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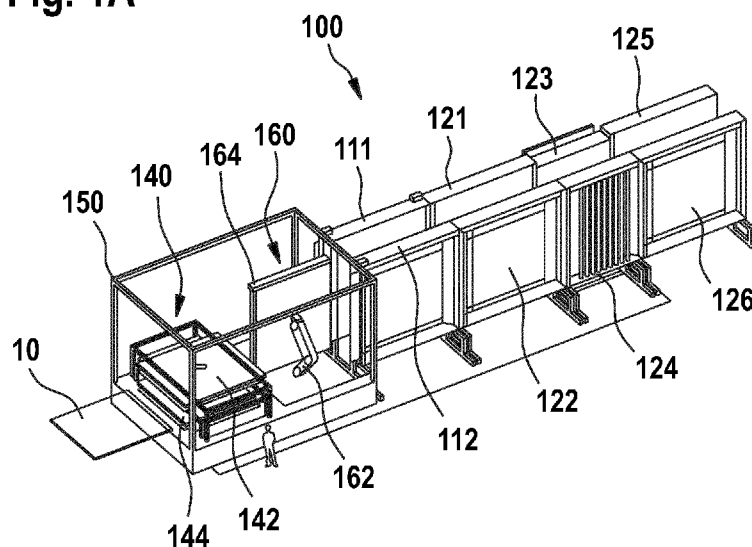
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CESSING A SUBSTRATE, AND METHOD FOR LOADING A SUBSTRATE

Fig. 1A



(57) Abstract: An apparatus (140) for loading a substrate in a vacuum processing system (100) is described. The apparatus (140) includes a first holder (142) for holding a substrate (10), and a second holder (144) for holding a substrate (10) vertically stacked with the first holder (142).



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**APPARATUS FOR LOADING A SUBSTRATE IN A VACUUM
PROCESSING SYSTEM, SYSTEM FOR PROCESSING A SUBSTRATE,
AND METHOD FOR LOADING A SUBSTRATE**

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FIELD

[0001] Embodiments of the present disclosure relate to an apparatus for loading a
substrate in a vacuum processing system, a system for processing a substrate, and a
method for loading a substrate. Embodiments of the present disclosure particularly
relate to an apparatus for loading a substrate in a vacuum processing system for
display manufacturing, a system configured for vacuum processing of a substrate to
manufacture display devices, and a method for loading a substrate in a vacuum
processing system for display manufacturing.

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BACKGROUND

[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. During the sputter deposition process,
a target having a target material to be deposited on the substrate is bombarded with
ions generated in a plasma region to dislodge atoms of the target material from a
surface of the target. The dislodged atoms can form the material layer on the
substrate. In a reactive sputter deposition process, the dislodged atoms can react with
a gas in the plasma region, for example, nitrogen or oxygen, to form an oxide, a
nitride or an oxynitride of the target material on the substrate.

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[0003] Coated materials may be used in several applications and in several
technical fields. For instance, an application lies in the field of microelectronics, such
as generating semiconductor devices. Also, substrates for displays are often coated
by a sputter deposition process. Further applications include insulating panels,
substrates with TFT, color filters or the like.

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[0004] For example, in display manufacturing, it is beneficial to reduce the manufacturing costs of displays, e.g., for mobile phones, tablet computers, television screens, and the like. A reduction in manufacturing costs can be achieved, for example, by increasing a throughput of a vacuum processing system, such as a sputter deposition system. Further, the footprint can be a relevant factor for reducing the cost of ownership for a vacuum processing system.

[0005] 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 that provide for at least one of an increased throughput and a reduced footprint of a vacuum processing system.

SUMMARY

[0006] In light of the above, an apparatus for loading a substrate in a vacuum processing system, a system for processing a substrate, and a method for loading a substrate are provided. Further aspects, benefits, and features of the present disclosure are apparent from the claims, the description, and the accompanying drawings.

[0007] According to an aspect of the present disclosure, an apparatus for loading a substrate in a vacuum processing system is provided. The apparatus includes a first holder for holding a substrate, and a second holder for holding a substrate vertically stacked with the first holder.

[0008] According to another aspect of the present disclosure, a system for vacuum processing of a substrate is provided. The system includes a processing module configured for layer deposition on the substrate and the apparatus according to the embodiments described herein.

[0009] According to yet another aspect of the present disclosure, a system for vacuum processing of a substrate is provided. The system includes the apparatus according to the embodiments described herein, a first load lock chamber, optionally

a second load lock chamber, and a vacuum chamber configured for the processing of the substrate.

[0010] According to a further aspect of the present disclosure, a method for loading a substrate is provided. The method includes loading a substrate at a first position on a first holder vertically stacked with a second holder, and horizontally moving the first holder with the substrate from the first position to a second position.

[0011] Embodiments are also directed at apparatuses for carrying out the disclosed methods and include apparatus parts for performing each described method aspect. These method aspects may be performed by way of hardware components, a computer programmed by appropriate software, by any combination of the two or in any other manner. Furthermore, embodiments according to the disclosure are also directed at methods for operating the described apparatus. The methods for operating the described apparatus include method aspects for carrying out every function of the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] 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:

FIGS. 1A and 1B show a vacuum processing system having a loading arrangement according to embodiments described herein;

FIGS. 2 and 3 show vacuum processing systems according to embodiments described herein;

FIGS. 4A and 4B show a loading arrangement having an apparatus for loading a substrate in a vacuum processing system according to embodiments described herein;

FIGS. 5A and 5B show holders for a loading arrangement according to embodiments described herein;

FIG. 6 shows a flowchart illustrating methods according to embodiments described herein; and

5 FIG. 7 shows a loading arrangement having an apparatus for loading a substrate in a vacuum processing system according to further embodiments described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

10 [0013] 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
15 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.

20 [0014] Embodiments of the present disclosure provide vertically stacked holders (also referred to as “loaders”) for substrates, particularly large area substrates, in a vacuum processing system. A first (substrate) holder is provided above a second (substrate) holder. Embodiments particularly relate to an in-line configuration with vertically aligned Bernoulli loaders / Bernoulli holders.

25 [0015] Providing stacked holders, such as vertically stacked Bernoulli holders or loaders, can reduce the area of a clean room. The first holder and the second holder are not arranged next to each other but above each other or at least partially above each other. This reduces the footprint of a vacuum processing system including the holders or other loaders e.g. for loading substrates on a carrier, which may be provided on a swing module.

[0016] Embodiments of the present disclosure refer to the display industry. For example, displays can be manufactured with processes like chemical vapor deposition and physical vapor deposition on large area substrates. For example, TFT displays can be manufactured on large area substrates. Due to increasing display sizes, a size of the vacuum processing system, particularly in the case of horizontal loading of substrates, increases. In the present disclosure, a clean room area for loading of substrates can be reduced in size, i.e. in footprint size, because the holders, such as substrate loaders, are vertically stacked. The displays can be flat or smoothly curved or bended parts. For example, glass substrates of various generations can be used for display manufacturing.

[0017] FIGS. 1A and 1B show a system 100 for the vacuum processing of a substrate 10 (also referred to as “vacuum processing system”) according to embodiments described herein.

[0018] The system 100 includes a processing module configured for layer deposition on the substrate 10 and an apparatus 140 for loading the substrate 10 in the system 100 according to the embodiments described herein. The apparatus 140 includes a first holder for holding a substrate, such as a first substrate, and a second holder for holding another substrate, such as a second substrate, vertically stacked with the first holder. The first holder can be a first loader and the second holder can be a second loader. In some implementations, the apparatus 140 can be referred to as “handling apparatus”. The apparatus 140 can be a loading arrangement or loading module, or can be part of a loading arrangement or loading module.

[0019] The substrate 10 can be handed over at a (e.g. customer scara) loading/unloading position. This is typically done with the substrate being in a horizontal orientation. For example, the substrates can be handed over from a substrate cassette. A substrate can be provided to the first holder, such as a first Bernoulli holder 142. For example, the first holder can be a holder for loading substrates on a swing module 160. Processed substrates can be received from the second holder, such as a second Bernoulli holder 144. For example, the second holder can be a holder for unloading substrates from the swing module 160.

[0020] The first holder and the second holder may be exchanged. Further, one or both holders can be utilized for the loading and unloading of substrates.

[0021] According to embodiments of the present disclosure, the holders can be stacked to be at least partially vertically above each other. A carrier, such as an electrostatic chuck (E-Chuck), can be provided on the swing module 160. A substrate can be loaded onto the carrier using the first holder and/or the second holder. The substrate can be loaded in a horizontal state. After loading of the substrate on the carrier, the swing module 160, and particularly a swing module plate 164 of the swing module 160, can be moved from an essentially horizontal orientation to an essentially vertical orientation e.g. by a movement of an arm 162 of the swing module 160. FIGS. 1A and 1B show the swing module 160 in an essentially vertical orientation.

[0022] The swing module 160 can be configured to load the carrier having the substrate positioned thereon into a first load lock chamber 111 and/or a second load lock chamber 112. The swing module 160 can rotate clockwise or counterclockwise from the horizontal orientation. Accordingly, carriers can be loaded into each of the load lock chambers and/or can be unloaded from each of the load lock chambers. For example, the load lock chambers may be utilized alternately.

[0023] The load lock chambers can be evacuated. After evacuation of the load lock chambers, the carriers can be transported into one or more vacuum chambers of the vacuum processing system, such as vacuum chambers 121-126. As shown in FIGS. 1A and 1B, two lines can be provided. The first load lock chamber 111 and vacuum chambers 121, 123, and 125 can form a first system side. The second load lock chamber 112 and vacuum chamber 122, 124, and 126 can form a second system side.

[0024] As described with respect to FIG. 2, the vacuum chambers of the first system side and the second system side can each provide one vacuum region (see FIG. 1B) that can be independent from each other, or can provide one joint vacuum region (FIG. 2). The areas of the vacuum chambers 121, 122, 125, and 126 can provide transfer regions for carrier transport and/or carrier waiting. The vacuum chambers 123 and 124 can provide deposition regions having one or more deposition

sources or deposition source arrays, which are indicated by reference numerals 133 and 134.

[0025] Further to the vacuum side of the vacuum processing system, an atmospheric side including the holders/loaders and the swing module 160 can be provided. FIGS. 1A and 1B show a clean room area 150. A loader module, which can include, or be, the apparatus 140 of the present disclosure, and the swing module 160 can be provided in the clean room area 150. Due to the arrangement of the first holder and the second holder above each other, a width W of the vacuum processing system 100 can be reduced, for example by 50% or more as compared to systems, in which holders are arranged next to each other. Particularly, the clean room area 150 can be reduced in size, i.e. a footprint can be reduced.

[0026] FIG. 2 shows a schematic top view of a system 200 for vacuum processing of a substrate according to further embodiments described herein. The system 200 can also be referred to as “vacuum processing system”.

[0027] The system 200 includes a vacuum processing module 201 configured for layer deposition on the substrate and the apparatus according to the embodiments described herein. The apparatus can be included in the loading module. The system 200 can include a swing module (e.g., the swing module 160 illustrated in FIGs. 1A and B) and one or more load lock chambers connected to the vacuum processing module 201, for example, via one or more valves, such as a first gate valve 252 and a second gate valve 254. The one or more load lock chambers can include the first load lock chamber 111 and the second load lock chamber 112. In some embodiments, the swing module and the one or more load lock chambers can constitute a combined swing module and load lock chamber. Substrate carriers 20 having the substrate positioned thereon can be transferred between the load lock chambers and the vacuum processing module 201 via the one or more valves.

[0028] Carriers are locked into the system 200 via the first load lock chamber 111 and/or the second load lock chamber 112. FIG. 2 shows the first load lock chamber 111 for the upper portion (first system side or a first (upper) in-line unit 202) of a vacuum chamber 210 of the vacuum processing module 201 and the second load lock

chamber 112 for the lower portion (second system side or a second (lower) in-line unit 203) of the vacuum chamber 210 of the vacuum processing module 201. According to some embodiments, which can be combined with any other embodiments described herein, the substrates are processed in an essentially vertical orientation within the vacuum processing module 201.

[0029] According to some embodiments, the loading module and the swing module as well as the entrances/exits of the load lock chambers can be provided in an enclosure providing a predefined atmospheric condition for the substrates 10 outside of the vacuum within the vacuum processing module 201. For example, a dry air purge can be provided. The enclosure can be configured to provide a clean room environment, such as the clean room area described with respect to FIGs. 1A and B.

[0030] The substrate 10 and the substrate carrier 20 can “swing” on the swing module and can be loaded through an open door of one of the load lock chambers. After closing of the door, the door and a housing of the load lock chamber form a vacuum chamber of the load lock chamber, which can be evacuated. After the evacuation of the vacuum chamber of the load lock chamber, the valves, such as the first gate valve 252 or the second gate valve 254, can be opened to lock the substrate 10 into the vacuum chamber 210 of the vacuum processing module 201.

[0031] According to some embodiments, which can be combined with other embodiments described herein, the one or more valves, such as the first gate valve 252 or the second gate valve 254, can be magnetic latch lock valves. The magnetic latch lock valve includes a magnetic element at the lock valve door or at the housing of the load lock chamber opposite to the lock valve door for providing a magnetic force for moving the latch lock valve in a sealed position and/or for removing the latch lock valve out of the sealed position.

[0032] The vacuum processing module 201 can have two in-line units, such as the first (upper) in-line unit 202 and the second (lower) in-line unit 203, sharing common sputter deposition sources. The first load lock chamber 111 can be connected to the first (upper) in-line unit 202 such that substrate carriers can be exchanged between the first load lock chamber 111 and the first (upper) in-line unit 202, for example, via

the first gate valve 252. The second load lock chamber 112 can be connected to the second (lower) in-line unit 203 such that substrate carriers can be exchanged between the second load lock chamber 112 and the second (lower) in-line unit 203, for example, via the second gate valve 254.

5 [0033] The vacuum processing module 201 includes the vacuum chamber 210 having a first deposition area 214, a second deposition area 214', and a chamber wall. For example, the chamber wall is a vertical chamber wall of the vacuum chamber 210. In some implementations, the chamber wall can include a first chamber wall 211 adjacent to the first deposition area 214 and a second chamber
10 wall 211' adjacent to the second deposition area 214'. The first chamber wall 211 and the second chamber wall 211' can define boundaries of the vacuum chamber 210, e.g., substantially parallel to a first transport direction 1 and/or a second transport direction 1' for the substrate carriers 20 past one or more sputter deposition sources. The first chamber wall 211 and the second chamber wall 211', which can be
15 vertical chamber walls, can be substantially parallel to each other.

[0034] According to some embodiments, which can be combined with other embodiments described herein, the system 200 can be configured as a dual-line system, for example, provided with one single vacuum chamber. For example, the vacuum processing module 201 has two first areas and two second areas. One first
20 area 212 of the two first areas can be provided adjacent to the first deposition area 214 and the other first area 212' of the two first areas can be provided adjacent to the second deposition area 214'. One second area 216 of the two second areas can be provided adjacent to the first deposition area 214 and the other second area 216' of the two second areas can be provided adjacent to the second deposition area 214'.
25 For example, the first deposition area 214 can be sandwiched between the one first area 212 and the one second area 216. Likewise, the second deposition area 214' can be sandwiched between the other first area 212' and the other second area 216'.

[0035] In some implementations, at least one deposition area of the first deposition area 214 and the second deposition area 214' includes a partition provided in a
30 chamber region between the one or more sputter deposition sources and the chamber wall. For example, a first partition 215 is provided in a chamber region between the

one or more sputter deposition sources and the first chamber wall 211. A second partition 215' can be provided in a chamber region between the one or more sputter deposition sources and the second chamber wall 211'. According to some embodiments, the partitions, such as the first partition 215 and the second partition 215', can be separation walls, such as vertical walls. For example, the partition can extend substantially parallel to the chamber wall and/or the respective transport direction, such as the first transport direction 1 and the second transport direction 1'.

[0036] The partition separates the chamber region into the respective deposition area and a transportation area, wherein the transportation area is at least partially shielded from the one or more sputter deposition sources. For example, the first partition 215 separates the chamber region between the one or more sputter deposition sources and the first chamber wall 211 into the first deposition area 214 and a first transportation area 213. The second partition 215' can separate the chamber region between the one or more sputter deposition sources and the second chamber wall 211' into the second deposition area 214' and a second transportation area 213'. According to some embodiments, which can be combined with other embodiments described herein, the transportation area is configured as at least one of a substrate cooling area and a substrate waiting area. The coated substrates can cool after deposition and/or wait for a load lock chamber to open and/or a path to become clear.

[0037] The deposition area, such as the first deposition area 214 and/or the second deposition area 214', can have two or more deposition sub-areas each having one or more sputter deposition sources. Each deposition sub-area can be configured for layer deposition of a respective material. The sputter deposition sources in at least some of the deposition sub-areas can be different. In some implementations, at least some of the two or more deposition sub-areas can be configured for deposition of different materials. FIG. 2 shows five sputter deposition sources. The first sputter deposition source 222 can provide a first material. The second, the third, and the fourth sputter deposition source 224 can provide a second material. The fifth sputter deposition source 226 can provide a third material. For example, the third material can be the same material as the first material. Accordingly, a three layer stack can be

provided on the substrate, such as a large area substrate. For example, the first and the third material can be molybdenum and the second material can be aluminum.

[0038] The two or more deposition sub-areas can be separated from each other using deposition separation units 227 (also referred to as “deposition separation shielding”). As an example, deposition separation units 227 can be provided between the sputter deposition sources for providing different materials on the substrate. The deposition separation units 227 can provide for separating a first processing area in the deposition area, such as the first deposition area 214, from a second processing area in the deposition area, wherein a different material is deposited on the first processing area as compared to the second processing area. The deposition separation units 227 have an opening configured for allowing a passage of substrates through the opening.

[0039] According to further embodiments, which can be combined with other embodiments described herein, similar to FIG. 1B, the first system side and the second system side can be provided with deposition sources being arranged at opposing walls of the vacuum processing system. Further, additionally, the first system side and the second system side can be provided by individual vacuum chambers.

[0040] According to some embodiments, which can be combined with other embodiments described herein, the vacuum processing module 201 of the system 200 provides for a simultaneous processing of two or more substrates using two in-line units in order to increase the throughput. Optional common sputter deposition sources for a simultaneous deposition of material onto substrates (see FIG. 2) allow for a higher throughput. The simultaneous processing using two in-line units within one vacuum chamber 210 reduces a footprint of the system 200. Particularly for large area substrates, the footprint can be a relevant factor for reducing the cost of ownership for the system 200.

[0041] The substrates, as for example shown in FIGS. 2 and 1B, have a continuous or quasi-continuous flow along the sputter deposition sources. The substrates can be provided on carriers within the vacuum chamber 210. The substrates enter the

vacuum chamber 210 through load locks, which can include the first gate valve 252 configured for access to the first (upper) in-line unit 202 and the second gate valve 254 configured for access to the second (lower) in-line unit 203. The load lock chambers, which can be vented and evacuated, are provided at the gate valves such that the vacuum in the vacuum processing module 201 can be maintained even during the loading and unloading of the substrates.

[0042] The system 200 can include a first area or areas and a second area or areas, which can be track switch areas (first area(s): track switching load/unload; second area(s): track switching return). The track switch directions are indicated with reference numerals 4 and 5. The first area(s) and the second area(s) 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. The first areas can be separated by a first separation 256. The second areas can be separated by a second separation 258.

[0043] According to some embodiments, one single vacuum chamber, such as the vacuum chamber 210, for deposition of layers therein can be provided. Alternatively (see FIG. 1B) to one single vacuum chamber, one vacuum chamber for the first system side and one vacuum chamber for second system side can be provided. A configuration with one single vacuum chamber or two vacuum chambers, respectively, having a plurality of areas, such as the first area(s) and the deposition area(s), 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(s)) of the vacuum chamber 210 with respect to another area (e.g., the deposition area) of the vacuum chamber 210.

[0044] In some embodiments, an atmosphere in the vacuum chamber 210 can be individually controlled by generating a technical vacuum, for example with vacuum pumps connected to the vacuum chamber 210, and/or by inserting process gases in the deposition area(s) in the vacuum chamber 210. According to some embodiments,

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

[0045] According to some embodiments, which can be combined with other embodiments described herein, the substrate is in a substantially vertical orientation (substantially vertical = vertical $\pm$ 15°), for example, during the vacuum deposition process and/or during transportation of the substrate through the vacuum chamber 210. As used throughout the present disclosure, terms like “vertical direction” or “vertical orientation” are understood to distinguish over “horizontal direction” or “horizontal orientation”.

[0046] According to some embodiments, which can be combined with other embodiments described herein, the system 200 is configured for dynamic sputter deposition on the substrate(s). A dynamic sputter deposition process can be understood as a sputter deposition process in which the substrate is moved through the deposition area along the transport direction while the sputter deposition process is conducted. In other words, the substrate is not stationary during the sputter deposition process.

[0047] In some implementations, the system 200 according to the embodiments described herein is configured for dynamic processing. The system 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, for example, a large area substrate such as a rectangular glass plate. The processing tools, such as the one or more sputter deposition sources, extend mainly in one direction (e.g., the vertical direction) and the substrate is moved in a second, different direction (e.g., the first transport direction 1 or the second transport direction 1', which can be horizontal directions).

[0048] 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 limited by the ability to move the substrate 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 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. In contrast thereto, for a stationary processing apparatus, the deposition area or processing area would basically correspond to the area of the substrate.

[0049] 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 apparatus 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.

[0050] According to some embodiments, which can be combined with other embodiments described herein, the system 200 includes a magnetic levitation system for holding the substrate carrier 20 in a suspended state. Optionally, the system 200 can use a magnetic drive system configured for moving or conveying the substrate carrier 20 in the transport direction, such as the first transport direction 1. The magnetic drive system can be included in the magnetic levitation system or can be provided as a separate entity.

[0051] FIG. 3 shows a front view of the vacuum processing system 100 shown in FIGS. 1A and 1B or the vacuum processing system 200 shown in FIG. 2. The (handling) apparatus such as a holder module and a swing module is not drawn in FIG. 3 for easier explanation.

[0052] The apparatus may include the first holder such as a first Bernoulli holder, and the second holder, such as a second Bernoulli holder, having a surface

configured to face a substrate 10, such as a large area substrate, and a gas supply (not shown) configured to direct a stream of gas between the surface and the substrate 10. The Bernoulli holder is configured to provide a pressure, e.g., an under-pressure or a reduced pressure, between the substrate 10 and the surface for levitation of the substrate 10. In particular, a gap or space can be provided between the surface and the substrate 10 through which the stream of gas flows. The substrate 10 is levitating based upon the Bernoulli Effect. This is explained in more detail with respect to FIGS. 5A and 5B, features, details, and aspects of embodiments described they are can be combined with other embodiments described herein.

[0053] A pressure is provided between the substrate and the surface for levitation of the substrate to hold the substrate in a levitating or suspended state. A Bernoulli holder (or Bernoulli-type holder) supports the substrate without making (direct) mechanical contact with the face of the substrate. In particular, the substrate floats on a gas cushion. That is, the handling apparatus is contactless on the face of the substrate 10. The terms “reduced pressure” and “under pressure” can be defined with respect to an ambient pressure in which the Bernoulli holder is located. In particular, the pressure, such as the reduced pressure or the under pressure, between the substrate and the surface is configured for levitation of the substrate. For example, a difference between the pressure and the ambient pressure is sufficient to compensate for the weight force of the substrate 10.

[0054] According to some embodiments, which can be combined with other embodiments described herein, the substrate carriers 20 are supported within the vacuum processing system with a magnetic levitation system. The magnetic levitation system includes first magnets 480 which support the substrate carrier 20 in a hanging position without mechanical contact. The magnetic levitation system provides a levitation, i.e. contactless support, of the substrate carriers. Accordingly, particle generation due to movement of the carriers within the system for dynamic deposition can be reduced or avoided. The magnetic levitation system includes the first magnets 480, which provide a force to the top of the substrate carrier, which is substantially equal to the gravity force. That is, the substrate carriers are hanging contactlessly below the first magnets 480.

[0055] Further, the magnetic levitation system can include second magnets 482, which provide for a translational movement along a transportation direction of the substrate carriers. The substrate carrier 20 can be supported without contact within the system by the first magnets 480 and moved within the system, e.g., between the load lock chambers, such as the first load lock chamber 111 and the second load lock chamber 112, and the vacuum processing module 301, using the second magnets 482.

[0056] As shown in FIGS. 4A and 4B, a first holder, such as a first Bernoulli holder 142 (or PV holder) and the second holder, such as a second Bernoulli holder 144 (or PV holder) are vertically stacked. The holders can be mounted to a frame or frame assembly supporting the holders. For example, the frame can include a first frame 452 for supporting the first holder, a second frame 454 for supporting a first pin array 442, a third frame 456 for supporting the second holder, and a further frame for supporting a second pin array 444. According to some embodiments, which can be combined with other embodiments described herein, the first holder and/or the second holder can be moved as indicated by arrows 492 and 494 to move the holders over the swing module 160.

[0057] The first holder can be a hot Bernoulli loader or hot PV loader. The hot PV loader can be used to heat the substrates before processing of the substrates, i.e. before loading into the vacuum processing system. The second holder can be a cold Bernoulli unloader or cold PV unloader. The cold PV unloader can be used to unload substrates after processing and to cool the substrates to room temperature in a controlled manner.

[0058] The first holder and the second holder may be moved horizontally between the frame structure and the swing module 160. Further, the holders and the swing module 160 may be moved vertically relative to each other to place a substrate on a carrier on the swing module 160 or to remove a substrate from a carrier from the swing module. The vertical relative movement can be provided by movement of the swing module, the holders, or both.

[0059] The first pin array 442 and the second pin array 444 can for instance be mounted to the frame or frame assembly. A robot having, for example, a fork arm can place substrates 10 on a pin array or can remove substrates from the pin array. For example, the pin arrays can function as a handover position between the vacuum processing unit and the customer's fab, i.e. for a (e.g. customer scara) robot. The loading pin array (e.g. one of the first pin array 442 and the second pin array 444) and the unloading pin array (e.g. the other one of the first pin array 442 and the second pin array 444) can provide a customer robot-to-Bernoulli glass transfer position of the frame supporting the Bernoulli holders. Further, portions of the frame can be moved to be positioned over the swing module e.g. to the Bernoulli-to-swing glass transfer position of the frame supporting the Bernoullis.

[0060] A clean room environment or clean room area 150 can be provided for loading outside of the vacuum, i.e. outside of the load lock chambers.

[0061] FIG. 5A shows a schematic view of a holder 500, such as the first holder and/or the second holder, for holding a substrate 10 e.g. for loading into a vacuum processing module according to embodiments described herein. The substrate 10 can be a large area substrate. Two of the holders 500 shown in FIG. 5A are vertically stacked according to embodiments described herein and as exemplarily shown in FIGS. 4A and 4B. Other apparatuses for loading a substrate or holding a substrate may also be utilized and stacked above each other according to embodiments of the present disclosure.

[0062] The holder 500 includes a Bernoulli-type holder 510 having a surface 512 configured to face the substrate, and a gas supply 530 configured to direct a stream 534 of gas between the surface 512 and the substrate 10. The Bernoulli-type holder 510 is configured to provide a pressure between the substrate 10 and the surface 512 for levitation of the substrate 10.

[0063] A gap or space 514 can be provided between the surface 512 and the substrate 10 through which the stream 534 of gas flows. The gap or space 514 provided by the gas stream can be beneficial in that the position of the substrate 10 can be controlled with respect to a small dimension and small variation in that

dimension relative to the Bernoulli-type holder 510. 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 510. 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, cleaning of particles from the surface of the substrate may be provided by controlling the Bernoulli gap.

[0064] The Bernoulli-type holder 510 levitates the substrate 10 based upon the Bernoulli Effect. A pressure, such as a reduced pressure or under pressure, is provided between the substrate 10 and the surface 512 for levitation of the substrate 10 to hold the substrate 10 in a levitating or suspended state. The holder 500 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 holder 500 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 510, one or more substrate alignment devices can be provided, for example pins or rollers, which protrude from the Bernoulli-type holder 510. The stream 534 of gas provided by the holder 500 can be used for a treatment of the substrate 10.

[0065] The terms “reduced pressure” and “under pressure” can be defined with respect to an ambient pressure, such as atmospheric pressure, in which the holder 500 is located, for example, in the clean room environment described with respect to FIGs. 1A, 4A and 4B (indicated with reference numeral “150”). In particular, the pressure, such as the reduced pressure or the under pressure, between the substrate 10 and the surface 512 is configured for levitation of the substrate 10. As an example, a difference between the pressure and the ambient pressure is sufficient to compensate for the weight force of the substrate 10.

[0066] 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 51 and four lateral surfaces (or substrate edges) can be provided. The two main surfaces 51 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 530 can be configured to direct the stream 534 of gas between the surface 512 of the Bernoulli-type holder 510 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 530 is configured to direct the stream 534 of gas along substantially the whole substrate surface, such as the first main surface and/or the second main surface.

[0067] An area of the surface 512 of the Bernoulli-type holder 510 can be equal to, or greater than, an area of the substrate surface facing the surface 512 of the Bernoulli-type holder 510, such as the first main surface and/or the second main surface. The surface 512 of the Bernoulli-type holder 510 and the substrate surface facing the surface 512 of the Bernoulli-type holder 510 can be arranged substantially parallel to each other when the substrate 10 is held by the Bernoulli-type holder 510.

[0068] The embodiments described herein can be utilized for evaporation on large area substrates, e.g., for display manufacturing. 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 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.

[0069] 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 11, and GEN 12, or a larger generation substrates.

[0070] According to some embodiments, the gas supply 530 includes one or more first conduits 531 and/or a gas distribution plate 532. The pressure in the one or more first conduits can be controlled, particularly individually controlled, to control the air gap between the surface 512 and the main surface 51 of the substrate. The gas distribution plate 532 can have the surface 512 configured to face the substrate 10. For example, the gas distribution plate 532 can be provided between the one or more first conduits 531 and the large area substrate. In some implementations, the one or more first conduits 531 are configured to supply the gas into a distribution space 533 above the gas distribution plate 532. The gas distribution plate 532 can have holes or nozzles such that gas from the distribution space 533 is directed between the surface 512 and the substrate 10 to provide the stream 534 of gas. In particular, the gas distribution plate 532 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 512) of the gas distribution plate 532.

[0071] The holder 500 includes a gas outlet 540. The gas outlet 540 can include one or more second conduits. For example, the gas supplied by the gas supply 530 can flow between the surface 512 and the substrate 10, and can then be guided into one or more second conduits (indicated with reference numeral “542”) e.g. provided at one or more lateral sides of the substrate 10 and/or the gas distribution plate 532 so as to receive the gas from the gap or space 514. The gas can exit the Bernoulli-type holder 510 through an exit 541, which can be another second conduit. In some implementations, the gas exiting the Bernoulli-type holder 510 can be returned to one or more conditioning devices. According to some embodiments, which can be

combined with other embodiments described herein, the gas outlet 540 can be connected and/or in fluid communication with the vacuum pump to exhaust the gas guided into the Bernoulli gap. Additionally or alternatively to controlling the pressure in the gas inlet, a vacuum pump connected to the gas outlet can be controlled for controlling the Bernoulli gap, that is the width of the Bernoulli gap. Exhausting air from the apparatus may also be provided with individual control of different local areas for improving uniformity of the substrate treatment.

[0072] 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.

[0073] FIG. 5B shows a schematic view of a Bernoulli-type holder 300 according to further 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 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 gap can be locally controlled, for example in zones of the surface 322 of the Bernoulli-type holder 300. As the substrate 10 is floating on the gas cushion, to ensure the substrate 10 does not slide off the Bernoulli-type holder 300, one or more substrate

alignment devices 316 can be provided, for example pins or rollers, which protrude from the Bernoulli-type holder 300.

[0074] The Bernoulli-type holder 300 includes a gas supply 330 configured to direct a stream of gas between a 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.

[0075] 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 for the gas. The two or more return lines can correspond to zones of the surface 322. The zones can be individually controlled. According to embodiments described herein, a local Bernoulli Effect at a number of discrete distributed positions 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 provided at a backside of the aperture plate 320, as shown in the enlarged section of FIG. 5B. 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.

[0076] FIG. 6 shows a flowchart of a method 600 for loading and/or unloading a substrate or substrate carrier into/from a vacuum processing system according to embodiments described herein. The method 600 can use the apparatuses and systems according to the embodiments described herein and can also be utilized with stacked

holders other than Bernoulli holders. Likewise, the apparatuses and systems can be configured to implement the method 600.

[0077] The method 600 includes, in block 610, loading the substrate on a first holder of two or more vertically stacked holders in a first position. Block 620 indicates moving the first holder horizontally from the first position to a second position. In block 630 the substrate is loaded on a substrate receiving surface at the second position. Block 630 may also include a vertical movement of the first holder and the substrate receiving surface relative to each other. At the first position, the method may further include loading the substrate on a first pin array of two or more vertically stacked pin arrays and loading the substrate on the first holder from the first pin array.

[0078] A method may further include unloading a substrate from a vacuum processing system. The substrate can be loaded on a second holder of the two or more vertically stacked holders at the second position, e.g. from the substrate receiving surface. The substrate can be moved horizontally from the second position to the first position. The substrate can be unloaded from the second holder at the first position, for example on a second pin array of two or more vertically stacked pin arrays.

[0079] According to embodiments described herein, the method for loading a substrate in a vacuum processing system can be conducted using any one of 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.

[0080] A Bernoulli-type holder can be used for loading the substrate, such as a large area substrate, on a substrate support surface and/or for unloading the large area substrate from the substrate support surface. The substrate support surface can be provided by a substrate carrier, such as an E-chuck, positioned, for example, on a swing module.

[0081] A method for loading and/or unloading a substrate in a dynamic deposition system can include at least a loading and holding of a substrate in a Bernoulli-type holder, a treating or pre-treating of the substrate in the Bernoulli-type holder using a stream of gas, and a loading of the substrate after the treating. The treatment of the substrate can include at least one of a heating of the substrate and a degassing or outgassing of the substrate. The treatment can further include providing at least one of a clean, dry, and chemically-inert environment for the substrate.

[0082] FIG. 7 shows the apparatus, such as a loading arrangement, of the present disclosure having a first holder 712 or first loader, such as a hot pressure vacuum (PV) loader or hot Bernoulli holder/loader. The first holder 712 can be connected to a first frame. The first frame can be provided on a linear guide 762, such as linear slides. The linear slides can be used to carry the first holder 712 and/or to move the first holder 712 e.g. along a horizontal direction. Further, a second holder 714 or second loader is shown. The second holder 714 can be a cold pressure vacuum (PV) unloader or a cold Bernoulli holder/unloader. The second holder 714 can be connected to the first frame or a second frame. The second frame can be provided on another linear guide, such as linear slides. The linear slides can be used to carry the second holder and/or to move the second holder 714 along a horizontal direction.

[0083] According to embodiments described herein, a PV holder or PV loader can be considered as a Bernoulli holder, wherein a vacuum pump is provided at the exhaust conduit or the exhaust conduits of the Bernoulli 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 the 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. The terms PV holder, PV loader (PV unloader), Bernoulli holder, Bernoulli-type 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.

[0084] 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.

[0085] The first holder 712 and the second holder 714 can be configured to load and/or unload substrates from a pin array. FIG. 7 shows a first pin array 724 and a second pin array 722, which are at least partially provided on top of each other. As indicated by arrows 725, the pin arrays can be vertically moved for improved loading and unloading of substrates. The pin arrays can be bats of fingers for a robot, such as an atmospheric robot, to pick/place substrates.

[0086] A magnetic levitation arrangement 732 can be provided at a position of the swing module. The magnetic levitation arrangement 732 can be configured to magnetically levitate the substrate carrier 20, particularly after the rotation of the carrier from a horizontal loading/unloading position to a vertical processing position.

[0087] According to some embodiments, which can be combined with other embodiments described herein, a cooling plate assembly 752 may further be provided. The cooling plate assembly 752 may contact a carrier, for example an E-chuck or another carrier, and/or may cool the carrier.

[0088] A hot Bernoulli holder can be configured to heat a substrate before processing. A cold Bernoulli holder can be configured to cool a substrate after processing. For heating, hot air can be provided for the Bernoulli holder and/or an aperture plate of the Bernoulli holder can be heated. For cooling, cold air can be provided for the Bernoulli holder and/or an aperture plate of the Bernoulli holder can be cooled.

[0089] FIG. 7 partially shows a schematic view of an apparatus for loading a substrate carrier 20 into a vacuum processing system according to embodiments

described herein. The vacuum processing system can be similar to the processing system described with respect to FIG. 2.

[0090] The apparatus can load substrates into a first load lock chamber (see 111 in FIG. 2) connectable to the vacuum processing system and a second load lock chamber (see 112 in FIG. 2) connectable to the vacuum processing system. The system further includes a swing module (see 160 in FIG. 1) for supporting and loading the substrate carrier 20 into the first load lock chamber and for supporting and loading the substrate carrier 20 into the second load lock chamber. The swing module or loading station can have a support surface configured to support the substrate carrier 20. For example, a substrate carrier can be fixed to the support surface using mechanical devices, electrical devices, magnetic devices, electromagnetic devices, and any combinations thereof.

[0091] The swing module or loading station can be moveable between a first orientation, which can be a first lock-in position, and a second orientation, which can be a second lock-in position different from the first lock-in position. The movement of the swing module or loading station between the first orientation and the second orientation different from the first orientation can include a rotation, for example, around a first rotational axis, and can optionally further include a translational movement of the swing module or loading station, e.g., in a horizontal and/or vertical direction. For example, the swing module or loading station can have a vertical rotational axis as indicated by arrow 772 for a rotation at the bottom. Furthermore, one or more horizontal and/or motorized axes can be provided. For example, as shown in FIG. 7, three horizontal and/or motorized axes 774, 776, and 778 can be provided.

[0092] In some implementations, the swing module or loading station can move the substrate or substrate carrier, respectively, rotatably in a first direction and a second direction. For example, the first direction can be for loading/unloading in a first load lock chamber and the second direction can be for loading/unloading in a second load lock chamber. The first direction can be a clockwise direction and the second direction can be a counterclockwise direction, or the first direction can be a

counterclockwise direction and the second direction can be a clockwise direction. The loading station can also be referred to as a “bi-directional swing module”.

[0093] According to an aspect of the present disclosure, an apparatus for loading a substrate in a vacuum processing system is provided. The apparatus includes a first holder for holding a substrate, and a second holder for holding a substrate vertically stacked with the first holder.

[0094] One or more of the following aspects can be applied to the apparatus individually or in combination. The first holder can be at least partially provided above the second holder. At least one of the first holder and the second holder can be Bernoulli holders or PV holders. The first holder can be a hot Bernoulli holder and/or the second holder can be a cold Bernoulli holder. The hot Bernoulli holder can be a Bernoulli loader configured for heating a substrate before processing of the substrate. The second holder can be a cold Bernoulli unloader configured for cooling a substrate after processing of the substrate.

[0095] The apparatus can include a swing module for changing a substrate orientation between a horizontal orientation and vertical orientation. The swing module can be provided under atmospheric pressure. The swing module can be provided in a clean room environment. The swing module can be configured to support a carrier. The swing module can include a magnetic levitation arrangement for supporting the carrier and/or a cooling plate assembly for cooling the carrier. The swing module can be a bi-directional swing module. The swing module can be configured to rotate the carrier and/or a substrate in a clockwise and a counterclockwise direction.

[0096] The apparatus can include a first pin array configured to support the substrate, and a second pin array configured to support the substrate vertically stacked with the first pin array. The first holder can be provided above the first pin array in a first position and the second holder can be provided above the second pin array in the first position. The first holder and the second holder can be horizontally movable between the first position and a second position. The first holder and the second holder can be horizontally movable between a first position and a second

position. The first holder and the second holder can be connected to a frame or a frame assembly, respectively. The frame or the frame assembly can be movable. The frame or the frame assembly can be supported by linear guides or linear slides.

[0097] According to a further aspect of the present disclosure, a system for processing a substrate is provided. The system includes the apparatus according to the present disclosure and as described above. The system further includes a first load lock chamber, optionally a second load lock chamber, and a vacuum chamber configured for processing the substrate.

[0098] One or more of the following aspects can be applied to the system individually or in combination. The substrate can be a large area substrate. The system can be configured for display manufacturing.

[0099] According to another aspect of the present disclosure, a method for loading a substrate is provided. The method includes loading a substrate at a first position on a first holder vertically stacked with a second holder, horizontally moving the first holder with the substrate from the first position to a second position, and loading the substrate at the second position on a substrate receiving surface.

[00100] One or more of the following aspects can be applied to the method individually or in combination. The method can further include at least one of vertically moving the first holder and the substrate receiving surface relatively to each other, loading the substrate at the first position on a first pin array, unloading the substrate at the first position from the second holder on a second pin array, and unloading the substrate from the second pin array. The method can include loading the substrate at the second position on the second holder and horizontally moving the second holder with the substrate from the second position to the first position. The method can include pretreating the substrate while being held by the first holder. The pretreating may include heating of the substrate. Heating of the substrate can be provided by the first holder being a hot Bernoulli holder. Hot air can be provided in a Bernoulli gap for heating of the substrate. The method can include at least one of heating the substrate while being supported or levitated by the first holder and

cooling the substrate while being supported or levitated by the second holder. The substrate can be a large area substrate.

[00101] Embodiments of the present disclosure provide vertically stacked holders (also referred to as “loaders”) for substrates, particularly large area substrates, in a vacuum processing system. A first (substrate) holder is provided above a second (substrate) holder. Embodiments particularly relate to an in-line configuration with vertically aligned Bernoulli loaders / Bernoulli holders. Providing stacked holders, such as vertically stacked Bernoulli holders or loaders, can reduce the area of a clean room. The first holder and the second holder are not arranged next to each other but above each other or at least partially above each other. This reduces the footprint of a vacuum processing system including the holders or other loaders e.g. for loading substrates on a carrier, which may be provided on a swing module.

[00102] 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 loading a substrate in a vacuum processing system, comprising:

a first holder for holding a substrate; and

5 a second holder for holding a substrate vertically stacked with the first holder.

2. The apparatus of claim 1, wherein the first holder is at least partially provided above the second holder.

10 3. The apparatus of claim 1 or 2, wherein at least one of the first holder and the second holder are Bernoulli holders or PV holders.

4. The apparatus of any one of claims 1 to 3, wherein the first holder is a hot Bernoulli holder and wherein the second holder is a cold Bernoulli holder.

15 5. The apparatus of claim 4, wherein the hot Bernoulli holder is a Bernoulli loader configured for heating a substrate before processing of the substrate and/or wherein the second holder is a cold Bernoulli unloader configured for cooling a substrate after processing of the substrate.

20 6. The apparatus of any one of claims 1 to 5, further comprising:
a swing module for changing a substrate orientation between a horizontal orientation and a vertical orientation.

7. The apparatus of claim 6, wherein the swing module is provided at least one of: under atmospheric pressure and in a clean room environment.

8. The apparatus of claim 6 or 7, wherein the swing module is at least one of:

5 configured to support a carrier,

configured to rotate the carrier and/or a substrate in a clockwise and a counterclockwise direction, and

a bi-directional swing module.

10 9. The apparatus of any one of claims 6 to 8, wherein the swing module comprises at least one of:

a magnetic levitation arrangement for supporting the carrier;

a cooling plate assembly for cooling the carrier;

a first pin array configured to support the substrate; and

15 a second pin array configured to support the substrate vertically stacked with the first pin array.

20 10. The apparatus of claim 9, wherein the first holder is provided above the first pin array in a first position and the second holder is provided above the second pin array in the first position.

11. The apparatus of any one of claims 1 to 10, wherein the first holder and the second holder are horizontally movable between the first position and a second position.

12. The apparatus of any of claims 1 to 11, wherein the first holder and the second holder are connected to a frame or a frame assembly.

5 13. The apparatus of claim 12, wherein the frame or the frame assembly are at least one of movable and supported by linear guides or linear slides.

14. A system for processing a substrate, comprising:
the apparatus according to any of claims 1 to 13;
10 a first load lock chamber;
optionally a second load lock chamber; and
a vacuum chamber configured for processing the substrate.

15. A method for loading of a substrate, comprising:

15 loading a substrate at a first position on a first holder vertically stacked with a second holder;

horizontally moving the first holder with the substrate from the first position to a second position; and

loading the substrate at the second position on a substrate receiving surface.

20

16. The method of claim 15, further comprising at least one of:

vertically moving the first holder and the substrate receiving surface relative to each other;

loading the substrate at the first position on a first pin array; and

pretreating the substrate while being held by the first holder.

5

17. The method of claim 16, wherein the pretreating includes at least one of heating of the substrate and heating of the substrate by the first holder being a hot Bernoulli holder.

10 18. The method of claim 17, wherein hot air is provided in a Bernoulli gap for heating of the substrate.

19. The method of any of claims 15 to 18, further comprising at least one of:

loading the substrate at the second position on the second holder;

15 horizontally moving the second holder with the substrate from the second position to the first position;

unloading the substrate at the first position from the second holder on a second pin array; and

unloading the substrate from the second pin array.

20

20. The method of any of claims 15 to 19, further comprising at least one of:

heating the substrate while being supported or levitated by the first holder;

and

cooling the substrate while being supported or levitated by the second holder.

Fig. 1A

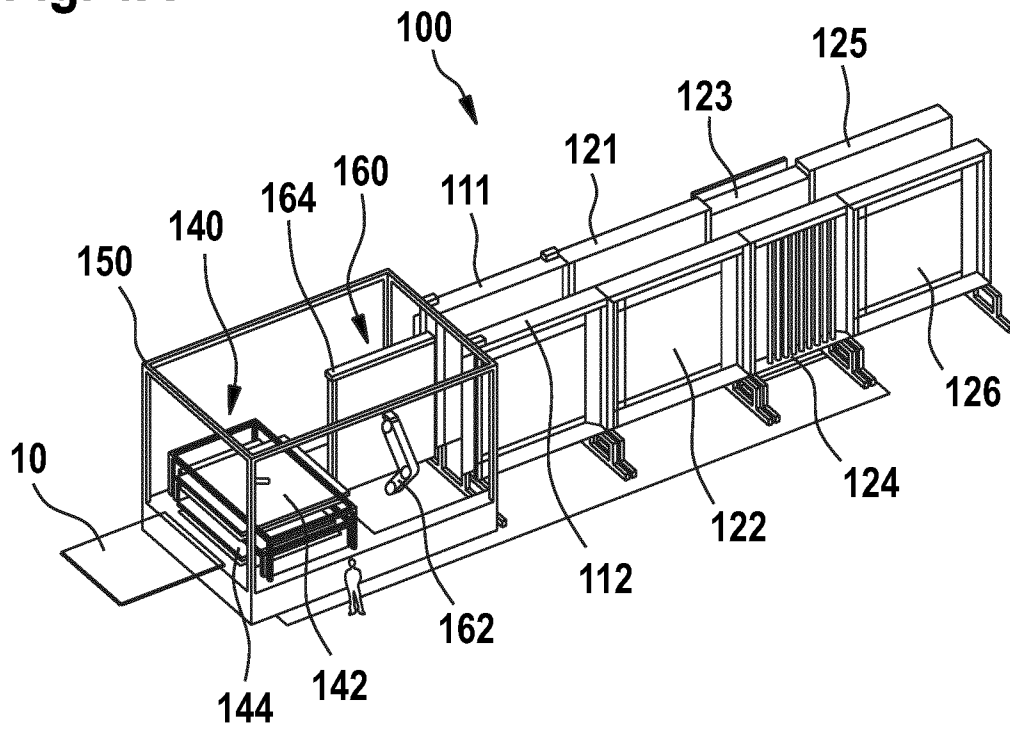
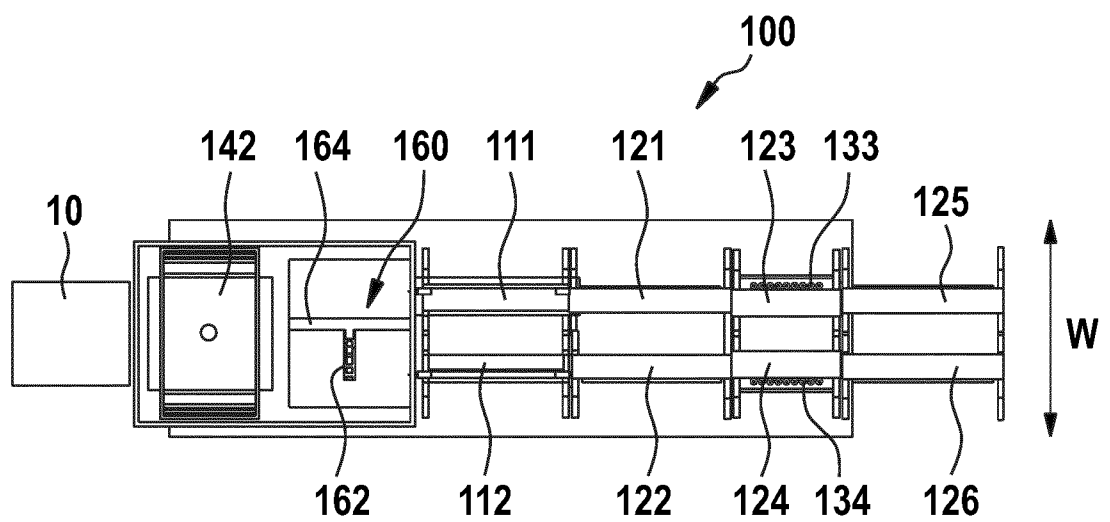


Fig. 1B



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Fig. 2

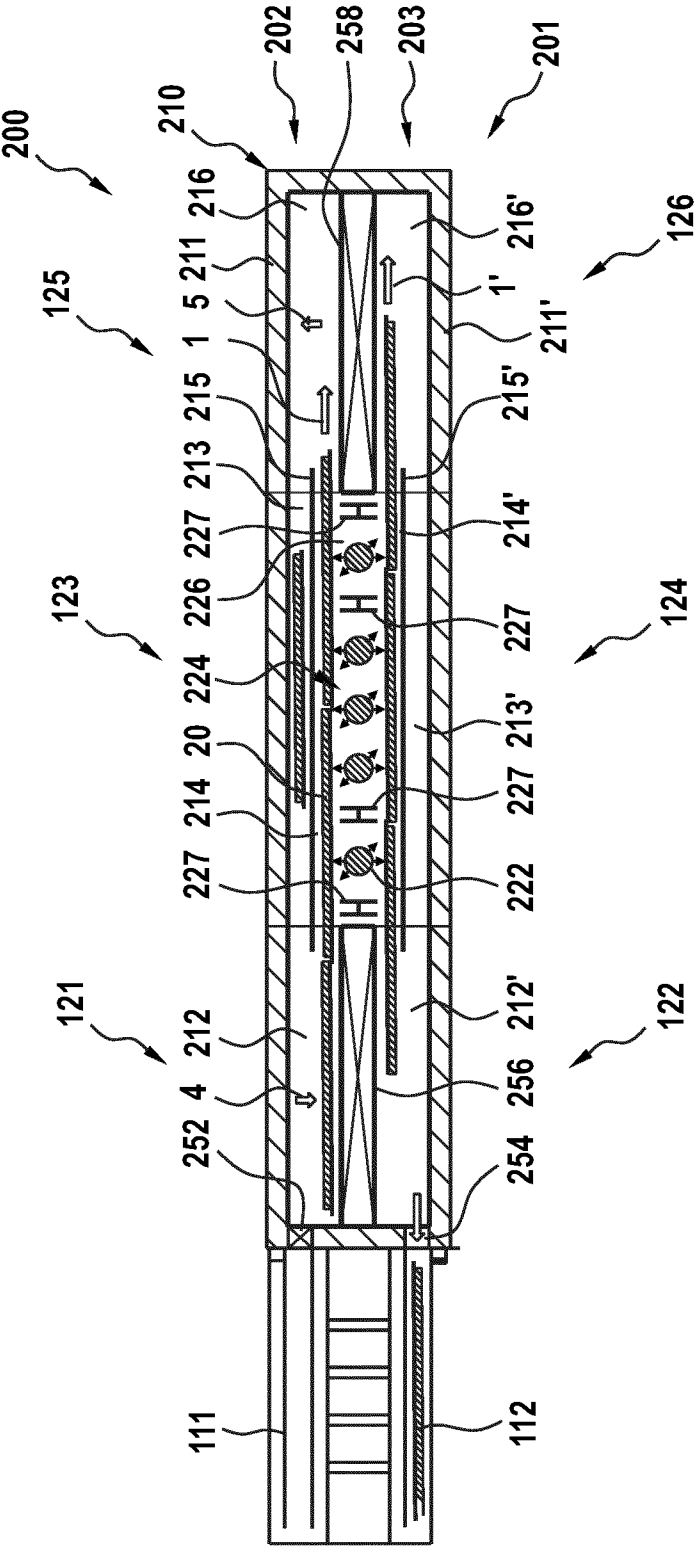
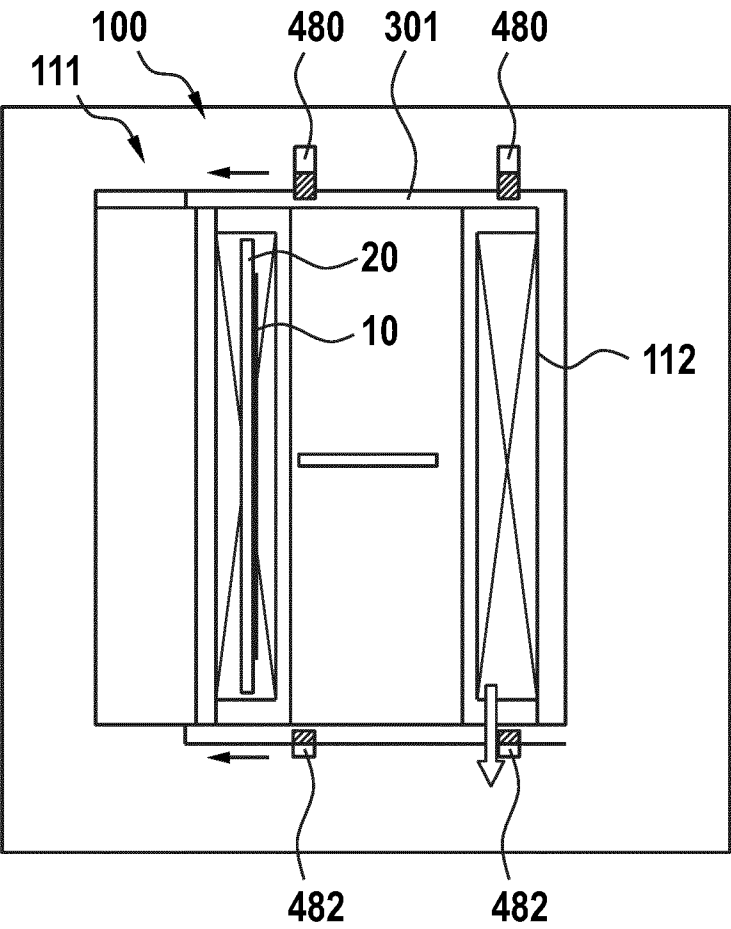


Fig. 3



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Fig. 4A

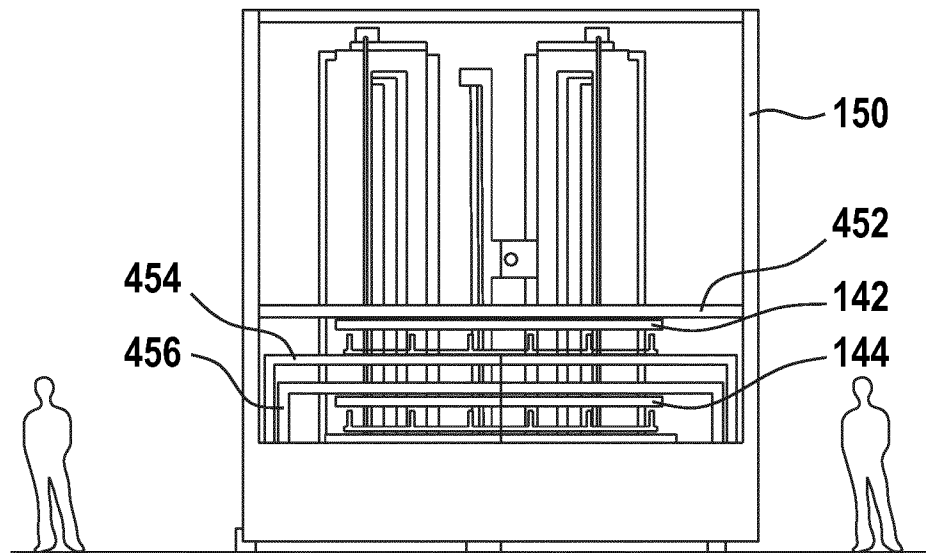
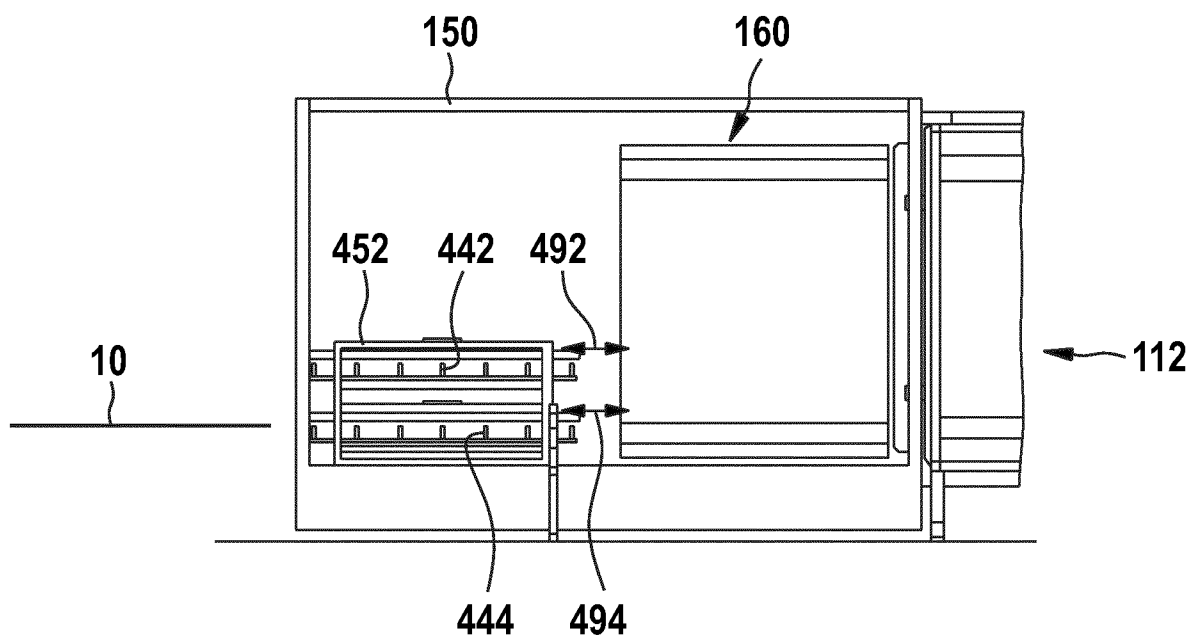


Fig. 4B



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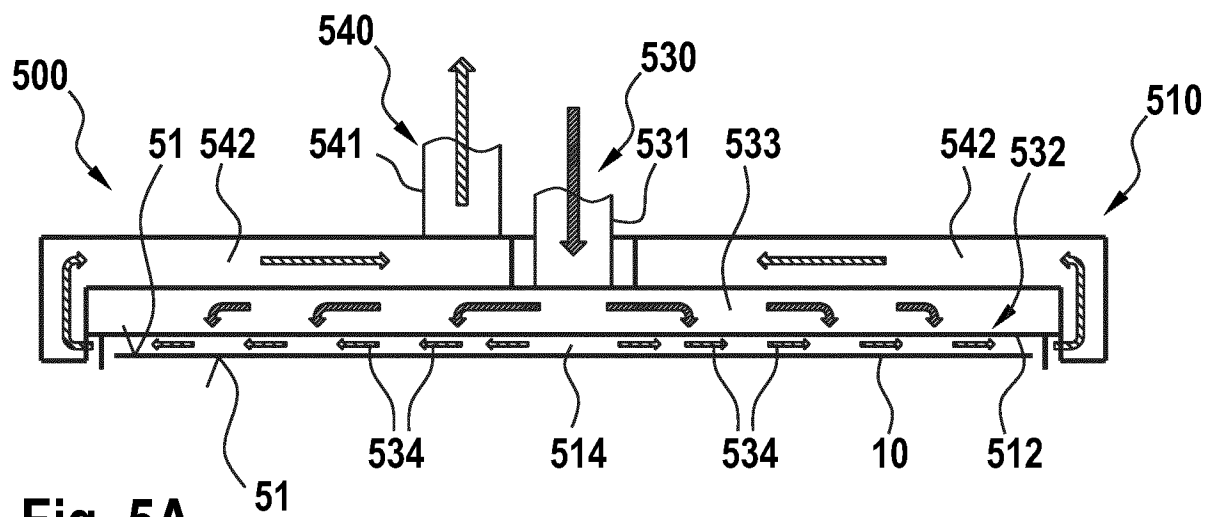


Fig. 5A

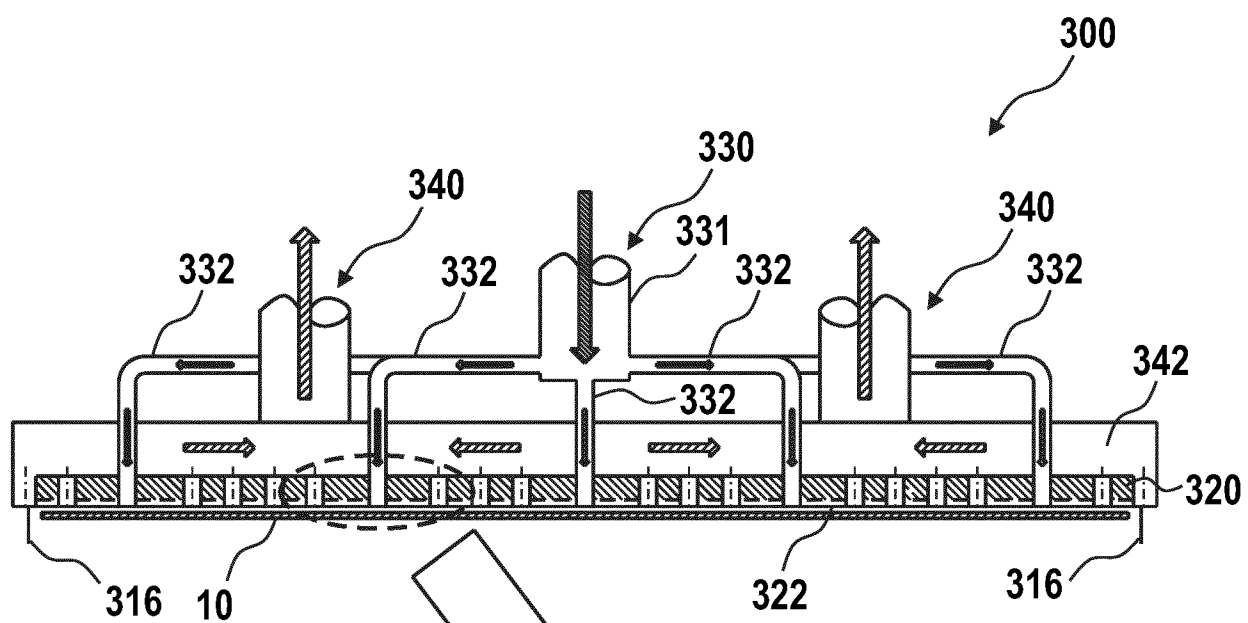
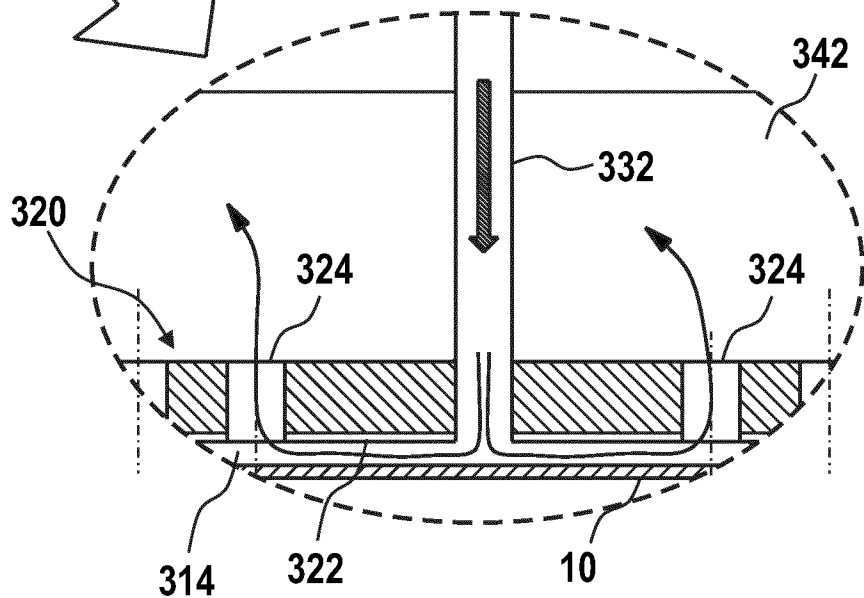
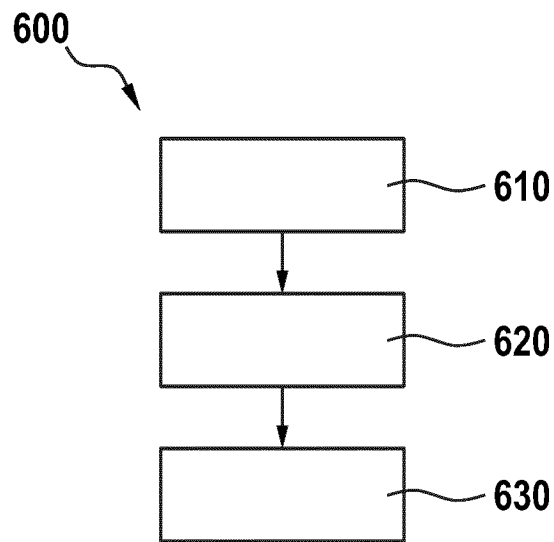


Fig. 5B



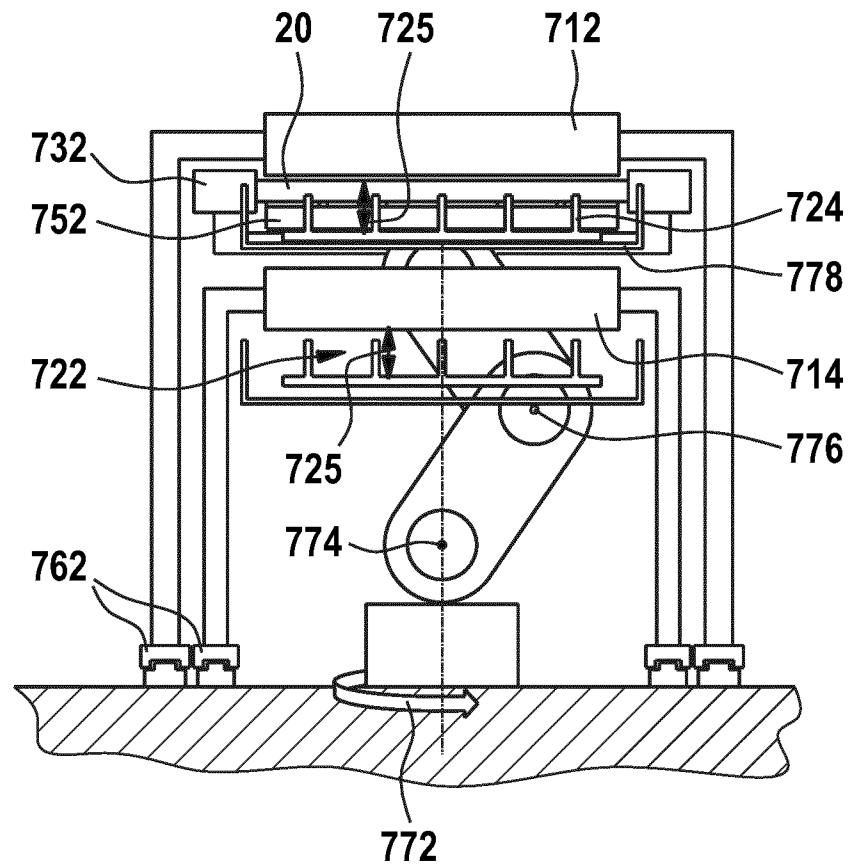
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Fig. 6



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Fig. 7



INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/059668

A. CLASSIFICATION OF SUBJECT MATTER
 INV. H01L21/677 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

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X	US 2003/191551 A1 (GOTOH HIDETO [JP] ET AL) 9 October 2003 (2003-10-09)	1-3, 11-13, 15,19
Y	paragraph [0046]; figures 4,7	4-10, 16-18,20
X	----- WO 2010/078264 A2 (ARCHERS INC; LEI LAWRENCE CHUNG-LAI [US]; MAK ALFRED [US]; LIU REX [US] 8 July 2010 (2010-07-08) paragraph [0066]; figures 1A,9	1,2, 11-15
X	----- WO 02/23597 A2 (APPLIED MATERIALS INC [US]) 21 March 2002 (2002-03-21)	1,2
A	abstract; figures 2-7 ----- -/-	15



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

1 December 2017

Date of mailing of the international search report

07/12/2017

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Authorized officer

Oberle, Thierry

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/059668

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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Y A	WO 2015/117638 A1 (APPLIED MATERIALS, INC.) 13 August 2015 (2015-08-13) abstract; figures 11,12A,12B -----	6-10 1,15

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Information on patent family members

International application No

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