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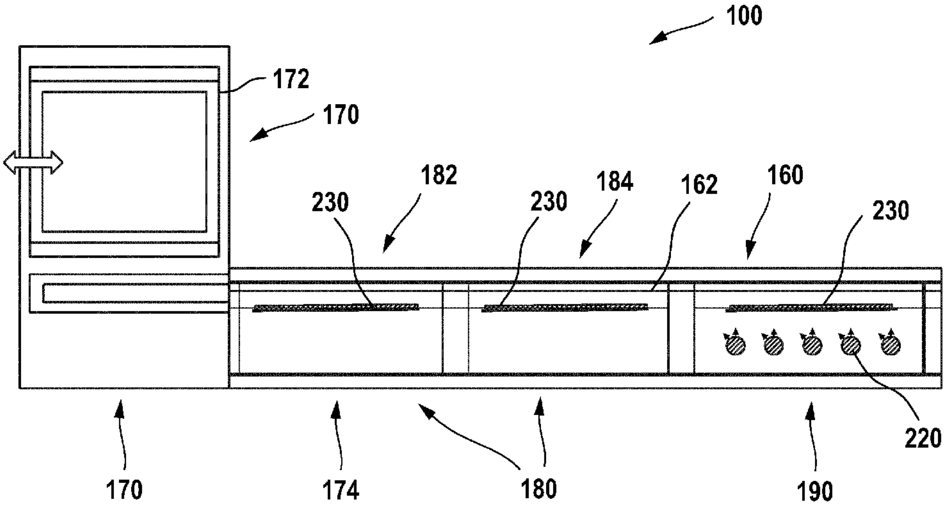
Fig. 1



(57) **Abstract:** The present disclosure provides an apparatus for heat treatment (200) of a carrier (212) in a processing system. The apparatus includes a carrier (212) configured to support a substrate (230) in a substrate receiving area (232), the carrier (212) having one or more edge portions (214) extending outside the substrate receiving area (232) and a heating arrangement (240) configured to provide heat energy to the one or more edge portions (214).

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[Continued on next page]

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APPARATUS FOR HEAT TREATMENT, SUBSTRATE PROCESSING SYSTEM AND METHOD FOR PROCESSING A SUBSTRATE

TECHNICAL FIELD

[0001] The present disclosure generally relates to substrate processing, such as large area substrate processing. Particularly, the present disclosure relates to substrate processing on carriers carrying substrates in a substrate processing apparatus. Further, the present disclosure relates to apparatuses for heat treatment, to substrate processing systems and methods for processing a substrate. In particular, the present disclosure relates to apparatuses for heat treatment of a carrier, e.g. a carrier for carrying a substrate in a processing system.

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. Coated materials may be used in several applications and in several technical fields. For instance, one application lies in the field of 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] Substrate processing systems may include an atmospheric portion, e.g. a clean room, one or more vacuum chambers and a load lock chamber for loading substrates from the atmospheric portion to the one or more vacuum chambers. The load lock chambers may be frequently evacuated and vented to load and/or unload substrates. Further, particularly for large area substrates, two different concepts may be provided. On the one hand, substrates may be handled directly by a robot or the like. On the other hand, substrates may be loaded on a carrier (a substrate carrier) and the substrate carrier supporting the substrate may be handled in a vacuum processing system. While carriers increase the equipment guided through the system and may have some disadvantageous, carriers have the advantage that glass breakage can be reduced, particularly when considering substrates having a substrate area of up to several square meters and a thickness of below 1 mm, such as a few tens millimeters.

[0004] Vacuum processing systems may provide a cycle for substrates from atmosphere to vacuum and back to atmosphere. Typically, a plurality of substrates are simultaneously processed in the system, e.g. may be provided at various positions of the cycle. Display manufacturers or other operators of vacuum processing systems may interrupt operation of a vacuum processing system for several reasons. Interruption, i.e. process idle may occur and substrates supported in carriers (as well as carriers as such) remain in the present position of the cycle. The change from process idle to processing cycles with new substrates may change desorption behavior and particle load or gas levels in the processing system.

[0005] In light of the above, apparatuses, systems, and methods that overcome at least some of the problems in the art are beneficial.

SUMMARY

[0006] According to an aspect of the present disclosure, an apparatus for heat treatment of a carrier in a processing system is provided. The apparatus includes a carrier configured to support a substrate in a substrate receiving area the carrier having one or more edge portions extending outside the substrate receiving area and a heating arrangement configured to provide heat energy to the one or more edge portions.

[0007] According to an aspect of the present disclosure, a substrate processing system is provided. The system includes the apparatus for heat treatment according to an aspect of the present disclosure.

[0008] According to an aspect of the present disclosure, a substrate processing system for processing a substrate supported by a carrier is provided. The system provides a substrate-carrier arrangement, including a first apparatus for heat treatment configured to heat a first area of the substrate-carrier arrangement and a second apparatus for heat treatment, configured to heat a second area of the substrate-carrier arrangement.

[0009] According to an aspect of the present disclosure, a method for processing a substrate is provided. The method includes loading the substrate on a carrier in a substrate receiving area, introducing the carrier into a substrate processing system, and heating an area of the carrier that is different from the substrate receiving area with an apparatus for heat treatment.

[0010] 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.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] 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:

[0012] Figure 1 shows a top view of a processing system according to embodiments described herein;

[0013] Figure 2A shows a front view of a carrier carrying a substrate according to embodiments described herein;

[0014] Figure 2B shows a top view of a carrier carrying a substrate according to embodiments described herein;

[0015] Figures 3A to 3D show areas prone for heat treatment and a carrier according to embodiments described herein;

[0016] Figure 4 shows a top view of a substrate processing system according to embodiments described herein;

[0017] Figures 5A and 5B show a side view of an atmospheric module according to embodiments described herein; and

[0018] Figures 6A and 6B show flow diagrams of a method according to embodiments described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0019] 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.

[0020] Figure 1 shows a top view of a substrate processing system 100 according to embodiments described herein. The processing system may include modules. Modules can be or include chambers. The processing system includes one or more atmospheric modules 170. The atmospheric modules may include a swing module 172. Furthermore, the processing system may include one or more load lock modules 174 which may also be referred to herein as a “pre-vacuum module 182”. Further, the processing system may include one or more transfer modules 180. The one or more transfer modules 180 may include one or more high-vacuum modules 184.

[0021] According to embodiments described herein, the processing system includes one or more processing modules 190. Vacuum conditions may be applied to the one or more processing modules 190 and/or the transfer modules 180 and/or the load lock modules 174.

The load lock modules 174, the processing modules 190 and/or the transfer modules 180 including the pre-vacuum modules 182 and the high-vacuum modules 184 may include chambers. The processing system may be used to process a substrate 230.

[0022] Processing of a substrate may be understood as transferring material to a substrate. For example, deposition material may be deposited on the substrate, for example, by a CVD process or a PVD process, such as sputtering or evaporation. The substrate 230 may include a deposition material receiving side. The deposition material receiving side of the substrate may be regarded as the side of the substrate facing a deposition source. Further, processing of a substrate may also include transportation of the substrate from one module to another module of the processing system.

[0023] According to embodiments described herein, the atmospheric module 170 may be connected to the one or more transfer modules 180. Additionally or alternatively, the atmospheric module 170 may be connected to the one or more processing modules 190. For example, a load lock module 174 may connect the atmospheric module and the one or more high vacuum modules 184 and/or processing modules 190. The load lock module or chamber may assist in equalizing pressure differences between modules. For example, atmospheric pressure is applied in one module and a vacuum is applied in the module which is connected to the one module via the load lock module.

[0024] The substrate processing system 100 may be a substrate processing system. The system may include a transport arrangement 160 for transferring one or more substrates 230. Particularly, the transport arrangement 160 may include transportation paths 162 extending through the processing system. For example, the one or more substrates 230 may be transported from the atmospheric module to the one or more processing modules. Further, the one or more substrates may be transported between the one or more processing modules. For example, a plurality of substrates may be transported. Particularly, the one or more substrates and/or the plurality of substrates may circulate through the substrate processing system 100. The substrates, for example, may cycle between the atmospheric module and the one or more processing modules. For example, such transportation may be along the transportation paths and/or along a transportation loop. According to embodiments of the present disclosure, the substrates are transported, e.g. the substrates may cycle, while being supported by a carrier.

[0025] Further, a pre-vacuum module may be arranged between the atmospheric module and the one or more processing modules. The atmospheric module may include atmospheric conditions. For example, the air pressure in the load module may include atmospheric air pressure. Thus, particles, like e.g. O_2, H_2O and N_2 may be present in the atmospheric module or generally outside of one of the vacuum chambers. The pre-vacuum module may include different pressure conditions compared to the atmospheric module. For example, the pre-vacuum chamber includes lower pressure conditions. The pressure in the pre-vacuum chamber may be below 10^{-1} mbar. The pre-vacuum chamber may be connected to one or more processing chambers. The processing chambers may include different pressure conditions compared to the atmospheric module and/or the pre-vacuum chamber. A load lock module may be arranged between the pre-vacuum chamber and the processing chambers. For example, the processing chamber may include vacuum conditions.

[0026] Vacuum conditions as used herein, include pressure conditions in the range of below 10^{-1} mbar or below 10^{-3} mbar, such as 10^{-7} mbar to 10^{-2} mbar. For example, vacuum conditions in the load lock module may be switched between atmospheric pressure conditions and subatmospheric pressure conditions, e.g. in a range at or below 10^{-1} mbar. For transferring a substrate into a high vacuum module, the substrate may be inserted into the load lock module provided at atmospheric pressure, the load lock module may be sealed, and subsequently may be set on a subatmospheric pressure in the range below 10^{-1} mbar. Subsequently, an opening between the load lock chamber and the high vacuum module may be opened, and the substrate may be inserted into the high vacuum module to be transported into the processing module.

[0027] Further, vacuum conditions in the processing modules may include process pressure conditions at or below 10^{-2} mbar, such as 10^{-3} mbar to 10^{-4} mbar. Base pressure conditions in the processing modules may be in the range of 10^{-7} mbar to 10^{-6} mbar, particularly in the range of 10^{-7} mbar to $5*10^{-6}$ mbar. Vacuum conditions may be applied through the use of vacuum pumps or other vacuum creating techniques.

[0028] According to embodiments described herein, the one or more processing modules or chambers contain one or more deposition sources 220. If more than one deposition source is present, the deposition sources may be arranged in a row. For example, the deposition sources are arranged next to each other. The deposition sources may extend vertically in length. In the vertical direction, multiple openings may be distributed. The openings may be in the form of nozzles. For example, material to be deposited on a substrate may be sprayed at the substrate through the multiple openings, e.g. through the nozzles.

[0029] According to embodiments, the one or more deposition sources may be rotatably fixed to a bottom side of the processing module. Particularly, two to ten deposition sources may be present in the one or more processing chambers. More particularly, three to seven deposition sources may be present in the one or more processing chambers.

[0030] The change from process idle to processing cycles with new substrates may change desorption behavior and particle load or gas levels in the processing system. According to embodiments of the present disclosure, the particle load may not only be changed by particles that enter the system by being attached to the substrates. The absorption of particles to further process components, like e.g. carriers further increase the particle load. Components, such as carriers, are provided with a decreased particle load in a dedicated manner.

[0031] According to embodiments described herein, the processing system further includes an apparatus for heat treatment 200. The apparatus may be located at and/or near the processing system, for example in at least one or more of the atmospheric module, the load lock module, the high vacuum module, and the transfer module, e.g. in a vacuum environment or not. Additionally or alternatively, the apparatus may be located inside the processing system. The apparatus may include one or more heating arrangements 240.

[0032] According to embodiments described herein, one or more substrates 230 may be carried by a carrier 212 through the substrate processing system 100. The carrier 212 may be transported via the transport arrangement in the processing system. The system may include a plurality of carriers 212 carrying a plurality of substrates 230. Each carrier 212 may carry one substrate. A plurality of carriers may be transported through the processing system simultaneously.

[0033] Figure 2A shows a front view of a carrier according to embodiments described herein.

[0034] According to embodiments described herein, the carrier includes one or more edge portions 214. The edge portions 214 extend outside the substrate receiving area. Further, the carrier 212 may carry a substrate 230. The substrate may be loaded onto the carrier. Particularly, the substrate may be loaded in a substrate receiving area 232. The substrate 230 may be attached to the carrier 212 via a holding arrangement 218. For example, the holding arrangement connects the carrier to the substrate. The holding arrangement may include mounts. The mounts may connect the carrier and the substrate. The holding arrangement may connect the substrate and the carrier mechanically. Additionally or alternatively, the holding arrangement may connect the substrate at the carrier electrostatically.

[0035] Additionally or alternatively and according to embodiments described herein, the carrier may include, or be, an electrostatic chuck (E-chuck). The E-chuck can have a supporting surface for supporting the substrate 230 thereon. In one embodiment, the E-chuck includes a dielectric body having electrodes embedded therein. The dielectric body can include 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 230 to fix the substrate 230 on the supporting surface.

[0036] Generally, E-chucks support substantially a whole surface of the substrate 230, such as the second main surface or backside. A bending of the substrate 230 can be avoided, since substantially the whole surface is attached to the defined supporting surface of the E-chuck. The substrate 230 can be supported more stably and a process quality can be improved.

[0037] According to some embodiments, which can be combined with other embodiments described herein, the substrate 230 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 x 0.92m), GEN 5, which corresponds to about 1.4 m^2 substrates (1.1 m x 1.3 m), GEN 7.5, which corresponds to about 4.29 m^2 substrates (1.95 m x 2.2 m), GEN 8.5, which corresponds to about 5.7m^2 substrates (2.2 m x 2.5 m), or even GEN 10, which corresponds to about 8.7 m^2 substrates (2.85 m x 3.05 m). Even larger generations such as GEN 11 and GEN 12 and corresponding substrate areas can similarly be implemented.

[0038] The one or more substrates may be oriented in a substantially vertical position. As used throughout the present disclosure, “substantially vertical” is understood particularly when referring to the substrate orientation, to allow for a deviation from the vertical direction or orientation of ±20° or below, e.g. of ±10° 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 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 ±20° or below. For example, during a deposition process and/or during transportation, the one or more substrates may be in a substantially vertical position.

[0039] For example, deposition material may be transferred from the vertically arranged deposition source to the substantially vertically oriented substrate. The material to be deposited may be coated on the substrate.

[0040] Embodiments of the present disclosure relate, for example, to an apparatus for heat treatment 200 of a carrier 212 in a processing system. The apparatus includes a heating arrangement 240 configured to provide heat energy to the one or more edge portions 214 of a carrier. The carrier is configured to support a substrate in a substrate receiving area 232, the carrier 212 having one or more edge portions 214 extending outside the substrate receiving area.

[0041] According to embodiments described herein, the swing module 172 may bring the one or more substrates into a substantially vertical position. The swing module may further bring a substrate-carrier-arrangement 250 in a substantially vertical position. The swing module may include a rotatable axis. The axis may be horizontally oriented. The swing module may be tiltable. For example, the swing module 172 may be tiltable by substantially about 90 degrees. The swing module may be oriented towards a load lock module 174. According to embodiments described herein, the swing module 172 may include a swing element 173. The swing element may be a table where a substrate carrier may be located. The substrates may be loaded on a carrier 212. The swing element may be tiltable towards the load lock module. Accordingly, a swing module may move a carrier having a substrate or a substrate by an angle from a non-vertical orientation (e.g. horizontal) to a non-horizontal orientation (e.g. vertical) and vice versa. The angle may be 60° or above and 120° or below, such as about 90°.

[0042] The carrier 212 may include a carrier frame 216. The edge portions 214 may provide a frame surrounding the substrate receiving area 232. The carrier frame 216 may display the outermost fringe of the carrier 212. The carrier frame 216 may at least partly surround the substrate receiving area 232. Alternatively, the carrier frame 216 may surround the substrate receiving area 232 completely. For example, the width of the carrier frame may range between 10 mm to 500 mm. Particularly, the width of the carrier frame may range between 50 mm to 400 mm. More particularly, the width of the carrier frame may range between 100 mm to 300 mm.

[0043] According to embodiments described herein, the apparatus for heat treatment 200 may further be located at the carrier 212. For example, the carrier frame 216 may serve as an area for providing the heating arrangement 240 to the carrier. Possible locations of the apparatus for heat treatment 200 are further described with respect to Figures 3A to 3D.

[0044] Figure 2B shows a top view of a carrier carrying a substrate according to embodiments described herein. The heating arrangement 240 may be arranged in vicinity of the carrier. Particularly, the heating arrangement may be arranged in vicinity of a substrate-carrier-arrangement 250.

[0045] According to embodiments, the apparatus for heat treatment 200 may be arranged such that heat energy reaches the carrier 212. The one or more heating arrangements 240 may be configured to provide heat energy to the edge portions 214. For example, the heating arrangement 240 may be arranged at entry sites of the modules. Additionally or alternatively, the heating arrangement may be integrated into the carrier 212.

[0046] The heating arrangement 240 may provide a heat energy of at least 1 kW/m^2. For example, the heat energy provided by the heating arrangement ranges between 4 kW/m^2 and 100 kW/m^2, particularly between 4 kW/m^2 and 10 kW/m^2. For example, the carrier may be heated to a temperature of 120 °C. Particularly, the carrier may be heated to a temperature of 100 °C, more particularly 80 °C. Additionally or alternatively, the carrier may be heated such that the heating of the carrier and the temperature surrounding the carrier lead to a temperature of the carrier of 100 °C, particularly 80 °C.

[0047] According to embodiments described herein, the heating arrangement 240 may provide radiation heating. The heating arrangement 240 may include one or more radiation heaters. Radiation heaters may extend to the one or more edge portions 214. A radiation heater may be selected from the group consisting of UV lamps, IR lamps, resistive heaters and combinations thereof. The heating arrangement may include a resistive heating wire and/or a magnetic material.

[0048] The heating arrangement 240 may be configured to heat an area of the carrier that is different from the substrate receiving area. This carrier area may also be called the heated carrier area 243. For example, the heating arrangement 240 is arranged such that the heat energy only reaches the area that is different or essentially different from the substrate receiving area 232 of the carrier i.e. the heated carrier area 243. The heated carrier area may be the carrier frame 216.

[0049] Heating of the substrate as a pre-treatment may be provided. However, a substrate having, for example, made of glass and having a thickness of 0.7 mm or below has a much smaller heat capacity as a solid carrier frame. Accordingly, heating of a substrate as a pre-treatment is different (e.g. lower power) as compared to heating of the carrier. A person skilled in the art will appreciate that heat radiation intended to heat the substrate, i.e. heat radiation in a substrate receiving area, may have some overlap with areas outside of the substrate receiving area. Similarly, heat radiation intended to heat areas outside of the substrate receiving area may have some (small) overlap with the substrate receiving areas. Yet, a skilled person may, as described above, distinguish between the two intentions.

[0050] Advantageously, heating of the carrier supports desorption of particles from the carrier. Impurities can thus be removed from the carrier. The carrier may be transported between different pressure conditions. The one or more carriers of the system can be stopped in different modules and thus under different pressure conditions. During the stay under atmospheric pressure conditions particles can adsorb to the carrier. These particles are transported to subsequent modules having different pressure conditions. The subsequent transport disturbs the ongoing process which thus has to settle before the process can be continued. It is thus advantageous, to remove the particles from the carrier to speed up settlement of the process.

[0051] Figures 3A to 3D show areas prone for heat treatment and a carrier according to embodiments described herein.

[0052] According to embodiments, heat treatment may be provided externally to the heated carrier area. Externally heating is to be understood as a heating arrangement that is located away from the heated carrier area 243. The heating arrangement may be arranged in the processing system. For example, the heating arrangement may be arranged at any side of the modules of the processing system.

[0053] Figure 3A shows an example of radiation heating. The heat energy may reach the carrier at an area that is different from the substrate receiving area. For example, the heat energy of the radiation heating may reach the carrier at the heated carrier area 243. Further, the heat energy of the radiation heating may reach the carrier at the carrier frame 216.

[0054] A further way to provide radiation heating to the heated carrier area, exemplarily shown in Figure 3B, may be provided by resistive heating. For example, dedicated resistive heaters may be used. Resistive heating is to be understood as the passage of an electric current through a conductor by which heat is produced. Such a resistive heater may be arranged in the vicinity of the carrier to be heated. For example, a resistive heater for radiation heating may be arranged at an entry site of the processing system. For example, the resistive heater may be located opposite the carrier frame.

[0055] According to embodiments, heat treatment may be provided internally to the heated carrier area. Internal heating is to be understood as a heating arrangement that is located at the heated carrier area. According to embodiments, the heating arrangement may be arranged at any side of the heated carrier area. For example, the heating arrangement may be arranged at the carrier frame 216.

[0056] Figure 3C shows a further embodiment to provide heating to the heated carrier area. Resistive heating may be further provided to the carrier 212. Resistive heating may be provided by attaching the resistive heater to the carrier. For example, the resistive heating wire is attached to the carrier 212. The resistive heater may be arranged inside the carrier frame. For example, resistive heater wires may be arranged inside the heated carrier area which may be driven by a current via contact pads. Exemplarily, the resistive heater wires may be arranged in the carrier frame 216.

[0057] Figure 3D shows a further embodiment to provide heating to the heated carrier area. Inductive heating may be further provided to the carrier. Inductive heating may be understood as heating by electromagnetic induction through heat generated in the element to be heated by eddy currents. The heating arrangement 240 may be inductively coupled to the heated carrier area. For example, a conductive wire may be arranged at the heated carrier area to provide inductive heating. For example, the conductive wire may be arranged in the carrier frame 216.

[0058] Alternatively, the heated carrier area may be provided as a conductive heated carrier area. A current may be applied to the conductive heated carrier area introducing inductive heating to the heated carrier area.

[0059] According to an embodiment, the heating arrangement further may include an energy source for providing energy to the heating arrangement. The Energy source may include a power supply for providing a voltage to the heating arrangement. For example, the power supply may provide a voltage to the resistive heating wire. The power supply may also be included for inductively coupling a current to the magnetic material.

[0060] Figure 4 shows a top view of a substrate processing system 100 according to embodiments described herein.

[0061] According to embodiments described herein, the substrate processing system 100 may include an atmospheric module 170 including a swing module 172, load lock modules 174, one or more transfer modules 180 and one or more processing modules 190. For example, one swing module 172 may be connected to a load lock module 174 which may be further connected to a pre-vacuum chamber 182. The pre-vacuum chamber may be connected to a high-vacuum chamber 184. The high-vacuum chamber may be connected to a processing chamber. The processing chamber may be connected to further processing chambers. Generally, the quantity of process chambers that may be subsequently arranged may vary between one chamber and eight processing chambers, particularly one and five processing chambers, more particularly one and three processing chambers. The substrate processing system 100 may further include the transport arrangement 160.

[0062] According to embodiments described herein, the heating arrangement 240 may be arranged at different sites in the substrate processing system 100. For example, the heating arrangement 240 may be arranged at the atmospheric modules 170. For example, the heating arrangement may be located at the swing module 172.

[0063] According to embodiments described herein, the apparatus for heat treatment 200 may be provided at the one or more transfer modules 180. The apparatus for heat treatment 200 may be arranged in the one or more transfer modules 180. The apparatus for heat treatment 200 or the one or more heating arrangements 240 may be located in the pre-vacuum module or chamber. Heating in the pre-vacuum chamber can be carried out statically. Static heating is to be understood as a heating arrangement that is stationary, for example, at a wall of the chamber. It may also be understood as a heating arrangement that is stationary, attached to a wall of the chamber. Stationary heating may include that the carrier is stopped inside the chamber.

Advantageously, particles may be removed in the beginning of processing a substrate. Thus, spreading of particles to subsequent chambers is prevented more effectively. Further, degassing of the carrier is promoted. Thus, an improved process stability and performance can be achieved.

[0064] According to embodiments described herein, the depletion of residual particles or gas may be monitored by a residual gas analysis (RGA) measurement. The monitoring and regulating of temperature may be carried out by a control system. For example, the control system may be a closed loop system. The measurement may be carried out in the one or more transfer modules 180 and/or in the one or more processing modules 190. For example, the RGA may be performed in the pre-vacuum chamber and a processing chamber. The RGA may be in relation to the regulation of the heating. According to embodiments, a closed loop system for heating of the carrier may be established. For example, the regulation of the apparatus for heat treatment 200 may correlate to the results of the RGA. For example, if a high particle amount or a high residual gas volume is measured, the temperature of the apparatus for heat treatment may be increased.

[0065] According to embodiments described herein, the apparatus for heat treatment 200 may be provided at a part of a wall of the modules or chambers. The modules or chambers may include a top wall, four side walls and/or a bottom wall. The apparatus for heat treatment may be arranged at every wall of the one or more transfer chambers and/or the one or more atmospheric modules. The apparatus for heat treatment 200 may be arranged at least at a part of the walls of the chamber. For example, the apparatus for heat treatment 200 may be arranged in an upper section, a lower section and/or a side section of the respective wall. The apparatus for heat treatment 200 may further cover the whole of the respective wall.

[0066] According to embodiments described herein, the transport arrangement 160 may be configured to transport the carrier 212 past the apparatus for heat treatment 200. For example, transport paths 162 may be configured to provide the carrier at a site in a module where heating of the apparatus for heat treatment may be applied to the carrier 212. For example, the carrier may be stopped opposite the heating arrangement 240.

[0067] According to embodiments described herein, heating may be provided to the carrier 212 during movement of the carrier. The carrier may be transported between the modules or chambers. For example, the carrier is transported between two transfer modules. One of the transfer modules may be a pre-vacuum chamber and the second transfer module may be a high-vacuum chamber. Heating may be provided to the carrier during transfer of the carrier. Heating may be provided to the carrier frame as pulsed heating, i.e. heating is subsequently turned on and off. For example, heating may be turned on and off depending on the position of the carrier and the substrate. For example, only the carrier, but not the substrate may be heated, e.g. by turning off the heating arrangement at specified positions of the carrier and/or substrate.

[0068] According to embodiments that can be combined with any other embodiment described herein, the carrier may include a substrate-carrier-arrangement. The carrier may be loaded with a substrate. The substrate may be present in the substrate receiving area of the carrier. According to embodiments described herein, the substrate processing system may include a carrier providing the substrate-carrier-arrangement. The system may include a first apparatus for heat treatment 252. The first apparatus for heat treatment 252 may be configured to heat a first area of the substrate-carrier-arrangement. The system may further include a second apparatus for heat treatment 254. The second apparatus for heat treatment 252 may be configured to heat a second area of the substrate-carrier-arrangement.

[0069] According to embodiments described herein, the first apparatus for heat treatment 252 may provide heat energy of a lower power than the second apparatus for heat treatment 254. For example, less heat energy is provided to the first area than to the second area of the substrate-carrier-arrangement.

[0070] According to embodiments described herein, the first area of the substrate-carrier-arrangement may be the substrate receiving area of the substrate-carrier-arrangement. According to embodiments described herein, the second area of the substrate-carrier-arrangement may be an edge portion of a carrier of the substrate-carrier-arrangement. For example, the first apparatus for heat treatment 252 may provide heating to the substrate receiving area and the second apparatus for heat treatment 254 may provide heating to the edge portion and/or the carrier frame.

[0071] According to embodiments described herein, heating of the second area may be regulated by a closed loop system. For example, the closed loop system may be the closed loop system as described above. The closed control system may for example include a residual gas analysis (RGA).

[0072] According to embodiments described herein, the substrate processing system may be configured to stop the process. For example, the carriers are stopped in a current position. This may allow for e.g. loading new substrate-carrier-arrangements into the processing system. Further, the carriers or substrate-carrier-arrangements may be cycled through the substrate processing system. The transport arrangement may then be in a loop configuration. For example, one continuous transportation path is provided.

[0073] Figures 5A and 5B show a side view of an atmospheric module 170 according to embodiments described herein. According to embodiments that can be combined with any other embodiment described herein, the atmospheric module may include one or more swing modules. The swing module may bring the substrate in a substantially vertical position. The atmospheric module may further provide one or more load lock modules or chambers. The swing module 172 may be provided with carriers. The carriers may include a substrate in the substrate receiving area.

[0074] According to embodiments described herein, the atmospheric module may provide the apparatus for heat treatment 200. For example, the swing module 172 may provide the apparatus for heat treatment. Additionally or alternatively, the one or more load lock modules 174 may provide the apparatus for heat treatment 200. Thus, heating may be provided to the carrier in the atmospheric module. The apparatus for heat treatment 200 may be configured to heat the carrier. The apparatus for heat treatment 200 may be oriented such that heat energy may reach the carrier. For example, the heat energy reaches edge portions of the carrier and/or the carrier frame.

[0075] Advantageously, particle or gas adsorption at the carrier may be reduced for carriers in or close to a processing module. This may be achieved in an early stage of the process. Thus, less particles are transferred into the processing system. A low particle or gas load on the carrier in an early stage of the process is advantageously since the process is subjected to fewer variations.

[0076] Figures 6A and 6B show flow diagrams of a method according to embodiments described herein. The method may be performed by using the substrate processing system 100 according to embodiments descried herein.

[0077] According to embodiments that can be combined with any embodiments described herein, box 610 includes loading the substrate on a carrier in a substrate receiving area. The carrier and the substrate may be a substrate-carrier-arrangement. The carrier being loaded with the substrate may be placed on a swing module. The swing module may be the swing module as described according to embodiments herein. The substrate-carrier-arrangement may be brought into a vertical position by the swing module.

[0078] According to embodiments that can be combined with any embodiments described herein, box 620 includes introducing the carrier into a substrate processing system. For example, the substrate-carrier-arrangement is introduced into the substrate processing system. The carrier and/or the substrate-carrier-arrangement may be introduced vertically. The carrier may be connected to a transport arrangement as described in embodiments herein. Thus, the carrier and/or the substrate-carrier-arrangement may be transported through the substrate processing system. The substrate-carrier-arrangement may be introduced in a load lock module or chamber as described herein.

[0079] According to embodiments that can be combined with any embodiments described herein, box 630 includes heating an area of the carrier that is different from the substrate receiving area with an apparatus for heat treatment. The area of the carrier being different from the substrate receiving area may be the heated carrier area. Heating may be provided with the heating arrangement as described in embodiments herein. The apparatus for heat treatment may include a heating arrangement as described herein.

[0080] According to embodiments described herein that can be combined with any other embodiment described herein, the method 600 may include a plurality of substrates 230 that may be simultaneously transported through the substrate processing system on a plurality of carriers. The substrate may be included in the plurality of substrates and the carrier may be included in the plurality of carriers. Thus, one or more carriers and/or substrates may be transported through the substrate processing system at the same time. The carriers may be transported via the transportation arrangement, for example via transportation paths through the substrate processing system. The transportation arrangement may be configured as a loop.

[0081] According to embodiments described herein, the method may further include a transportation cycle. Box 640 may include transporting at least one carrier of the plurality of carriers to one or more atmospheric modules. For example, the at least one carrier is transported to the load lock module. Additionally or alternatively, the substrate-carrier-arrangement may be transported to the atmospheric module.

[0082] According to embodiments described herein, box 650 may include transporting of the at least one carrier from the one or more atmospheric modules to one or more transfer modules. The transfer modules may be pre-vacuum modules or chambers and or high-vacuum modules or chambers as described according to embodiments herein.

[0083] According to embodiments described herein, box 660 may include transporting of the at least one carrier from the one or more transfer modules to one or more processing modules. For example, the carrier and/or substrate-carrier-arrangement may be transported to the one or more processing modules. Deposition material may be transferred to the one or more substrates in the processing module or chamber.

[0084] According to embodiments described herein, box 670 may include transporting the at least one carrier back to the one or more atmospheric modules. The carrier may be transported on the transportation paths arranged in a loop configuration.

[0085] According to embodiments described herein, box 680 may include stopping the substrate processing system. The at least one carrier may maintain in the one or more atmospheric modules. The carrier and/or the substrate-carrier-arrangement and/or the substrate may be removed from the substrate processing system. For example, the processed substrates may be removed from the processing system. A new substrate may be loaded on the carrier. According to embodiments described herein, box 690 may include starting the substrate processing system. The plurality of carriers and/or the carrier may be stopped in the atmospheric module and/or the transfer module and/or the processing module.

[0086] According to embodiments described herein, the duration of one transportation cycle may be dependent on the number of modules included in the processing system. For example, the duration of one cycle is about 10 minutes or below. Particularly, the duration may be about 5 minutes. The duration of loading a carrier and/or substrate-carrier-arrangement may be 90 seconds. Particularly, the duration of loading may be 60 seconds.

[0087] According to embodiments described herein that can be combined with any other embodiment described herein, the at least one carrier may be heated between the one or more atmospheric modules and the one or more processing modules. The carrier may be heated during transport from the atmospheric module to the transfer module. Additionally or alternatively, the carrier may be heated during the transport through the transfer module. For example, the carrier may be heated during the transport from the pre-vacuum module to the high-vacuum module. Heating may be provided by one or more apparatuses for heat treatment as described in embodiments herein.

[0088] According to embodiments described herein that can be combined with embodiments described herein, the method 600 may include heating the area of the carrier that is different from the substrate receiving area during transport of the carrier. The heated carrier area may be heated. For example, one or more apparatuses for heat treatment are arranged such that the heated carrier area is heated. Additionally or alternatively, edge portions of the carrier may be heated. Heating may occur during stopping of the processing system.

[0089] Advantageously, particles that may absorb to the carrier in atmospheric modules may be removed from the carrier. For example, such absorption may increasingly take place during stopping of the processing system when the carrier is placed in an atmospheric module. Thus, degassing of the carrier may be ensured. Further, efficiency of the process is improved. Additionally, the time between stopping and starting of the process and the total particle load in the processing system is decreased.

[0090] According to embodiments described herein, the method 600 may further include heating the area of the carrier that is different from the substrate receiving area during transport of the carrier from the one or more atmospheric modules to the one or more transfer modules and/or during transport of the carrier from the one or more transfer modules to the one or more processing modules.

[0091] According to embodiments described herein, arrow 692 may indicate determining the gas load in the vicinity of the carrier and arrow 694 may indicate regulating the apparatus for heat treatment upon determining the gas load. Gas load may be used synonymously to particle load. The gas load may be determined via residual gas analysis (RGA) described with respect to embodiments herein. Regulating the heating may be carried out by the control system as described in embodiments herein.

[0092] 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. Apparatus (200) for heat treatment of a carrier (212) in a processing system, the carrier being configured to support a substrate (230) in a substrate receiving area (232), the carrier (212) having one or more edge portions (214) extending outside the substrate receiving area (232), the apparatus (200) comprising:

a heating arrangement (240) configured to provide heat energy to the one or more edge portions (214).

2. The apparatus (200) according to claim 1, wherein the one or more edge portions (214) provide a frame (216) surrounding the substrate receiving area (232).

3. The apparatus (200) according to claim 2, wherein the heating arrangement (240) is configured to provide heat energy to the frame (216).

4. The apparatus (200) according to any of claims 1 to 3, wherein the heating arrangement (240) includes:

one or more radiation heaters.

5. The apparatus (200) according claim 4, wherein the one or more radiation heaters extend to the one or more edge portions (214).

6. The apparatus (200) according to any of claims 4 to 5, wherein the one or more radiation heaters include one or more of the group comprising an IR lamp, an UV lamp, resistive heaters, and combinations thereof.

7. The apparatus (200) according to any of claims 1 to 6, wherein the heating arrangement (240) includes:

a resistive heating wire and/or a magnetic material.

8. The apparatus (200) according to claim 7, wherein the resistive heating wire is attached to the carrier (212).

9. The apparatus (200) according to claim 8, wherein the heating arrangement (240) is integrated into the carrier (212).

10. The apparatus (200) according to any of claims 7 to 9, wherein the heating arrangement (240) includes:

an energy source for providing energy to the heating arrangement (240).

11. The apparatus (200) according claim 10, wherein the energy source includes a power supply for providing a voltage to the resistive heating wire or a power supply for inductively coupling a current to the magnetic material.

12. The apparatus (200) according to any of the preceding claims, wherein the heating arrangement (240) provides heat energy of at least 1 kW/m^2.

13. Substrate processing system (100), comprising:

the apparatus (200) for heat treatment according to any of claims 1 to 12.

14. The substrate processing system (100) according to claim 13, wherein the system further includes a transport arrangement (160) configured to transport the carrier (212) past the apparatus for heat treatment (200).

15. The substrate processing system (100) according to claim 13 or 14, wherein the system further includes one or more transfer modules (180) and wherein the apparatus for heat treatment (200) is provided at the one or more transfer modules (180).

16. The substrate processing system (100) according to claims 13 to 15, wherein the system further includes one or more atmospheric modules (170), the apparatus for heat treatment (200) is provided at the one or more atmospheric modules (170).

17. Substrate processing system (100) for processing a substrate (230) supported by a carrier (212) providing a substrate-carrier arrangement (250), comprising:

a first apparatus for heat treatment (252) configured to heat a first area of the substrate-carrier-arrangement (250); and

a second apparatus for heat treatment (254), configured to heat a second area of the substrate-carrier-arrangement (250).

18. The substrate processing system (100) of claim 17, wherein the first apparatus for heat treatment (252) provides heat energy of a lower power than the second apparatus for heat treatment (254).

19. The substrate processing system (100) according to claims 17 or 18, wherein the first area is a substrate receiving area (232) of the substrate-carrier arrangement (250).

20. The substrate processing system (100) according to claims 17 to 19, wherein the second area is an edge portion (214) of a carrier (212) of the substrate-carrier arrangement (250).

21. The substrate processing system (100) according to claims 17 to 20, wherein heating of the second area is regulated by a closed loop control system.

22. The substrate processing system (100) according to claim 21, wherein the closed control system includes a residual gas analysis.

23. Method (600) for processing a substrate (230), the method comprising:

loading the substrate (230) on a carrier (212) in a substrate receiving area (232);

introducing the carrier (212) into a substrate processing system (100); and

heating an area of the carrier that is different from the substrate receiving area (232) with an apparatus for heat treatment (200).

24. The method (600) according to claim 23, wherein a plurality of substrates (230) are simultaneously transported through the substrate processing system (100) on a plurality of carriers (212), the substrate (230) being included in the plurality of substrates (230) and the

carrier (212) being included in the plurality of carriers (212), the method further comprising:

a transportation cycle comprising:

transporting at least one carrier (212) of the plurality of carriers (212) to one or more atmospheric modules (170);

transporting the at least one carrier (212) from the one or more atmospheric modules (170) to one or more transfer modules (180);

transporting the at least one carrier (212) from the one or more transfer modules (180) to one or more processing modules (190);

transporting the at least one carrier (212) back to the one or more atmospheric modules (170);

stopping the substrate processing system (100), wherein the at least one carrier (212) maintains in the one or more atmospheric modules (170); and

starting the substrate processing system (100), wherein the at least one carrier (212) is heated between the one or more atmospheric modules (170) and the one or more processing modules (190).

25. The method (600) according to claims 23 to 24, the method further comprising:

determining the gas load in the vicinity of the carrier; and

regulating the apparatus for heat treatment (200) upon determining the gas load.

26. The method (600) according to claims 23 to 25, the method further comprising:

heating the area of the carrier (212) that is different from the substrate receiving area (232) during transport of the carrier (212).

27. The method (600) according to claims 23 to 26, the method further comprising:

heating the area of the carrier (212) that is different from the substrate receiving area (232) during transport of the carrier (212) from the one or more atmospheric modules (170) to the one or more transfer modules (180) and/or during transport of the carrier (212) from the one or more transfer modules (180) to the one or more processing modules (190).

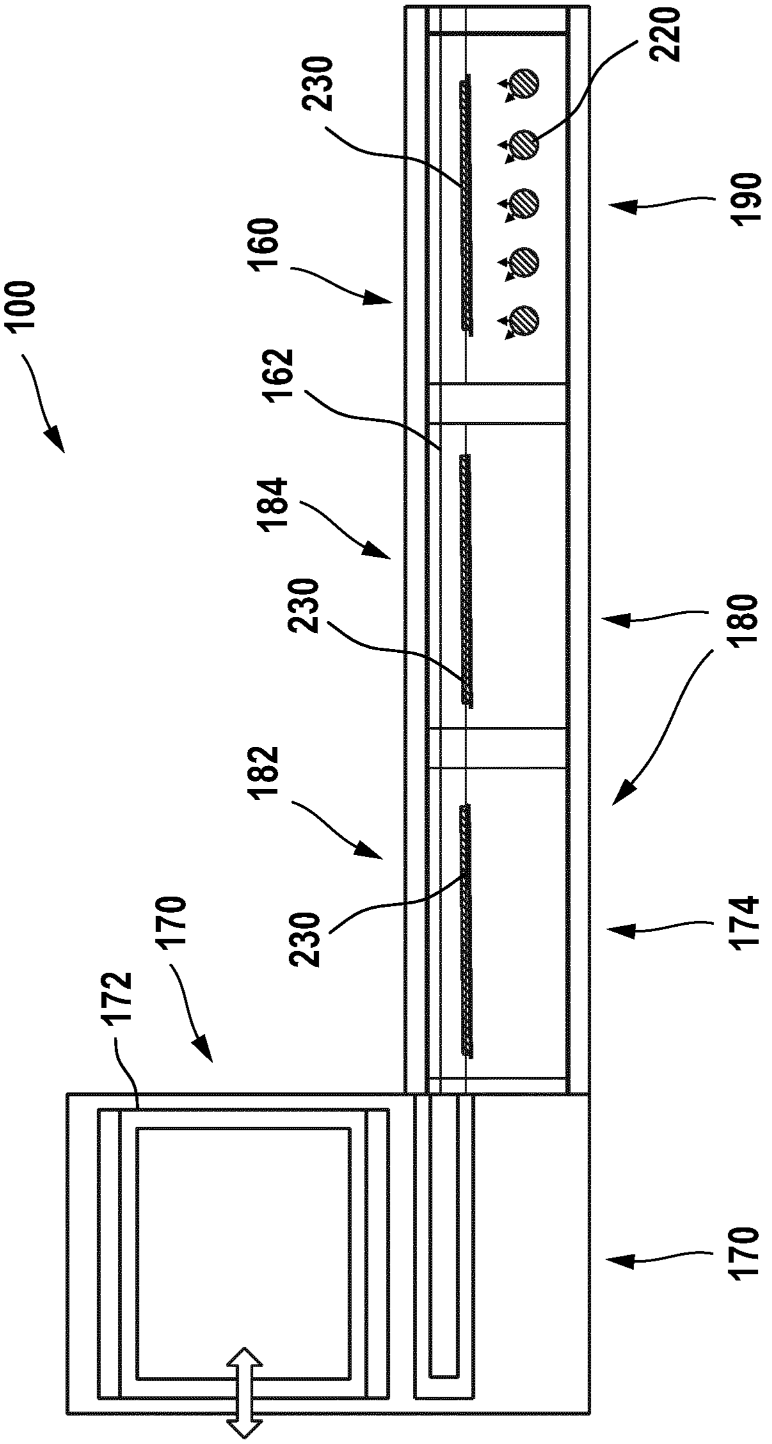


Fig. 1

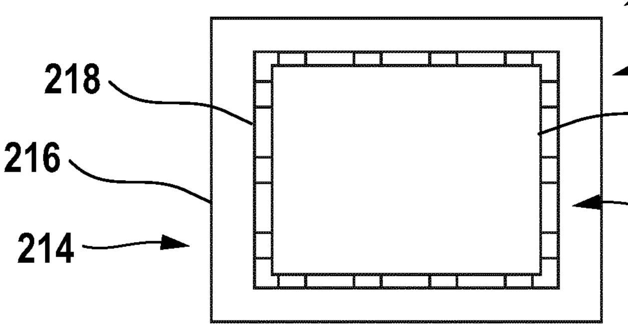


Fig. 2A

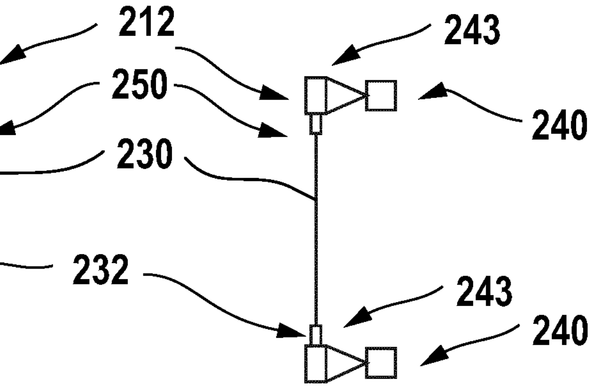


Fig. 2B

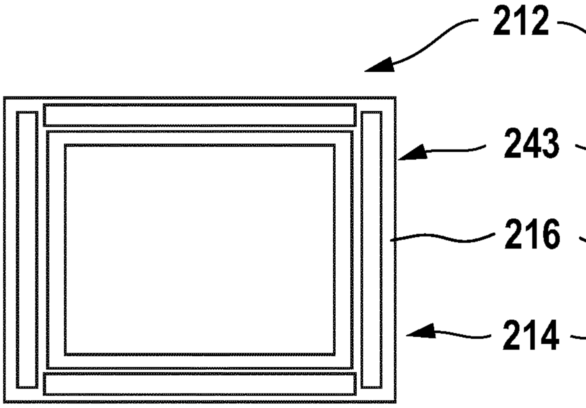


Fig. 3A

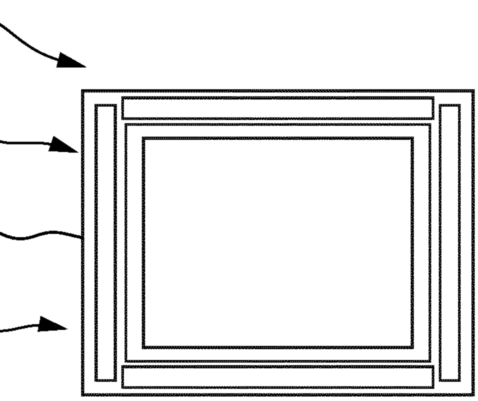


Fig. 3B

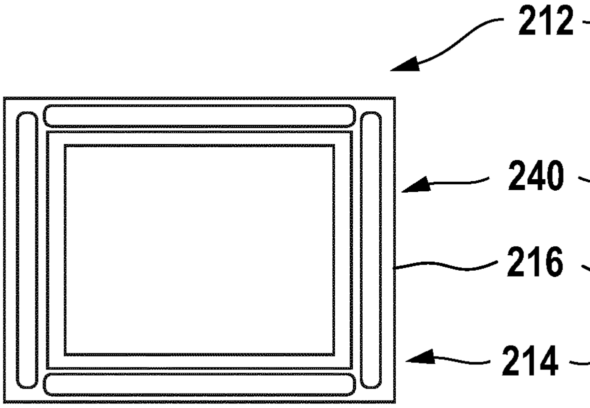


Fig. 3C

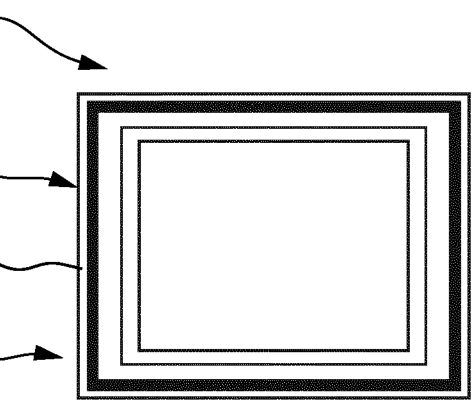
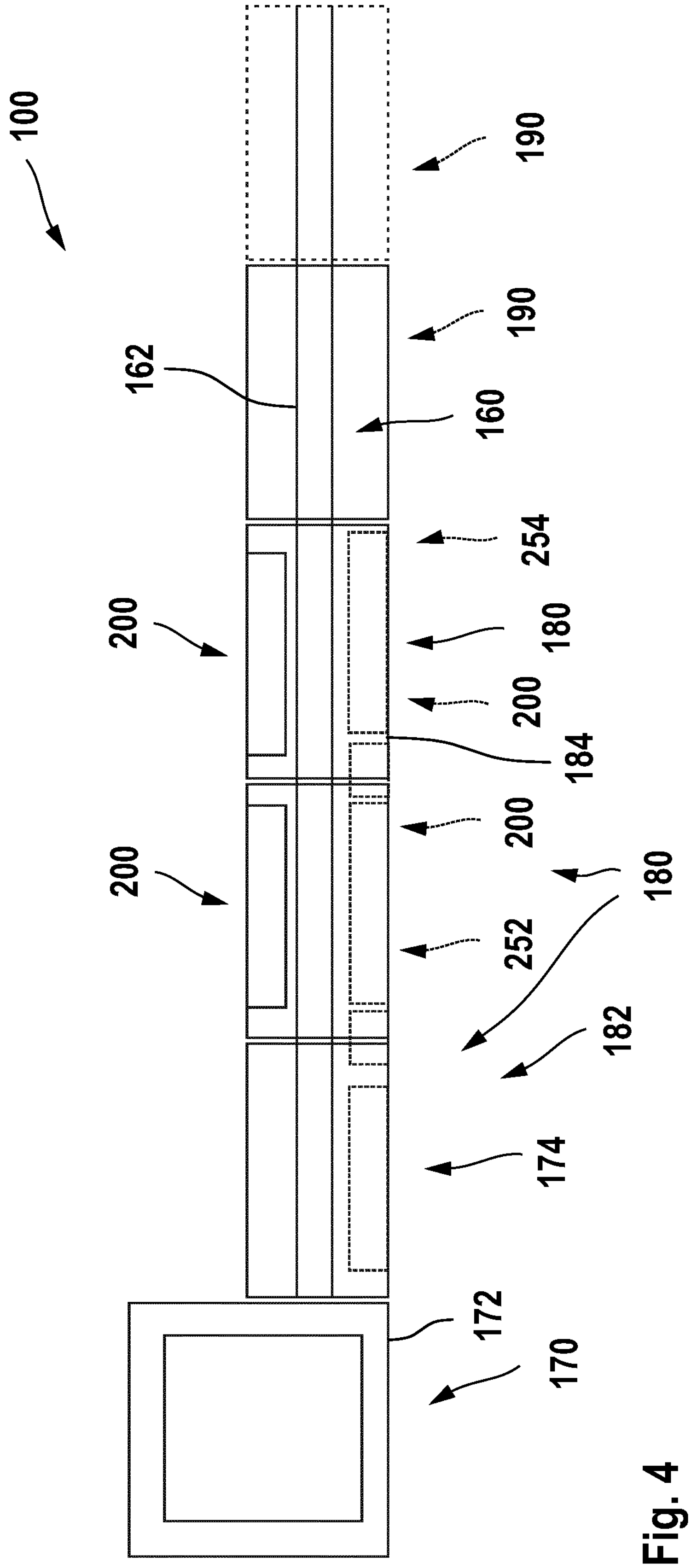


Fig. 3D


100
190
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162
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254
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174
172
170

Fig. 4

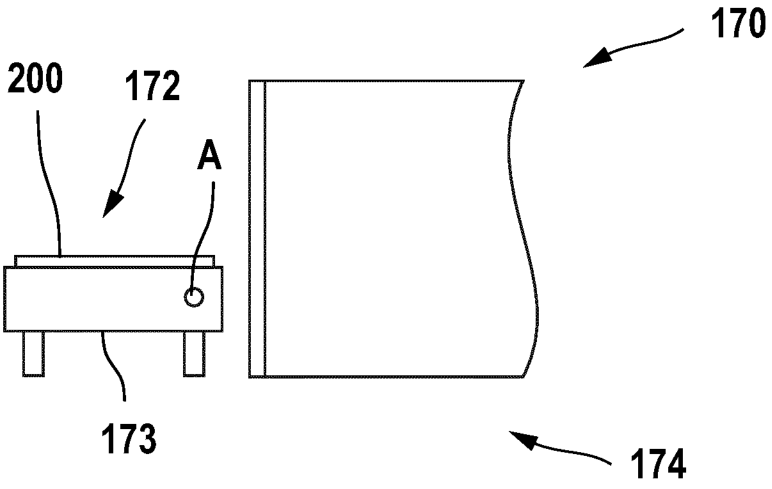

Fig. 5A

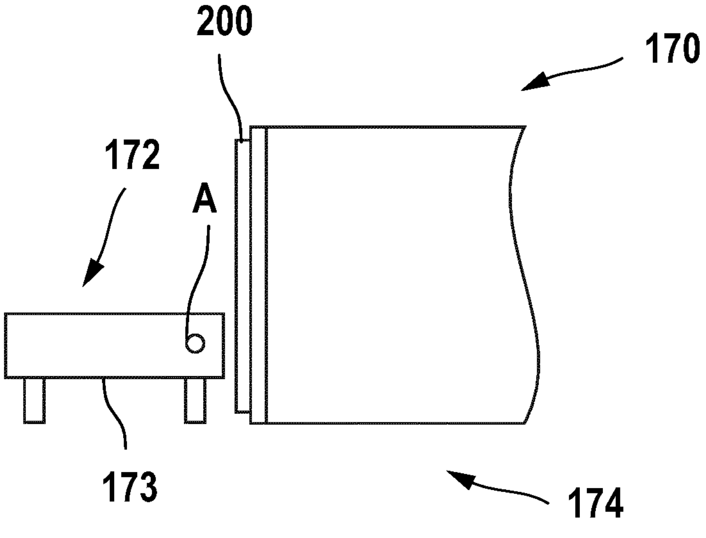

Fig. 5B

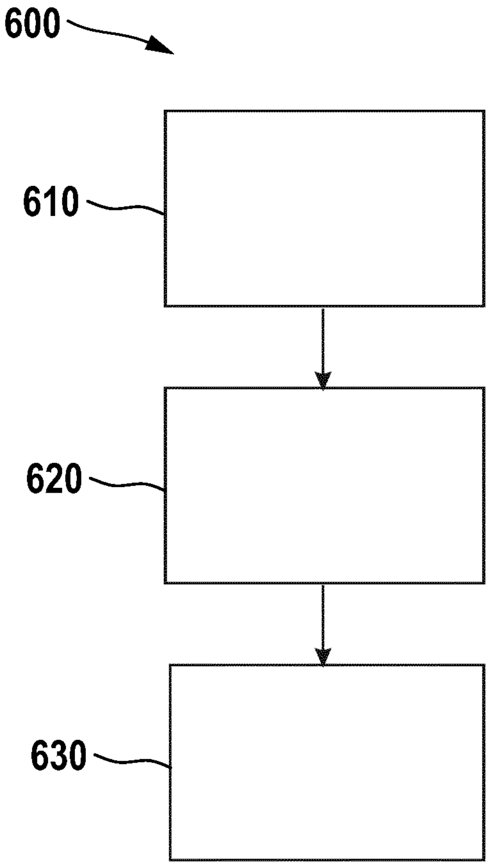

Fig. 6A

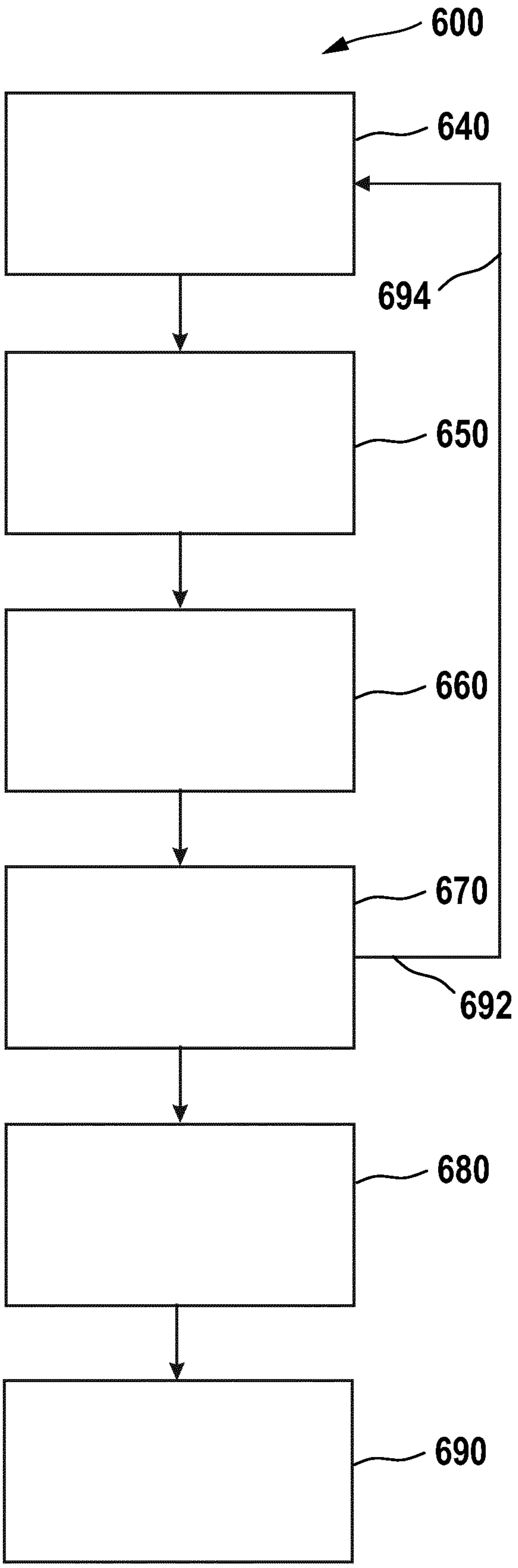

Fig. 6B

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/064242

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/67 H01L21/677 H01L21/687 C23C14/50 C23C14/56
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 2008/092821 A1 (OTSUKA TORU [JP] ET AL) 24 April 2008 (2008-04-24)	1-23
A	abstract claims 1-10 paragraphs [0007] - [0011] figures 1-8 -----	24-27
X	US 2015/361581 A1 (CARLSON DAVID K [US]) 17 December 2015 (2015-12-17)	17,23
A	abstract claims 1-20 figures 1-5 -----	1-16, 18-22, 24-27
A	US 5 580 607 A (TAKEKUMA TAKASHI [JP] ET AL) 3 December 1996 (1996-12-03) abstract claims 1-4 column 11, lines 10-26 figures 1-14 -----	1-27

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

19 February 2019

Date of mailing of the international search report

27/02/2019

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2018/064242

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