material removal. The tools must work with corresponding precision.

In a fourth exemplary embodiment of the present invention, the features of the second and third embodiments are combined. At least one sealing device of at least one separating area is so wide that it comprises at least two rows of pin elements. The pin elements of the rows of pin elements can then be created according to the second embodiment, the third embodiment or a combination of the two.

A further aspect of the present invention is a method for the production of a substrate holder according to the invention, preferably with a material removal for forming pin elements, sealing devices and/or further pin elements. All the advantages and properties described for the substrate holder can be transferred by analogy to the method and vice versa.

The substrate holder preferably comprises a material of one of the following material classes

- Preferably made of ceramic, in particular
  - SiC, Si_3N_4
- Pure metal, in particular
  - Aluminium
- Pure metal alloy
  - Nickel-based alloy, copper-based alloy, aluminium-based alloy
- Metal-carbon alloy
  - Steel, in particular
    - Free machining steel
    - tool steel

In the preferred monolithic design, the pin elements and sealing devices are then made of the same material, since they were made from the substrate holder.

The substrate holder is processed using at least one of the following manufacturing processes

- Machining, in particular
  - milling
- Chemical processing, in particular in connection with
  - lithography, in particular with
    - photolithography
    - imprint lithography
    - DMD exposure
  - development
  - stripping
  - masking
  - etching

- Ion beam machining
- Sandblasting with preceding masking of the regions not to be sandblasted
- Laser machining
- Casting
- Pressing
- Forging
- Hot embossing
- Imprinting with subsequent thermal or electromagnetic hardening
- 3D printing

The applied processing method preferably creates the pin elements and sealing devices from a semi-finished product by material removal, casting or plasticising processes.

The following manufacturing processes remove material from a semi-finished product to create the substrate holder: all machining processes, in particular milling, all chemical processing, in particular etching, ion beam processing, sandblasting and laser processing.

The casting process creates the substrate holder from a solidifying melt.

The manufacturing processes of pressing, forging and hot stamping plasticise a semi-finished product, preferably a circular disc, by the repeated or prolonged action of a die and/or a forging tool on the semi-finished product.

In the imprinting manufacturing process, an imprinting mass is embossed and then hardened thermally and/or by means of electromagnetic radiation.

In the 3D printing method, a component is sintered and built up point by point from a powder by the action of a Laser through hardening. The method is often also referred to as additive manufacturing.

Another aspect of the present invention is a method for holding a substrate with a substrate holder according to the invention, preferably in the frame of a treatment process. All the advantages and properties described for the substrate holder can be transferred by analogy to the subject of the method and vice versa.

Further advantages, features and details of the invention will become apparent from the following description of preferred embodiments and the drawings. These show:

Figure 1 a plan view and an enlargement of the prior art

Figure 2 a plan view and an enlargement of a substrate holder

Figure 3 a partial front view and a partial side view of a first embodiment

Figure 4 a partial plan and side view of a second embodiment

Figure 5 a partial plan and side view of a third embodiment

Figure 6 a partial plan and side view of a fourth embodiment and

Figure 7 a partial side view of an application.

In the figures, the same components or components with the same function are indicated by the same reference signs.

Figure 1 shows a schematic, non-scale top and side view of a separating area 4 comprising a single sealing device 5^{PA}. This is an exemplary separating area 4 as known from the prior art. To manufacture the sealing devices 5^{PA}, all the pin elements 6 along the sealing devices 5^{PA} are removed. This breaks the homogeneity of a pin element surface density. The sealing devices 5^{PA} have the same height as the pin elements 6 and therefore create the negative effects mentioned above.

Figure 2 shows a schematic, non-dimensionally accurate, simplified view of a substrate holder 1 comprising several zones 2, 2‘, in particular a first zone 2 and a further zone 2‘, which have fixation elements 3, in particular vacuum fixtures. The zones 2, 2‘ are separated from one another by separating areas 4. A separating area 4 generally comprises at least one sealing device 5 (in Figure 2, a sealing device 5‘ according to Figure 4 is shown as an example, but alternative sealing devices 5‘, 5‘‘, 5‘‘‘, as shown in Figures 3 or 5 to 7, are also conceivable). In special cases, the separating area 4 can also have only a single sealing device 5. The sealing devices 5 of the separating area 4 cannot be shown in the (not enlarged) view from above for reasons of space. Therefore, the enlargement B shows a schematic, non-scale, simplified, enlarged view of a separating area 4 that has three

sealing devices 5‘, which separate a first zone 2 from a second zone 2’. In the illustrated embodiment, there are two rows of pin elements 6 between the sealing devices 5‘. Furthermore, it can be seen that there are further pin elements 6‘ in the area of the sealing devices 5‘, which are preferably designed on a side facing the substrate 7 during operation, i.e. they project from the substrate holder or the sealing device 5‘. The further pin elements 6‘ are thus integrated into the sealing device 5‘. The separating area 4 created in this way is not able to hermetically seal the two zones 2 from one another in a vacuum-tight manner when the substrate 7 is placed on it (not shown). Due to the dimensions of the pin elements 6, as listed below, and/or the further pin elements 6‘ and/or, preferably, the use of multiple sealing devices 5‘ per separating area 4 a sealing device labyrinth is created that at least impedes or slows down the passage of a fluid, in particular gas, between the two zones 2. The flow resistance is increased for this purpose. This allows adjacent zones 2 to be operated at different vacuum or pressure levels. On the other hand, the distance between the pin elements 6 and/or further pin elements 6‘ can be further minimised. With this design, it is advantageously possible to manufacture or place sealing devices 5’ between the pin elements 6, and in particular to use the installation space as economically as possible.

Figure 3 shows a schematic, not to scale top and side view of a separating area 4, comprising a sealing device 5, in a first exemplary embodiment of the present invention. The pin elements 6 are arranged in a hexagonal grid, which has the advantage that each pin element 6 is at the same distance p_p (pin pitch) from its nearest neighbours. This pin element arrangement achieves a particularly high level of homogeneity and isotropy. On the one hand, the sealing device 5 is manufactured between the pin elements 6 and, on the other hand, it has a non-vanishing, but preferably very small, seal recess s_r. In contrast to the prior art, no pin elements 6 are removed, but the sealing devices 5 are placed between the pin elements 6. In the illustrated embodiment, the sealing device 5 is designed strip-shaped, wherein the strip-shaped sealing device 5 has a substantially straight course. However, wave-shaped or other shapes for the sealing device 5 are also conceivable. For example, the sealing devices 5 are slightly corrugated around the pin elements 6, i.e. not as straight over short distances as in Figure 3. However, such an additional representation is omitted. Because no pin elements 6 have to be removed, the pin element surface density can remain constant over the separating area 4. In the special case of Figure 3, the separating area 4 has only a single sealing device 5. It is conceivable that a separating area 4 may have several such sealing devices 5.

Figure 4 shows a schematic, not to scale top and side view of a separating area 4 comprising three sealing devices 5', in a second exemplary embodiment of the present invention. In this case, the pin elements 6, 6‘ are arranged along a square grid. It is also conceivable to use a different grid, in particular a hexagonal grid. This embodiment has pin elements 6 that are directly bonded to the base plane of the substrate holder 1 and further pin elements 6‘ that are located on the sealing devices 5‘. This compact design allows the pin pitch p_p between the pin elements 6 and further pin elements 6‘ to be selected even closer than in solutions in which only pin elements 6 are provided between the sealing devices 5, as indicated in Figure 3 by way of example. Preferably, the pin distance between two pin elements 6 is the same as the distance between a pin element 6 and a further pin element 6‘. Pin elements 6 and further pin elements 6’ are arranged equidistantly, in particular along a radial direction of the substrate holder starting from a centre or along a planned bonding direction. This maintains the homogeneity of a pin element distribution of the pin elements 6, 6‘ over the sealing devices 5‘. However, it is also conceivable that the pin spacing between two pin elements 6 differs from the pin spacing between a pin element 6 and a further pin element 6‘. The pin elements 6 and further pin elements 6‘ have a pin element diameter p_d (pitch diameter) and/or a cross-sectional area, which is defined, for example, by a contact surface or bearing surface, with which the pin element 6 or the further pin element 6‘ contacts the substrate 7, and/or which is dimensioned perpendicular to a direction in which the pin elements 6 or the further pin elements 6‘ extend. If the pin elements 6 and/or further pin elements 6' have a geometry that deviates from a circular shape, the pin element diameter p_d is to be reinterpreted accordingly. For example, if the geometry is a square, the parameter p_d represents a side length of the square or the length of its diagonal. The pin elements 6 have a pin element height p_h (pitch height). The sealing device has a width s_w (seal width), a height s_h (seal height) and a recess, a depression or a set-back s_r (seal recess). The height s_h can therefore also be interpreted as the height of the pin element 6‘ in relation to the surface of the sealing device 5‘. In particular, the design variant of Figure 4 proves to be particularly advantageous because it is comparatively easy to manufacture.

Figure 5 shows a schematic, not to scale top and side view of a separating area 4, which is formed from three sealing devices 5‘‘, in a third exemplary embodiment of the present invention. The dimensions will not be named again. They can be found in the description of Figure 4. This embodiment has only pin elements 6 that are directly bonded to the base plane of the substrate holder 1, as well as sealing devices 5‘‘. However, the other pin elements 6 within the sealing devices 5‘‘ extend to the base plane of the substrate holder 1

and are completely surrounded by the sealing device 5‘‘. They are integrated into the sealing device 5‘‘. This embodiment has the advantage that the mechanical, in particular elastic, properties of all pin elements 6 are identical, since their geometric parameters match. The manufacturing tools required for this must be able to cut regions out of the sealing devices 5‘‘.

Figure 6 shows a schematic, not to scale top and side view of a separating area 4 comprising three sealing devices 5‘‘, 5‘‘‘, in a fourth exemplary embodiment of the present invention. It can be seen that the sealing device 5‘‘‘ extends over three rows of pin elements and is designed such that the two outer rows of pin elements are manufactured according to the second embodiment (see Figure 4) and the centre row of pin elements is manufactured according to the third embodiment of the invention (see Figure 5). The fourth embodiment according to the invention thus represents a combination of two other embodiments. Furthermore, it is intended to show that a sealing device 5‘‘‘ can extend over several rows of pin elements. Accordingly, the sealing device 5‘‘‘ has a different sealing device width s_w’. It is not absolutely necessary that the second and third embodiments are combined in the fourth embodiment. It is also conceivable that the sealing device width s_w' comprises at least two rows of pin elements, the pin elements of which are constructed exclusively in accordance with the second embodiment. Similarly, one can imagine a sealing device comprising a sealing device width s_w‘ of at least two pin element rows, whose pin elements 6 or further pin elements 6’ are designed exclusively according to the third embodiment. The distinguishing feature would then be exclusively the sealing device width s_w'. Furthermore, it is to be shown that different sealing devices, for example the sealing devices 5‘‘, 5‘‘‘, can also be combined within a separating area 4. For the sake of clarity, not all possible combinations are shown. The skilled person knows and understands how the embodiments and parameters can be combined to produce any sealing devices and separating areas.

All pin elements 6, 6‘ and sealing devices 5, 5’, 5‘‘, 5‘‘‘ shown in the figures are shown monolithic or integral, i.e. made of one and the same component. For the sake of completeness, it is mentioned again that the sealing devices 5, 5‘, 5‘‘, 5‘‘‘ and/or the pin elements 6, 6' can theoretically also be individual components inserted into the substrate holder 1. Such embodiments could be used at lower pin element and sealing device densities. Furthermore, the choice of individual sealing devices 5, 5‘, 5‘‘, 5‘‘‘ and/or pin elements 6, 6' could be used to select a material that differs from the substrate holder 1.

Figure 7 shows a schematic, not to scale side view of a separating area 4 comprising three sealing devices 5‘, 5‘‘, according to a fourth embodiment of the present invention (see Figure 6), on which a substrate 7 rests. On the left side of the side view is zone 2 with a pressure p1 created by the vacuum fixture. On the right side of the side view is zone 2' with a pressure p2 created by the vacuum fixture. The two pressures p1 and p2 do not necessarily have to be the same. However, a sealing device labyrinth is created by the separating area 4, which makes it extremely difficult for fluid to flow from one zone to the other. If the pumps for the zones 2, 2' work efficiently enough, the desired pressures p1 and p2 can be controlled and regulated. However, the substrate 7 does preferably not come into contact with the sealing device surface of the sealing devices 5‘‘, 5‘‘‘ at any time, and the pin element spacing of the pin elements 6, 6’ can not only be designed to be minimal, but ideally also homogeneous.

List of reference signs:

1	substrate holder
2, 2‘	zone
3	fixation element
4	separating area
5^{PA}, 5, 5‘, 5‘‘, 5‘‘‘	sealing device
6, 6‘	pin element, further pin elements
7	substrate
ph	pin element height
pd	pin element diameter
pp	pin element spacing
sw, sw'	sealing device width
sh	sealing device height
sr	sealing device recess

Claims

1. A substrate holder (1) for holding a substrate (7) during a treatment process, for example during a bonding process, lithography process, coating process and/or cleaning process, the substrate holder (1) having a separating area (4) for separating areas with different pressure levels that arise between the substrate holder (1) and the substrate (7) when the substrate (7) is held, the separating area (4) having at least
   - a sealing device (5, 5‘, 5’‘, 5’’‘) and
   - a pin element (6) and/or a further pin element (6‘),

   wherein
   - the pin element (6’) and/or the further pin element (6‘) and
   - the sealing device (5, 5’, 5‘‘, 5‘’)

   are designed in such a way that, in order to form a non-contact sealing area, the pin element (6) and/or the further pin element (6‘) prevent contact in the separating area (4) between the sealing device (5, 5’, 5‘‘, 5‘’') and the substrate (1) at least in sections when the substrate (1) is held.

2. The substrate holder (1) according to claim 1, wherein the pin element (6) and/or the further pin element (6‘) projects with respect to the sealing device (5, 5’, 5‘‘, 5‘’').

3. The substrate holder (1) according to one of the preceding claims, wherein the further pin element (6‘) is integrated into the sealing device (5, 5’, 5‘‘, 5‘’').

4. The substrate holder (1) according to claim 3, wherein, for the purpose of integrating the further pin element (6‘) into the sealing device (5, 5’, 5‘‘, 5’’‘), the further pin element (6‘) is arranged on the sealing device (5, 5’, 5‘‘, 5‘‘’).

5. The substrate holder (1) according to claim 3 or 4, wherein, for the purpose of integrating the further pin element (6‘) into the sealing device (5, 5’, 5‘‘, 5‘‘’), the further pin element (6’) is surrounded by the sealing device (5, 5‘, 5’‘, 5’’‘) at least partially, preferably circumferentially and most preferably completely circumferentially, and is preferably embedded in a recess in the sealing device (5, 5‘, 5’‘, 5’’‘).

6. The substrate holder (1) according to one of the preceding claims, wherein the substrate holder (1) has a first zone (2) and a second zone (2'), wherein the first zone (2) is separated from the second zone (2') by the separating area (4).

7. The substrate holder (1) according to claim 6, wherein the separating area (4) has several sealing devices (5, 5‘, 5’’, 5’’’), in particular each with a further pin element (6‘), wherein the sealing devices (5, 5’, 5‘’, 5‘’') are arranged one behind the other along a direction running from the first zone (2) to the second zone (2').

8. The substrate holder (1) according to one of the preceding claims, wherein the separating area (4) has a closed contour, for example a frame-shaped contour.

9. The substrate holder (1) according to one of the preceding claims, wherein a lateral extent of the sealing device (5, 5‘, 5’’, 5’’’) is greater than a lateral extent of the further pin element (6').

10. The substrate holder (1) according to one of the preceding claims, wherein
    - the pin element (6) and/or the further pin element (6‘) and the sealing device (5, 5’, 5‘’, 5‘’') or
    - preferably the substrate holder (1)

    are

    monolithically designed.

11. The substrate holder (1) according to one of the preceding claims, wherein multiple further pin elements (6‘) are integrated in a common sealing device (5, 5’, 5‘’, 5‘’').

12. The substrate holder (1) according to one of the preceding claims, wherein a pin element spacing is between 0.1 mm and 10 mm, preferably between 0.2 mm and 5 mm, more preferably between 0.5 mm and 2.5 mm, most preferably between 1.0 mm and 2.0 mm, and utmost preferably approximately 1.5 mm.

13. The substrate holder (1) according to one of the preceding claims, wherein respective pin spacings between adjacent pin elements (6) or further pin elements

(6‘) on the one hand and further pin elements (6’) or pin element (6) on the other hand are substantially constant along a predetermined direction.

14. A method for the production of a substrate holder (1) according to one of the preceding claims, preferably with a material removal for forming pin element (6), sealing device (5, 5‘, 5’’, 5’’’) and/or further pin element (6').

15. A method for holding a substrate (7) with a substrate holder (1) according to one of claims 1 to 13, preferably in the frame of a treatment process.