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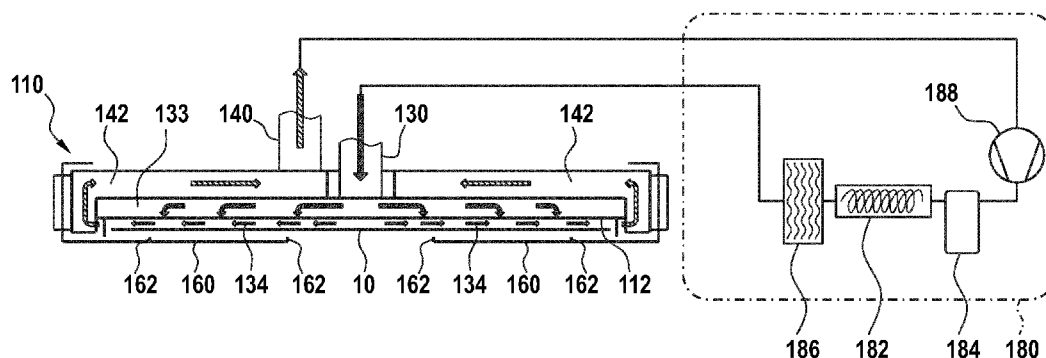
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SUBSTRATE INTO A VACUUM PROCESSING MODULE, AND SYSTEM FOR VACUUM PROCESSING OF A SUBSTRATE

Fig. 1C



(57) Abstract: An apparatus (100) for holding a substrate (10) is described. The apparatus (100) includes a Bernoulli-type holder (110) having a surface (112) configured to face the substrate (10), and one or more adjusting means (188) configured to adjust the temperature of the substrate (10).

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**APPARATUS AND METHOD FOR HOLDING A SUBSTRATE, APPARATUS
AND METHOD FOR LOADING A SUBSTRATE INTO A VACUUM
PROCESSING MODULE, AND SYSTEM FOR VACUUM PROCESSING OF A
SUBSTRATE**

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FIELD

10 [0001] Embodiments of the present disclosure relate to an apparatus for holding a substrate, a system for vacuum processing of a substrate, a method for holding a substrate, and an apparatus and a method for loading a substrate into a vacuum processing module.

BACKGROUND

15 [0002] Techniques for layer deposition on a substrate include, for example, sputter deposition, thermal evaporation, and chemical vapor deposition. A sputter deposition process can be used to deposit a material layer on the substrate, such as a layer of a conducting material or an insulating material. Coated materials may be used in several applications and in several technical fields. For instance, one application lies in the field of
20 microelectronics, such as for generating semiconductor devices. Also, substrates for displays are often coated by physical vapor deposition, e.g. a sputter deposition process, or chemical vapor deposition (CVD). Further applications include insulating panels, substrates with TFT, color filters or the like.

[0003] In order to improve a quality, for example, purity and/or homogeneity, of the
25 layers deposited on the substrates, the substrates should meet some demands. For example, a substrate surface on which the layer is to be deposited should have a uniform temperature and/or should be free from extraneous matter, such as foreign particles. Further, an outgassing of the substrate within a vacuum chamber of the vacuum processing system should be reduced or even avoided.

30 [0004] In view of the above, apparatuses, systems, and methods that overcome at least some of the problems in the art are beneficial. The present disclosure particularly aims at

providing apparatuses, systems, and methods for holding and/or preparing a substrate that is to be loaded into a vacuum chamber of a vacuum processing system.

SUMMARY

5 [0005] In light of the above, an apparatus for holding a substrate, a system for vacuum processing of a substrate, a method for holding a substrate, and an apparatus and a method for loading a substrate into a vacuum processing module are provided. Further aspects, benefits, and features of the present disclosure are apparent from the claims, the description, and the accompanying drawings.

10 [0006] According to an aspect of the present disclosure, an apparatus for holding a substrate is provided. The apparatus includes a Bernoulli-type holder having a surface configured to face the substrate, and one or more adjusting means configured to adjust the temperature of the substrate.

15 [0007] According to another aspect of the present disclosure, an apparatus for holding a substrate is provided. The apparatus includes a Bernoulli-type holder having a surface configured to face the substrate, and one or more adjusting means configured to adjust a gap between the surface and the substrate.

20 [0008] According to yet another aspect of the present disclosure, an apparatus for holding a substrate is provided. The apparatus includes a contact-less holder having a surface configured to face the substrate, and one or more adjusting means configured to adjust the temperature of the substrate and/or to adjust a gap between the surface and the substrate.

25 [0009] According to a further aspect of the present disclosure, a system for vacuum processing of a substrate is provided. The system includes a vacuum processing module configured for a vacuum deposition process on the substrate, at least one load lock chamber connected to the processing module, and the apparatus according to the embodiments described herein.

[0010] According to another aspect of the present disclosure, a method for holding a substrate is provided. The method includes holding the substrate with a Bernoulli-type holder, wherein the substrate is a large area substrate, and adjusting the temperature of the substrate.

- 5 [0011] According to yet another aspect of the present disclosure, a method for holding as substrate is provided. The method includes holding the substrate with a contact-less holder, wherein the substrate is a large area substrate, and adjusting the temperature of the substrate.

- 10 [0012] According to a further aspect of the present disclosure, a method for loading a substrate into a vacuum processing module is provided. The method includes holding a substrate according to the method of the embodiments described herein, and loading the substrate onto a substrate carrier provided at a load lock chamber connected to the vacuum processing module using the holder.

- 15 [0013] According to a further aspect of the present disclosure, an apparatus for handling a substrate is provided. The apparatus includes a Bernoulli-type holder for loading the substrate onto a substrate support surface and/or for unloading the substrate from the substrate support surface.

- 20 [0014] According to a yet further aspect of the present disclosure, an apparatus for holding a substrate is provided. The apparatus includes a contact-less holder, such as a Bernoulli-type holder, having a surface configured to face the substrate, and at least one of: one or more pressure regulators, one or more valves, a compressor, a vacuum pump, one or more mass flow controllers, and one or more proportioning valves.

BRIEF DESCRIPTION OF THE DRAWINGS

- 25 [0015] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments. The accompanying drawings relate to embodiments of the disclosure and are described in the following:

- FIG. 1A shows a schematic view of an apparatus for holding a substrate and optionally loading the substrate into a vacuum processing module according to embodiments described herein;
- 5 FIG. 1B shows a schematic view of an apparatus for holding a substrate and optionally loading the substrate into a vacuum processing module according to further embodiments described herein;
- FIG. 1C shows a schematic view of an apparatus for holding a substrate and optionally loading the substrate into a vacuum processing module according to yet further embodiments described herein;
- 10 FIGs. 2A-B show schematic views of a substrate alignment in a Bernoulli-type holder according to embodiments described herein;
- 15 FIG. 3A shows a schematic view of a Bernoulli-type holder according to embodiments described herein;
- FIG. 3B shows a schematic view of a Bernoulli-type holder according to further embodiments described herein;
- 20 FIG. 4 shows a schematic view of a Bernoulli-type holder according to embodiments described herein;
- FIGs. 5A and 5B show schematic views of a Bernoulli-type holder according to embodiments described herein and illustrating zones of the holder;
- 25 FIG. 6 shows a schematic top view of a system for vacuum processing of a substrate according to embodiments described herein;

FIGs. 7A and 7B show schematic views of a Bernoulli-type holder according to embodiments described herein and illustrating zones of the holder;

FIG. 8 shows a flow chart of a method for holding a substrate according to embodiments described herein;

FIG. 9 shows a flow chart of a method for holding a substrate and for loading a substrate into a vacuum processing module according to embodiments described herein; and

FIG. 10 shows schematic views of a Bernoulli-type holder according to embodiments described herein and illustrates zones of the holder.

DETAILED DESCRIPTION OF EMBODIMENTS

[0016] Reference will now be made in detail to the various embodiments of the disclosure, one or more examples of which are illustrated in the figures. Within the following description of the drawings, the same reference numbers refer to same components. Only the differences with respect to individual embodiments are described. Each example is provided by way of explanation of the disclosure and is not meant as a limitation of the disclosure. Further, features illustrated or described as part of one embodiment can be used on or in conjunction with other embodiments to yield yet a further embodiment. It is intended that the description includes such modifications and variations.

[0017] According to the present disclosure, a Bernoulli-type holder is used to adjust a temperature of a substrate, such as a large area substrate. For example, a gap or space is provided between the surface of the Bernoulli-type holder and the substrate through which a stream of gas flows. The adjustment of the temperature and optionally a cleaning of particles from the surface of the substrate can be achieved by a control of the Bernoulli gap. Particularly, the Bernoulli gap may be locally controlled for local temperature control.

This can result in improved temperature uniformity of the substrate. Furthermore, the small gap protects the substrate surface from incidental environmental particle contamination and protects the substrate surface from coming into contact with the Bernoulli-type holder.

[0018] Some embodiments of the present disclosure direct a stream of gas across at least one surface of a substrate, such as a large area substrate, in a controlled manner. The stream of gas can be used for at least one of a treatment of the substrate, for example, before the substrate is loaded into a vacuum processing module, and a holding of the substrate in a levitating state. In particular, the stream of gas can be used for levitation of the substrate. The stream of gas can be used for a removal of foreign particles e.g. from the surface of the substrate on which a material layer is to be deposited can optionally be used for an outgassing of the substrate. For example, an outgassing of the substrate can be performed using the stream of gas before the substrate is put on a substrate carrier, such as an E-chuck. The carrier can be an E-chuck, a frame like carrier with clamps or any carrier supporting the substrate from the backside or from the edges. A quality, such as a purity and/or a homogeneity, of the deposited layers can be improved. Further, the stream of gas can be used to generate a reduced pressure or under pressure above the substrate such that the substrate levitates. In particular, the stream of gas can simultaneously provide two functions, namely a holding function and a treatment or pre-treatment function, such as cleaning, for the substrate.

[0019] According to embodiments of the present disclosure, the treatment or pre-treatment function, for example the temperature control of the substrate, can be individually controlled in different areas of a holder, for example, a PV (Pressure-Vacuum) or Bernoulli holder. A local temperature control of the substrate, such as a large area substrate, can be provided by the gap control of the Bernoulli holder. According to some embodiments, which can be combined with other embodiments described herein, atmospheric heating and/or conditioning of substrates such as display glass can be provided.

[0020] For example, controlling the glass temperature uniformity may be achieved by at least one of a dynamic adjustment of the Bernoulli gap, a patterned Bernoulli design to make individual control of local temperature possible, for example, by adjusting the gap for an individual Bernoulli pattern, and a movement of the glass during heating to avoid

imprinting temperature non-uniformity. The terms PV-holder, PV-loader (PV-unloader), Bernoulli-type holder, Bernoulli holder and Bernoulli loader (Bernoulli unloader) can be used exchangeably in the present disclosure. The Bernoulli holder is a contact-less holder or touch-less holder configured for contactlessly holding the substrate. In particular, the contact-less holder or touch-less holder is a gas stream holder configured for levitating the substrate.

[0021] According to embodiments described herein, a Bernoulli holder or PV holder can be a contact-less holder or a touch-less holder, particularly wherein the substrate is supported without mechanical contact by a gas stream, i.e. by a pressure difference based e.g. on the Bernoulli effect. That is, the term Bernoulli holder or PV holder as used herein may be replaced with contactless or touch-less holder.

[0022] According to embodiments described herein, a PV holder can be considered as a Bernoulli-type holder, wherein a vacuum pump is provided at the exhaust conduit or the exhaust conduits of the Bernoulli-type holder. The PV holder can be an array of pressure and vacuum cells. For example, a large array of small "Pressure and Vacuum Cells" can be provided. According to the present disclosure, a PV holder is a type of a Bernoulli holder, wherein the vacuum is additionally provided at an outlet side, e.g. of gas circulation. One or more of the cells can be individually controlled, for example in zones of an aperture plate. A holder may also be referred to as loader, lifter, chuck, gripper, or unloader.

[0023] FIG. 1A shows a schematic view of an apparatus 100 for holding a substrate 10 and optionally loading the substrate 10 into a vacuum processing module according to embodiments described herein. In some implementations, the apparatus 100 can be used for loading the substrate 10 into a load lock chamber of a vacuum processing system. The substrate 10 can be a large area substrate.

[0024] The apparatus 100 includes a Bernoulli-type holder 110 having a surface 112 configured to face the substrate, and one or more adjusting means configured to adjust the temperature of the substrate. For example, the one or more adjusting means can be configured to adjust a gap or space 114 between the surface 112 and the substrate 10 for adjusting the temperature. In some implementations, the one or more adjusting means

include at least one of: one or more pressure regulators, one or more valves, a compressor, a vacuum pump, one or more mass flow controllers, heater, differential pressure gauges between a supply line and a return line, and one or more proportioning valves.

[0025] The apparatus 100 can include a gas supply 130 configured to direct a stream 134 of gas between the surface 112 and the substrate 10. The Bernoulli-type holder 110 is configured to provide a pressure between the substrate 10 and the surface 112 for levitation of the substrate 10.

[0026] The gap or space 114 can be provided between the surface 112 and the substrate 10 through which the stream 134 of gas flows. The gap or space 114 can also be referred to as “Bernoulli gap”. The gap or space 114 provided by the gas stream can be beneficial in that the position of the substrate 10 can be well controlled with respect to a small dimension and small variation in the dimension relative to the Bernoulli-type holder 110. Furthermore, the small gap protects the substrate surface from incidental environmental particle contamination and protects the substrate surface from coming into contact with the Bernoulli-type holder 110. According to embodiments described herein, the temperature of the substrate can be controlled by controlling the Bernoulli gap. Particularly, the Bernoulli gap may be locally controlled for local temperature control. This can result in improved temperature uniformity of the substrate, such as a large area substrate. Additionally or alternatively, according to embodiments described herein, the cleaning of particles from the surface of the substrate may be provided by controlling the Bernoulli gap, i.e. the gap of the PV holder.

[0027] The Bernoulli-type holder 110 levitates the substrate 10 using the Bernoulli Effect. A pressure, such as a reduced pressure or under pressure, is provided between the substrate 10 and the surface 112 for levitation of the substrate 10 to hold the substrate 10 in a levitating or suspended state. The apparatus 100 supports the substrate 10 without making (direct) mechanical contact on the face of the substrate. In particular, the substrate 10 floats on a gas cushion, and in particular a thin gas cushion. That is, the apparatus 100 is contactless on the face of the substrate. As the substrate 10 is floating on the gas cushion, to ensure the substrate 10 does not slide off the Bernoulli-type holder 110, one or more substrate alignment devices 116 (or actuation pins) can be provided, for example pins or rollers, which protrude from the Bernoulli-type holder 110. The one or more substrate

alignment devices 116 are further described with respect to FIGs. 2A and B. The stream 134 of gas provided by the apparatus 100 can be used for a treatment of the substrate 10.

[0028] The terms “reduced pressure” and “under pressure” can be defined with respect to an ambient pressure, such as atmospheric pressure, in which the apparatus 100 is located, for example, in the enclosure described with respect to FIG. 6 (indicated with reference numeral “550”). In particular, the pressure, such as the reduced pressure or the under pressure, between the substrate 10 and the surface 112 is configured for levitation of the substrate 10. For example, a difference between the pressure and the ambient pressure is sufficient to compensate for the weight force of the substrate 10.

[0029] The substrates according to embodiments described herein can have main surfaces and lateral surfaces. For example, e.g. for a rectangular-shaped substrate, two main surfaces 11 and four lateral surfaces (or substrate edges) can be provided. The two main surfaces 11 can extend substantially parallel to each other and/or can extend between the four lateral surfaces, i.e. the edges of the substrate. An area of each of the main surfaces is larger than an area of each of the lateral surfaces. A first main surface of the two main surfaces can be configured for layer deposition thereon. The first main surface can also be referred to as the “frontside” of the substrate 10. A second main surface of the two main surfaces opposite the first main surface can be referred to as the “backside” of the substrate 10. The gas supply 130 can be configured to direct the stream 134 of gas between the surface 112 of the Bernoulli-type holder 110 and a main surface, for example, the first main surface or the second main surface, of the substrate 10. In some implementations, the gas supply 130 is configured to direct the stream 134 of gas along substantially the whole substrate surface, such as the first main surface and/or the second main surface. The Bernoulli loader can also at least one of grip, heat, degas and load the substrate from the backside and load the substrate into a fixture like carrier. Receiving the substrate from a customer unit or unloading the substrate to a customer unit may be provided by a portion of the Bernoulli loader where Bernoulli elements can have different height positions to realize the substrate handover. In the case of a belt-conveyor-like customer device the substrate may be shifted/ slid onto the Bernoulli.

[0030] An area of the surface 112 of the Bernoulli-type holder 110 can be equal to, or greater than, an area of the substrate surface facing the surface 112 of the Bernoulli-type

holder 110, such as the first main surface and/or the second main surface. The surface 112 of the Bernoulli-type holder 110 and the substrate surface facing the surface 112 of the Bernoulli-type holder 110 can be arranged substantially parallel to each other when the substrate 10 is held by the Bernoulli-type holder 110.

5 [0031] According to some embodiments, which can be combined with other embodiments described herein, the substrate 10 is a large area substrate. The large area substrate can have a size of at least 0.01 m^2 , specifically at least 0.1 m^2 , and more specifically at least 0.5 m^2 . For instance, a large area substrate or carrier can be GEN 4.5, which corresponds to about 0.67 m^2 substrates ($0.73 \times 0.92 \text{ m}$), GEN 5, which corresponds
10 to about 1.4 m^2 substrates ($1.1 \text{ m} \times 1.3 \text{ m}$), GEN 7.5, which corresponds to about 4.29 m^2 substrates ($1.95 \text{ m} \times 2.2 \text{ m}$), GEN 8.5, which corresponds to about 5.7 m^2 substrates ($2.2 \text{ m} \times 2.5 \text{ m}$), or even GEN 10, which corresponds to about 8.7 m^2 substrates ($2.85 \text{ m} \times 3.05 \text{ m}$). Even larger generations such as GEN 11 and GEN 12 and corresponding substrate areas can similarly be implemented.

15 [0032] According to some embodiments, which can be combined with other embodiments described herein, the substrate 10 is selected from the group consisting of GEN 1, GEN 2, GEN 3, GEN 3.5, GEN 4, GEN 4.5, GEN 5, GEN 6, GEN 7, GEN 7.5, GEN 8, GEN 8.5, GEN 10, GEN 11, and GEN 12. In particular, the substrate 10 can be selected from the group consisting of GEN 4.5, GEN 5, GEN 7.5, GEN 8.5, GEN 10, GEN
20 11, and GEN 12, or a larger generation substrates.

[0033] According to some embodiments, the gas supply 130 includes one or more first conduits 131 and/or a gas distribution plate 132. The pressure in the one or more first conduits can be controlled, particularly individually controlled, to control the air gap between the surface 112 and the main surface 11 of the substrate. The gas distribution plate
25 132 can have the surface 112 configured to face the substrate 10. For example, the gas distribution plate 132 can be provided between the one or more first conduits 131 and the large area substrate. In some implementations, the one or more first conduits 131 are configured to supply the gas into a distribution space 133 above the gas distribution plate 132. The gas distribution plate 132 can have holes or nozzles such that gas from the
30 distribution space 133 is directed between the surface 112 and the substrate 10 to provide the stream 134 of gas. In particular, the gas distribution plate 132 can be configured to

distribute the gas such that the gas flows between the substrate 10, for example, one of the main surfaces, and the surface (i.e., the surface 112) of the gas distribution plate 132.

[0034] The apparatus 100 includes a gas outlet 140. The gas outlet 140 can include one or more second conduits. For example, the gas supplied by the gas supply 130 can flow between the surface 112 and the substrate 10, and can then be guided into one or more second conduits (indicated with reference numeral “142”) e.g. provided at one or more lateral sides of the substrate 10 and/or the gas distribution plate 132 so as to receive the gas from the gap or space 114. The gas can exit the Bernoulli-type holder 110 through an exit 141, which can be another second conduit. In some implementations, the gas exiting the Bernoulli-type holder 110 can be returned to one or more conditioning devices, as it is explained with respect to FIG. 1C. The one or more adjusting means can include at least one conditioning device of the one or more conditioning devices. According to some embodiments, which can be combined with other embodiments described herein, the gas outlet 140 can be connected and/or in fluid communication with the vacuum pump to exhaust the gas guided in the gap, i.e. the Bernoulli (air) gap. Additionally or alternatively, to controlling the pressure in the gas inlet or gas supply 130, a vacuum pump connected to gas outlet 140 can be controlled for controlling the Bernoulli gap, such as the width of the Bernoulli gap. Exhausting air from the apparatus 100 may also be provided using an individual control for different local areas e.g. for improving uniformity of the substrate treatment.

[0035] The term “substrate” or “large area substrate” as used herein shall particularly embrace inflexible substrates, e.g., glass plates and metal plates. However, the present disclosure is not limited thereto and the term “substrate” can also embrace flexible substrates such as a web or a foil. According to some embodiments, the substrate can be made from any material suitable for material deposition. For instance, the substrate can be made from a material selected from the group consisting of glass (for instance soda-lime glass, borosilicate glass etc.), metal, polymer, ceramic, compound materials, carbon fiber materials, mica or any other material or combination of materials which can be coated by a deposition process. Substrates for controlling the glass temperature uniformity according to embodiments described herein can be any kind of flat or smoothly shaped substrate. The substrate can be received from customer side and loaded onto the Bernoulli with a

specially shaped surface to load the glass into a fixture (carrier) with the purpose to influence substrate stability or layer properties by bringing the substrate into a specific shape.

[0036] FIG. 1B shows a schematic view of an apparatus for holding a substrate 10 and optionally loading the substrate 10 into a vacuum processing module according to further embodiments described herein. The apparatus of FIG. 1B is similar to the apparatus illustrated in FIG. 1A and further includes an auxiliary substrate support 150.

[0037] According to some embodiments, which can be combined with other embodiments described herein, the apparatus 100, and in particular the Bernoulli-type holder 110, includes the auxiliary substrate support 150. The auxiliary substrate support 150 can be configured to mechanically support the substrate 10. For example, the auxiliary substrate support 150 has one or more support elements 152, such as posts or pins, e.g., stationary pins, lift pins or retractable pins, configured to contact and support the substrate 10.

[0038] The auxiliary substrate support 150 can be configured such that another stream 154 of gas can flow along a substrate surface of the substrate 10, for example, the first main surface and/or the second main surface. For example, the stream 134 of gas directed between the surface 112 of the Bernoulli-type holder 110 and the substrate 10 can flow along the first main surface of the substrate 10, for example, the frontside. The other stream 154 of gas provided by the auxiliary substrate support 150 can flow along the second main surface of the substrate 10, for example, the backside. A simultaneous treatment of both main surfaces can be provided.

[0039] In some implementations, the auxiliary substrate support 150 can include a casing 156. The casing 156 can be configured such that the other stream 154 of gas can flow through the casing 156 and along the substrate surface of the substrate 10, for example, the backside. The Bernoulli loader can receive the substrate directly from the customer robot fork, e.g. not using an auxiliary substrate support. The same can be provided analogously for unloading. An auxiliary substrate support can also be a Bernoulli in addition to the Bernoulli loader.

[0040] In some implementations, the Bernoulli-type holder 110 and the auxiliary substrate support 150 can be movable with respect to each other. For example, the Bernoulli-type holder 110 can be moved away from the auxiliary substrate support 150 for loading a substrate 10 onto the auxiliary substrate support 150, for example, the one or more support elements 152. In some implementations, a loading device such as a robot can be used to put the substrate 10 on the one or more support elements 152. The Bernoulli-type holder 110 can be moved to a position above the substrate 10 for performing a treatment, such as a preheating and/or degassing of the substrate 10. After the treatment process, the Bernoulli-type holder 110 can move the substrate 10 from the auxiliary substrate support 150, for example, to a load lock chamber or to an intermediate position before loading to a load lock chamber.

[0041] FIG. 1C shows a schematic view of the apparatus 100 of FIG. 1A according to further embodiments described herein. Although not shown in FIG. 1C, the apparatus can further include the auxiliary substrate support described with respect to FIG. 1B.

[0042] According to some embodiments, which can be combined with other embodiments described herein, the apparatus 100 includes one or more conditioning devices for adjusting at least one physical and/or chemical property of the gas directed between the surface 112 and the substrate 10, such as a large area substrate. The one or more conditioning devices can also be referred to as “gas conditioning means”. The physical and/or chemical property of the gas is selected for a treatment of the substrate 10. The adjusting means can include at least one conditioning device of the one or more conditioning devices, such as the heater 182.

[0043] Specifically, the physical and/or chemical property of the gas can be selected for a pre-treatment of the substrate 10 before the substrate 10 is loaded into a vacuum processing module. For example, the pre-treatment of the substrate 10 can include at least one of heating the substrate 10, degassing the substrate 10, and providing a defined (e.g., clean, dry) environment, particularly for the surface of the substrate 10 on which a material layer is to be deposited. According to yet further example, which may alternatively or additionally be provided, the gas can be ionized for improved particle removal from the substrate surface. For example, ionization of the gas can be provided with varying polarization.

[0044] The pre-treatment can be performed using the one or more conditioning devices of the Bernoulli-type holder 110. For example, the gas exiting the Bernoulli-type holder 110 through the gas outlet 140 can be returned to the one or more conditioning devices. As indicated by reference numeral 180, the one or more conditioning devices can be located
5 remotely. The remote area can be somewhere in the factory but does not necessarily need to be next to or close to the Bernoulli-type holder 110 or a system for vacuum processing.

[0045] According to some embodiments, which can be combined with other embodiments described herein, the one or more conditioning devices can be selected from the group including a heater 182 configured for heating the gas, a dryer 184 configured for
10 drying the gas, a filter 186 configured for filtering the gas, the compressor 188 for circulating the gas, a gas ionizer, and any combination thereof.

[0046] In some embodiments, the PV (Pressure-Vacuum) or Bernoulli-type holder 110 is provided with a heating function, for example, using the heater 182. In another embodiment, a heater (see FIG. 3B) may also be incorporated inside the Bernoulli-type
15 holder 110, e.g., either instead of or in addition to the heater 182. Accordingly, the Bernoulli-type holder 110 can also be referred to as “Bernoulli heater”. The additional heater may heat the hardware, such as the surface 112 of the Bernoulli-type holder. According to some embodiments, which can be combined with other embodiments described herein, two or more additional heaters can be provided to heat different zones of
20 the Bernoulli-type holder e.g. to different temperatures.

[0047] The dryer 184 can be configured to remove humidity from the gas that is to be supplied to the Bernoulli-type holder 110. The filter 186 can be an ultra-filter, e.g., a filter utilizing a semi-permeable membrane, or a high-efficiency particulate arresting (HEPA) filter. In another embodiment, an ultra-filter (not shown) may be incorporated in the
25 Bernoulli-type holder 110, e.g., either instead of or in addition to the filter 186. The compressor 188 can be configured for circulating the gas within the apparatus 100, for example, from the gas outlet 140 to the gas supply 130, further through the gap or space 114, and finally to the gas outlet 140 again. Additionally to the compressor, a vacuum pump may be provided to exhaust gas at the outlet of the Bernoulli-type holder 110.

[0048] According to some embodiments, which can be combined with other embodiments described herein, the gas circulating in the apparatus 100 can be nitrogen. At least one of dry, hot, and filtered gas, such as nitrogen or other gases disclosed herein, can be provided for the Bernoulli-type holder 110 and the substrate 10, such as the (main) surface to be processed, contactlessly held in the Bernoulli-type holder 110. The surface of the substrate 10 can be heated and/or cleaned. The environment provided by the gas having the adjusted physical and/or chemical property can be at least one of hot, dry, clean, and chemically-inert, to allow for a degassing of the substrate 10 or substrate surface. For example, moisture adhering to the surface of the substrate 10 can be reduced.

[0049] According to some embodiments, which can be combined with other embodiments described herein, the Bernoulli-type holder 110 further includes one or more safety retainers 160 configured to be positioned below the substrate 10, such as a large area substrate. A gap can be provided between the substrate 10 and the one or more safety retainers 160, in particular when the substrate 10 is in the levitating or suspended state. The one or more safety retainers 160 can also be referred to as “fail-safe substrate retainers”. The one or more safety retainers 160 can retain the substrate 10 in the event of a sudden unexpected loss of gas flow through the Bernoulli-type holder 110. The one or more safety retainers 160 can have contact elements 162 in the case that an emergency contact between the substrate 10 and the one or more safety retainers 160 occurs.

[0050] In some implementations, the one or more safety retainers 160 are configured to be rotatable with respect to the substrate 10. For example, the one or more safety retainers 160 can be rotatable from a first position to a second position. In the first position, the one or more safety retainers 160 can be positioned directly below the substrate 10 to hold or catch the substrate 10, e.g., in case of a malfunction of the Bernoulli-type holder 110. In the second position, the one or more safety retainers 160 can be positioned away from the substrate 10 such that the substrate 10 can be released or taken away from the Bernoulli-type holder 110. Specifically, the one or more safety retainers 160 can be rotatable so that the safety retainers may quickly move out of the way when necessary, e.g., just prior to a pick or place action with the substrate 10. In some embodiments, an angle between the first position and the second position can be about 90°. In other words, the one or more safety retainers 160 can be rotated by 90° from the first position to the second position or from

the second position to the first position. The rotation can be a rotation in a plane that is substantially horizontally oriented.

[0051] The Bernoulli-type holder 110 provides a device for pre-heating and/or degassing of the substrate 10 (e.g., of adsorbed water) before the substrate 10 enters a vacuum system. Further, a controlled clean dry chemically-inert environment for the substrate surface on which a material layer is to be deposited can be provided, while the substrate 10 is degassing and waiting to be processed. Moreover, the Bernoulli-type holder 110 provides a device for transporting and picking/placing the substrate 10 directly from/upon a carrier (e.g., an E-chuck) or support surface without any additional devices or locations of support (such as lift pins) to be arrayed on the backside of the substrate 10. The Bernoulli-type holder 110 can accomplish the functions without adding considerable footprint to a vacuum processing system.

[0052] As illustrated in FIGs. 1A, 1B and 1C, at least one substrate alignment device (or actuation device for the moving of the substrate), for example, four substrate alignment devices can be provided. In particular, one or more substrate alignment devices can be provided at, for example adjacent to, each one of the four lateral sides of the substrate 10 or at two lateral sides diagonally opposite to each other. The one or more substrate alignment devices at each lateral side can be positioned off-center with respect to the respective lateral side. For example, the one or more substrate alignment devices at each lateral side can be positioned at a corner portion of the respective lateral side. A restricted movement or loose alignment of the substrate 10 can be facilitated.

[0053] FIGs. 2A-B show schematic views of a substrate alignment in a Bernoulli-type holder according to embodiments described herein.

[0054] According to some embodiments, the apparatus includes the one or more substrate alignment devices 116, such as pins or rollers. In particular, the Bernoulli-type holder can include the one or more substrate alignment devices 116 to align the substrate 10 before the substrate 10 is put on a substrate support, such as the substrate carrier, which can be an E-Chuck. In some implementations, the one or more substrate alignment devices 116 include at least one of one or more moveable substrate alignment devices and one or more fixed substrate alignment devices. The one or more substrate alignment devices 116

provide for an improved alignment of the substrate 10 on the substrate support, such as the substrate carrier, before the substrate carrier having the substrate 10 positioned thereon is loaded into the load lock chamber or the vacuum processing system.

[0055] As the substrate 10 is floating on the gas cushion, to ensure the substrate 10 does not slide off the Bernoulli-type holder, there are the one or more substrate alignment devices 116 provided, for example pins or rollers, which can protrude from the face of the Bernoulli-type holder which surrounds the substrate 10. At least one substrate alignment device can be provided for each of the four (lateral) edges of the substrate 10, such that the in-plane movement of the substrate 10 is restricted to an area which is slightly larger than the areal dimensions of the substrate 10, e.g., less than $\pm 20\text{mm}$, preferably less than $\pm 8\text{mm}$, and more preferably less than $\pm 3\text{mm}$, e.g., in both dimensions (X and Y in a horizontal plane).

[0056] FIG. 2A shows the one or more substrate alignment devices 116 in an open position. FIG. 2B shows the one or more substrate alignment devices 116 in a closed or aligned position. According to some embodiments, at least some substrate alignment devices of the one or more substrate alignment devices 116 can be movable between the open position and the closed position, for example, in a plane substantially parallel to the main surface(s) of the substrate 10. As illustrated exemplarily by arrows 276 in FIG. 2B, the substrate alignment devices may be utilized for a movement of the substrate 10 relative to the Bernoulli-type holder, e.g. the surface 112. The alignment device can be operated to move the glass during heating to avoid temperature non-uniformity. For example, the one or more substrate alignment devices include an actuator to move the substrate over the surface during heating.

[0057] According to embodiments described herein, an alignment device, which may also be referred to as an actuation pin according to embodiments of the present disclosure, may stop a substrate, such as a glass, from moving out of a surface of the Bernoulli chuck, may move the glass during heating to avoid temperature non-uniformity, and/or may position the glass for proper positioning of the glass on a carrier or another surface, on which the substrate is to be loaded.

[0058] In some implementations, the substrate 10 can be picked up, for example, from the auxiliary substrate support with the one or more substrate alignment devices 116 being in the open position. The substrate 10 can be held by the Bernoulli-type holder in the levitating state, i.e., without mechanical contact. Before the substrate 10 is placed on the substrate support, such as an E-Chuck, the one or more substrate alignment devices 116 can be moved into the closed position such that the substrate 10 is aligned with respect to the substrate support. For example, the one or more substrate alignment devices 116 can be moved from the open position to the closed position after the substrate 10 has been moved to a load lock chamber and before the substrate 10 is put on the substrate support provided by, or at, the load lock chamber.

[0059] In some embodiments, at least some substrate alignment devices of the one or more substrate alignment devices 116, such as pins or rollers, may be mounted in such a way that they are able to move from the open position or condition which defines an area which may be larger than the substrate by, for example, 10 to 15mm on each side, to the closed position or condition which can align the substrate 10 by making contact with the edge of the substrate 10 and pushing the substrate 10 toward a set of opposing substrate alignment devices, which also may be similarly moveable or may be mounted in a fixed position. Since the substrate 10 is floating on a gas cushion there is very little resistance to the movement induced by the moveable substrate alignment devices. The moveable substrate alignment devices may be moved to a predetermined stop position which would leave a small clearance, e.g., less than 5mm and preferably less than 2mm, but would not clamp the substrate 10 between the opposing set of moveable or fixed substrate alignment devices and the fixed substrate alignment devices. Alternatively, the moveable substrate alignment devices may be moved forward until the substrate 10 is very lightly clamped between the opposing sets of substrate alignment devices without leaving clearance. After releasing the pressure condition levitating the substrate 10 and transferring the substrate 10 to the new position, the moveable clamping devices may be opened and/or the entire assembly including the Bernoulli-type holder with the substrate alignment devices may be moved slightly so as to no longer make contact with the edge of the substrate 10. The assembly may then be safely moved vertically away from the substrate 10.

[0060] FIG. 3A shows a schematic view of a PV (Pressure-Vacuum) or Bernoulli-type holder 300 according to embodiments described herein. The Bernoulli-type holder 300 uses a “local” Bernoulli effect at a number of discrete distributed positions to hold the substrate 10 in the levitating state. The Bernoulli-type holder 300 can be configured to supply heated gas, such as hot nitrogen, to the substrate 10 for levitation and/or pre-treatment (e.g., preheating) of the substrate 10. For example, the Bernoulli-type holder 300 can include a heater (not shown) for heating the gas. The gas can be hot, filtered and dry nitrogen. According to embodiments of the present disclosure, the local Bernoulli effect can be utilized to locally adjust the pretreatment function of the gas, for example, to locally adjust the temperature. For example, the Bernoulli (air) gap can be locally controlled, for example in zones of the surface 322 of the Bernoulli-type holder 300.

[0061] The Bernoulli-type holder 300 includes a gas supply 330 configured to direct a stream of gas between the surface 322 of the Bernoulli-type holder 300 and the substrate 10 for levitation of the substrate 10. The gas supply 330 includes a main supply pipe 331 and a plurality of distribution pipes or conduits 332 connected to the main supply pipe 331. The plurality of distribution pipes or conduits 332 are configured to direct the stream of gas between the surface 322 and the substrate 10.

[0062] The Bernoulli-type holder 300 includes an aperture plate 320. The aperture plate 320 provides the surface 322 of the Bernoulli-type holder 300 that faces the substrate 10. The aperture plate 320 includes a plurality of return apertures or openings 324. The opening can be in fluid communication with two or more return lines, such as gas outlet conduits, for the gas. The two or more return lines can correspond to zones of the surface 322. For example, each return line can have, or correspond to, a respective zone. The Bernoulli-type holder 300 can for instance include two or more individual gas outlet conduits for two or more zones. The zones can be individually controlled. According to embodiments described herein, a local Bernoulli effect at a number of discrete distributed positions, such as the zones, can be provided. For example, the plurality of return apertures or openings 324 can be distributed, and particularly uniformly distributed, along the surface 322. The plurality of distribution pipes or conduits 332 can extend through the aperture plate 320 to supply the gas into the gap or space 314 between the surface 322 and the substrate 10. Gas supplied by the gas supply 330 can flow into the gap or space 314 via

the plurality of distribution pipes and can then flow from the gap or space 314 through the plurality of return apertures or openings 324 to a gas outlet 340, for example, via one or more outlet conduits 342 or return lines, such as the two or more return lines, provided at a backside of the aperture plate 320, as it is shown in the enlarged section of FIG. 3A. The plurality of return apertures or openings 324 through which the gas can exit the gap or space 314 allows for creating a local Bernoulli effect for levitation of the substrate 10.

[0063] In some implementations, the Bernoulli-type holder 300 includes one or more retaining pins 316 for retaining the substrate 10. The one or more retaining pins 316 can be configured similarly or identically to the one or more substrate alignment devices described with respect to, for example, FIGs. 2A and B.

[0064] FIG. 3B shows a schematic view of a Bernoulli-type holder 350 according to further embodiments described herein. The Bernoulli-type holder 350 of FIG. 3B is similar to the Bernoulli-type holder 300 described with respect to FIG. 3A, and a description of similar or identical elements is not repeated. In particular, also the Bernoulli-type holder 350 uses a “local” Bernoulli effect at a number of discrete distributed positions to hold the substrate 10 in the levitating state.

[0065] The Bernoulli-type holder 350 can have a gas supply 360 including one or more gas inlets 361 provided at lateral sides of the Bernoulli-type holder 350. The Bernoulli-type holder 350 includes a gas distribution arrangement 370 having the surface 372 that faces the substrate 10 such that the stream of gas can be directed between the surface 372 and the substrate 10 for levitation of the substrate 10. The gas distribution arrangement 370 is connected to the one or more gas inlets 361 and is configured for directing the gas into the gap or space 314 between the surface 372 and the substrate 10. For example, the gas distribution arrangement 370 can have one or more conduits and/or openings to direct the gas into the gap or space 314. In some implementations, the gas distribution arrangement 370 is configured for uniformly distributing the gas across the surface 372.

[0066] In some implementations, the gas distribution arrangement 370 has a plurality of return apertures or openings 374. The plurality of return apertures or openings 374 can be distributed, and specifically uniformly distributed, along the surface 372. Gas supplied by the gas supply 360 can flow into the gap or space 314 and can then flow from the gap or

space 314 through the plurality of return apertures or openings 374 to the gas outlet 340, for example, via one or more outlet conduits 342 provided at a backside of the gas distribution arrangement 370, as is shown in the right enlarged section of FIG. 3B. The plurality of return apertures or openings 374 through which the gas can exit the gap or space 314 allows for creating a uniformly-distributed local Bernoulli effect for levitation of the substrate 10.

[0067] According to some embodiments, which can be combined with other embodiments described herein, the Bernoulli holder (PV-holder) may include one or more heating elements 392, such as resistive heating elements (see left enlarged view in FIG. 3B). The one or more heating elements can be configured to heat the surface of the Bernoulli-type holder. A local Bernoulli effect is provided as indicated by reference numeral 301. The one or more heating elements 392 may be individually controlled for different zones of the holder. For example, two or more heating elements are provided to individually heat the two or more zones of the surface of the Bernoulli-type holder. Additionally or alternatively, a dynamic temperature control of the substrate temperature, particularly individually in different zones, may be provided using the gap control of the Bernoulli air gap, i.e. the gap between the surface of the showerhead and the substrate. In some implementations, the one or more heating elements can be configured to provide a temperature gradient across the surface of the Bernoulli-type holder.

[0068] The substrates of the present disclosure can be supported on a substrate support, e.g., during a vacuum deposition process and/or a loading of the substrate into a vacuum processing module. It is noted that the terms “substrate support”, “carrier” and “substrate carrier” can be used synonymously. In some implementations, the substrate support includes, or is, an electrostatic chuck (E-chuck). The E-chuck can have a supporting surface for supporting the substrate 10 thereon. In one embodiment, the E-chuck includes a dielectric body having electrodes embedded therein. The dielectric body can be fabricated from a dielectric material, preferably a high thermal conductivity dielectric material such as pyrolytic boron nitride, aluminum nitride, silicon nitride, alumina or an equivalent material. In some implementations, the dielectric body can be made of a polymer material such as polyimide. The electrodes may be coupled to a power source, which provides

power to the electrodes to control a chucking force. The chucking force is an electrostatic force acting on the substrate 10 to fix the substrate 10 on the supporting surface.

[0069] Unlike open-frame carriers, an E-chuck supports substantially a whole surface of the substrate 10, such as the second main surface or backside. A bending of the substrate 10 can be avoided, since substantially the whole surface is attached to the defined supporting surface of the E-chuck. The substrate 10 can be supported more stably and a process quality can be improved.

[0070] In some implementations, the substrate support includes, or is, an electrodynamic chuck or Gecko chuck (G-chuck). The G-chuck can have a supporting surface for supporting the substrate thereon. The chucking force is an electrodynamic force acting on the substrate 10 to fix the substrate 10 on the supporting surface.

[0071] FIG. 4 shows another embodiment of an apparatus for holding a substrate 10, particularly a large area substrate, such as a PV (Pressure-Vacuum) or Bernoulli-type holder 300. The Bernoulli-type holder 300 is similar to the embodiments described with respect to FIGS. 3A and 3B. For example, a Bernoulli-type holder can be used in the display industry. A Bernoulli-type holder, i.e. a Bernoulli chuck, can be used to handle glass to move the glass from one place to another. For example, a glass, i.e. a substrate, can be transferred from a deposition equipment to a customer unit and vice versa. According to embodiments described herein, and atmospheric loading and unloading apparatus for display glass can be provided, wherein a temperature control of the glass temperature can be provided.

[0072] A common solution in the display industry is to heat the glass inside of the vacuum to avoid non-uniformities of the glass temperature by convection. Embodiments described herein provide a holding apparatus configured for atmospheric heating. The apparatus according to embodiments described herein, for example a Bernoulli-type holder, is configured to provide a dynamic temperature control.

[0073] A main supply pipe 331 provides gas to individual conduits 332, such as individual gas inlet conduits. The individual conduits 332 provide gas, for example dry air, nitrogen, argon or other gas, in a gap between the aperture plate 320, which may be

considered as a gas showerhead, and the substrate. The aperture plate 320 can have different zones, wherein each conduit of the individual conduits may be associated with one or more of the zones. The pressure within the conduits 332 can be individually controlled for each of the zones. In some implementations, the surface includes two or more zones, e.g. 5 or more zones, being in fluid communication with individual gas inlet conduits to individually direct a stream of gas to the two or more zones.

[0074] One or more adjusting means configured to adjust the gap between the surface of the Bernoulli-type holder and the substrate are provided. In some implementations, the one or more adjusting means are two or more adjusting means configured to locally adjust the gap in the two or more zones. The one or more adjusting means may include at least one of: one or more pressure regulators, one or more valves, a compressor, a vacuum pump, one or more mass flow controllers, differential pressure gauges between supply and return line, and one or more proportioning valves. Accordingly, the gas pressure of zones between the aperture plate and the substrate can be individually controlled. This allows for a local temperature control of the substrate using a local gap control. A local PV or Bernoulli effect is provided.

[0075] Aspects described herein provide an atmospheric heating and local conditioning of substrates, such as display glass, with controlling the glass temperature uniformity. According to various embodiments, at least one of a dynamic adjustment of the Bernoulli gap, a patterned Bernoulli designed to make individual control of local temperature possible, for example, by adjusting the gap for an individual Bernoulli pattern, i.e. zones of the Bernoulli pattern, and movement of the glass e.g. with alignment pins 316 during heating to avoid imprinting temperature and non-uniformity can be provided.

[0076] During operation of the holding apparatus, such as the Bernoulli-type holder 300, the glass may be heated to a set point between 100°C to 140°C, such as about 120°C. For example, the glass may be heated to within $< 3^{\circ}\text{C}$ to the setpoint within 20 seconds or less, such as 10 seconds or less. This may be provided through a supply of hot gas, such as hot, filtered, dry nitrogen. Further, portions of the Bernoulli-type holder 300, such as the aperture plate 320, e.g. the showerhead, may be heated. The Bernoulli-type holder may include a heated showerhead. A Bernoulli holder may also be used for cooling the substrate after processing when the substrate, e.g. a display glass, comes out of the vacuum

processing system at a high temperature. A high temperature might have negative influence on the layer when exposed to atmosphere at these high temperatures as well as causing unacceptable high stress or deformation during uncontrolled cool-down without using the Bernoulli holder.

- 5 [0077] Using the holding apparatus providing a Bernoulli effect, i.e. a Bernoulli effect loader, provides the advantage that a substrate can be loaded onto a completely flat surface. Accordingly, a surface of a carrier, on which the substrate is loaded, has no perturbations or non-uniformities. No holes for lift pins, pines, tees, or “golf tees” are needed. For example, the surface of an E-chuck can be a flat plate without any recesses or holes.
- 10 [0078] FIG. 4 shows individually controllable supplies, for example conduits 332 or gas inlet conduits, to control the gap between the surface 322 and the substrate 10. The pressure in the supply line or conduits can be controlled, particularly individually controlled, for individual zones of the Bernoulli-type holder. The pressure in the gap can be individually controlled for the two or more zones. According to yet further
- 15 embodiments, a vacuum at a return line, for example at the one or more gas outlets 340, may also be controlled. For example, the vacuum may also be individually controlled for different zones of the Bernoulli-type holder.

- [0079] According to some embodiments, which can be combined with other embodiments described herein, a local Bernoulli effect can be provided at a number of
- 20 discretely distributed positions. An air gap or gap between the surface 322 and the substrate can be controlled, for example in a range of 10 μm to 100 μm , such as 20 μm to 70 μm . There can be an adjustable deviation from a nominal gap, e.g. the Bernoulli air gap, of, for example, about 30 μm . The distance between the holder surface and the substrate can be used to locally adjust the temperature. For example, if a region of the substrate has a
- 25 too high temperature, the gap can be increased in size in a respective zone of the Bernoulli-type holder. The increased distance reduces the thermal conduction. The temperature in the region can be dynamically adjusted to the desired temperature. Temperature uniformity can be provided across the substrate using the individual control of zones or discrete positions. The zones or discrete positions can be provided in a pattern as described below.
- 30 Embodiments of the present disclosure can provide a hot “local” Bernoulli effect loader.

[0080] According to some embodiments, which can be combined with other embodiments described herein, an apparatus for holding a substrate may include a first camera 420 to measure the temperature profile of the substrate, see e.g. FIG. 4. For example, the first camera 420 can be an infrared (IR) camera. A temperature detection can be used to set the adjustment of the gap control, i.e., to control the Bernoulli air gap. Additionally or alternatively, a second camera 425 to measure deformations of the substrate can be provided. Deformations of the flat substrate can thus be measured. For example, the second camera can be a polarization camera or a camera of a speckle measurement arrangement.

[0081] Fig. 5A shows a Bernoulli-type holder 110 having a first exemplary Bernoulli pattern with various zones. The surface of the Bernoulli-type holder 110 can include two or more zones, such as 5 or more zones. In some implementations, the two or more zones can have a generally radial pattern, a radial pattern, an oval pattern, an elliptical pattern, or a combination thereof.

[0082] Exemplarily, zones 510-1- and 510-2 are indicated in FIG. 5A. Alignment pins 316 or respective actuation pins are shown. A gap control can be provided in the zones of the Bernoulli-type holder individually. FIG. 5A exemplarily shows 30 zones. According to some embodiments, which can be combined with other embodiments described herein, five or more zones can be provided.

[0083] In another example, as illustrated in FIG. 5B, six types of differently shaped zones 510-1 to 510-6 are provided in the aperture plate 320, i.e. a gas distribution showerhead. According to some examples, the gas distribution showerhead may have 13 zones with different shapes, such as six different shapes. According to some embodiments, which can be combined with other embodiments described herein, some or all of the zones may be individually controlled. For example, the pressure in a conduit, such as a gas inlet conduit, providing gas to the zone or area may be individually controlled. The gap between the surface of the aperture plate facing the substrate and the substrate can be locally and/or dynamically adjusted to provide dynamic temperature control of the substrate, particularly locally varying temperature control. This allows for temperature uniformity of the substrate. The conduits or gas supplies can be assigned to individual items, zones, or areas of the Bernoulli pattern to control the temperature uniformity.

[0084] FIG. 6 shows a schematic top view of a system 500 for vacuum processing of a substrate according to embodiments described herein.

[0085] The system 500 includes a vacuum processing module configured for a vacuum deposition process on the substrate, at least one load lock chamber connected to the processing module, and the apparatus according to the embodiments described herein. The system 500 exemplarily shows a first load lock chamber 520 and a second load lock chamber 521. The at least one load lock chamber can have a chamber housing 526 and a door 522, wherein the door 522 is configured to close an opening 524 in the chamber housing 526. The opening 524 in the chamber housing 526 can be configured such that the substrate 10 can be loaded into, and unloaded from, the chamber housing 526 through the opening 524.

[0086] According to some embodiments, the door 522 can be configured to support the substrate 10 or substrate support 20. The door 522 can be rotatable around a rotational axis 523, which can be a substantially horizontal rotational axis. For example, the door 522 can be rotatable between a first or open position and a second or closed position. In the first or open position, the door 522 can be oriented substantially horizontally such that the substrate 10 or substrate support 20 can be put on the door 522, for example, a support surface provided by the door 522. The door 522 having the substrate 10 and/or substrate support 20 positioned thereon can then rotate from the first or open position to the second or closed position to load the substrate 10 or substrate support 20 into the chamber housing 526. The second or closed position can be a substantially vertical position of the door 522. The substrate 10 and/or the substrate support 20 can be moved from a horizontal orientation to a vertical orientation and vice versa using the rotation of the door 522.

[0087] In some implementations, the system 500 includes an enclosure 550 surrounding at least the load lock chamber, such as the first load lock chamber 520 and the second load lock chamber 521. In the example shown in FIG. 6, the first load lock chamber 520 having the chamber housing 526 and the door 522 in an open (horizontal) position would be under atmospheric pressure. The second load lock chamber 521 having the door 522 in a closed (vertical) position at the chamber housing 526 would be under vacuum.

[0088] FIG. 6 shows the load lock chambers positioned in the enclosure 550 providing a predefined atmospheric condition for the substrates outside of the vacuum within the vacuum processing module of the vacuum processing system, which can be an in-line processing system. The enclosure 550 can be provided as a clean room environment.

5 Cleanrooms maintain particle-free air through the use of filters employing, for example, laminar or turbulent air flow principles. Further, the enclosure 550 can provide an environment for having a defined temperature. Within the enclosure 550, the temperature can be provided with high stability.

[0089] The vacuum processing module has a vacuum chamber 510. The vacuum chamber 510 is connected to the at least one load lock chamber, for example, using gate valves 540. The substrates can be loaded from the load lock chamber into the vacuum chamber 510 through the gate valves 540. The substrates can be unloaded from the vacuum chamber 510 into the load lock chamber through the gate valves 540, and particularly through the same gate valve through which a respective substrate has been loaded into the vacuum chamber 510.

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[0090] According to some embodiments, one single vacuum chamber, such as the vacuum chamber 510, for deposition of layers therein can be provided. A configuration with one single vacuum chamber having a plurality of areas, such as a first area 512, a second area 518 and a deposition area 515 between the first area 512 and the second area 518, can be beneficial in an in-line processing system, for example, for dynamic deposition. The one single vacuum chamber with different areas does not include devices for vacuum tight sealing of one area (e.g., the first area 512) of the vacuum chamber 510 with respect to another area (e.g., the deposition area 515) of the vacuum chamber 510. In some implementations, further chambers can be provided adjacent to the vacuum chamber 510, such as the load lock chamber(s) or further processing chambers. The vacuum chamber 510 can be separated from adjacent chambers by valves, such as the gate valves 540, which may have a valve housing and a valve unit.

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[0091] In some embodiments, an atmosphere in the vacuum chamber 510 can be individually controlled by generating a technical vacuum, for example with vacuum pumps connected to the vacuum chamber 510, and/or by inserting process gases in the deposition area(s) in the vacuum chamber 510. According to some embodiments, process gases can

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include inert gases such as argon and/or reactive gases such as oxygen, nitrogen, hydrogen and ammonia (NH₃), Ozone (O₃), or the like.

[0092] The system 500 has one or more sputter deposition sources, such as one or more bi-directional sputter deposition sources, in the vacuum chamber 510. In some implementations, the one or more sputter deposition sources can be connected to an AC power supply (not shown) such that the one or more sputter deposition sources can be biased in an alternating manner. However, the present disclosure is not limited thereto and the one or more sputter deposition sources can be configured for DC sputtering or a combination of AC and DC sputtering.

[0093] In some implementations, the system 500 includes one or more transportation paths at least partially extending through the vacuum chamber 510. For example, a first transportation path can start in and/or extend through the first area 512 and can further extend through the deposition area 515 and optionally through the second area 518. The one or more transportation paths, such as the first transportation path, can provide or be defined by, a transport direction 3 of the substrates past the one or more sputter deposition sources.

[0094] The substrates 10 can be positioned on respective substrate supports or carriers, such as E-chucks. The substrate support 20 can be configured for transportation along the one or more transportation paths or transportation tracks extending in the transport direction 3. Each substrate support 20 is configured to support a substrate 10, for example, during a vacuum deposition process or layer deposition process, such as a sputtering process or a dynamic sputtering process. The substrate support 20 can include a plate or a frame configured for supporting the substrate 10, for example, using a support surface provided by the plate or frame. Optionally, the substrate support 20 can include one or more holding devices (not shown) configured for holding the substrate 10 at the plate or frame. The one or more holding devices can include at least one of mechanical, electrostatic, electrodynamic (van der Waals), and electromagnetic devices. For example, the one or more holding devices can be mechanical and/or magnetic clamps. In some implementations, the substrate support 20 is an E-chuck.

[0095] According to some embodiments, which can be combined with other embodiments described therein, the substrate 10 is in a substantially vertical orientation, for example, during the vacuum deposition process and/or during transportation of the substrate 10 through the vacuum chamber 510. As used throughout the present disclosure, 5 “substantially vertical” is understood particularly when referring to the substrate orientation, to allow for a deviation from the vertical direction or orientation of $\pm 20^\circ$ or below, e.g. of $\pm 10^\circ$ or below. This deviation can be provided for example because a substrate support or carrier with some deviation from the vertical orientation might result in a more stable substrate position or a facing down substrate orientation might reduce 10 particles on the substrate during deposition even better. Yet, the substrate orientation, e.g., during a layer deposition process, is considered substantially vertical, which is considered different from the horizontal substrate orientation, which may be considered as horizontal $\pm 20^\circ$ or below.

[0096] Specifically, as used throughout the present disclosure terms like “vertical 15 direction” or “vertical orientation” are understood to distinguish over “horizontal direction” or “horizontal orientation”. The vertical direction can be substantially parallel to the force of gravity.

[0097] According to some embodiments, which can be combined with other embodiments described herein, the system 500 is configured for dynamic sputter 20 deposition on the substrate(s). A dynamic sputter deposition process can be understood as a sputter deposition process in which the substrate 10 is moved through the deposition area 515 along the transport direction 3 while the sputter deposition process is conducted. In other words, the substrate 10 is not stationary during the sputter deposition process.

[0098] In some implementations, the system 500 is configured for dynamic processing. 25 The system 500 can particularly be an in-line processing system, i.e., a system for dynamic deposition, particularly for dynamic vertical deposition, such as sputtering. An in-line processing system or a dynamic deposition system according to embodiments described herein provides for a uniform processing of the substrate 10, for example, a large area substrate such as a rectangular glass plate. The processing tools, such as the one or more 30 sputter deposition sources, extend mainly in one direction (e.g., the vertical direction) and

the substrate 10 is moved in a second, different direction (e.g., a transport direction 3, which can be a horizontal direction).

[0099] Apparatuses or systems for dynamic vacuum deposition, such as in-line processing apparatuses or systems, have the advantage that processing uniformity, for example, layer uniformity, in one direction is only limited by the ability to move the substrate 10 at a constant speed and to keep the one or more sputter deposition sources stable. The deposition process of an in-line processing apparatus or a dynamic deposition apparatus is determined by the movement of the substrate 10 past the one or more sputter deposition sources. For an in-line processing apparatus, the deposition area or processing area can be an essentially linear area for processing, for example, a large area rectangular substrate. The deposition area can be an area into which deposition material is ejected from the one or more sputter deposition sources for being deposited on the substrate 10. In contrast thereto, for a stationary processing apparatus, the deposition area or processing area would basically correspond to the area of the substrate 10.

[00100] In some implementations, a further difference of an in-line processing system, for example, for dynamic deposition, as compared to a stationary processing system can be formulated by the fact that the dynamic in-line processing system can have one single vacuum chamber with different areas, wherein the vacuum chamber does not include devices for vacuum tight sealing of one area of the vacuum chamber with respect to another area of the vacuum chamber. Contrary thereto, a stationary processing system may have a first vacuum chamber and a second vacuum chamber which can be vacuum tight sealed with respect to each other using, for example, valves.

[00101] According to some embodiments, which can be combined with other embodiments described herein, the system 500 includes a magnetic levitation system for holding the substrate support 20 in a suspended state. Optionally, the system 500 can use a magnetic drive system configured for moving or conveying the substrate support 20 within the vacuum chamber 510, for example, in the transport direction 3. The magnetic drive system can be included in the magnetic levitation system or can be provided as a separate entity.

[00102] According to some embodiments, which can be combined with other embodiments described herein, the system 500 can be configured as a dual-line system. For example, the vacuum processing module can include two in-line units, such as a first (upper) in-line unit and a second (lower) in-line unit, for vacuum deposition. The first in-line unit 501 and the second in-line unit 502 can be combined in a mirrored manner. The first in-line unit 501 and the second in-line unit 502 can both be provided in the same vacuum chamber, such as the vacuum chamber 510. The first in-line unit 501 and the second in-line unit 502 share common sputter deposition sources, which can be bi-directional sputter deposition sources. The common sputter deposition sources for a simultaneous deposition of material onto substrates allow for a higher throughput. The simultaneous processing using two in-line units within one vacuum chamber 510 of the system 500 reduces a footprint of the system 500. Particularly for large area substrates, the footprint can be a relevant factor for reducing the cost of ownership for the system 500.

[00103] Each in-line unit, such as the first (upper) in-line unit and the second (lower) in-line unit, includes a first area 512, a deposition area 515, and optionally a second area 518. The first areas extend parallel to each other and the deposition areas extend parallel to each other, wherein the one or more sputter deposition sources are provided between the deposition areas. The second areas can extend parallel to each other.

[00104] According to some embodiments, the system 500 includes the one or more sputter deposition sources, such as one or more first sputter deposition sources 532, one or more second sputter deposition sources 534 and one or more third sputter deposition sources 536. The two or more deposition sub-areas can be separated from each other using deposition separation units 538 (also referred to as “deposition separation shielding”). For example, deposition separation units 538 can be provided between the sputter deposition sources for providing different materials on the substrate. According to some embodiments, which can be combined with other embodiments described herein, the deposition area(s) can be included in a scalable chamber section 514. For example, the vacuum chamber 510 can be manufactured or constructed from at least three sections. The at least three sections can be connected to each other to form the vacuum chamber 510. The first section of the at least three sections provides the first area(s). The second section

of the at least three sections provides the scalable chamber section 514 and the deposition area(s), and the third section of the at least three sections provides the second area(s).

[00105] The scalable chamber section 514 provides the processing tools, for example, the one or more sputter deposition sources. The scalable chamber section 514 can be provided in various sizes in order to allow for a varying amount of processing tools to be provided in the scalable chamber section 514. For example, the vacuum chamber 510 is configured to accommodate variable numbers of sputter deposition sources.

[00106] In some implementations, the deposition area 515 includes a partition 517 provided in a chamber region between the one or more sputter deposition sources and a chamber wall of the vacuum chamber 510. For example, a first partition is provided in a chamber region between the one or more sputter deposition sources and a first chamber wall of the first in-line unit 501. A second partition can be provided in a chamber region between the one or more sputter deposition sources and a second chamber wall of the second in-line unit 502. According to some embodiments, the partition 517, such as the first partition and the second partition, can be separation walls, such as vertical walls. For example, the partition 517 can extend substantially parallel to the chamber wall and/or a respective transport direction, such as the transport direction 3.

[00107] The partition 517 of an in-line unit separates the chamber region into the respective deposition area and a respective transportation area, wherein the transportation area 516 is at least partially shielded from the one or more sputter deposition sources. The system 500 can be configured for substrate transportation along the first transportation path through the deposition area 515 of a respective in-line unit and along a second transportation path through the transportation area 516 of a respective in-line unit. In particular, the first transportation path can be a forward transportation path. The second transportation path can be a return transportation path.

[00108] The first area 512 and the second area 518 can be track switch areas (first area 512: track switching load/unload; second area 518: track switching return) configured for moving the substrate or substrate carrier from the first transportation path to the second transportation path and/or vice versa. The first area 512 and the second area 518 are sufficiently long enough to allow for the track switch. The track switch areas can be at

each end of the dynamic-deposition zone. This allows for a continuous substrate flow (dynamic deposition) without the need for “run up” and “run away” chamber sections. The in-line processing system has a smaller footprint.

[00109] The first in-line unit 501 may include a first track switching and/or load-unload area in the first area 512 and the second in-line unit 502 may include a second track switching and/or load-unload area in the first area 512. The first track switching and/or load-unload area and the second track switching and/or load-unload area can be separated from each other by a first separation 513. The track switching and/or load-unload areas provide for a substrate movement transverse to the transport direction 3 past the sputter deposition sources. The two track switching and/or load-unload areas can be utilized simultaneously in order to improve the throughput of the system 500.

[00110] Within the track switching and/or load-unload area, the substrate support 20 with the substrate 10 is moved on a path for processing the substrate 10, such as the first transportation path. Thereafter, one substrate after the other is moved past the processing tools, for example, the sputter deposition sources. Accordingly, the substrates are processed in the deposition area 515 of the vacuum chamber, for example, the scalable chamber section 514.

[00111] The second area 518 provides a track switching return area, such as a first track switching return area of the first in-line unit 501 and a second track switching return area of the second in-line unit 502. The first track switching return area and the second track switching return area can be separated by a second separation 519. The track switching return areas provide for a movement transverse to the transport direction 3 past the sputter deposition sources. Accordingly, a substrate support 20 with the substrate 10 can return to the first area 512 and optionally to the load lock chamber with a distance to the sputter deposition sources that is different (i.e., larger) from the distance to the sputter deposition sources during processing.

[00112] According to some embodiments, which can be combined with other embodiments described herein, a system can be configured for display manufacturing, particularly of large area substrates. Material may be deposited with chemical vapor

deposition and/or physical vapor deposition. For example, a TFT display may be manufactured.

[00113] Further embodiments, modifications, details and aspects of apparatuses for holding a substrate, which may be combined with other embodiments described herein, can be understood with references to FIGS. 7A and 7B.

[00114] FIGS. 7A and 7B show a Bernoulli-type holder 300 or PV holder, respectively. A schematic view of an aperture plate is shown. As described above, two or more zones, such as four more zones, five or more zones, six or more zones, or 10 or more zones can be provided. The zones can be individually controlled, i.e. the gap between the surface of the aperture plate and the substrate can be individually controlled. For example, the pressure in gas inlets (gas inlet conduits) and/or the vacuum at gas outlets (gas outlet conduits) can be individually controlled.

[00115] According to some embodiments, which can be combined with other embodiments described herein, the zones 750 can have a generally radial pattern or a generally circular pattern. For example the pattern can be radial, circular, elliptical, or oval. This is shown in figures 7A and 7B. The shape of the pattern (oval versus circular) may, for example, depend on the ratio of a width W and a length L of the substrate, i.e. the respective dimensions of the aperture plate.

[00116] When the glass heats up from one side, e.g. the front side, when loaded on the Bernoulli holder or PV holder, the glass tends to curl up into a dome-shape. That is, heating from one side only may result in an undesired bending or curling of the substrate. According to some embodiments, which can be combined with other embodiments described herein, an apparatus for holding is configured to hold the glass flat or in a desired shape, particularly despite the tendency to curl. Accordingly, the shape of the pattern of the zones can be configured to allow for compensation of the dome shape of the substrate. Embodiments are configured to apply a different force (per unit area) on the substrate, e.g. depending upon the specific location of that area on the glass. The generally radial (circular or oval or elliptical) pattern of the zones allow for applying more force per unit area the farther from the center of the glass that particular area is on the substrate. That is to say, more force can be provided by the Bernoulli holder or PV holder toward the

edges and corners. The holding characteristics, i.e. the contactless holding characteristics, of folders according to embodiments described herein can be controlled in a generally radial pattern.

[00117] The gas pressure in inlets of the Bernoulli holder or PV holder and/or the gas pressure in outlets of the Bernoulli holder or PV holder can be individually controlled for different zones. FIG. 7A shows a plurality of outlet (e.g. return) apertures or openings 324, i.e. vacuum orifices, and a plurality of inlet apertures or openings 323, i.e. pressure orifices. According to embodiments described herein, the pressure orifices and the vacuum orifices, that is the inlet openings and the outlet openings, can provide a pressure cell or a pressure and vacuum cell. For example, each pressure orifice can be surrounded by four vacuum orifices. Each vacuum orifice can be surrounded by four pressure orifices. An area of pressure and vacuum cells is provided according to embodiments described herein. The pressure and vacuum cells (of the present cells) can be individually controlled zone-by-zone. Accordingly, different holding forces for levitation forces (per unit area) can be provided for each zone. For example, one or more zones can be generally circularly shaped (or oval or elliptical) to compensate for a curling or bending of the substrate supported by the substrate holder, particularly as a function of the distance from the center of the substrate and/or as a function of the distance from the center of the substrate and the dimensional ratio of the substrate.

[00118] FIG. 8 shows a flow chart of a method 800 according to embodiments described herein, such as the method for holding a substrate, such as a large area substrate. The method 800 can utilize the apparatuses and systems according to the embodiments described herein.

[00119] The method includes holding the substrate with a Bernoulli-type holder and adjusting the temperature of the substrate (block 810). Optionally the method can include removing particles from the substrate in a gap between a surface of the Bernoulli-type holder and the substrate by varying the gap between the surface and the substrate (block 820). The temperature of the substrate can be adjusted, for example, using the gap control. The gap control may be provided individually for different zones to provide uniformity of the substrate temperature across the surface of the substrate.

[00120] Such a method for holding a substrate may also be provided for a method for loading a substrate into a vacuum processing module or a method for treatment of a substrate for a vacuum deposition process in a vacuum processing module.

[00121] In some implementations, the temperature of the substrate is adjusted by at least one of: a control of a gap between a surface of the Bernoulli-type holder and the substrate, and a heating or a cooling of the surface of the Bernoulli-type holder. The surface of the Bernoulli-type holder can include two or more zones. The temperature of the substrate can be individually controller in the two or more zone and/or the gap between the surface of the Bernoulli-type holder and the substrate can be individually controlled in the two or more zones.

[00122] The method can implement various individual control aspects, such as at least one of: individually controlling the temperature by an individual control of a local Bernoulli effect in the two or more zone, individually controlling the temperature by individually adjusting the temperature of the surface in the two or more zones, individually controlling the pressure in supply lines corresponding to the two or more zones, and individually controlling a vacuum in return lines corresponding to the two or more zones.

[00123] According to some embodiments, the method 800 further includes loading the substrate onto a carrier (block 830), and loading the substrate carrier having the substrate positioned thereon into a load lock chamber (block 840). For example, the substrate is loaded onto the substrate carrier before the substrate carrier having the substrate positioned thereon is loaded into the load lock chamber. The substrate carrier can be an E-chuck, which may be fixed to a support surface provided by the load lock chamber, such as the rotatable door described with respect to FIG. 6.

[00124] In some implementations, the method 800 further includes a guiding of a stream of gas via a gas supply of the Bernoulli-type holder along a surface of the substrate while holding the substrate with the Bernoulli-type holder, and a treating of the substrate with the stream of gas while guiding the stream of gas, wherein at least one physical and/or chemical property of the gas is selected for the treating of the substrate.

[00125] According to some embodiments, the treatment of the substrate comprises at least one of heating the substrate and degassing the substrate. The treatment can further include providing at least one of a clean, dry, and chemically-inert environment at least for the surface of the substrate. Particularly, heating of the substrate can be provided dynamically and/or individually for different zones of the substrate, i.e. zones of the Bernoulli-type holder.

[00126] FIG. 9 shows another flow chart of a method 900 for holding a substrate, for example a large area substrate. The method includes holding the substrate with a Bernoulli-type holder (block 910). Further, particles are removed from the substrate in a gap between the surface of the Bernoulli-type holder and the substrate, e.g. by varying a gap between the surface and the substrate (block 920). In the display industry, particles of the substrate can be critical to product quality. Substrates that are loaded in a processing system, such as a deposition system, may contain particles. Further particles may be added during loading and/or unloading of the substrate. According to embodiments described herein, by varying the size of the gap of a Bernoulli-type holder the number of particles can be reduced.

[00127] A Bernoulli-type holder or PV-holder can be provided as a portion of a processing system, for example at the front end for loading the substrate in a load lock chamber. The Bernoulli-type holder can be provided as an atmospheric part of the system. As described above, loading of the substrate and heating of the substrate can be provided. Additionally or alternatively, removal of the particles on substrate, for example a display glass, can be provided. By adjusting the pressure in a gas inlet of the Bernoulli-type holder and/or adjusting a vacuum in a gas outlet of the Bernoulli-type holder, the size of the gap, i.e. the Bernoulli air gap, can be varied. For example, individually controllable supplies can control the gap, for example between a size of 20 μm to 200 μm . A high gas velocity for the Bernoulli effect, such as a local high gas velocity at discretely distributed positions, such as zones of the Bernoulli holder, can remove particles from the surface of the substrate. Accordingly, locations on the substrate, such as a display glass can be cleaned by the Bernoulli effect.

[00128] According to some embodiments, which may be combined with other embodiments described herein, the gas provided in the gap may be ionized (block 930). For example, the gas may be ionized at a gas conditioning assembly or in an inlet conduit

for supplying gas in the gap between the surface of the Bernoulli holder and the substrate. The gas may be ionized with varying polarization. According to some embodiments, the size of the gap can be varied (block 940) to address different particle sizes, i.e. to remove particles of different sizes.

- 5 [00129] According to embodiments described herein, the methods can be conducted using computer programs, software, computer software products and the interrelated controllers, which can have a CPU, a memory, a user interface, and input and output devices being in communication with the corresponding components of the systems and apparatuses according to the embodiments described herein.
- 10 [00130] Embodiments described herein allow for particle removal on flat or smoothly curved or bended parts, such as substrates.

[00131] FIG. 10 shows a further example of a pattern of zones, wherein the pattern provides inner zones and outer zones, i.e. a generally radial pattern. Generally, radial can be understood with respect to FIG. 10, e.g. as one zone surrounding another zone, as zones
15 having a polar coordinate system with an origin at the center of the substrate or the center of the aperture plate increasing radial coordinates from one zone to another zone, particularly for at least a range of angular coordinates of 90° or 180°, specifically 360°.

[00132] The examples shown in FIG. 10 includes 4 zones. Each zone can be combined by rectangular elements. The rectangular elements may be easier to manufacture as for
20 example curved elements. The rectangular elements can be combined such that e.g. zone 4 surrounds, zone 3, zone 3 surrounds zone 2, and/or zone 2 surrounds zone 1. For polar coordinates for at least a range of 90° (for FIG. 10 exemplarily a range of 360°), the radial coordinates increase from zone 1, to zone 2, to zone 3, and to zone 4.

[00133] According to some embodiments, which can be combined with other
25 embodiments described herein, elements of a pattern can be combined, particularly rectangular elements or polygon-shaped elements can be combined, to form generally radial patterns, i.e. patterns which mimic a circle, an oval or an ellipse, or which follow one of the above characteristics.

[00134] The present disclosure provides at least some of the following aspects and advantages. The embodiments of the present disclosure direct a stream of gas across at least one surface of a substrate, such as a large area substrate, in a controlled manner. The stream of gas can be used for at least one of treating the substrate, for example, before the substrate is loaded into a vacuum processing module, and holding the substrate in a levitating state. The temperature uniformity of the substrate can be increased by control of the gap of a local Bernoulli effect. In particular, the stream of gas can be used for an outgassing of the substrate and/or for a removal of foreign particles from the surface of the substrate on which a material layer is to be deposited. For example, an outgassing of the substrate can be performed using the stream of gas before the substrate is put on a substrate carrier, such as an E-chuck. A quality, such as a purity and/or a homogeneity, of the deposited layers can be improved. Further, the stream of gas can be used to generate a pressure above the substrate such that the substrate levitates. In particular, the stream of gas can simultaneously provide two functions, namely a holding function and a treatment or pre-treatment function for the substrate. Particularly a local temperature control and/or a particle removal can be provided.

[00135] According to an aspect of the present disclosure, an apparatus for holding a substrate is provided. The apparatus includes a Bernoulli-type holder having a surface configured to face the substrate, and one or more adjusting means configured to adjust the temperature of the substrate. According to another aspect of the present disclosure, which may be combined with the aforementioned aspect, an apparatus for holding a substrate is provided. The apparatus includes a Bernoulli-type holder having a surface configured to face the substrate, and one or more adjusting means configured to adjust the gap between the surface and the substrate.

[00136] One or more of the following aspects can be applied to the apparatus individually or in combination. The one or more adjusting means can include at least one of: one or more pressure regulators, one or more valves, a compressor, a vacuum pump, one or more mass flow controllers, differential pressure gauges between a supply line and a return line, and one or more proportioning valves.

[00137] The surface can include two or more zones being in fluid communication with individual gas inlet conduits to individually direct a stream of gas to the two or more

zones. The surface can include five or more zones with individual gas inlet conduits. The two or more gas inlet conduits can be connected to a gas supply providing a stream of a gas between the surface and the substrate. The apparatus can include two or more individual gas outlet conduits for the two or more zones. The two more zones can be configured for a local Bernoulli effect. The one or more adjusting means are two or more adjusting means configured to locally adjust the gap in the two or more zones. The two or more zones can have a generally radial pattern, a radial pattern, an oval pattern or an elliptical pattern.

[00138] The Bernoulli holder can be a PV holder having an array of pressure and vacuum cells. A first outlet opening at the surface of the Bernoulli holder can be surrounded by four inlet openings at the surface of the Bernoulli holder and a first inlet opening at the surface of the Bernoulli holder can be surrounded by four outlet openings at the surface of the Bernoulli holder. The apparatus one or more adjusting means can be two or more adjusting means.

[00139] The apparatus can include one or more conditioning devices for adjusting at least one physical and/or chemical property of the gas directed between the surface and the substrate, wherein the physical and/or chemical property of the gas is selected for a treatment of the substrate. The one or more conditioning devices can be selected from the group consisting of a heater configured for heating the gas, a dryer configured for drying the gas, a filter for filtering the gas, a compressor, a gas ionizer, a vacuum pump, and any combination thereof.

[00140] The apparatus can include one or more substrate alignment devices. The one or more substrate alignment devices can include an actuator to move the substrate over the surface during heating. The apparatus can include one or more heating elements to heat the surface of the Bernoulli-type holder or two or more heating elements to individually heat the two or more zones of the surface of the Bernoulli-type holder. The one or more heating elements or the two or more heating elements are configured to provide a temperature gradient across the surface.

[00141] The apparatus can include a first camera to measure a temperature profile of the substrate and/or a second camera to measure a deformation of the substrate. The first

camera can be an infrared camera. The second camera can be a polarization camera or a speckle measurement arrangement.

[00142] According to a further aspect of the present disclosure, a system for vacuum processing of a substrate is provided. The system includes a processing module configured for a vacuum deposition process on the substrate, at least one load lock connected to the processing module, and the apparatus according to the present disclosure.

[00143] According to another aspect of the present disclosure, a method for holding a substrate is provided. The method includes holding the substrate with a Bernoulli-type holder, wherein the substrate is a large area substrate, and adjusting the temperature of the substrate.

[00144] The method can include one or more of the following aspects individually or in combination. The temperature of the substrate can be adjusted by at least one of: control of the gap between a surface of the Bernoulli-type holder and the substrate, and heating or cooling the surface of the Bernoulli-type holder. The surface of the substrate can include two or more zones and the temperature of the substrate can be individually controlled in the two or more zone. The temperature can be individually controlled by individual control of a local Bernoulli effect in the two or more zone. The gap in the two or more zones can be individually controlled. A pressure in supply lines corresponding to the two or more zones can be individually controlled. A vacuum in return lines corresponding to the two or more zones can be individually controlled. The temperature can be individually controlled by individually adjusting the temperature of the surface in the two or more zones.

[00145] According to yet another aspect of the present disclosure, a method for holding a substrate is provided. The method includes holding the substrate with a Bernoulli-type holder, wherein the substrate is a large area substrate, and removing particles from the substrate in a gap between a surface of the Bernoulli-type holder and the substrate by varying a gap between the surface and the substrate. The method can include ionizing a gas provided in the gap.

[00146] According to a further aspect of the present disclosure, a method for loading a substrate into a vacuum processing module is provided. The method includes holding a

substrate according to the aforementioned method for holding a substrate, and loading the substrate onto a substrate carrier provided at a load lock chamber connected to the vacuum processing module using the Bernoulli-type holder. The method can further include loading the substrate carrier having the substrate positioned thereon into the load lock chamber.

[00147] According to an aspect of the present disclosure, an apparatus for loading a substrate into a vacuum processing module is provided. The apparatus includes a Bernoulli-type holder having a surface configured to face the substrate, and at least one of one or more pressure regulators, one or more valves, a compressor, a vacuum pump, one or more mass flow controllers, and one or more proportioning valves.

[00148] While the foregoing is directed to embodiments of the disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

CLAIMS

1. An apparatus for holding a substrate, comprising:

a Bernoulli-type holder having a surface configured to face the substrate; and

5 one or more adjusting means configured to adjust the temperature of the substrate.

2. An apparatus for holding a substrate, comprising:

a Bernoulli-type holder having a surface configured to face the substrate; and

10 one or more adjusting means configured to adjust a gap between the surface and the substrate.

3. The apparatus according to claim 1 or 2, wherein the one or more adjusting means include at least one of: one or more pressure regulators, one or more valves, a compressor, a vacuum pump, one or more mass flow controllers, differential pressure gauges between a supply line and a return line, a heater, and one or more proportioning valves.

15

4. The apparatus according to any one of claims 1 to 3, wherein the surface includes two or more zones, or five or more zones, being in fluid communication with individual gas inlet conduits to individually direct a stream of gas to the two or more zones.

20

5. The apparatus according to claim 4, further comprising two or more individual gas outlet conduits for the two or more zones.

6. The apparatus according to any of claims 1 to 5, wherein the Bernoulli-type holder is a PV holder having an array of pressure and vacuum cells.

7. The apparatus according to any of claims 1 to 6, wherein a first outlet opening at the surface of the Bernoulli-type holder is surrounded by four inlet openings at the surface of the Bernoulli-type holder, and wherein a first inlet opening at the surface of the Bernoulli-type holder is surrounded by four outlet openings at the surface of the Bernoulli-type holder.

8. The apparatus according to any of claims 4 to 7, wherein the one or more adjusting means are two or more adjusting means configured to locally adjust the gap between the surface and the substrate in the two or more zones.

9. The apparatus according to any of claims 4 to 8, wherein the two or more zones have a generally radial pattern, a radial pattern, an oval pattern or an elliptical pattern.

10. The apparatus of any one of claims 1 to 9, further including one or more substrate alignment devices, wherein the one or more substrate alignment devices include an actuator to move the substrate over the surface during heating.

11. The apparatus according to any of claims 1 to 10, further comprising:

one or more heating elements to heat the surface of the Bernoulli-type holder, or

two or more heating elements to individually heat the two or more zones of the surface of the Bernoulli-type holder.

12. The apparatus according to claim 11, wherein the heating elements are configured to provide a temperature gradient across the surface of the Bernoulli-type holder.

13. The apparatus according to any of claims 1 to 12, further comprising at least one of:

5 a first camera configured to measure a temperature profile of the substrate; and

a second camera configured to measure a deformation of the substrate,

wherein the first camera is an infrared camera, and wherein the second camera is a polarization camera or a speckle measurement arrangement.

10 14. An apparatus for holding a substrate, comprising:

a contact-less holder having a surface configured to face the substrate; and

one or more adjusting means configured to adjust the temperature of the substrate and/or to adjust a gap between the surface and the substrate.

15 15. The apparatus of claim 14, wherein the contact-less holder is the Bernoulli-type holder according to any one of claims 1 to 13.

16. A system for vacuum processing of a substrate, comprising:

a processing module configured for a vacuum deposition process on the substrate;

20 at least one load lock chamber connected to the processing module; and

the apparatus of any one of claims 1 to 15.

17. A method for holding a substrate, comprising:

holding the substrate with a Bernoulli-type holder, wherein the substrate is a large area substrate; and

adjusting the temperature of the substrate.

5

18. The method according to claim 17, wherein the temperature of the substrate is adjusted by at least one of: a control of a gap between a surface of the Bernoulli-type holder and the substrate, and a heating or a cooling of the surface of the Bernoulli-type holder.

10

19. The method according to claim 17 or 18, wherein the surface of the Bernoulli-type holder includes two or more zones and least one of the following is individually controlled: the temperature of the substrate in the two or more zone, and the gap between the surface of the Bernoulli-type holder and the substrate in the two or more zones.

15

20. The method according to claim 19, further including at least one of:

individually controlling the temperature by an individual control of a local Bernoulli effect in the two or more zone;

individually controlling the temperature by individually adjusting the temperature
20 of the surface in the two or more zones;

individually controlling the pressure in supply lines corresponding to the two or more zones; and

individually controlling a vacuum in return lines corresponding to the two or more zones.

25

21. A method for holding a substrate, comprising:

holding the substrate with a contact-less holder, wherein the substrate is a large area substrate; and

adjusting the temperature of the substrate.

5

22. The method of claim 21, wherein the contact-less holder is a Bernoulli-type holder.

23. A method for loading a substrate into a vacuum processing module; comprising:

holding a substrate according to a method of claim 17 to 22; and

10 loading the substrate onto a substrate carrier provided at a load lock chamber connected to the vacuum processing module using the holder.

24. An apparatus for loading a substrate into a vacuum processing module, comprising:

a Bernoulli-type holder having a surface configured to face the substrate; and

15 at least one of: one or more pressure regulators, one or more valves, a compressor, a vacuum pump, one or more mass flow controllers, and one or more proportioning valves.

25. An apparatus for loading a substrate into a vacuum processing module, comprising:

a contact-less holder having a surface configured to face the substrate; and

20 at least one of: one or more pressure regulators, one or more valves, a compressor, a vacuum pump, one or more mass flow controllers, and one or more proportioning valves.

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Fig. 1A

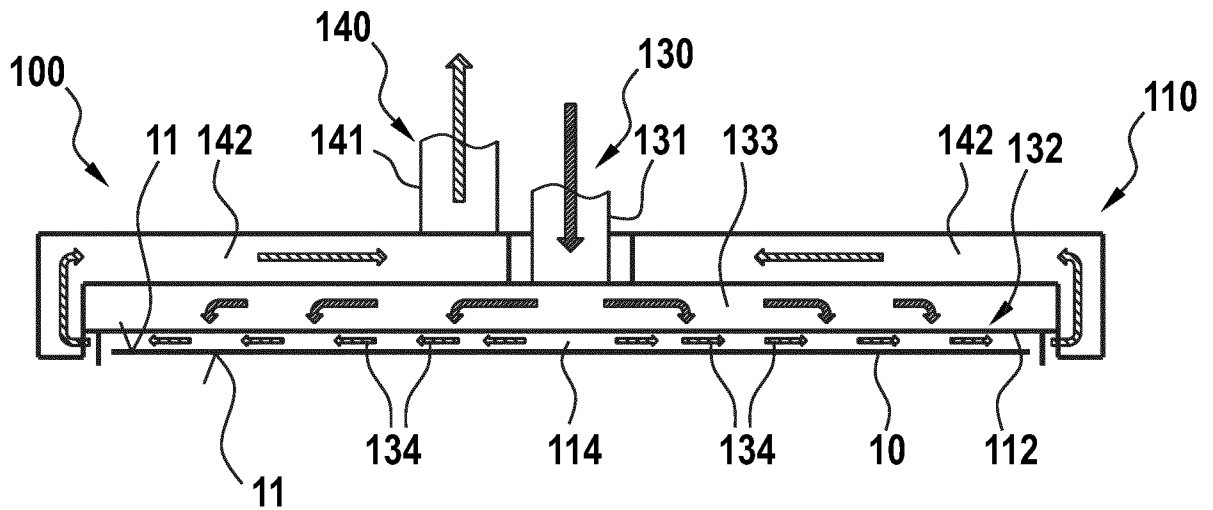


Fig. 1B

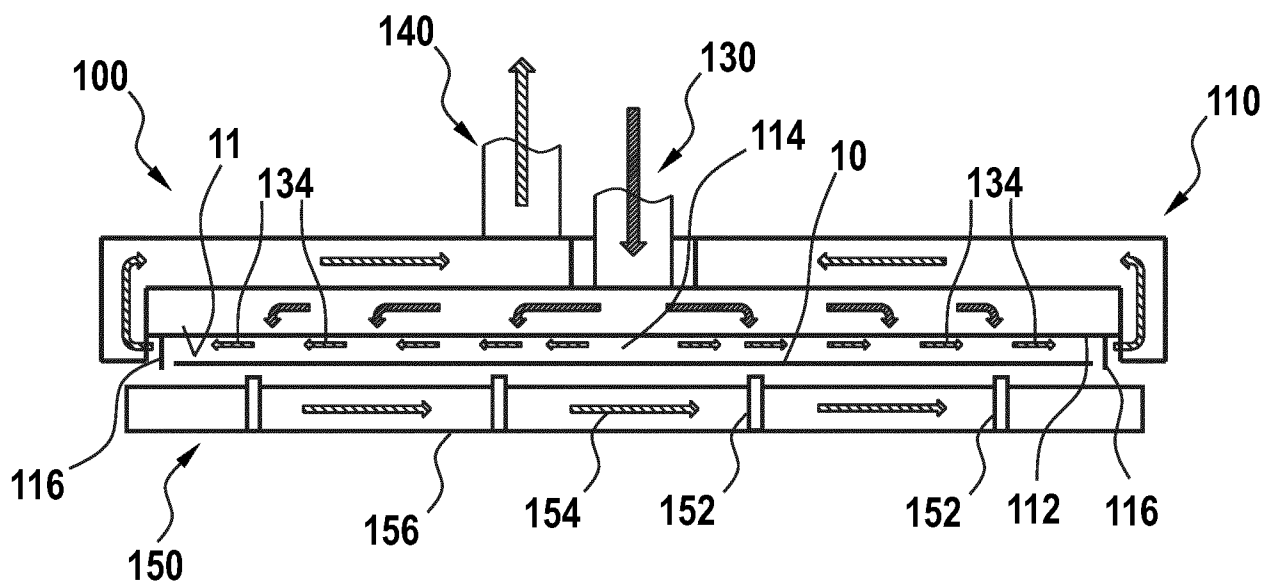
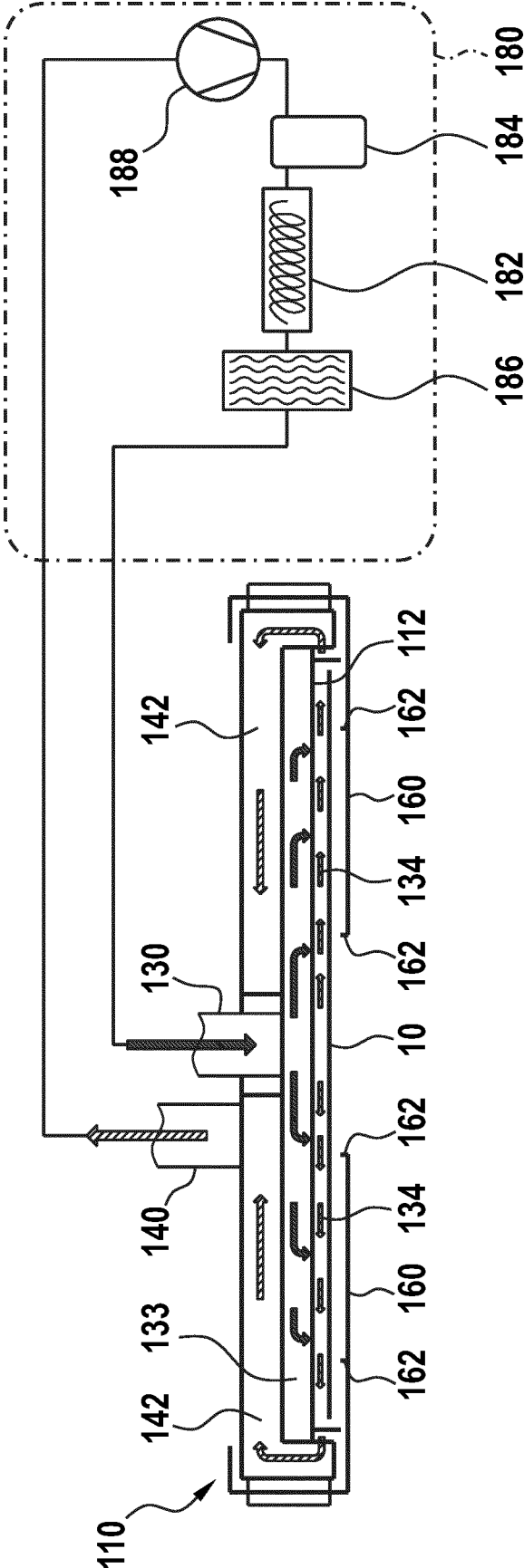


Fig. 1C



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Fig. 2A

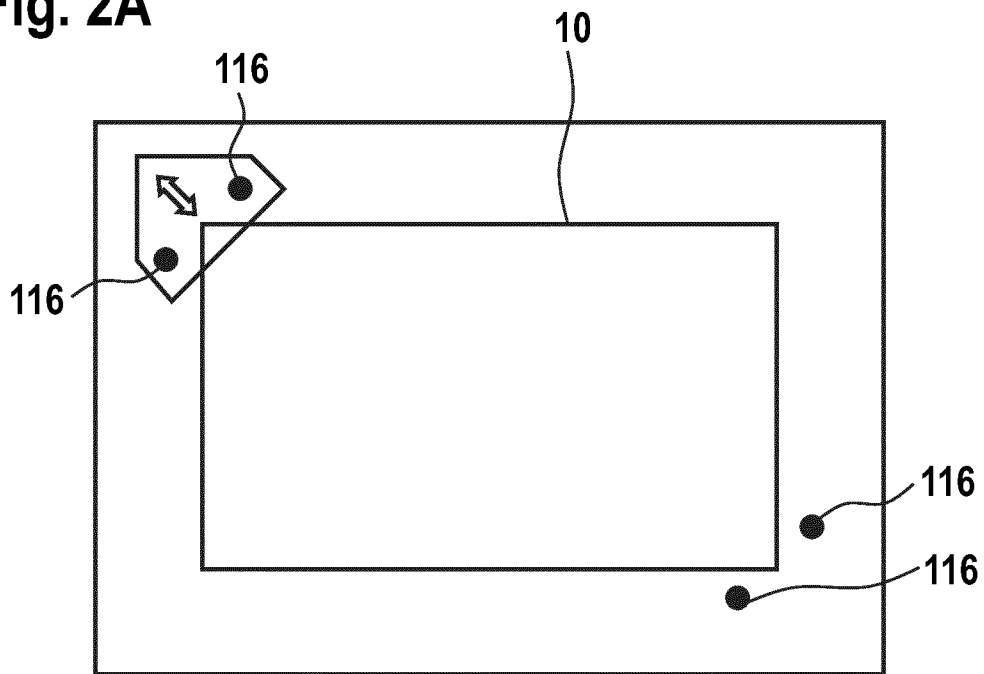


Fig. 2B

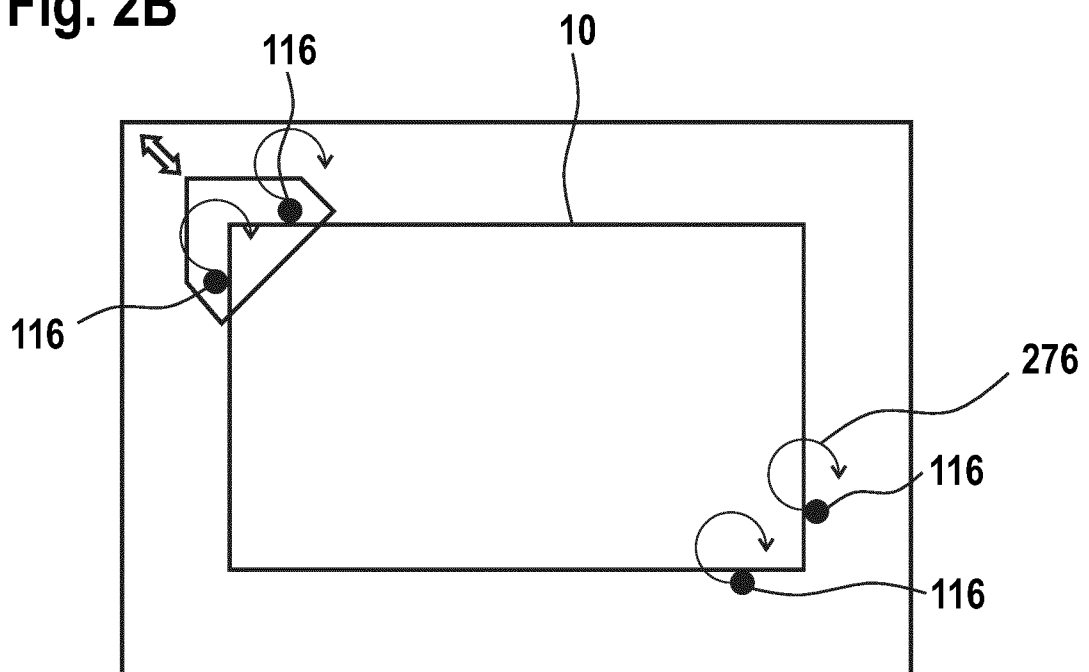


Fig. 3A

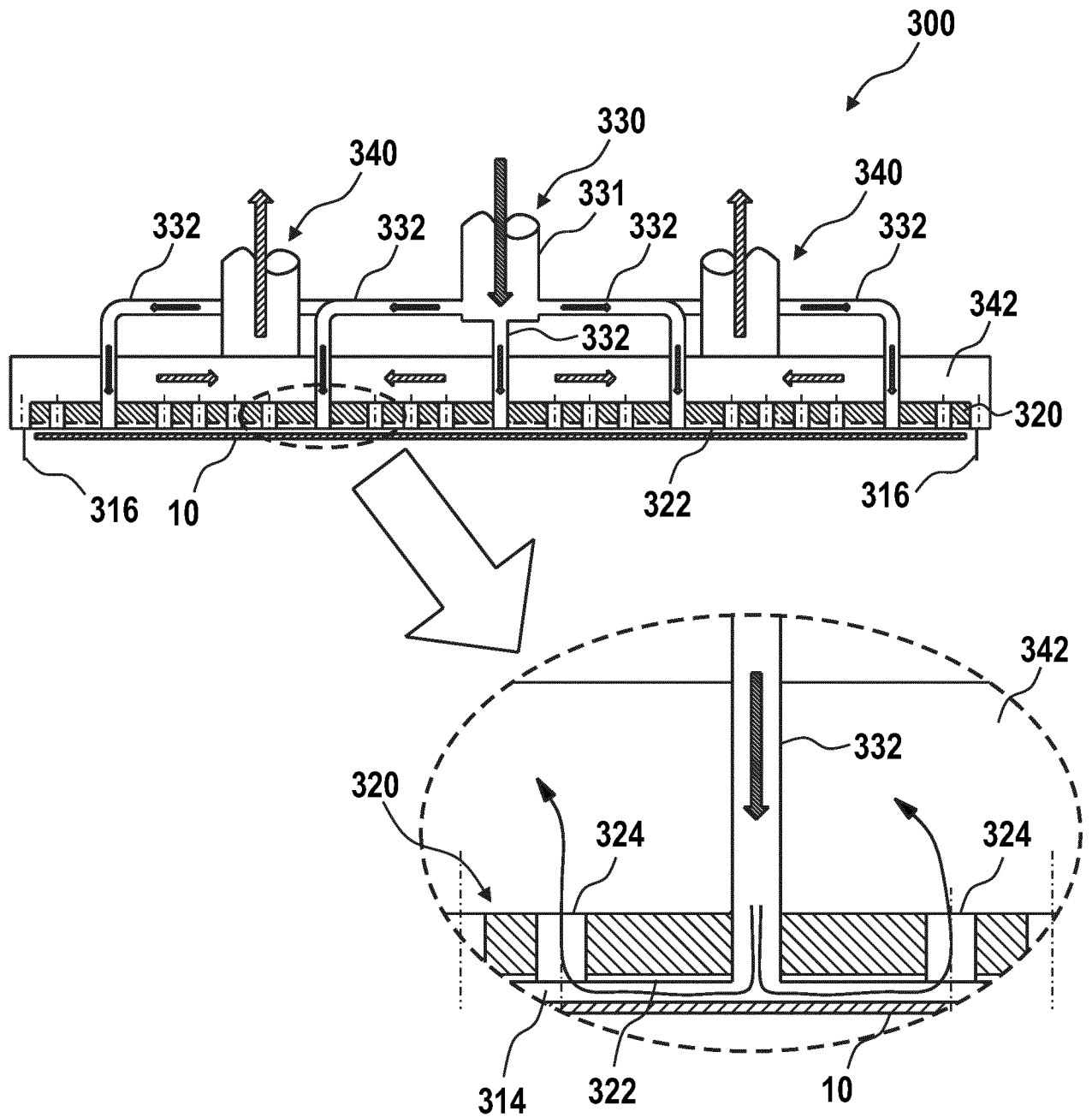
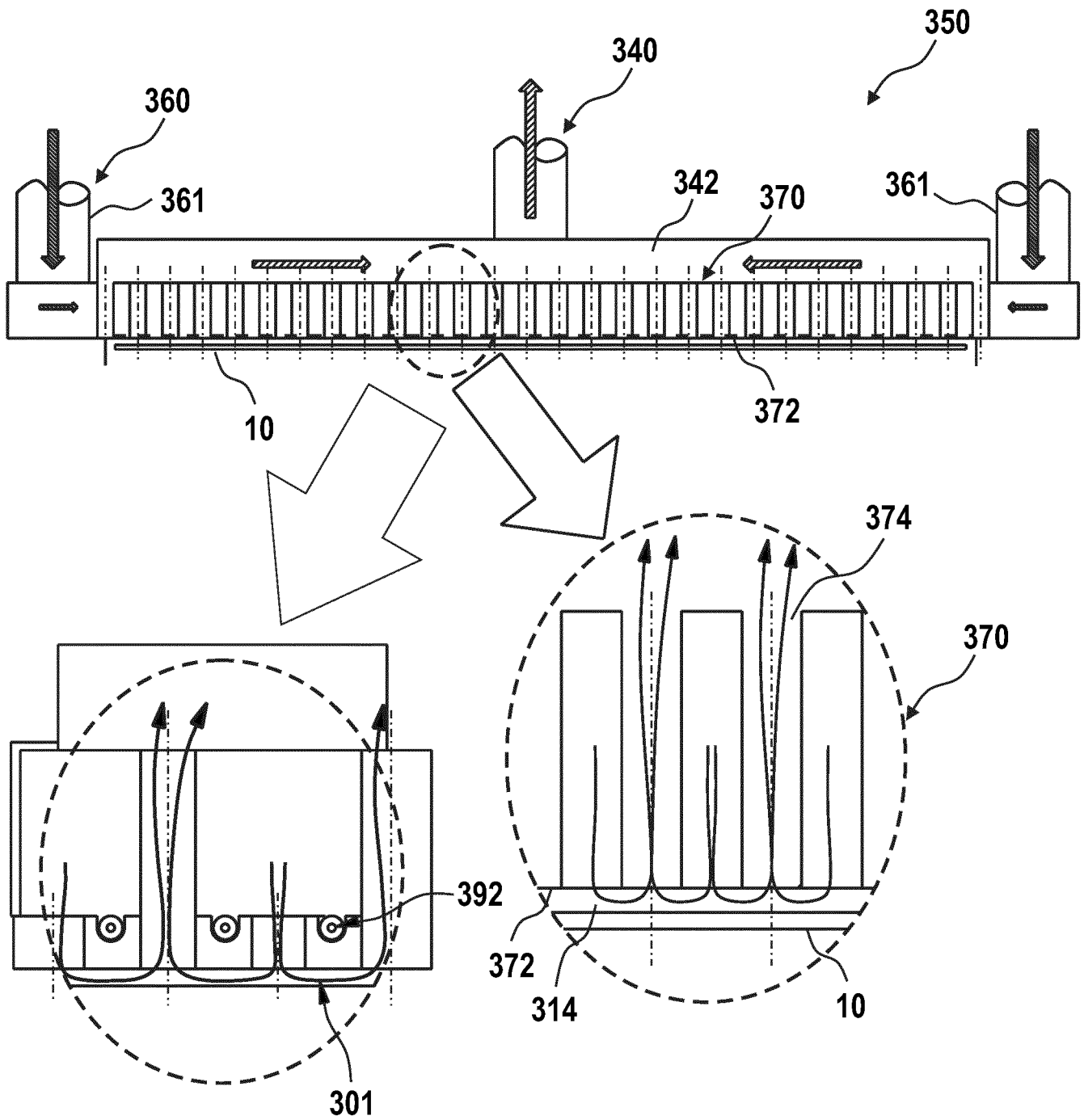
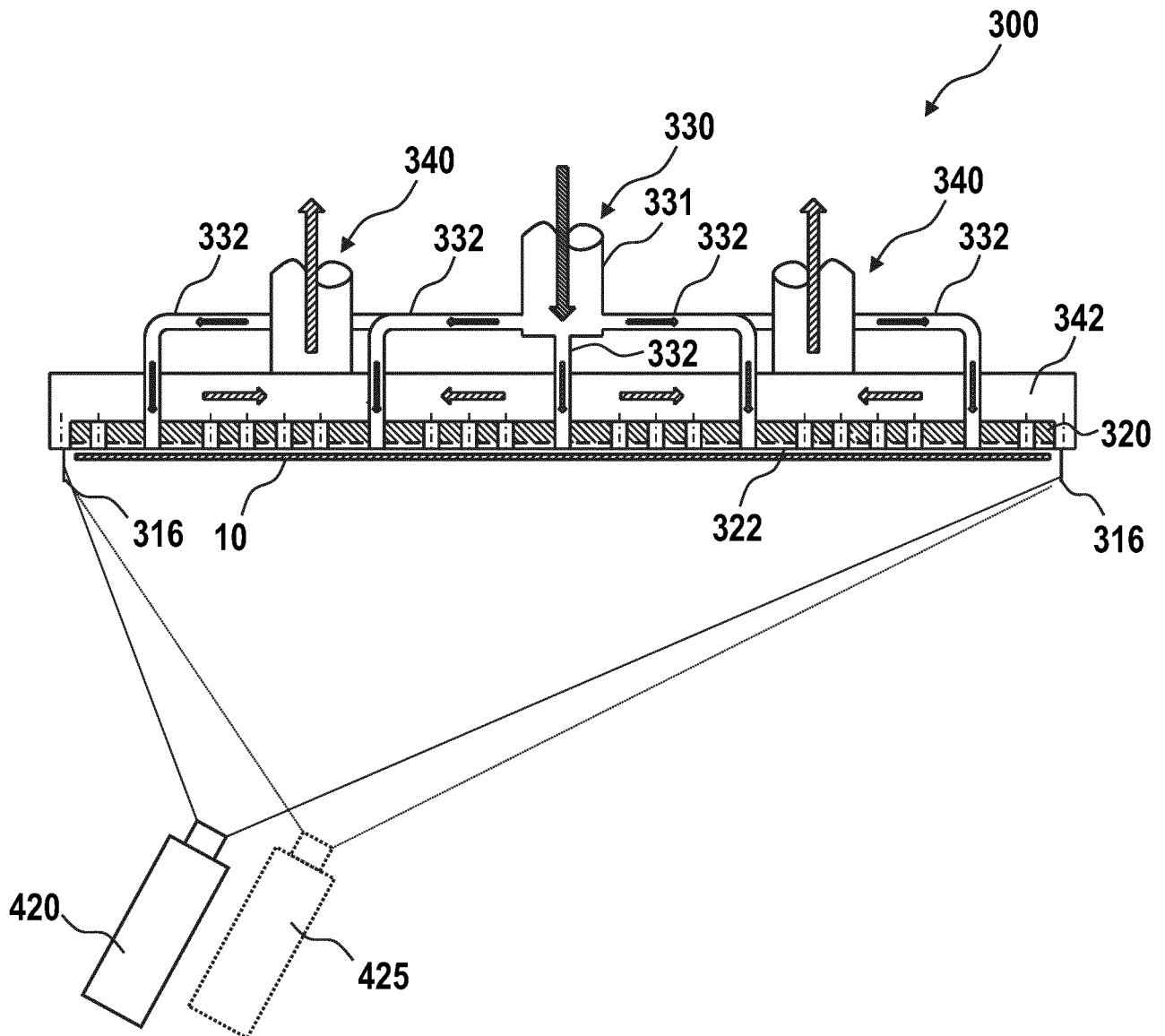


Fig. 3B



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Fig. 4



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Fig. 5A

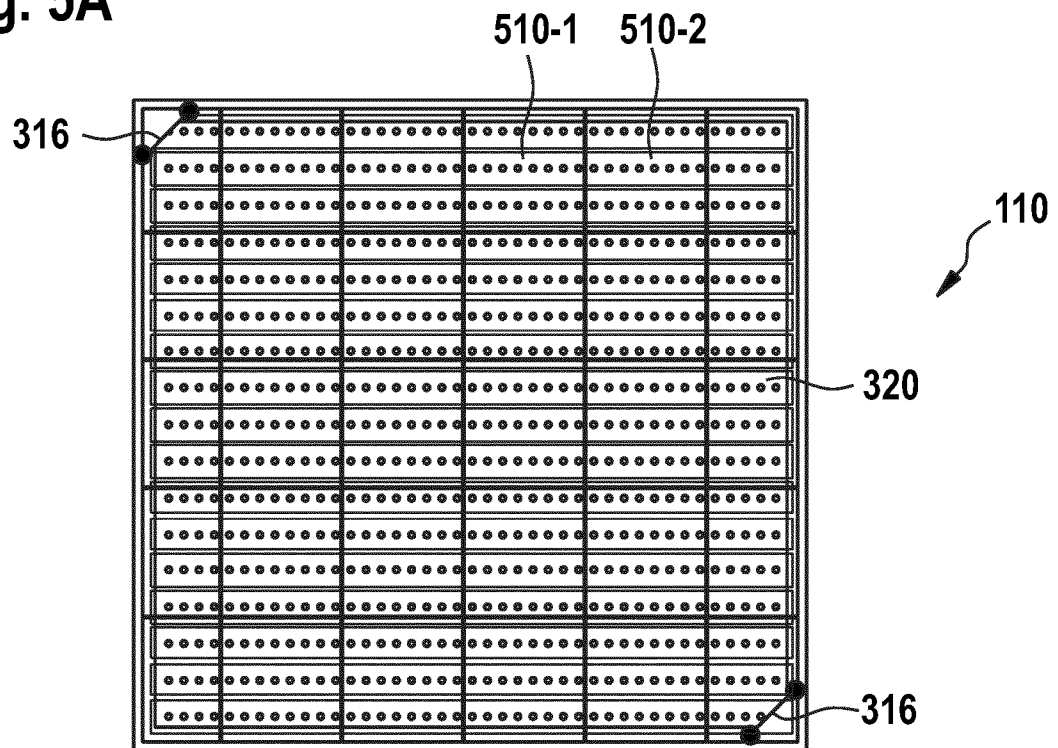


Fig. 5B

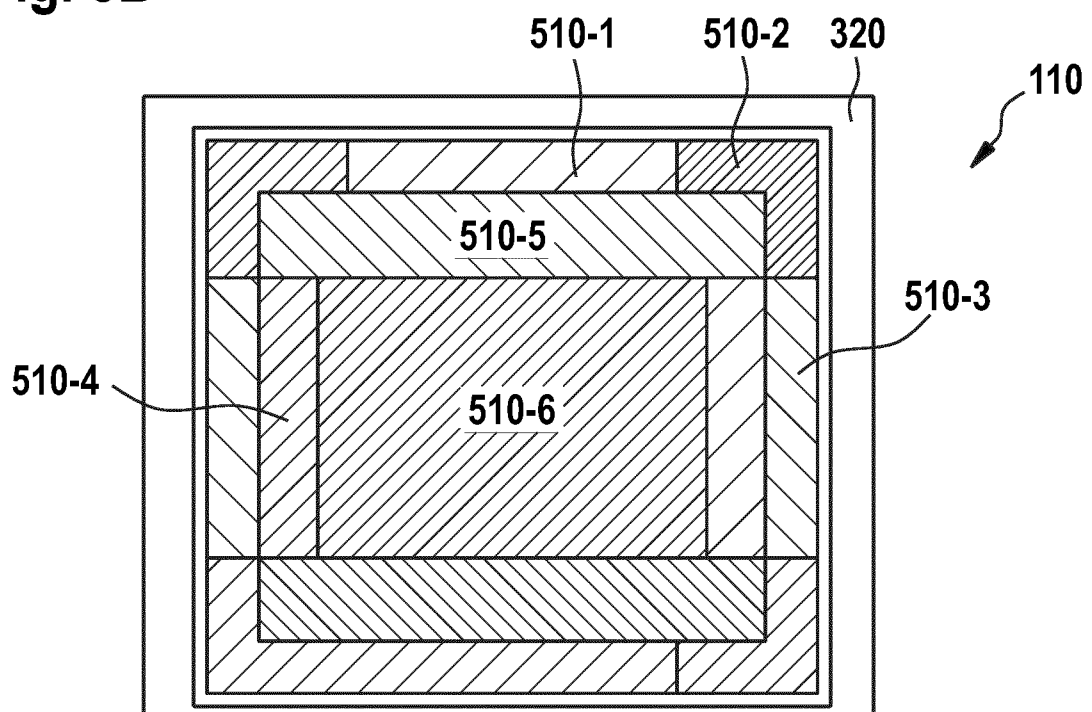


Fig. 6

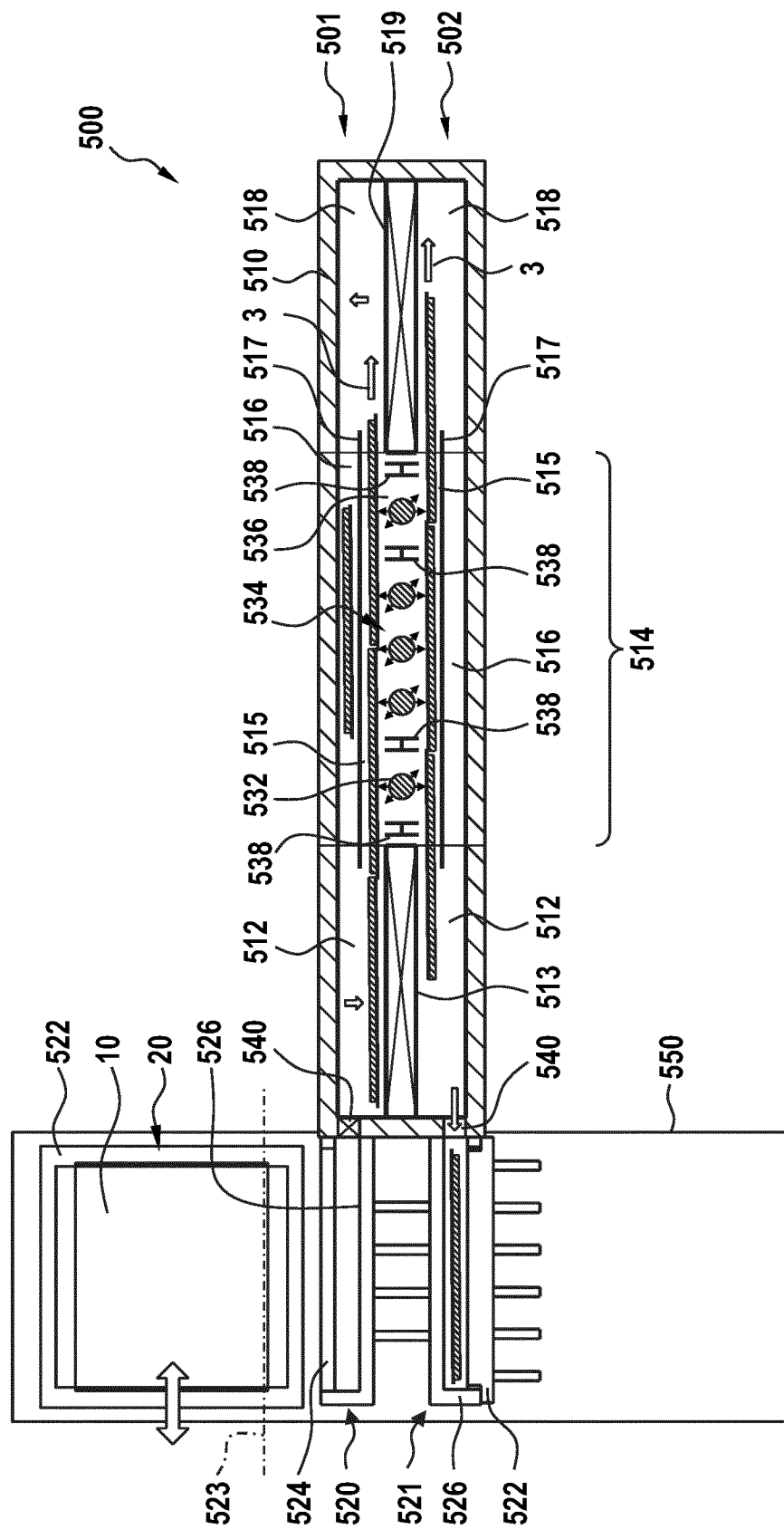


Fig. 7A

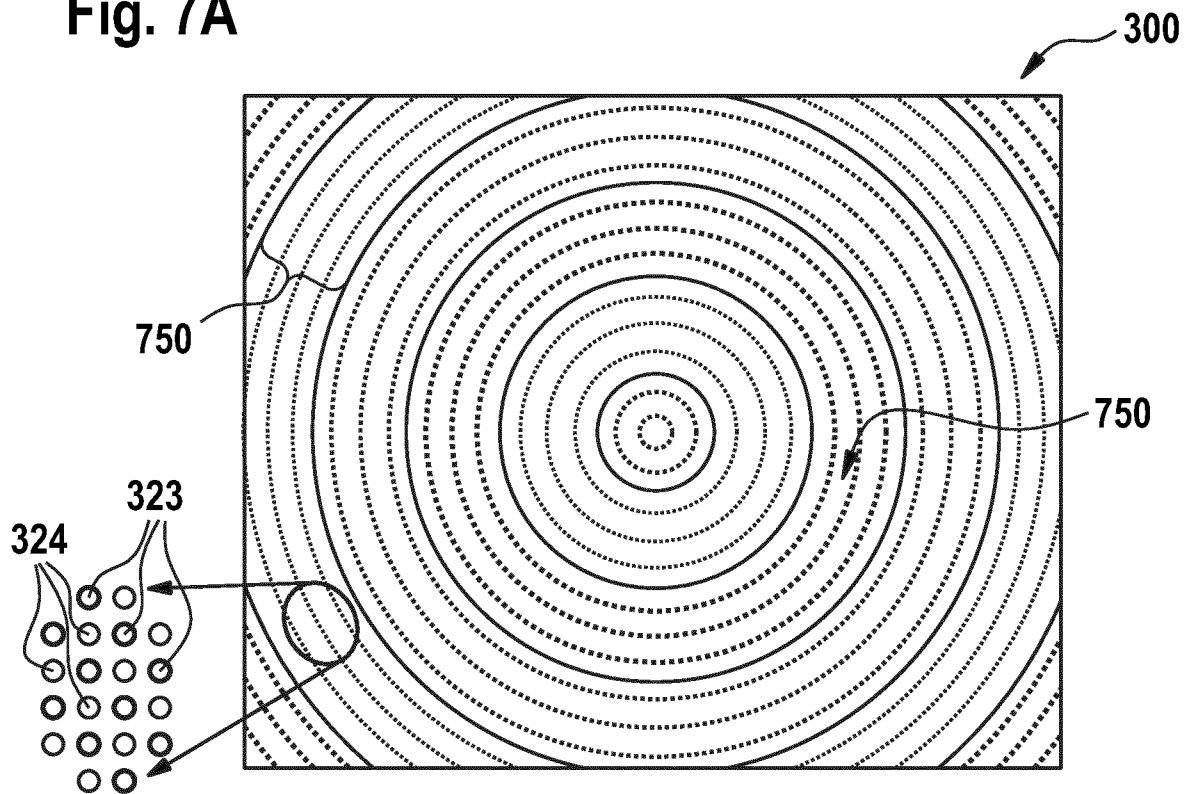
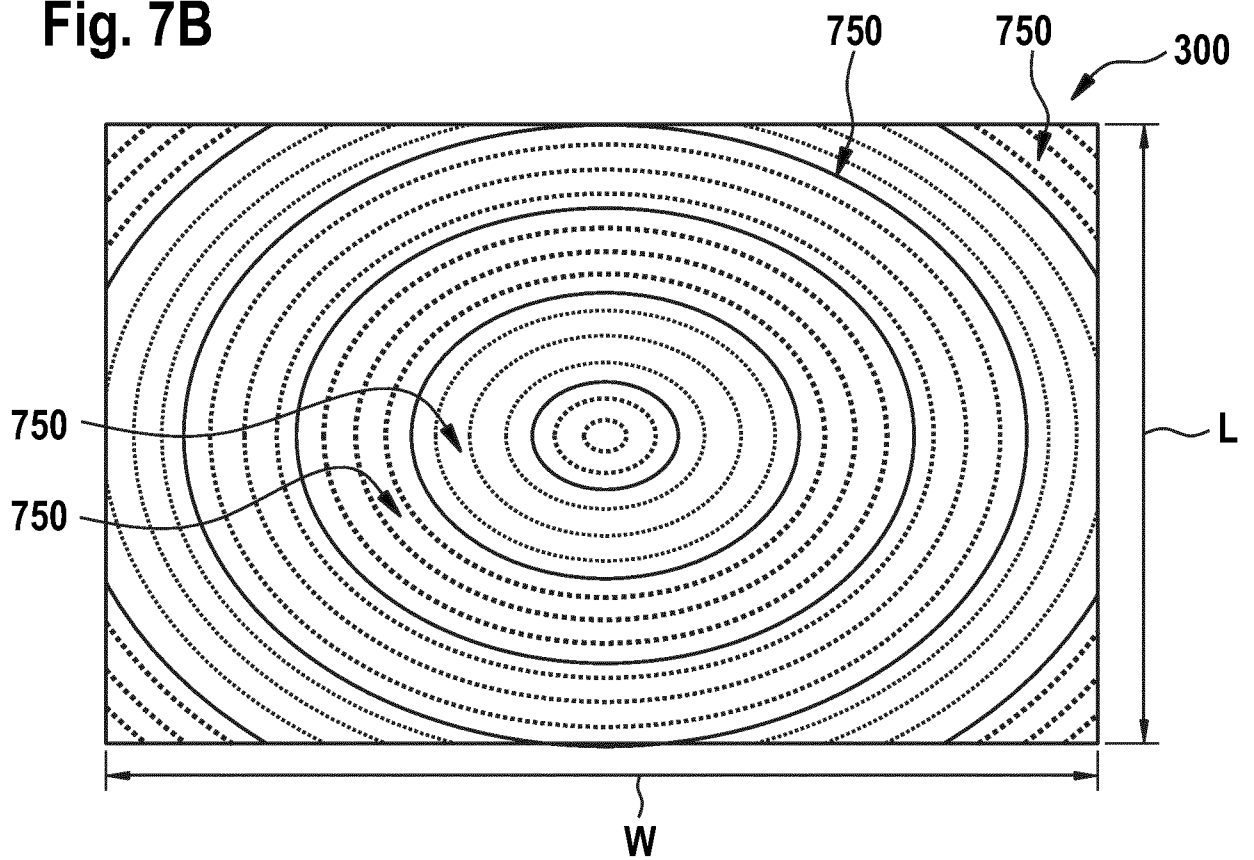
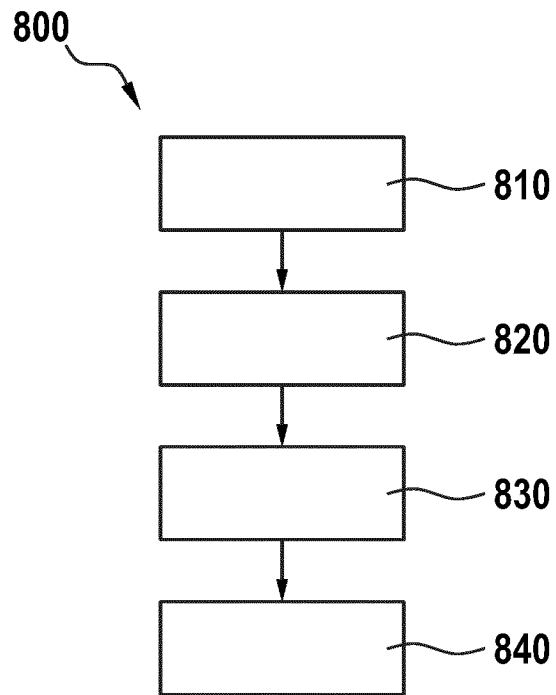
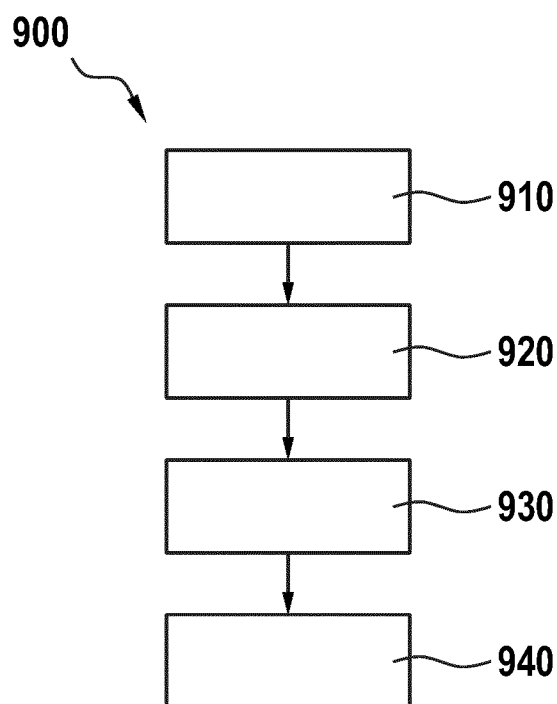


Fig. 7B



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Fig. 8**Fig. 9**

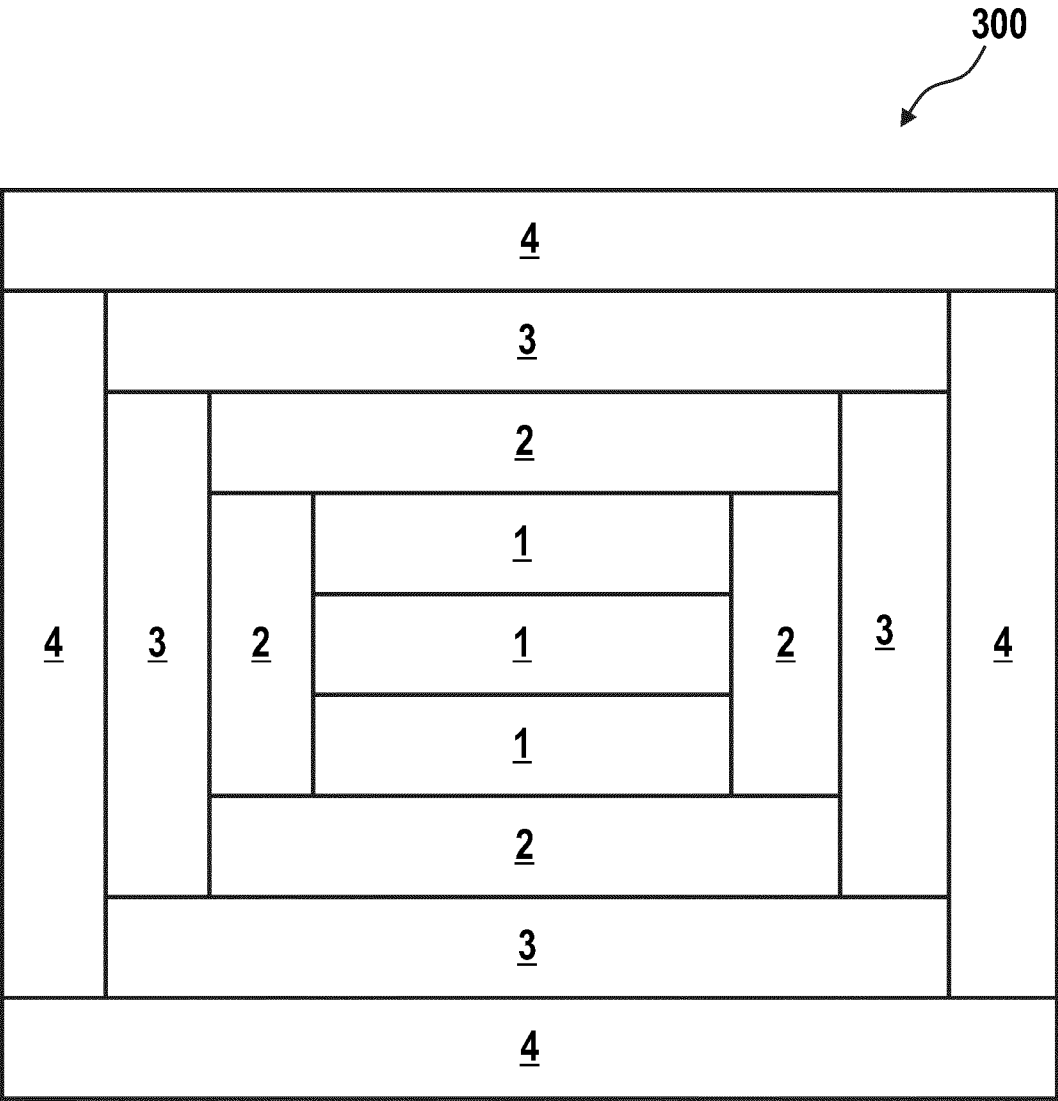


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/059669

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/683
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 242 718 B1 (FERRO ARMAND [US] ET AL) 5 June 2001 (2001-06-05) column 5, line 33 - line 36; figures 1B,2A,2B,3,4A-5 column 6, line 60 - column 7, line 45 abstract	1-4, 11-18, 21-25
X	WO 2008/087796 A1 (LINTEC CORP [JP]; TSUJIMOTO MASAKI [JP]) 24 July 2008 (2008-07-24) figures 1-3 ----- -/--	1-9,11, 12,14, 15, 17-22, 24,25



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

22 November 2017

Date of mailing of the international search report

29/11/2017

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Oberle, Thierry

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/059669

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	paragraph [0068]; figures 7,19 -----	1,17,21
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	paragraphs [0048], [0111] - [0124]; figures 3A-3C -----	
X	US 2009/087932 A1 (KONDOH KEISUKE [JP]) 2 April 2009 (2009-04-02)	1-4,11, 12,17, 18,24
A	paragraphs [0027] - [0035]; figures 1,2,4,3 -----	14,21,25

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International application No

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